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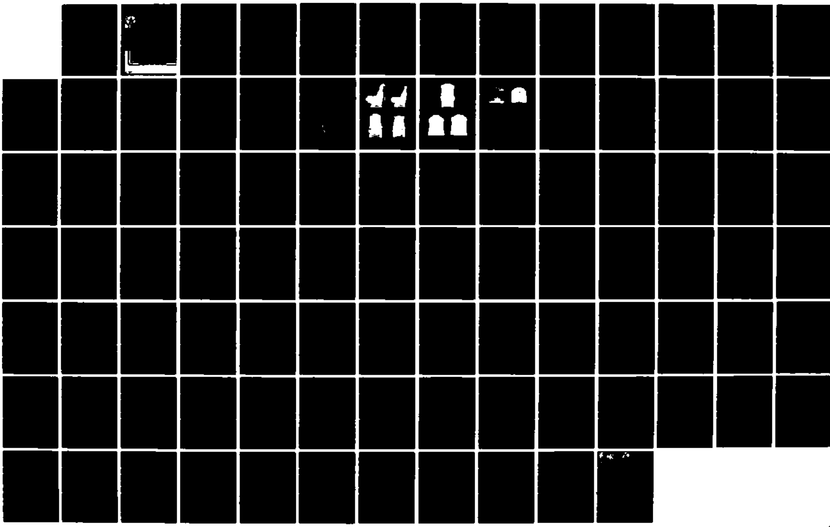

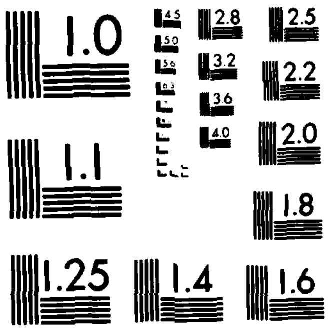

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IMPACT AND VIBRATION TESTING OF A MODIFIED UH-1 CREW SEAT

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June 1983

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20. ABSTRACT

The German Air Force has developed a modified UH-1 pilot seat designed to improve comfort by increasing support to the thigh and lower back, providing better vibration dampening and increasing cold weather comfort. This seat was tested for vibration dampening, pilot acceptance, and impact tolerance in a side-by-side test with the standard UH-1 seat. The modified seat is more comfortable than the standard UH-1 seat. The modified seat provides better impact protection than the standard seat, provided that the seat frame and restraint system do not tear loose. The modified seat does not provide better vibration dampening than the standard UH-1 seat.

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INTRODUCTION

In response to helicopter pilots' chronic complaints of lower back discomfort aggravated by cold drafts and excessive in-flight vibration, the German Air Force has commissioned the development of a modification kit to be retrofitted to the pilot and copilot seats of their UH-1D helicopters. The modification consists of a molded fiber glass seat pan and contoured seat and back cushions which are attached to the standard UH-1D seat frame once the support material has been removed. The cushions are intended to improve comfort by increasing support to the thighs and lower back, providing improved vibration dampening characteristics, and increasing cold weather comfort by eliminating the open weave design of the net seats.

An initial subjective evaluation of the modified seats was conducted by the German Air Force wherein pilots flew typical operational missions in the modified seat and then answered a questionnaire about the seat after the completion of the mission. Data from approximately 100 missions were analyzed. This study indicated that the majority of the respondents felt that the modified seat was generally less fatiguing than the standard seat, there were fewer complaints of back and extremity pain during flight, objectionable vibration was considerably reduced (i.e., writing on a knee board was felt to be easier), and the problem of cold drafts to the back and thighs was completely eliminated (Knoche, unpublished data).

Based on these initially encouraging results, the German Air Force accepted an offer from the United States Army Aeromedical Research Laboratory (USAARL) to conduct objective in-flight evaluations of the vibration dampening capability of the modified seat and to test the impact tolerance of the seat as compared to the United States Army UH-1H armored and unarmored seats. This report presents the results of those tests as well as the results of a questionnaire answered by United States Army pilots who flew in the modified seat.

METHODS

VIBRATION MEASUREMENTS

Vibration data were obtained for the modified seat and the standard UH-1H unarmored seat mounted in the copilot (left) and pilot (right) positions respectively of the same JUH-1H helicopter. Seven male volunteers with heights and weights shown in Table 1 were flown over a standard flight profile (Appendix A) twice, once in each seat, while their hands and feet rested lightly on the controls. Each subject wore the standard US Army flight suit, boots, gloves, and SPH-4 helmet. Vibration data were recorded continuously during the flight profile from three locations: the seat rail, the seat pad, and the mouth of the volunteer.

TABLE 1

VOLUNTEER ANTHROPOMETRY

VOLUNTEER	HEIGHT/PERCENTILE (cm)	(percent)*	WEIGHT/PERCENTILE (kg)	(percent)*	AGE (years)
1	175.3	(55)	84.1	(72)	35
2	188.0	(98)	77.3	(50)	34
3	181.6	(88)	82.7	(69)	34
4	168.9	(19)	64.6	(13)	31
5	172.7	(39)	71.4	(30)	33
6	172.7	(39)	61.4	(7)	36
7	172.7	(39)	68.2	(20)	36

* Churchill, Edmund, et al., 1971

The selection of the volunteers was based primarily on weight in order to assure the widest range possible from those aviators potentially available for this experiment. The flight profile was based on several considerations. Safety was most important. Therefore, any maneuvers which involved even moderate risk were excluded from consideration. The second consideration was reproducibility. A profile that could be flown with a high degree of reliability by a single test pilot from both the pilot and copilot positions was required. For this reason, nap-of-the-earth flight and complex maneuvers were excluded. Third, it was felt that the flight profile should resemble an actual mission as much as possible. Consequently, a flight profile which included takeoff, landing, three-foot hover, 50-foot hover, standard rate turns and level flight was adopted (Appendix A).

Prior to his participation in this study, each volunteer was briefed on potential risks. He then was weighed and measured and fitted with an accelerometer mouth mount. Photographs of each subject with the mouth mount in place were taken in order to document the position of the accelerometer relative to the estimated center of mass of his head (Appendix B).

At the time of the experiment, the subject positioned himself in the instrumented seat and assumed a normal flying position with his hands and feet resting on the controls. In this manner, he would be coupled to the controls but would not interfere with control movements. After calibration of the instrumentation, the mouth-mount accelerometer was passed to the subject who would place the accelerometer bite bar comfortably but firmly between his teeth. When the pilot was ready for takeoff, a technician started the tape recorder, performed a visual check to insure all equipment was operating correctly, and then informed the pilot that he could begin the flight. Data were collected continuously until the completion of the flight profile.

The instrumentation utilized for the vibration measurement and analysis portion of the study is shown in Figure 1. Three sets of accelerometers were used. The first set consisted of a Columbia triaxial piezoelectric accelerometer which was securely clamped to the left seat rail of the seat being tested. Three Kaig-Swiss charge amplifiers amplified the signal from the rail-mounted accelerometers and the amplified signal was recorded on an EMI 7000M tape recorder. An Endevco Model VT-3 pad weighing 513 grams and containing three orthogonally-mounted piezoresistive accelerometers was used to sense accelerations at the buttocks of the subject. Output from the ride pad was amplified by an Endevco Model 4470 signal conditioning system and recorded on the same tape recorder. The mouth-mount accelerometer consisted of five piezoresistive, critically damped, Entran Model EGAL 125-10D accelerometers which were mounted as shown in Figure 2. A Metraplex Series 300 instrumentation system which incorporated five Model 340D strain gauge amplifiers preconditioned the output of the mouth-mount accelerometers prior to recording. Additional signal inputs to the tape recorder included intercom communication and time code data produced by a Sistron Donner Model 8150 time code generator.

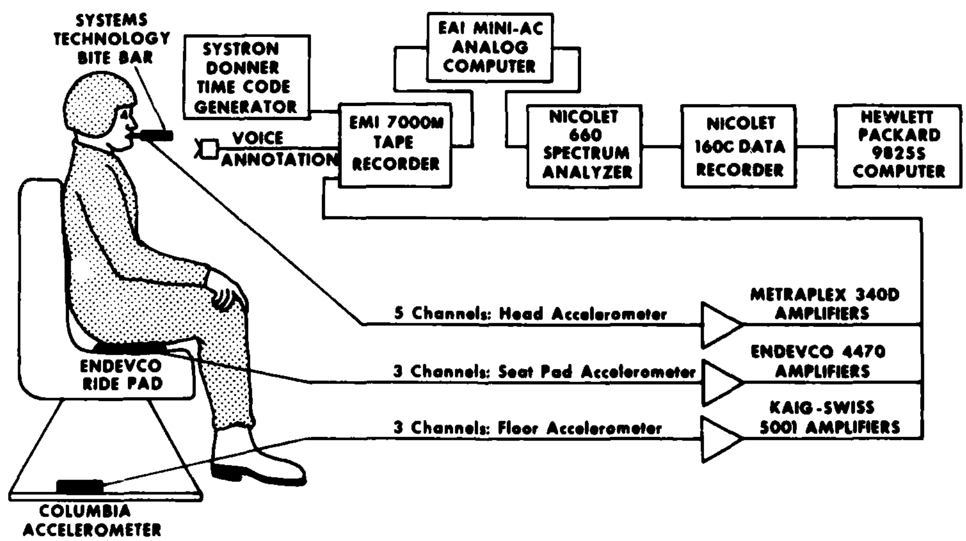


FIGURE 1. Instrument Diagram for Accelerometer Measurement

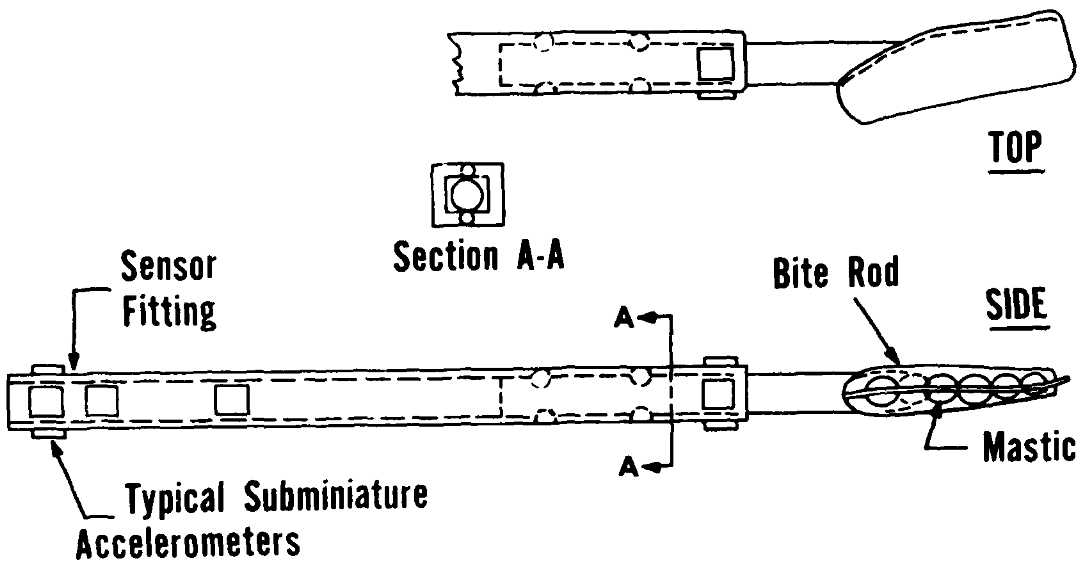


FIGURE 2. Bite Bar Accelerometer Mount

"Turn over" calibrations of the mouth-mount accelerometer were performed immediately prior to the flight of each subject. This involved inverting the mouth mount with respect to the sensitive axis of each accelerometer to provide a standard 9.8 m/s^2 calibration signal. The accelerometer output was monitored using a voltmeter to ascertain that the calibration factor of the accelerometer had not changed due to ambient temperature fluctuations or inadvertent damage to the accelerometer. A "turn over" calibration check also was performed on the ride pad accelerometers. After calibration, the ride pad was installed on the seat under test and taped down with masking tape. A 1.000 volt 100 Hz calibration signal was recorded at the beginning of each new tape using an Endevco Model 4825A accelerometer simulator to provide the input signal. This calibration signal provided a fixed reference on tape to indicate the sensitivity of each channel. This reference was used to scale the data during spectral anlaysis.

As shown in Figure 1, an EAI Mini-AC Analog computer was used to preprocess the mouth-mount accelerometer data. This preprocessing converted the output of the five mouth-mount accelerometers to three linear accelerations (X, Y, and Z) plus two angular accelerations (pitch and yaw), all of which were referenced to the approximate center of gravity of the volunteer's head. A detailed description of this data reduction procedure is contained in Appendix B.

The preprocessed acceleration data were transformed with the Nicolet 660 FFT analyzer. The settings for the Nicolet 660 FFT analyzer are shown in Table 2. Paired inputs to the two-channel Nicolet FFT analyzer are shown in Table 3. Vibration data were averaged over the entire flight to produce one spectrum for each accelerometer. Each of these spectra was stored on 5½ inch floppy disks using the Nicolet 160C Data Recorder. Once all data had been stored on disks, a Hewlett-Packard 9825S Desk Top Computer was used to compute resultant accelerations ($a_T = (a_x^2 + a_y^2 + a_z^2)^{1/2}$) for all recording positions. The data then were averaged over all subjects. These computations reduced the data to three spectra: one for the seat rail (floor), one for the seat pad (seat), and one for the volunteer's head.

TABLE 2

PARAMETER SETTINGS FOR NICOLET 660 SPECTRUM ANALYZER

PARAMETER	SETTING
MODE	1K CH A-B FFT
FUNCTION	RMS SPECTRUM
AVERAGE	SUM
CHANNEL A INPUT	1.0 Volts
	AC COUPLED (-3 dB @ 0.5 Hz)
	NORMAL MODE
CHANNEL B INPUT	1.0 VOLTS
	AC COUPLED (-3 dB @ 0.5 Hz)
	NORMAL MODE
CAPTURE CONTROL	CONTINUOUS (HANNING WINDOW)
FREQUENCY RANGE	200 Hz (2.0 SEC WINDOW)

Transmissibility functions were used to compare the resultant spectra. Transmissibility is the nondimensional ratio of the response acceleration (seat or head) to the excitation acceleration (seat rail). The resultant accelerations derived from the accelerations measured from the volunteer in the modified seat subtracted from the resultant accelerations derived from the accelerations measured from the same volunteer in the standard seat were used to describe the differences in the vibration levels between the two seats.

TABLE 3

VIBRATION SPECTRAL COMPONENTS AND THE DERIVATION OF THE COMPARATIVE SPECTRA

INPUT ACCELERATION		RESULTANT ACCELERATION SPECTRA	TRANSMISSIBILITY FUNCTIONS	DIFFERENCE GRAPHS
EXCITATION	RESPONSE			
X_f	X_h	$R_h=(X_h^2+Y_h^2+Z_h^2)^{1/2}$	$\frac{R_h}{R_s}$	$R_{h(st)}-R_{h(g)}$
Y_{+}	Y_h	$R_s=(X_s^2+Y_s^2)^{1/2}$	$\frac{R_h}{R_f}$	$R_{s(st)}-R_{s(g)}$
Z_f	Z_h	$R_f=(X_f^2+Y_f^2+Z_f^2)^{1/2}$	$\frac{R_s}{R_f}$	$R_{f(st)}-R_{f(g)}$
X_f, Y_f, Z_f	P_h		$\frac{P_h}{(X_f^2+Z_f^2)}$	$P_{h(st)}-P_{h(g)}$

f = FLOOR
g = GERMAN
h = HEAD
P = PITCH ACCELERATION
R = RESULTANT ACCELERATION
s = SEAT
st = STANDARD
X = X AXIS ACCELERATION
Y = Y AXIS ACCELERATION
Z = Z AXIS ACCELERATION

IMPACT TESTING

Impact testing of the German-modified seat and the standard armored and unarmored UH-1H seats was performed on the horizontal sled at the Civil Aeromedical Institute (CAMI) in Oklahoma City, Oklahoma, utilizing a 50th percentile anthropometric dummy. Tests were conducted according to the test plan in Appendix C. Each seat was mounted to the test sled as shown in Figure 3. The angle of the "floor" to the vertical was 16 degrees. This

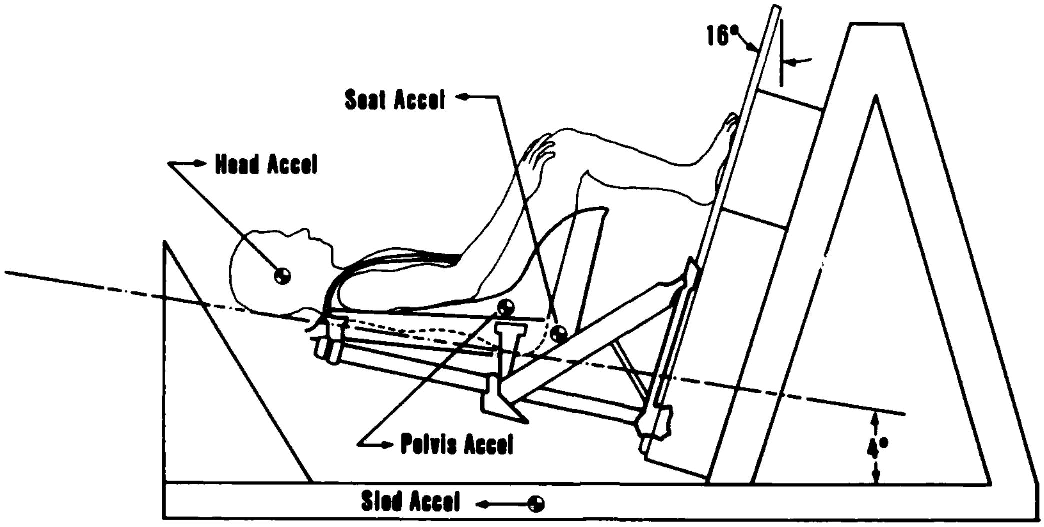


FIGURE 3. Test Sled Seating Configuration

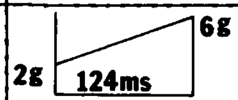
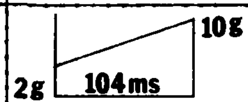
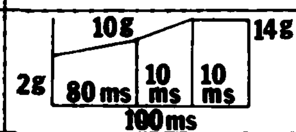
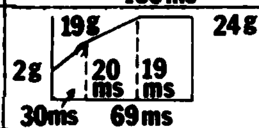
angle included 12 degrees to assure that the impact deceleration vector was aligned parallel to the dummy spine plus an additional 4 degrees forward pitch to offset the effect of gravity in reducing hyperflexion of the dummy spine during impact. Four degrees forward pitch allows the body's component of vertical acceleration in a 14.5g impact to cancel the effect of gravity. To facilitate reduction of the data, this particular value was selected to be identical to that being used in an ongoing triservice human surrogate impact test program being performed on the UH-60A Blackhawk helicopter pilot's seat. The seat height was adjusted to a mid-position setting (6 cm up from the bottom) to correspond to the height of the dummy.

A 50th percentile Department of Transportation Part 572 dummy was used for all impact tests. The dummy's total mass including helmet (regular size SPH-4) and clothing was 80 kg. All the joints were adjusted to provide 1 g resistance to rotation. Triaxial accelerometers were mounted at the head, chest, and pelvis of the dummy as shown in Figure 3. A specific procedure was used to insure identical positioning of the dummy in the seat for all tests (Appendix C). The inertia reel was set to the automatic position prior to all sled runs.

The dynamic sled inputs prescribed for the 11 tests are summarized in Table 4. Four pulse shapes and velocity changes were selected. The first (4.9 m/sec) attempted to simulate a hard landing that would collapse the skids on hard soil and bring the fuselage into contact with the ground without significant airframe deformation. The second (6.1 m/sec) was slightly more severe and would probably cause fuselage deformation. The

TABLE 4

IMPACT TEST DESCRIPTION

SEAT IDENTITY	TEST NO. (CAMI NO.)	Δν m/sec	DESCRIPTION PULSE SHAPE (g vs. t)	APPROXIMATE PERCENTILE CSDG CRASH * (g)	(Δν)
STD UH-1 PILOT SEAT ARMOR PLATE (RIGID FRAME) WITH CONTOURED OPEN WEAVE SUPPORT	1 (087)	4.9		48%	16%
	2 (088)	6.1		62%	30%
	3 (095)	7.3		72%	50%
	4 (097)	11.3		85%	90%
STD UH-1 PILOT SEAT TUBULAR RIGID FRAME WITH OPEN WEAVE SUPPORT	5 (090)	4.9	SAME AS TEST 1	48%	16%
	6 (089)	6.1	SAME AS TEST 2	62%	30%
	7 (091)	7.3	SAME AS TEST 3	72%	50%
STD UH-1 PILOT SEAT TUBULAR RIGID FRAME WITH CONTOURED FOAM BOTTOM AND BACK CUSHION	8 (092)	4.9	SAME AS TEST 1	48%	16%
	9 (093)	6.1	SAME AS TEST 2	62%	30%
	10 (094)	7.3	SAME AS TEST 3	72%	50%
	11 (096)	11.3	SAME AS TEST 4	85%	90%

* Department of Army, 1980

third pulse (7.3 m/sec) would have definitely caused fuselage deformation. It also represents a 50th percentile vertical velocity change based on the Aircraft Crash Survival Design Guide (ACSDG) (Department of the Army, 1980). The final pulse simulated a very severe crash (11.3 m/sec) that is known to cause back injury in most cases where a load limiting seat is not used. In all four cases, the pulses began with an initial 2g load. The pulse shape was selected to be consistent with a level impact of the UH-1H on hard soil. The velocity change and average g levels used in these pulses are related in Table 4 to the relative frequency of occurrence of these values for survivable rotary-wing and light fixed-wing aircraft accidents as stated in the ACSDG. All runs were photographed in frontal and profile views using 500 frame/second, 35 mm realtime cameras.

QUESTIONNAIRE SURVEY

Subjective data relating to the comfort, support, and vibration dampening capability of the modified seat were obtained by having all pilots who actually flew from that seat for over one hour answer a short questionnaire (Appendix D). These pilots were not specifically recruited to fly in the seat, nor were they prebriefed on the potential merits of the seat. Twelve pilots flew in the seat incidental to other research or training flight missions and were asked to respond to the questionnaire immediately post-flight.

MATERIALS

UH-1H ARMORED PILOT SEAT

The standard UH-1H armored seat is fully described in US Army Technical Manual TM 55-1520-210-20P-1 (Department of the Army, 1974), but the more prominent features will be described here. The seat consists of a contoured tubular metal frame attached to an armor plate "bucket." A net fabric is stretched over the contoured frame and when properly tightened, suspends the buttocks 2 to 4 cm above the armor plate. The armor plate bucket is attached to a tubular, rigid structural frame that is mounted to the aircraft floor by "I" beam tracks that provide for fore and aft adjustment of the seat. Vertical adjustment is obtained by means of sliding pin adjustments through the tubular steel structural frame. The lap belts are anchored to the aircraft floor; however, the shoulder harness is attached to the seat back. The seat is equipped with a mechanism to allow for tilting the entire seat backward to permit rescuers to extract a disabled pilot through the rear cabin.

UH-1H UNARMORED PILOT SEAT

The unarmored UH-1H seat is also described in US Army Technical Manual TM 55-1520-210-20P-1 (Department of the Army, 1974), and consists of a rigid contoured tubular structural frame over which a net fabric is stretched to provide buttock and back support (Figure 4). This frame differs from the armored seat frame in that it is designed to withstand greater vertical crash loads. The net suspends the buttocks 5 to 10 cm above the lower portion of the tubular frame in order to provide for stretch of the material under vertical impact loads. The seat frame is mounted on a structural frame that provides the same vertical and longitudinal adjustments as the armored seat frame. Both the lap belt and shoulder harness tiedowns are to the aircraft floor (Figure 5). There is no tiltback feature with this seat.

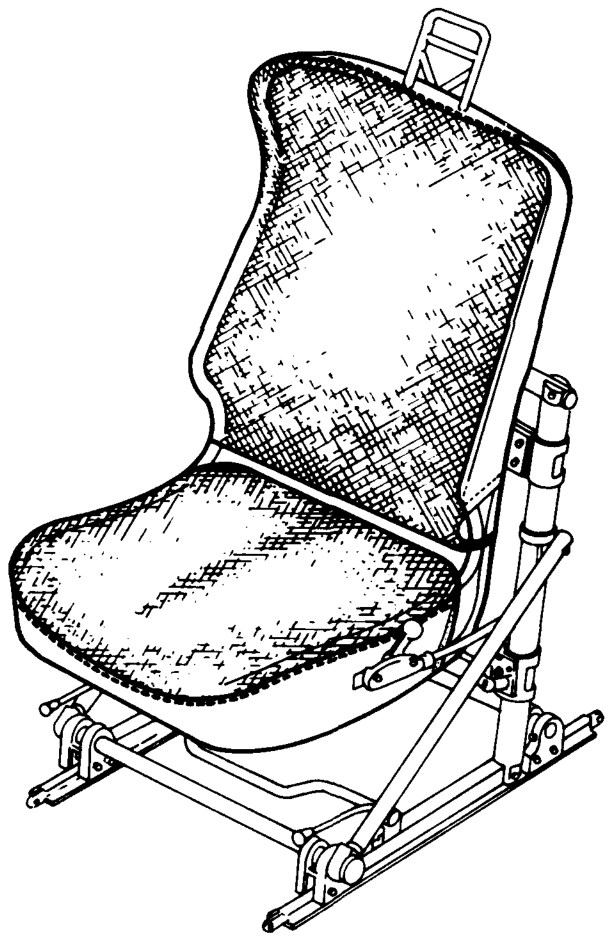


FIGURE 4. Unarmored Seat, Net Fabric

MODIFIED UH-1H PILOT SEAT (WEST GERMAN)

The West German modification kit for the unarmored UH-1H pilot seat was designed and produced by the firm F. S. Fehrer and is illustrated in Figures 6 through 14. It consists of a 3 mm thick fiber glass cloth-resin molded seat pan that is bolted by brackets to the standard unarmored seat contoured frame after the net has been removed. A 15 mm diameter hole is provided at the lowest point of the seat pan to insure venting of the cushions. Separate seat and back foam contoured cushions are fitted into the seat pan. The cushions were shaped so as to provide for increased lumbar support and extended thigh support compared to the standard seat. Due to the extended length of the bottom seat cushion, the forward edge was notched to permit full aft and lateral cyclic when the seat is adjusted to the forward-most position. The foam itself was designed to provide for maximum vibration dampening. According to the manufacturer, this is best achieved through a layering process alternating various densities of polyurethane foam with latex impregnated animal hair. Each cushion was, therefore, constructed of six layers as follows: 1) polyurethane foam, 4 mm thick; 2) latex-animal hair, 54 mm thick; 3) polyurethane foam, 80 kg/m^3, 50 mm thick; 4) latex-animal hair, 15 mm thick; 5) polyurethane foam, 120 kg/m^3, 25 mm thick; and 6) latex-animal hair, 2 mm thick. The cushions then were covered with a flame-resistant material that is applied to a lining of upholstery wadding. A cross section of the seat pan cushion is shown in Figure 15.

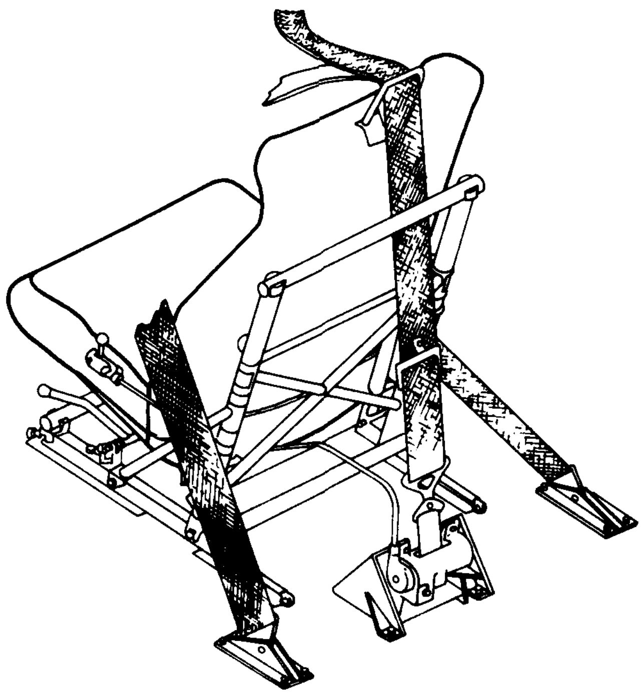


FIGURE 5. UH-1 Unarmored Seat, Rear View

FIGURE 6. German Seat, Side View

FIGURE 7. German Seat, Side View, Seat Cushions Removed

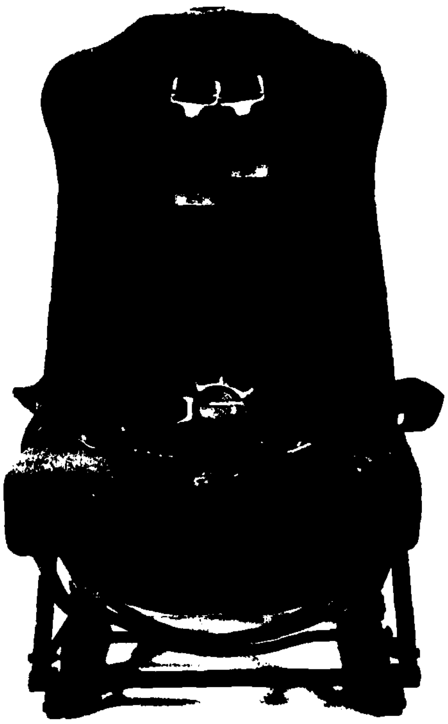


FIGURE 8. German Seat, Front View

FIGURE 9. German Seat, Front View, Seat Cushions Removed

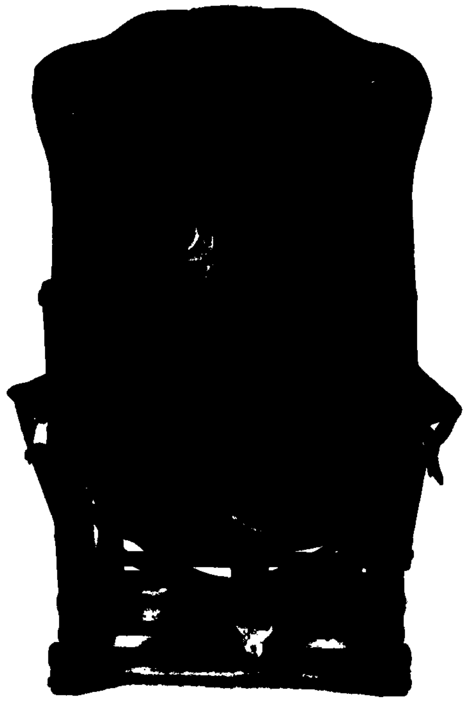


FIGURE 10. German Seat, Rear View

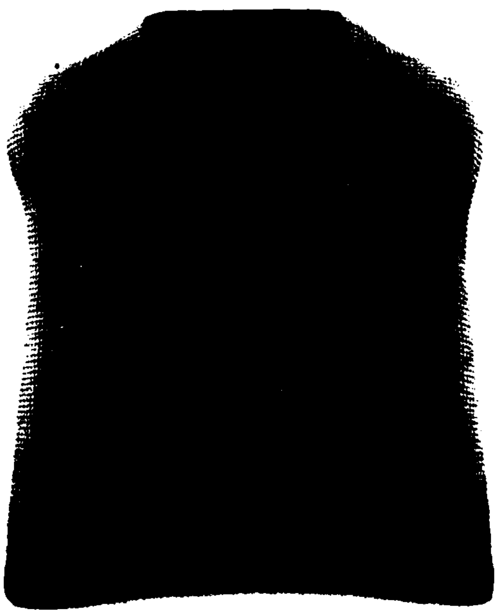


FIGURE 11. German Seat, Back Cushion, Front View

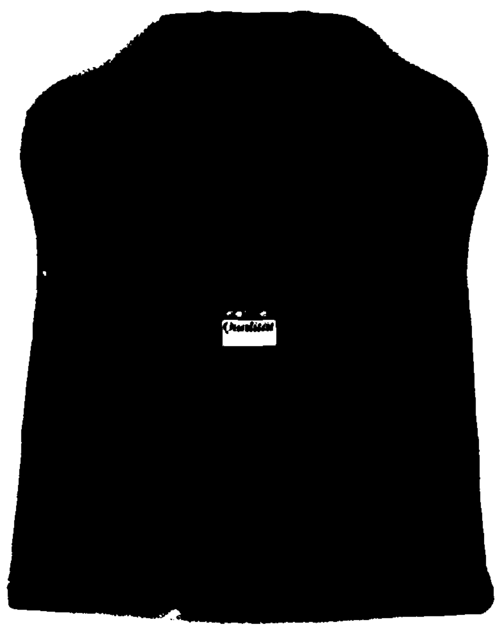


FIGURE 12. German Seat, Back Cushion, Rear View

FIGURE 13. German Seat Pan Cushion
Insert, Top View

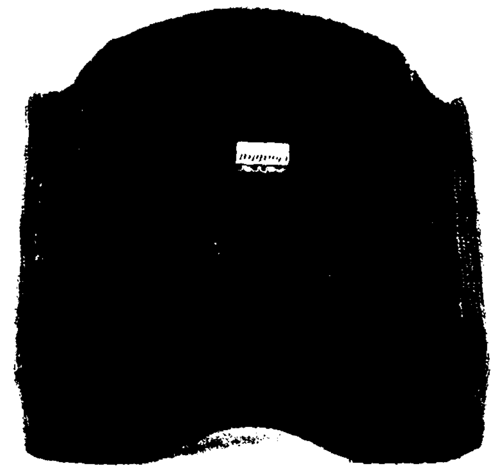


FIGURE 14. German Seat Pan Cushion
Insert, Bottom View

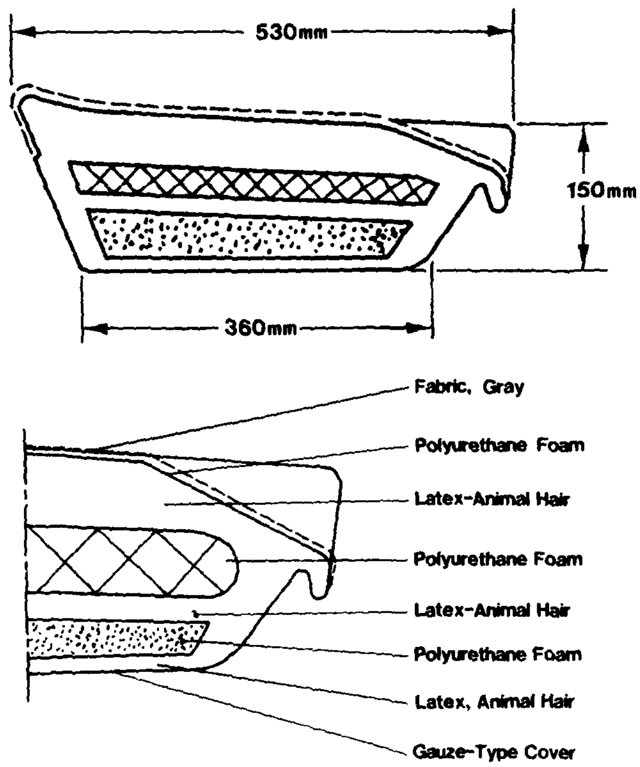


FIGURE 15. German Seat Cushion Cross-section
and Dimensions (in cm)

RESULTS

VIBRATION MEASUREMENTS

The linear floor-to-seat vibration transmissibilities for the unarmored and modified seat are compiled in Figure 16 for the principal and harmonic frequencies of the UH-1H main rotor frequency averaged over all subjects. Similarly, the linear floor-to-head vibration transmissibility and pitch floor-to-head vibration transmissibility are shown in Figures 17 and 18. Graphs depicting the difference between combined resultant acceleration spectra for the two seats are presented in Figure 19. The resultant average acceleration spectra for each subject and for the average of all subjects are presented in Appendix E. The transmissibility spectra are presented in Appendix F.

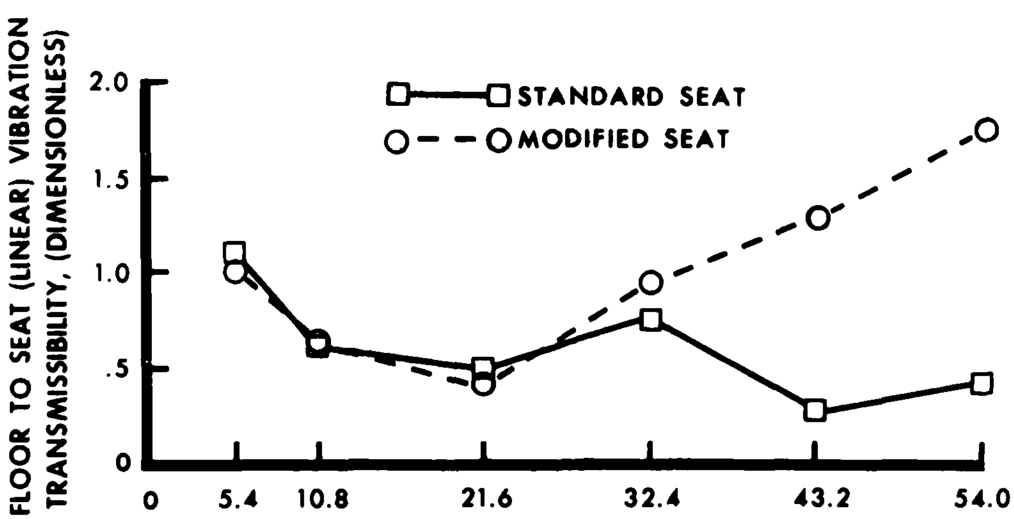


FIGURE 16. Floor-to-Seat Linear Vibration Transmissibilities

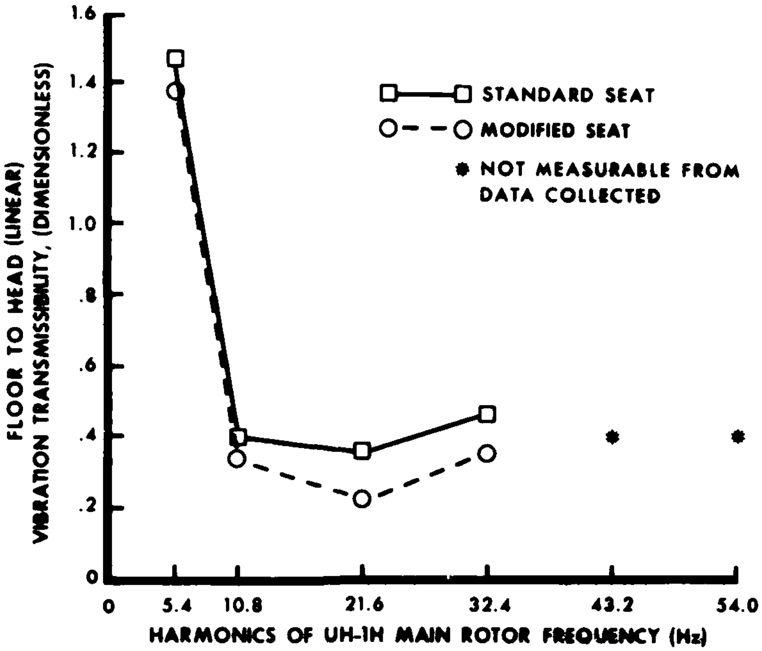


FIGURE 17. Floor-to-Head Vibration Transmissibilities for the Standard and Modified German Seat

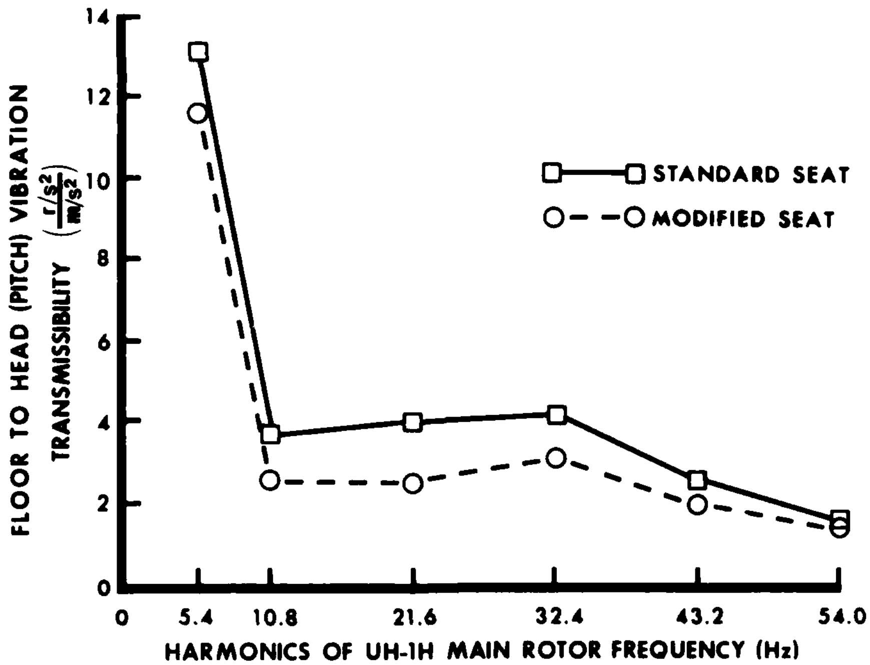


FIGURE 18. Floor-to-Head (Pitch) Vibration Transmissibilities for the Standard and Modified German Seat

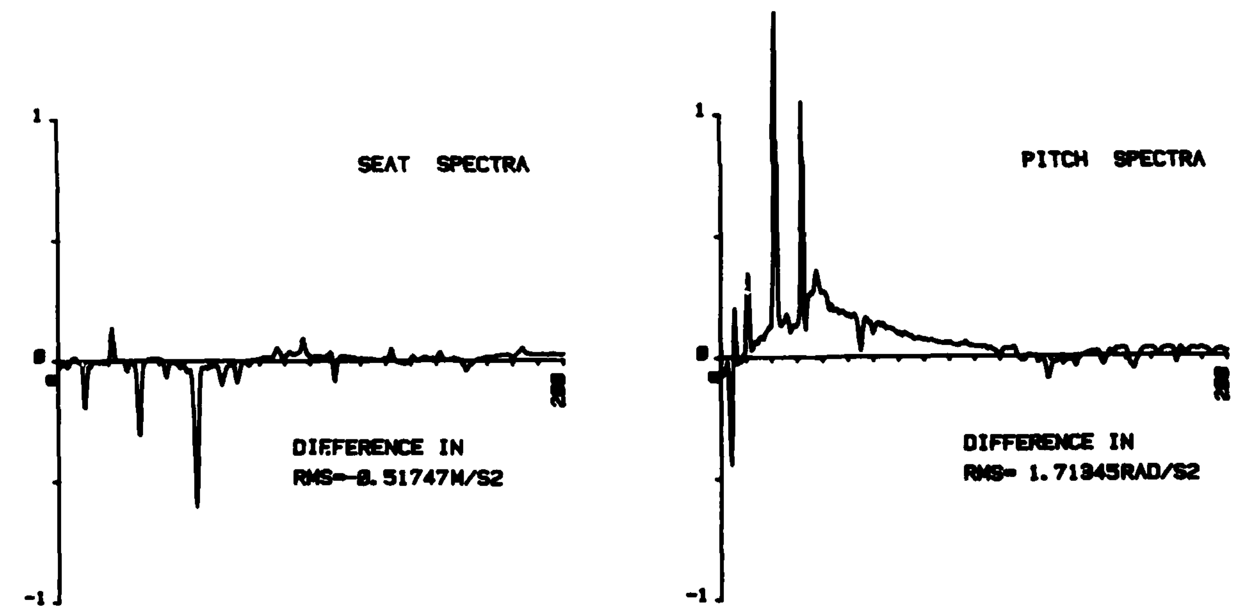


FIGURE 19. Difference in Combined Resultant Spectra

The comparative data from this experiment were used to determine the statistical significance of the differences observed. The statistical methods used were the multivariate analogue of the paired t-test using Hotellings T^2 as the test statistic and the General Linear Regression (GLR) model with dummy regression variable. The latter method was used to support the statistical results obtained from the multivariate test. The GLR technique was applied only to the acceleration composite scores at six selected frequencies: 5.4, 10.8, 21.6, 32.4, 43.2, and 54 Hz. These frequencies were selected since they are the major vibration frequency components transmitted from the floor of the UH-1H helicopter. The primary vibration frequency caused by the main rotor system is at 5.4 Hz, and the other five frequencies represent the successive odd-harmonic frequencies of the main rotor system. Additional details of the analyses are provided elsewhere (Holt and Wells, 1982).

The results of the multivariate test revealed that a statistically significant ($p \leq 0.05$) vector of mean differences of head, seat, and floor existed between the standard and German seat at 10.8 and 43.2 Hz in favor of the German seat. Use of Fisher's lambda test and the harmonic mean of the F-values from the multivariate tests for all six frequencies showed that the overall means of the vector of mean differences were statistically significant ($p \leq 0.05$) for the two seats, again in favor of the German seat. Neither seat configuration exceeds the International Standard Organization (ISO, 1974) guide for the evaluation of human exposure to whole body vibration fatigue-decreased proficiency boundary for 4 hours of operation.

IMPACT TESTING

Table 5 summarizes the results of the 11 sled tests conducted on the three different seat designs. The actual input pulses differed only slightly from the planned pulses shown in Table 4. The test plan had originally called for four sled tests to be carried out on each of the seats at 6g, 10g, 14g, and 24g. The 24g run was omitted for the standard unarmored seat since sufficient number of these seats were unavailable to conduct all four runs.

Figures 20 through 23 show the amplitude versus time acceleration tracings for the sled floor and the g_z dummy pelvis accelerations for each of the seats tested under the four impact conditions. The pelvis g_z accelerations were essentially identical for all seats for the 6g- and the 9g-impacts. However, for the 13g- and the 24g-sled impacts, pelvis peak g_z accelerations were considerably lower for the modified seat impacts than for either of the two standard seat impacts. This same trend is apparent for head and chest peak g_z accelerations (Table 5). The actual acceleration tracings for all 11 sled tests are contained in Appendix G.

TABLE 5

IMPACT DATA SUMMARY

CAMI RUN NO.	SEAT TYPE*	SLED PEAK g		SLED V (m/S)	SLED STOP DIST. (meters)	PELVIS PEAK g			CHEST PEAK g			HEAD PEAK g		
		Plan	Act			X	Y	Z	X	Y	Z	X	Y	Z
80-087	A	6	6.0	5.0	0.43	2.8	1.5	11.0	4.0	3.5	11.5	4.3	1.0	11.0
80-090	B	6	6.0	6.0	0.46	1.8	1.8	12.0	2.5	2.0	11.5	6.0	1.0	11.8
80-092	C	6	6.0	5.9	-	3.0	1.5	12.0	2.0	1.3	12.0	6.0	0.8	11.5
80-088	A	10	9.0	6.6	0.43	5.8	3.0	23.0	4.0	3.8	19.0	6.0	1.8	19.8
80-089	B	10	9.0	6.7	0.43	3.0	3.0	19.8	4.0	5.0	19.0	6.0	1.8	18.5
80-093	C	10	9.0	6.6	-	3.8	9.0	19.5	3.8	3.0	18.0	6.0	0.8	18.0
80-095	A	14	13.0	7.6	-	9.8	7.0	35.0	6.0	17.0	33.0	7.8	1.0	40.0
80-091	B	14	13.5	7.8	0.43	10.0	5.5	41.3	7.0	8.0	30.0	9.0	4.8	28.0
80-094	C	14	13.5	7.7	-	5.8	5.0	27.8	6.0	5.0	23.5	8.3	4.0	22.5
80-097	A	24	24.0	11.4	-	15.0	6.0	85.8	17.5	25.0	80.0	15.0	6.3	65.0
80-096	C	24	25.0	11.5	-	16.0	8.0	34.0	11.9	12.0	33.8	13.8	3.8	33.3

* A= STANDARD ARMORED, NET SUPPORT B= STANDARD UNARMORED, NET SUPPORT
C=GERMAN PROTOTYPE UNARMORED, WITH CUSHION

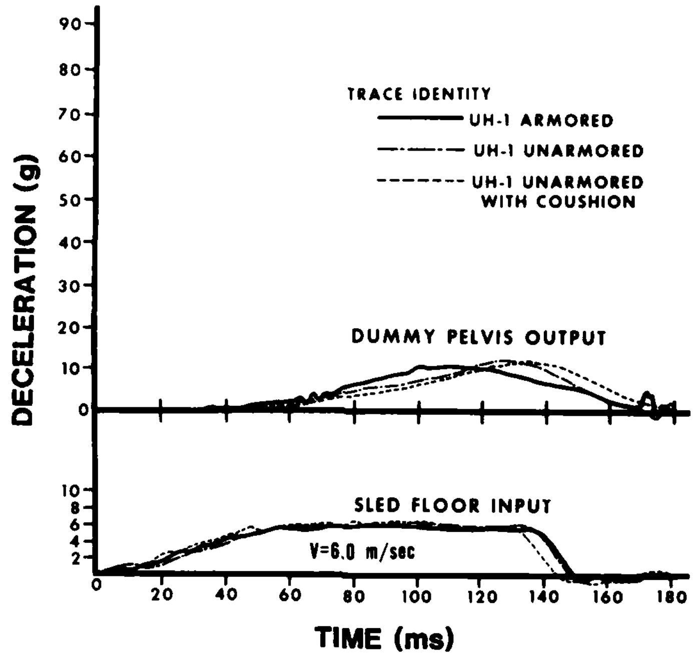


FIGURE 20. Comparison of Transmitted Acceleration to 50th Percentile Dummy Pelvis for Vertical (Z) Axis (Eyeballs Down) Loading (6g Peak)

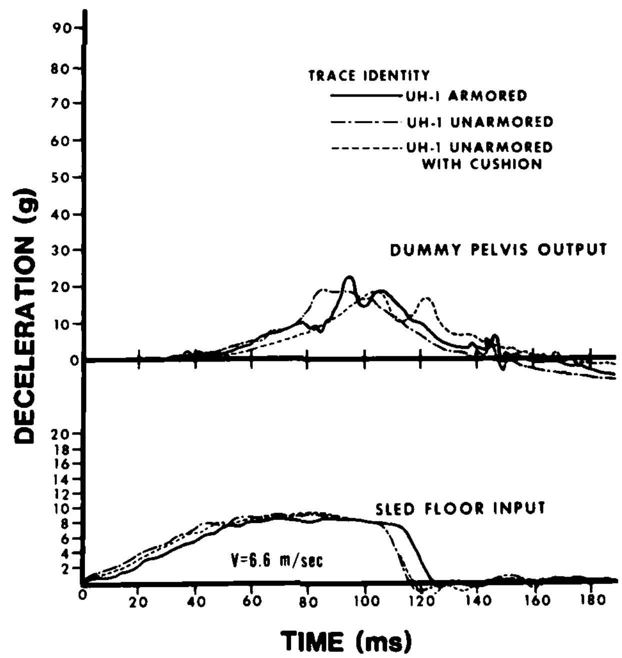


FIGURE 21. Comparison of Transmitted Acceleration to 50th Percentile Dummy Pelvis for Vertical (Z) Axis (Eyeballs Down) Loading (9g Peak)

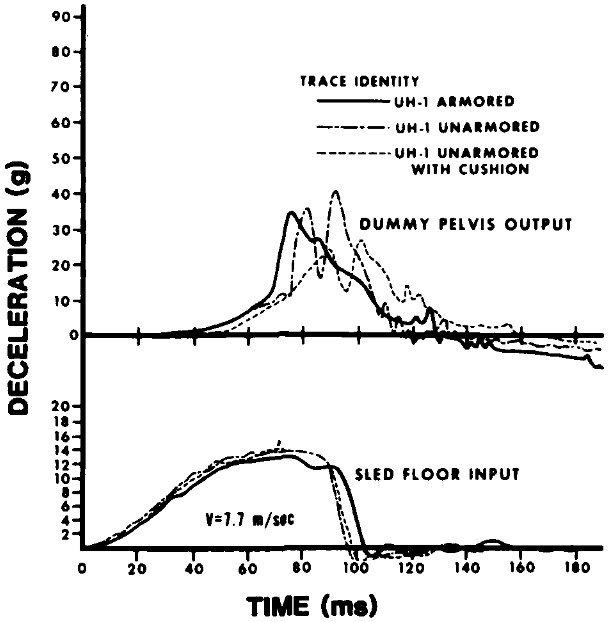


FIGURE 22. Comparison of Transmitted Acceleration to 50th Percentile Dummy Pelvis for Vertical (Z) Axis (Eyeballs Down) Loading (13g Peak)

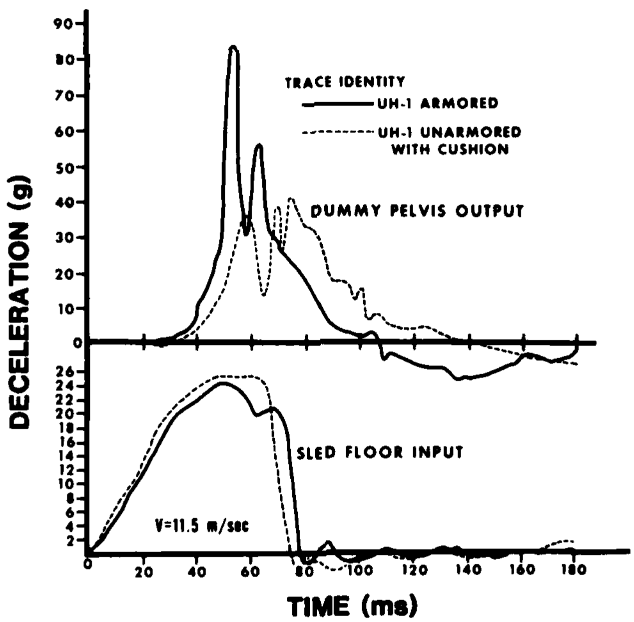


FIGURE 23. Comparison of Transmitted Acceleration to 50th Percentile Dummy Pelvis for Vertical (Z) Axis (Eyeballs Down) Loading (24g Peak)

QUESTIONNAIRE SURVEY

There were 12 pilots who flew in the modified seat for longer than one hour and were, therefore, asked to respond to the questionnaire. Although this sample size was not large enough to be statistically significant, given the magnitude of the differences observed, some interesting trends were noted. Eleven of the respondents (92%) rated the modified seat as better than the standard seat in terms of comfort and utility, and one felt it to be equal. The pilots who gave the modified seat higher ratings cited several positive factors. These were better back support (67%), better vibration isolation (75%), and better thigh support (83%).

The only negative comments made about the modified seat related to poor ventilation to the back and buttocks and also to problems in adjusting the modified seat low enough. Four out of six pilots who flew from the modified seat when the ambient temperature exceeded 24 degrees C complained of perspiration build-up on their backs and buttocks. This problem was not reported for temperatures below 24 degrees C. In the full down position, the modified seat cushion is approximately 3.5 cm higher than the standard seat net support. For this reason, 75% of those subjects who normally adjust their seat to the full down position complained that they were unable to adjust the modified seat low enough. However, none of them felt that this situation interfered with their ability to safely control the aircraft.

DISCUSSION

VIBRATION MEASUREMENTS

The statistical results indicate that the vibration transmitted by the two seats are different, with the modified seat performing slightly better overall than the standard seat, but the evidence is not overwhelming. The modified seat passed slightly less vibration to the head of the occupants than the standard seat, but this result is probably not operationally significant in terms of comfort or ability to read instruments or to write on a knee board. Looking at the difference graphs of the modified seat (Figure 19), the resultant linear acceleration of the head is consistently less in the spectrum from 0 to 200 Hz. However, the angular acceleration of the head is greater in the modified seat at 5.4 Hz, a critical frequency since it corresponds to whole-body resonance.

Over the rest of the spectrum, the modified seat transmits less angular acceleration to the head. Although the modified seat passes considerably more vibration above 43.2 Hz, the physiological effects above this frequency should be local, as the transmissibility of the whole body in this frequency range is very low (Griffin, 1975; Lewis, 1980). That the spectral characteristics of the transmissibilities of the two seats have different overall shape is attributed to differences in assumed posture of the occupants of each seat.

In a general sense, the effects of vibration are a logarithmic function of intensity. Not only are the relative differences in intensity between the two seats small, but the absolute level of the vibration is low. Therefore, even though the differences in vibration intensity transmitted by the standard and modified seat are statistically significant, these differences should be inconsequential from an operational or functional standpoint.

IMPACT TESTING

For sled impacts with peak acceleration exceeding 13g, the modified seat performed considerably better than either of the standard seats in reducing decelerative forces transmitted to the dummy. This was particulary pronounced at the highest sled impact level tested (24g). At the 24g level, peak pelvis acceleration in the modified seat was 60 percent less than that measured in the standard armored seat. This difference was significant enough to have changed the level of acceleration sustained by the subject from one that was distinctly nonsurvivable to one that was potentially survivable.

The load reducing capability of the modified seat is attributed to the construction of the fiber glass seat pan which exhibited marked deformability during impact at the higher levels (unlike the more rigid response of the standard seats). The reduction in transmitted accelerations demonstrated by the modified seat certainly is encouraging; however, it should be emphasized that all these experimental impacts consisted of essentially pure g_z loading. Due to the deformation characteristics of the fiber glass seat pan, it is assumed that the modified seat will perform equally as well under combined axis inputs as long as these forces do not exceed the tie-down strength of the seat frame. Unfortunately, previous impact testing of UH-1H helicopters has shown that the tie-down strength of the pilot seats is marginal at best. The longitudinal load limit for the occupied unarmored seat is approximately 21g, and that for the armored seat is only in the range of 10 to 15g (Haley, 1968; Reed, 1965). Consequently, unless the tie-down strength of the seat frame also is improved, the potential injury reducing capability of the modified seat may not be realized in many accidents due to the failure of the seat frame attachments.

QUESTIONNAIRE SURVEY

The majority of the subjects commented very favorably upon the increased thigh and lumbar support provided by the modified seat and they also perceived that the seat provided superior vibration dampening than the standard UH-1H seats. This latter observation is not well supported by objective vibration measurements and probably stems from the subjects' generally favorable opinion of the overall comfort of the seat.

The modified seat was designed to eliminate the problem of cold drafts to pilots' backs and buttocks while operating the helicopter with the doors open in the relatively low ambient temperatures generally encountered in Europe. Certainly, the seat met this objective; however, it appears that in operating temperatures above 24 degrees C, subjects complain of discomfort and perspiration build-up due to the poor ventilation afforded by the seat cushions. It is possible this particular negative feature of the seat could overshadow the positive comfort features when it is used in high temperature environments.

CONCLUSIONS

The modified seat appears to have achieved most of its design objectives by improving aircrew comfort through increased lumbar and thigh support and through the elimination of cold drafts to the back and buttocks during cold weather operations. Additionally, the modified seat will provide considerably better impact protection for its occupants than the standard seats, provided the seat frame and restraint system do not tear loose from their attachments during the crash sequence. However, the modified seat does not provide substantially better vibration dampening over that of the standard unarmored seat as determined by transmission of vibration to the test subjects' heads. It also should be considered that for operations in high ambient temperatures and humidities, the lack of ventilation through the cushions could prove to be a major source of discomfort to pilots, particularly during extended operations.

REFERENCES CITED

Churchill, E., et al. 1971. *Anthropometry of U. S. Army aviators - 1970.* Natick, MA: U. S. Army Natick Laboratories. Technical Report 72-52-CE.

Department of the Army. 1980. *Aircraft crash survival design guide.* Fort Eustis, VA: Applied Technology Laboratory, United States Army Research and Technology Laboratories. USARTL TR-79-22D.

Department of the Army. 1974. *Organizational maintenance repair parts and special tools lists; helicopter, utility-tactical transport UH-1B, UH-1C, UH-1D, UH-1H, UH-1M (Bell).* Washington, DC: Department of the Army. TM 55-1520-210-20P-1.

Griffin, M. J. 1975. Vertical vibration level and frequency. *Aviation, Space, and Environmental Medicine.* 46(3):269-276.

Haley, J. L. 1968. *Fundamentals of kinematics as applied to crash injury prevention.* Presented at Wayne State University 100th centennial celebration conference entitled "Impact Injury and Crash Injury Prevention;" 1968 May 9; Detroit, MI.

Holt, W. R., and Wells, J. H. 1982. *Statistical interim report: statistical comparison of vibration regimen between a standard and a German helicopter seat for humans.* Fort Rucker, AL: U.S. Army Aeromedical Research Laboratory. USAARL LR-83-1-5-1.

International Standards Organization Standard 2631. 1974. *Guide for the evaluation of human exposure to whole body vibration.*

Knoche, H. Unpublished data.

Laing, E. J., et al. 1973. *Vibration and temperature survey production UH-1H helicopter.* Edwards Air Force Base, CA: United States Army Aviation Test Activity. USAASTA Project No. 70-15-2.

Lewis, C. H., and Griffin, M. J. 1980. Predicting the effects of vibration frequency and axis and seating conditions on the reading of numeric displays. *Journal of Ergonomics.* 23(5):485-501.

Reed, J. L., and Holland, H. W. 1965. *UH-1D aircrew armored seat crash survival analyses.* Fort Eustis, VA: United States Army Aviation Materiel Laboratories. USAAVLABS TR-65-59.

APPENDIX A

EXPERIMENT FLIGHT PROFILE

1. Three foot hover (end of runway).
2. Normal takeoff (rate of ascent undefined).
3. 90 knot downwind, 1000 feet above ground level (AGL).
4. Normal approach, terminating at a 50 foot hover for 30 seconds.
5. Departure from 50 foot hover.
6. 110 knot downwind, 1000 feet AGL.
7. Normal approach terminating at a three foot hover.

APPENDIX B

HEAD ANGULAR ACCELERATION DETERMINATION

An accelerometer bite bar was developed by Jex. The bar is schematicized in Figure B-1.

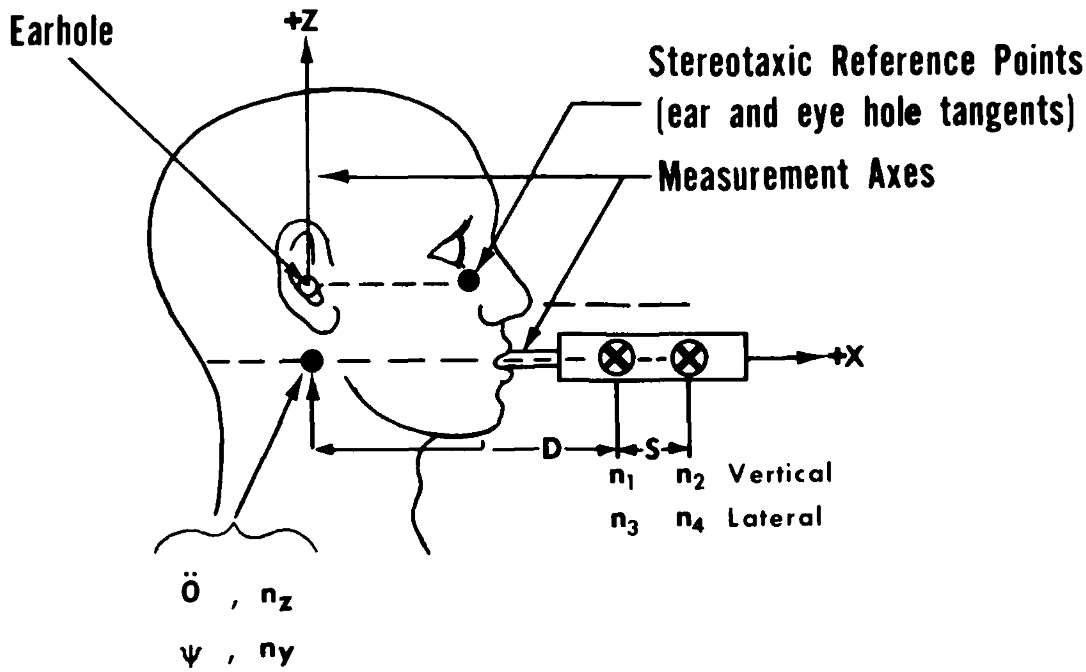


FIGURE B-1. Schematic View of Accelerometer Bite Bar.

The bar has a mass, with accelerometers, of 30 gms and a center of mass 11 cm from the anterior end of the bar. The bar uses 5 ENTRAN Model EGAL-125-10D ultraminiature accelerometers that are critically damped ($\zeta \approx 0.7$) and have a nominal frequency response of DC-150 Hz. The sensitive axis of each accelerometer is shown in Figure B-1. The Z_1, Z_2 and Y_1, Y_2 accelerometer pairs were phase-matched by selecting those units that had the most similar calibration curves, making the assumption that each accelerometer was a linear second order system.

Two major data translation steps are taken to normalize the angular acceleration of the head. First, the accelerometer bite bar configuration is made to mathematically correspond to the coordinate system defined in Figure B-1. This method is used to resolve inter-subject differences in the angle in which the bite bar sits. Second, from the measurement of acceleration at two points collinear with the center of mass of the head, the linear and angular acceleration of the head can be derived. The first step, the mouth-mount accelerometer reference model, is performed as follows: (refer to Figure B-2).

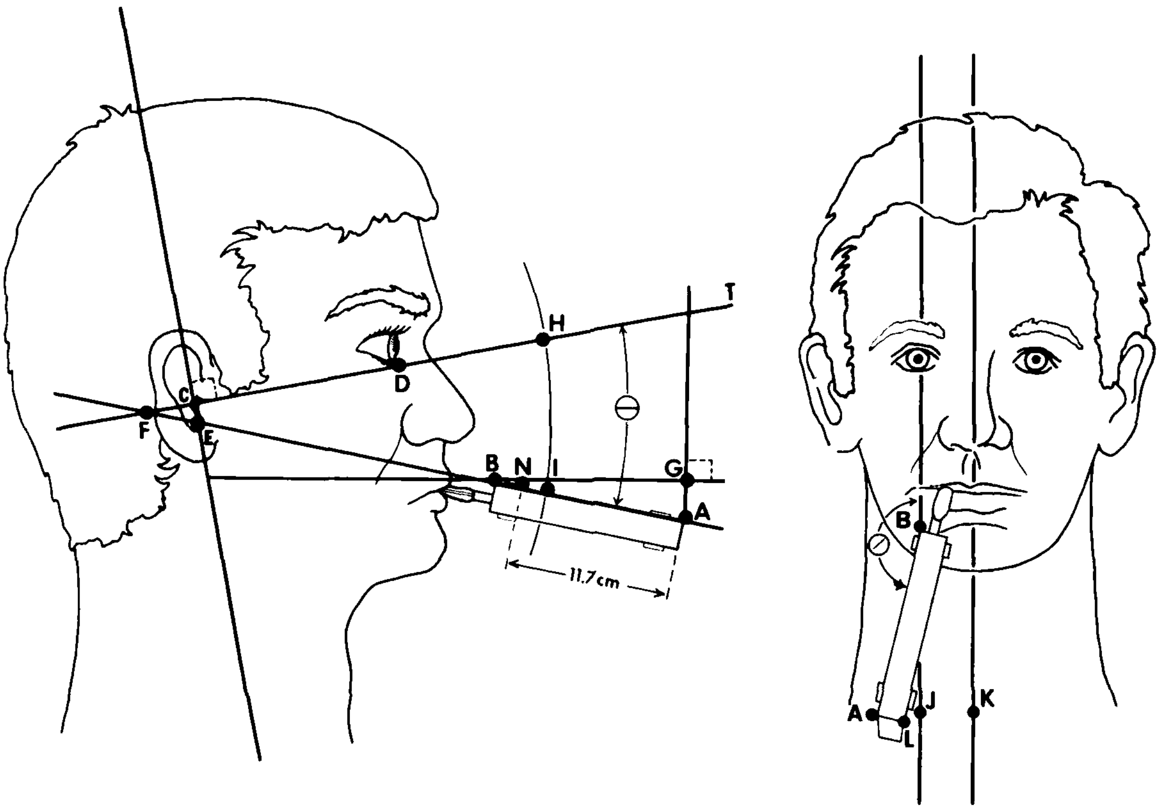


FIGURE B-2. Reference points for resolving inter-subject bite bar angle differences.

a. A side view and front view photograph are taken of the head of the subject with the bite bar in place. Distance from camera should be approximately three feet for adequate resolution.

b. The outline is traced onto paper.

c. The following reference points are identified on the tracing paper.

(1) A: anatomical top right distal corner of the bite bar.

(2) B: anatomical top right proximal corner of the bite bar.

(3) C: earhole.

(4) D: Eye point (point of intersection of cornea and cheek).

(5) E: point that intersects $\overline{AB}$ and line perpendicular to $\overline{CD}$.

(6) F: intersection of $\overline{AB}$ and $\overline{CD}$.

(7) G: point directly vertical to A, directly horizontal B.

(8) H: point of $\overline{FC}$ 100 units from F.

(9) I: point of $\overline{FA}$ 100 units from F.

(10) J: point on line that intersects B and is parallel to the sagittal plane, inferior to B, and is collinear with A on a line perpendicular to the line parallel to the sagittal plane.

(11) K: point on sagittal line collinear with $\overline{AJ}$.

(12) L: anatomical top left distal corner of bite bar.

(13) M: 0.83 = factor to accommodate stereotaxic effects

$$= \frac{\text{apparent width of proximal end of bite bar}}{\text{apparent width of distal end of bite bar}}$$

(14) N: location on bite bar 11.7 cm from A. To locate N, measure $\overline{AB}$ from the photo and solve for $\overline{AN}$ from the photo:

$$\frac{11.7}{16.4} = \frac{\overline{AN}}{\overline{AB}}$$

locate N by measuring $\overline{AN}$ from A.

(15) $\Theta = \angle HFI$

(16) $\Phi = 180° - \angle JBA$

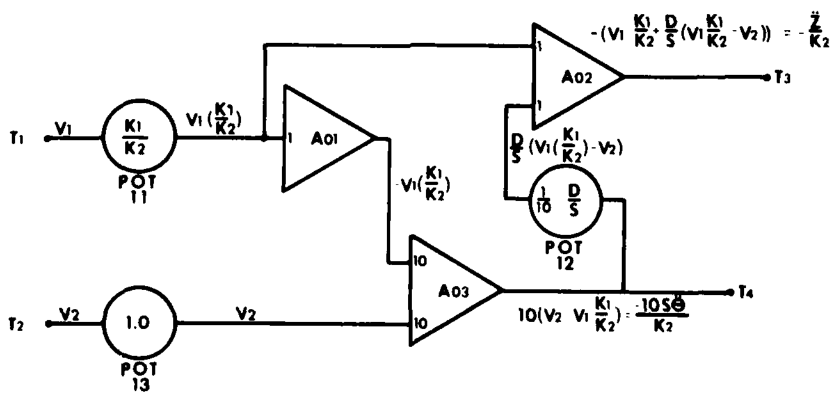


FIGURE B-3. Linear equation patch circuit.

The constants K_1 and K_2 are scaling factors for $\ddot{Z}_1$ and $\ddot{Z}_2$, respectively. These values are an average over trials of accelerometer sensitivity ($m/sec^2/volt$). The angular acceleration reduction follows the same process. Therefore, the constants K_1 and K_2 vary with the axis of measurement.

The ratio $\frac{D}{S}$ varies between subjects. V_1 and V_2 are the transducer input voltages. From the schematic diagram, the scaling equations reduce to:

$$\ddot{\theta} = -A_{03} \left(\frac{K_2}{S}\right), \ [rad/s^2]$$

$$\ddot{\phi} = -A_{03} \left(\frac{K_3}{S}\right), \ [rad/s^2]$$

$$\ddot{Z} = -A_{02} \ (K_2), \ [m/s^2]$$

$$\ddot{Y} = -A_{02} \ (K_3), \ [m/s^2]$$

NOTE: these equations assume a 1:1 record/reproduce ratio.

d. To find the actual length of $\overline{EN}$, measure the photographed $\overline{EN}$ ($\overline{EN}_p$) and solve as follows:

$$\frac{\overline{EN}_p}{\overline{EN}} = \frac{\overline{AB}_p}{16.4 \text{ cm}}$$

e. To find θ, locate K and I, each 100 units from F. Measure $\overline{HI}$. Solve as follows:

$$\sin^{-1} \frac{\overline{HI}}{100} = \Theta$$

If the bite bar is normal to begin with, G = A and $\overline{GB}$ = length of bite bar = 16.4 cm.

f. To find ϕ, measure $\overline{JB}_p$ and $\overline{AJ}_p$. To solve for $(180°-\phi)$

$$\tan^{-1} \frac{(\overline{AJ}_p)}{\overline{JB}_p} = (180°-\phi)$$

g. To find the actual length of $\overline{JK}$, measure the photographed $\overline{JK}$ and solve as follows:

$$\frac{\overline{AL}_p}{\overline{AL}} = \frac{\overline{JK}_p}{\overline{JK}}$$

After resolving the inter-subject bite bar angle differences, the following equations are used to reduce the $\ddot{Z}_1$, $\ddot{Z}_2$ (n_1, n_2 vertical) and $\ddot{Y}_1$, $\ddot{Y}_2$ (n_3, n_4 lateral) linear acceleration data pairs to a linear $\ddot{Z}_H$ and angular $\ddot{\theta}_H$ component. Referenced to the center of rotation of the head:

$$\ddot{Z}_H = \ddot{Z}_1 + \frac{D}{10} (\ddot{Z}_1 - \ddot{Z}_2), \ [m/s^2] \qquad (1)$$

$$\ddot{\Theta}_H = 98 (\ddot{Z}_2 - \ddot{Z}_1), \ [rad/s^2] \qquad (2)$$

Where $\ddot{Z}_1 = D\ddot{\Theta}_H$ = Head "vertical" acceleration, position 1 (Figure B-1)

$\ddot{Z}_2 = D\ddot{\Theta}_H + (D + S)\ddot{\Theta}_H$ = Head "vertical" acceleration, position 2 (Figure B-2)

D = distance from earhole to position 1 (cm)

S = distance from position 1 to position 2 (cm)

These two data translation methods are performed on a MINIAC analog computer. A schematic of the reduction process for the linear equation is shown in Figure B-3.

APPENDIX C

TEST PLAN

UH-1 PILOT SEAT IMPACT TESTING

INTRODUCTION

This plan outlines the impact tests to be conducted on three different pilot seats currently being used in Bell Model UH-1 (military) and 200 Series (commercial) helicopters. One of these seats has been developed by the Federal Armed Forces of West Germany. This new German seat is purported to provide better pelvis and thigh support than the standard US Army Pilot Seat. Separate flight and vibration table tests are being conducted by USAARL, but we have no capability to conduct impact tests. Comparative impact tests on these three production seats should provide valuable data for use by the aviation seating industry.

OBJECTIVE

To compare the transmission of crash force from the aircraft floor to a 50th percentile dummy pelvis in three types of helicopter seats.

MATERIALS

Standard UH-1 Pilot Seat, Armor Plate Frame with Contoured Open Weave Support

The standard UH-1 pilot seat, armor plate frame with contoured open weave support, provides adjustment fore-aft on "I" beam tracks and vertical adjustment on circular steel tubes. The seat back, bottom, and sides are flat, rigid, armor plate. A tubular metal frame (contoured at the bottom and back for the torso) has an open weave net stretched tightly over it to provide the sitting surface.

The lap belts are attached to the aircraft floor; however, the shoulder harness is attached to the aircraft seat back. This seat is described in detail in the manufacturer's reference drawing 178061-3 as shown in Department of Army Technical Manual TM 55-1520-210-20P-1.

Standard UH-1 Pilot Seat, Tubular, Rigid Open Frame with Open Weave Net Support

The standard UH-1 pilot seat, tubular, rigid open frame with open weave net support provides identical adjustments as for the armored seat. The sitting surface is provided by open weave net stretched over the tubular frame in similar manner to the armored seat; however, 7.6 cm more vertical depth is provided to permit the net material to stretch downward further under crash loads.

The lap belts and the shoulder straps are attached to the aircraft floor. This seat is described in detail in the manufacturer's reference drawing AL1018-5 as shown in Department of Army Technical Manual TM 55-1520-210-20P-1.

Standard UH-1 Pilot Seat, Tubular, Rigid, Open Frame with Contoured Foam Bottom and Back Cushions

The standard UH-1 pilot seat, tubular, rigid, open frame with contoured foam bottom and back cushions provides identical adjustments to the unarmored seat except that the contoured closed cell foam cushion is used for the bottom and back torso support and that a new lap belt and shoulder harness is used with both items still attached to the aircraft floor. The lap belt and shoulder harness release buckle is a "plug-in" type. The harness is marketed by the Auto-flug Co. of West Germany.

TEST PROCEDURE

Seat Orientation

The seat is to be mounted on the test sled. The angle of the "floor" to the vertical should be 16 3 degrees to assure that the impact deceleration vector is parallel to the dummy spine. The 16 degree angle includes 4 degrees additional forward pitch to offset the effect of gravity in reducing the hyperflexion (forward) movement on the dummy. This seat orientation is identical to that used by Wayne State University in an on-going tri-service cadaver impact test program on the UH-60 Black Hawk pilot seat.

The aircraft "floor" is to be extended a minimum of 38.1 cm forward of the seat's leading edge to provide foot support.

The seat is to be adjusted to a midway height to match the dummy size, i.e., 6.4 cm up from the bottom position.

Anthropomorphic Dummy

A 50th percentile dummy, constructed to the standards of Department of Transportation Spec. Part 572, is to be used. The joints shall be adjusted to provide 1 g resistance to rotation. Suitable accelerometers to provide X and Z acceleration shall be located in the head and the pelvis of the dummy. If possible, a string potentiometer, connected to the hip joint, to show vertical displacement with time shall also be provided. If possible, within time constraints, shoulder strap load shall also be measured.

Dynamic Test Description

The dynamic pulse required for all tests is stated in Table 4 (p. 14). Four pulse shapes are shown starting at 4.9 m/sec to simulate a hard landing which would bottom out the skids on hard soil and bring the fuselage into contact with the ground without significant airframe deformation. The 6.1 m/sec pulse is slightly more severe and would probably cause fuselage deformation, and it also represents a 50th percentile velocity change based on the data shown in TR-71-22, "The Aircraft Crash Survival Design Guide (ACSDG)." The final pulse at 11.3 m/sec represents a very severe crash that is known to cause back injury in most cases where a load limiting seat is not used. All four pluses show that a 2 g level is applied immediately and that the resistance increases with time. The shape of the pulse is consistent with the UH-1 cross-tube gear for flat impacts on hard soil. The velocity change and average g levels used in these pulses are related to the values stated in the ACSDG as shown in Table 4.

Instrumentation

a. Head X and Z Accelerometer

b. Pelvis X and Z Accelerometer

c. Sled Longitudinal Accelerometer

d. Shoulder Strap Load (Optional)

e. String Potentiometer (Optional)

f. Cameras

   (1) 500 Frame per sec (min.) color (2 required)

   (2) Real Time (selected tests) (1 required)

   (3) Pre and Post Test (Profile and Front Views) (35 mm Color)

Inertia Reel Setting

The inertia reel is to be set in the automatic position prior to all sled runs.

Dummy Positioning

It is important that the dummy be positioned exactly the same prior to each test. The following procedure will accomplish this:

a. Six targets will be located at the dummy head, shoulders and hips for use in boresighting.

b. Push the dummy rearward at both knees with a force of approximately 150 lbs. to insure that the pelvis is against the seat back.

c. Tighten lap belt straps with force of 50 pounds.

d. The dummy will be fitted with standard regular size SPH-4 helmet. (to be supplied by USAARL).

Data Presentation

a. Acceleration, force, and displacement vs. time data may be presented to the original oscillograph rolls (1 each required).

b. Contact size (4" x 5") pre and post test photos (1 each required).

c. Film (1 copy each of selected runs).

APPENDIX D

QUESTIONNAIRE

Date _______________

Height _____ Weight _____

Age _____ Sex _____ Years of flight status _____

Total hours - Rotary wing _____ Fixed wing _____ UH-1 _____

Number of hours flown in the modified seat - this flight _____ total _____

Time of flight _____ Temperature _____

Type of flight: Instrument _____ Night _____ Tactical terrain _____

Nonstandard maneuvers _____ NVG _____ Cruise _____

(CHECK THE ANSWER YOU THINK MOST APPROPRIATE)

1. How do you rate the modified seat in comparison to the standard UH-1 seat with respect to comfort and utility?

   1. Much worse _____ 2. Slightly worse _____ 3. Equal _____

   4. Slightly better _____ 5. Much better _____

2. Do you experience back discomfort when flying in the standard UH-1 seat?

   1. Never ___ 2. Occasionally ___ 3. Frequently ___ 4. Always ___

   If you ever experience back discomfort in the standard seat -

   a. After how many hours of continuous flying? _____

   b. Did you experience less back discomfort ___; more back discomfort ___; no back discomfort ___ while flying in the modified seat?

3. Do you think the modified seat provides better back support?

   1. Yes _____ 2. No _____ 3. No difference _____

4. Do you think the modified seat provides better vibration isolation?

   1. Yes _____ 2. No _____ 3. No difference _____

5. Was heat buildup or perspiration more of a problem with the modified seat than with the standard UH-1 seat?

1. Yes _____ 2. No _____ 3. No difference _____. If yes, was it significant enough to cause discomfort? 1. Yes _____ 2. No _____

6. Do you think the modified seat provides better thigh support than the standard UH-1 seat?

1. Yes _____ 2. No _____ 3. No difference _____

7. Do you normally fly with the standard UH-1 seat in the full down position?

1. Yes _____ 2. No _____

8. Did you experience any difficulty in adjusting the modified seat to a comfortable position with respect to height?

1. Yes _____ 2. No _____

If yes -

a. Were you unable to adjust it -

1. High enough _____ 2. Low enough _____

b. Do you feel that this poses a serious problem to your flying comfort or safety: 1. Yes _____ 2. No _____

9. Did you experience any difficulty in adjusting the modified seat to a comfortable position with respect to distance from the pedals?

1. Yes _____ 2. No _____

If yes -

a. Were you unable to adjust it -

1. Forward enough _____ 2. Backward enough _____

b. Do you feel that this poses a serious problem to your flying comfort or safety? 1. Yes _____ 2. No _____

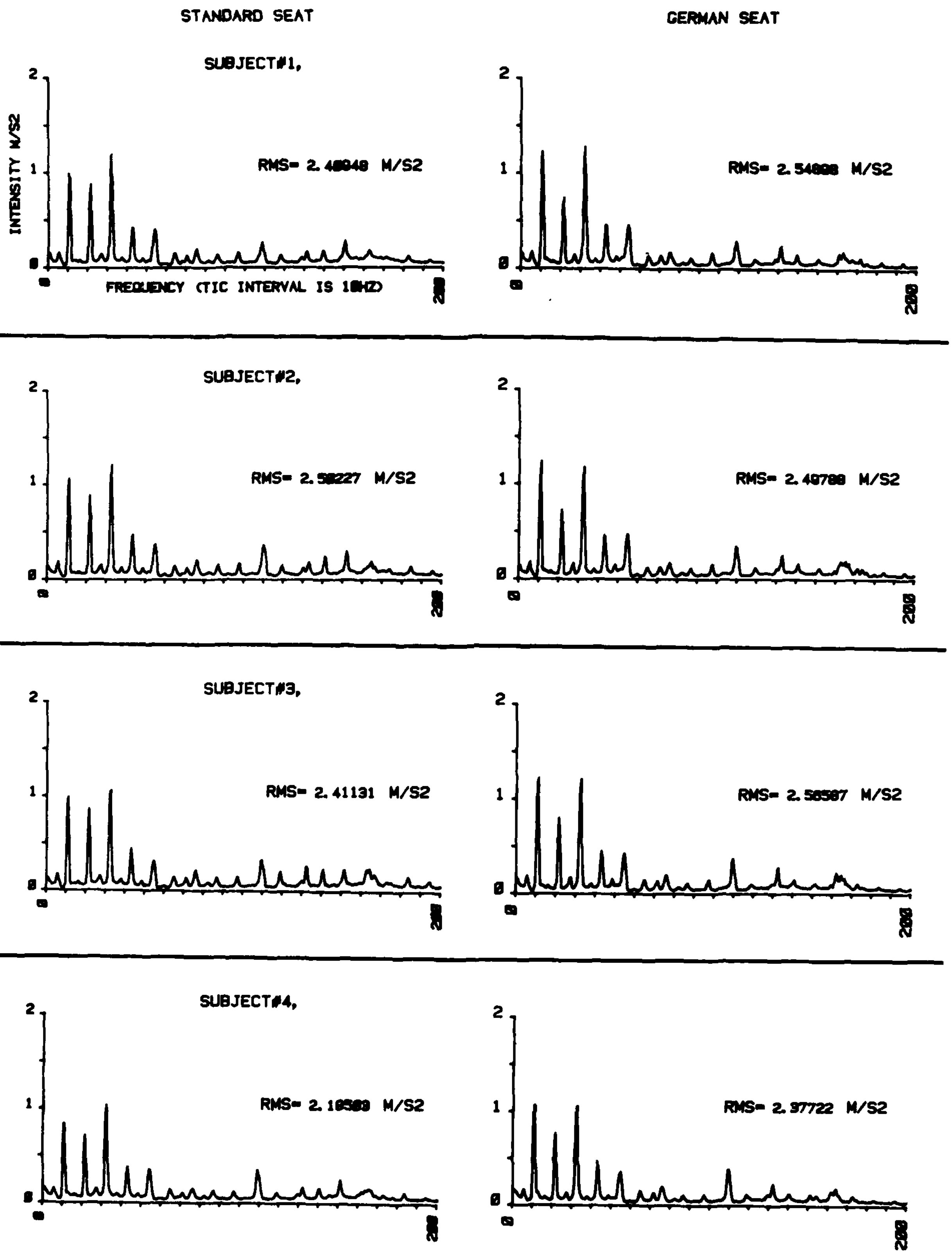
10. Please describe any features of the modified seat that you like or dislike.

____

____

APPENDIX E

RESULTANT AVERAGE ACCELERATION SPECTRA


STANDARD SEAT
GERMAN SEAT
SUBJECT#1,
INTENSITY M/S2
FREQUENCY (TIC INTERVAL IS 10HZ)
RMS= 2.40948 M/S2
RMS= 2.54000 M/S2
SUBJECT#2,
RMS= 2.50227 M/S2
RMS= 2.49700 M/S2
SUBJECT#3,
RMS= 2.41131 M/S2
RMS= 2.50507 M/S2
SUBJECT#4,
RMS= 2.10500 M/S2
RMS= 2.37722 M/S2
0
1
2
200

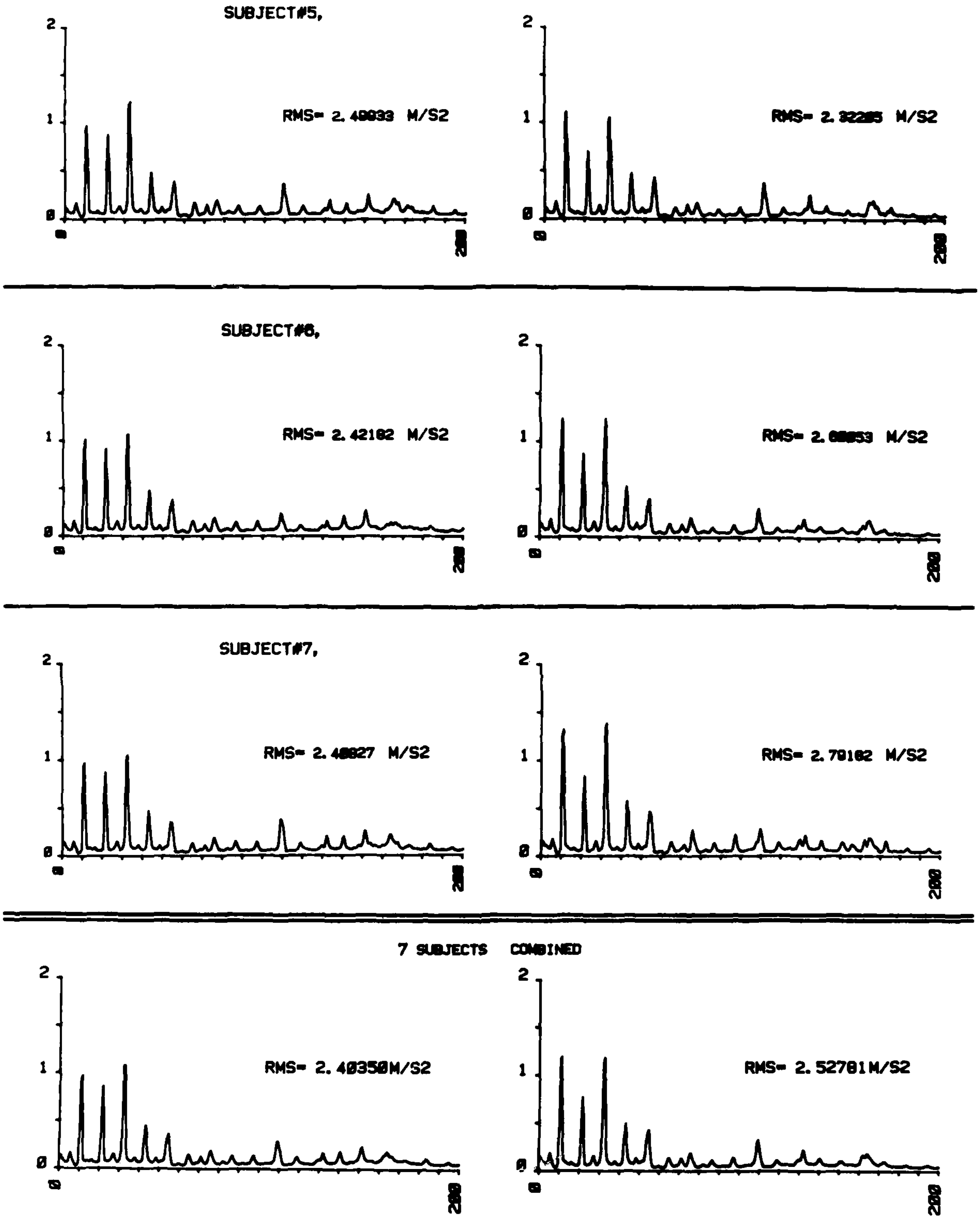
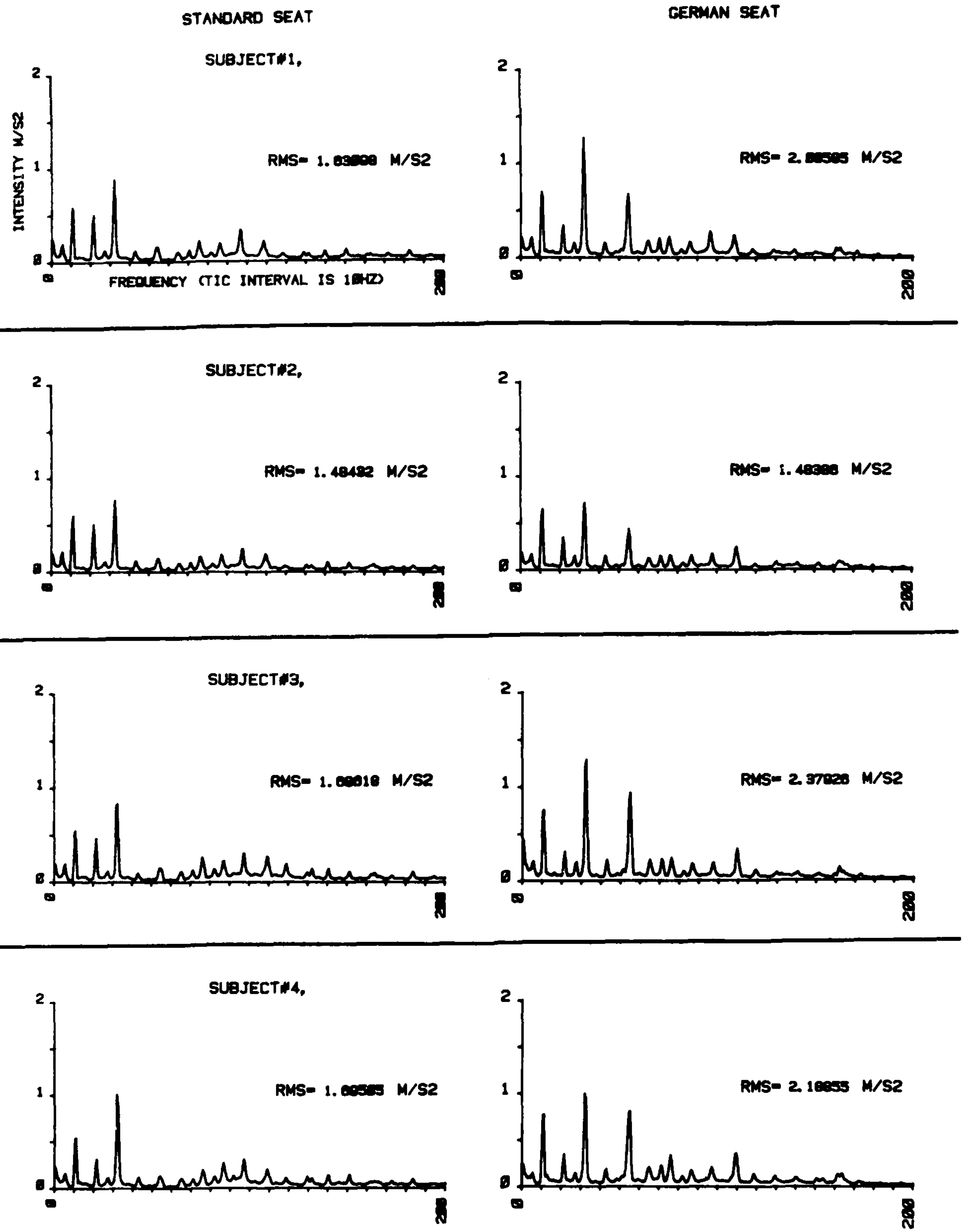


FIGURE E-1. Resultant Spectra, Floor


STANDARD SEAT
GERMAN SEAT
SUBJECT#1,
INTENSITY M/S2
RMS= 1.83000 M/S2
RMS= 2.08585 M/S2
FREQUENCY (TIC INTERVAL IS 10HZ)
SUBJECT#2,
RMS= 1.48482 M/S2
RMS= 1.48388 M/S2
SUBJECT#3,
RMS= 1.68018 M/S2
RMS= 2.37828 M/S2
SUBJECT#4,
RMS= 1.69585 M/S2
RMS= 2.18855 M/S2

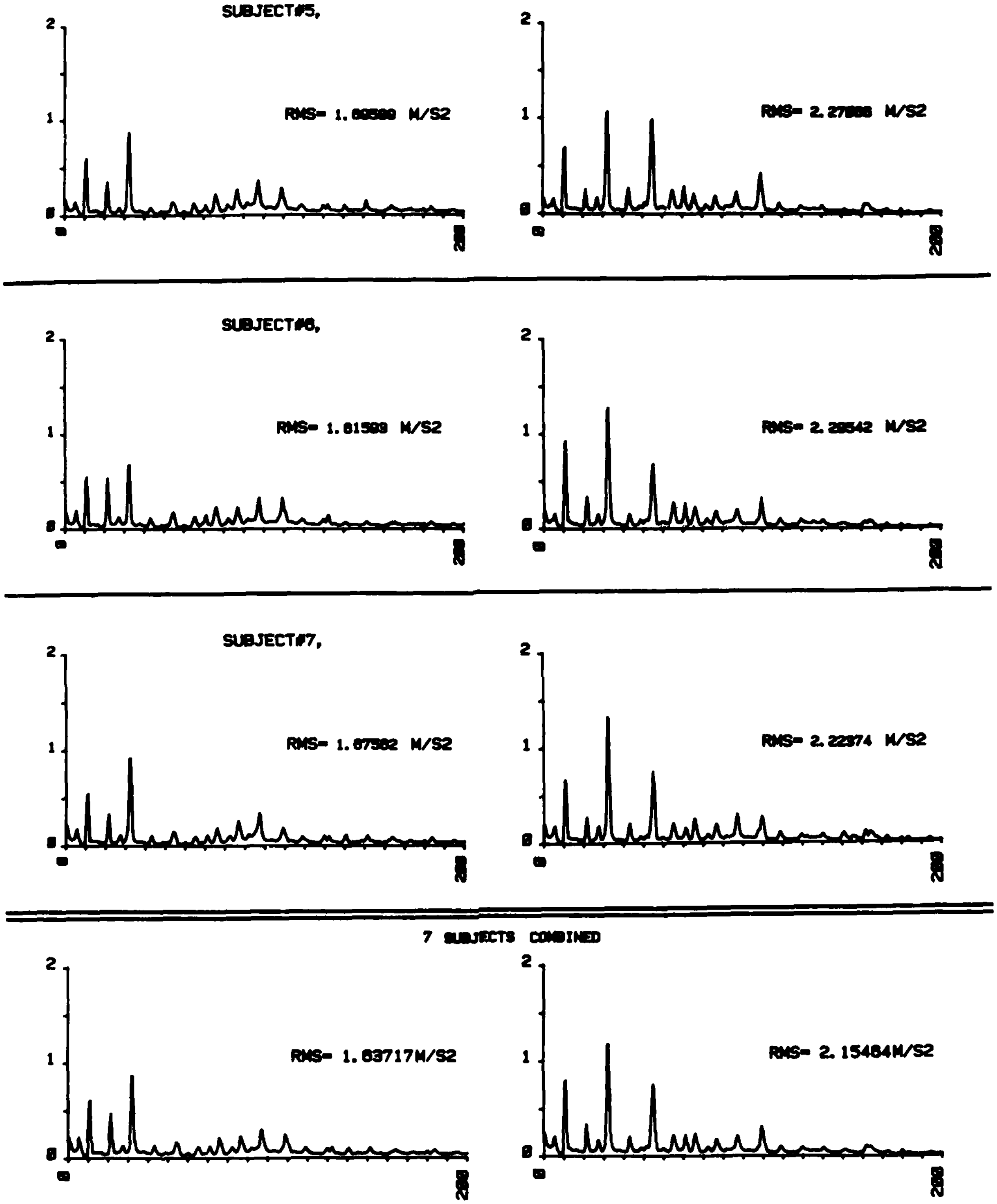
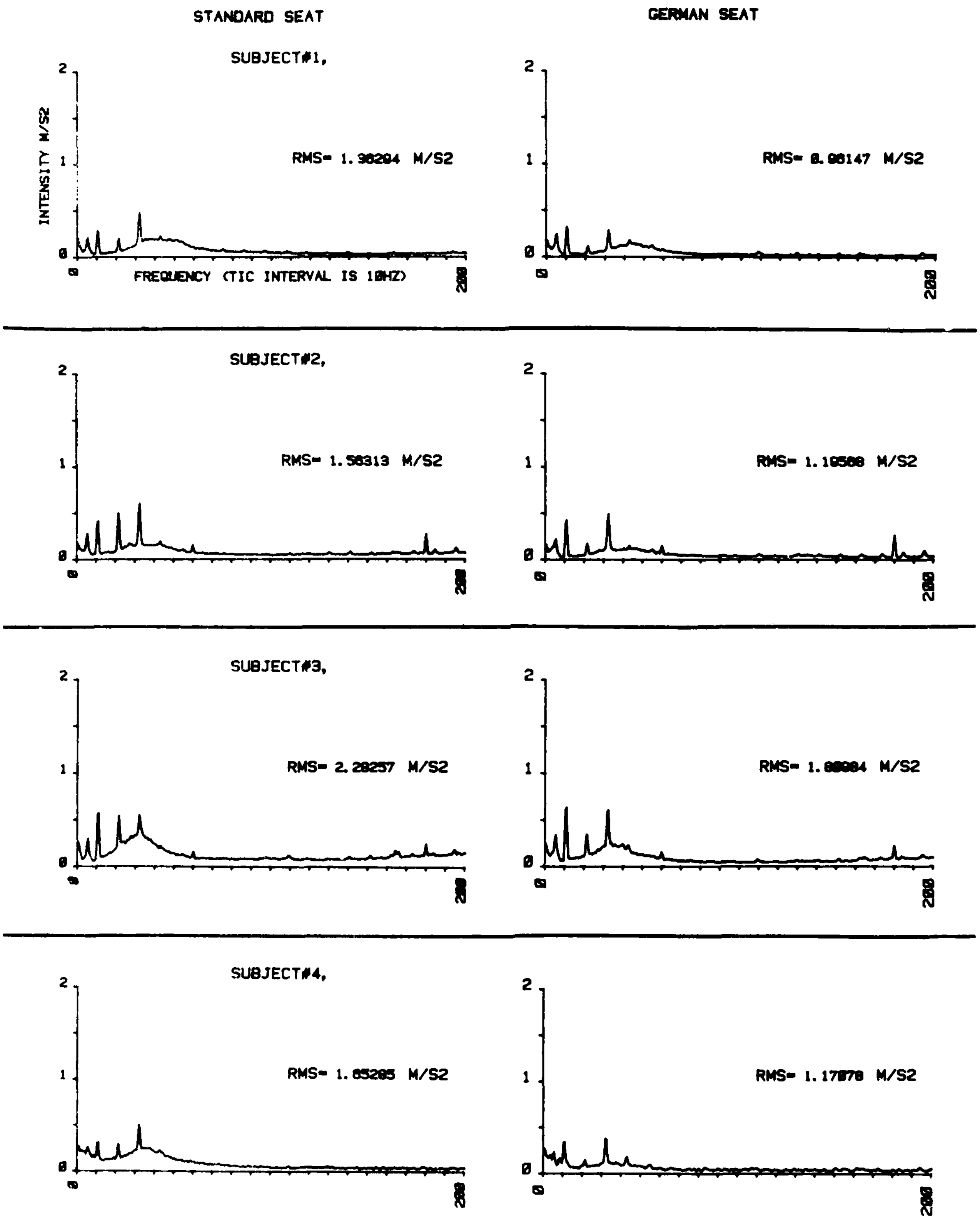


FIGURE E-2. Resultant Spectra, Seat



STANDARD SEAT
GERMAN SEAT
SUBJECT#1,
INTENSITY M/S2
RMS= 1.30204 M/S2
RMS= 0.90147 M/S2
FREQUENCY (TIC INTERVAL IS 10HZ)
SUBJECT#2,
RMS= 1.50313 M/S2
RMS= 1.19500 M/S2
SUBJECT#3,
RMS= 2.20257 M/S2
RMS= 1.80004 M/S2
SUBJECT#4,
RMS= 1.05205 M/S2
RMS= 1.17070 M/S2
2
1
0
200

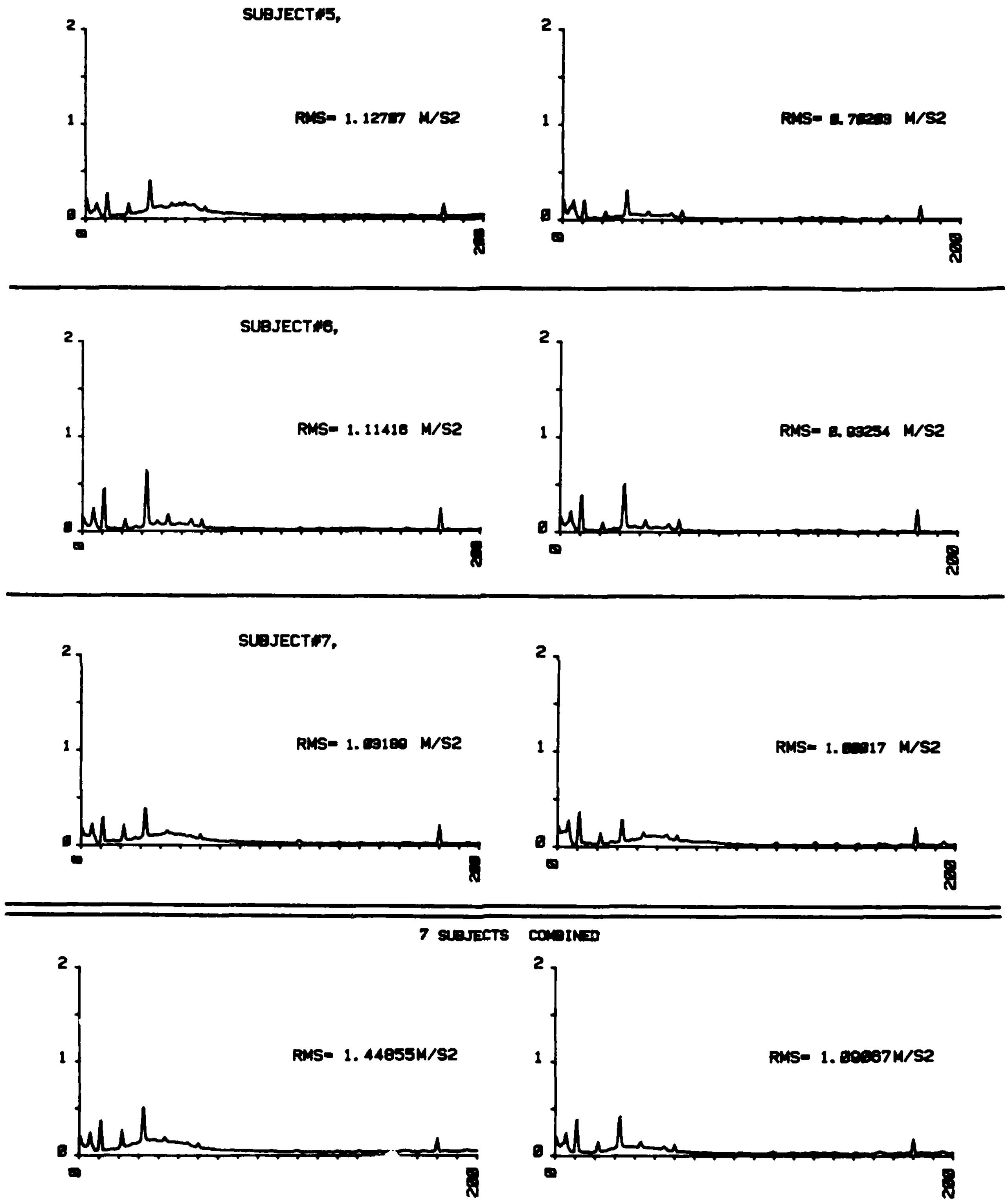
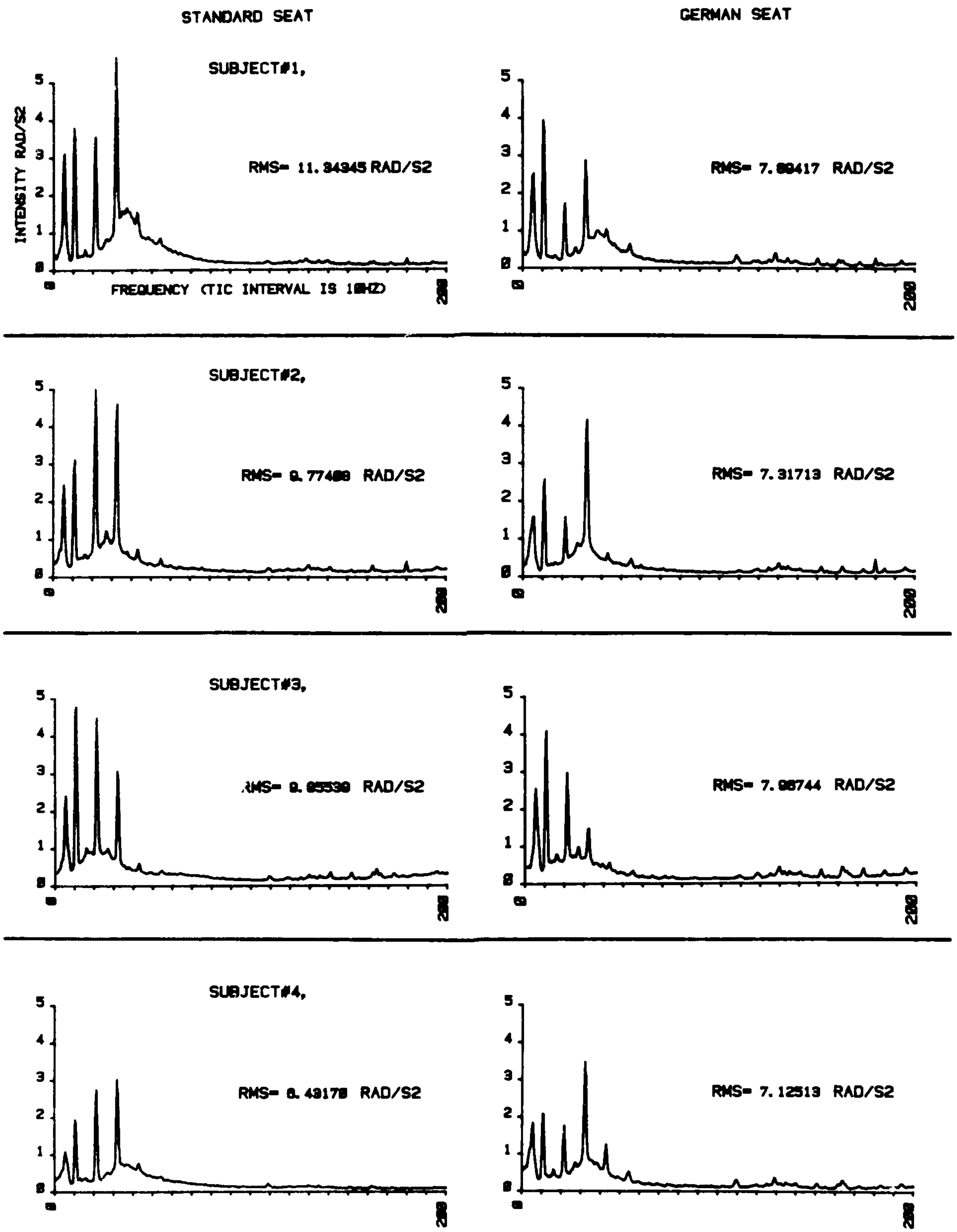


FIGURE E-3. Resultant Spectra, Head


STANDARD SEAT
GERMAN SEAT
SUBJECT#1,
INTENSITY RAD/S2
RMS= 11.84345 RAD/S2
FREQUENCY (TIC INTERVAL IS 10HZ)
RMS= 7.80417 RAD/S2
SUBJECT#2,
RMS= 9.77480 RAD/S2
RMS= 7.31713 RAD/S2
SUBJECT#3,
RMS= 9.85530 RAD/S2
RMS= 7.98744 RAD/S2
SUBJECT#4,
RMS= 6.43170 RAD/S2
RMS= 7.12513 RAD/S2
0
1
2
3
4
5
200

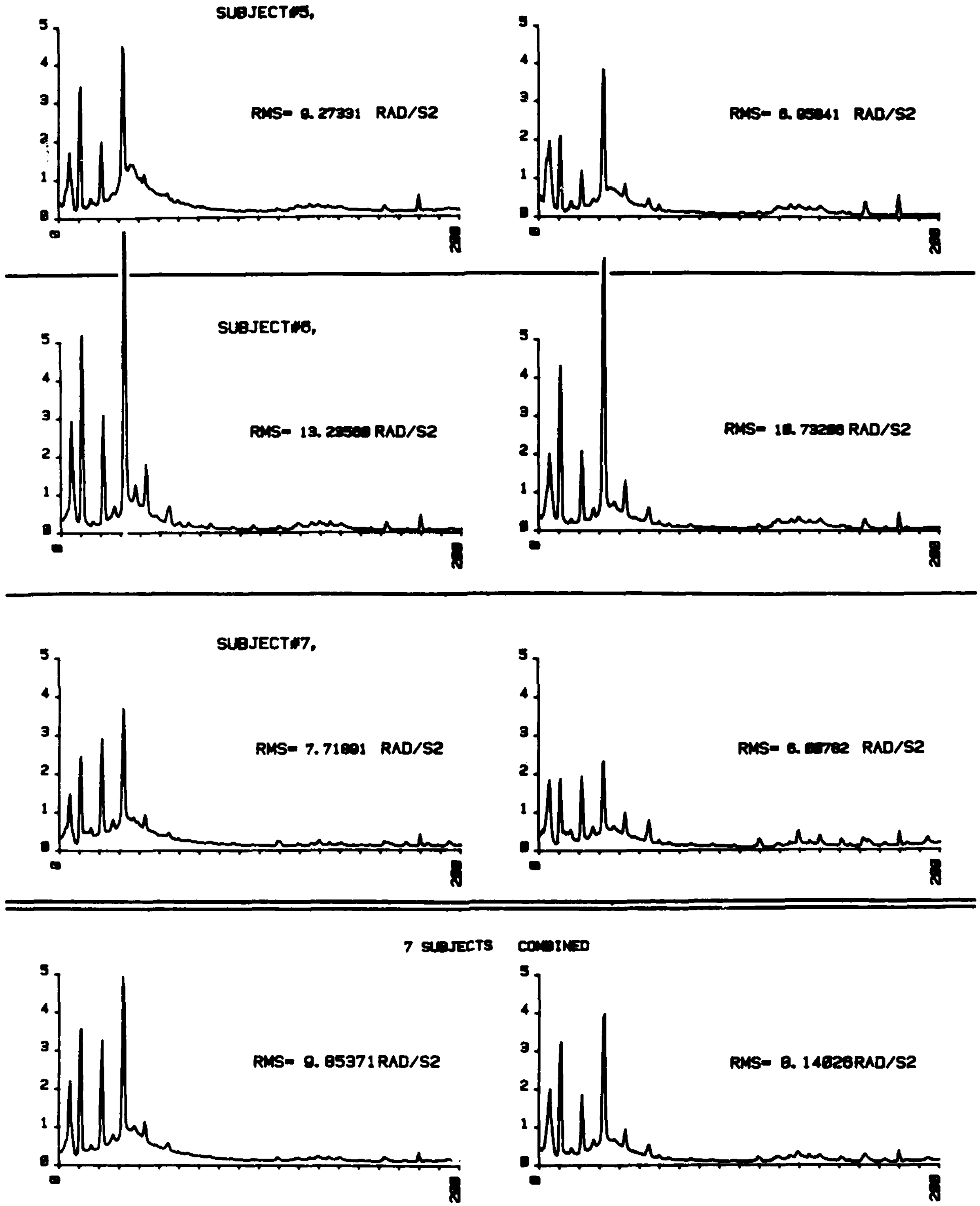
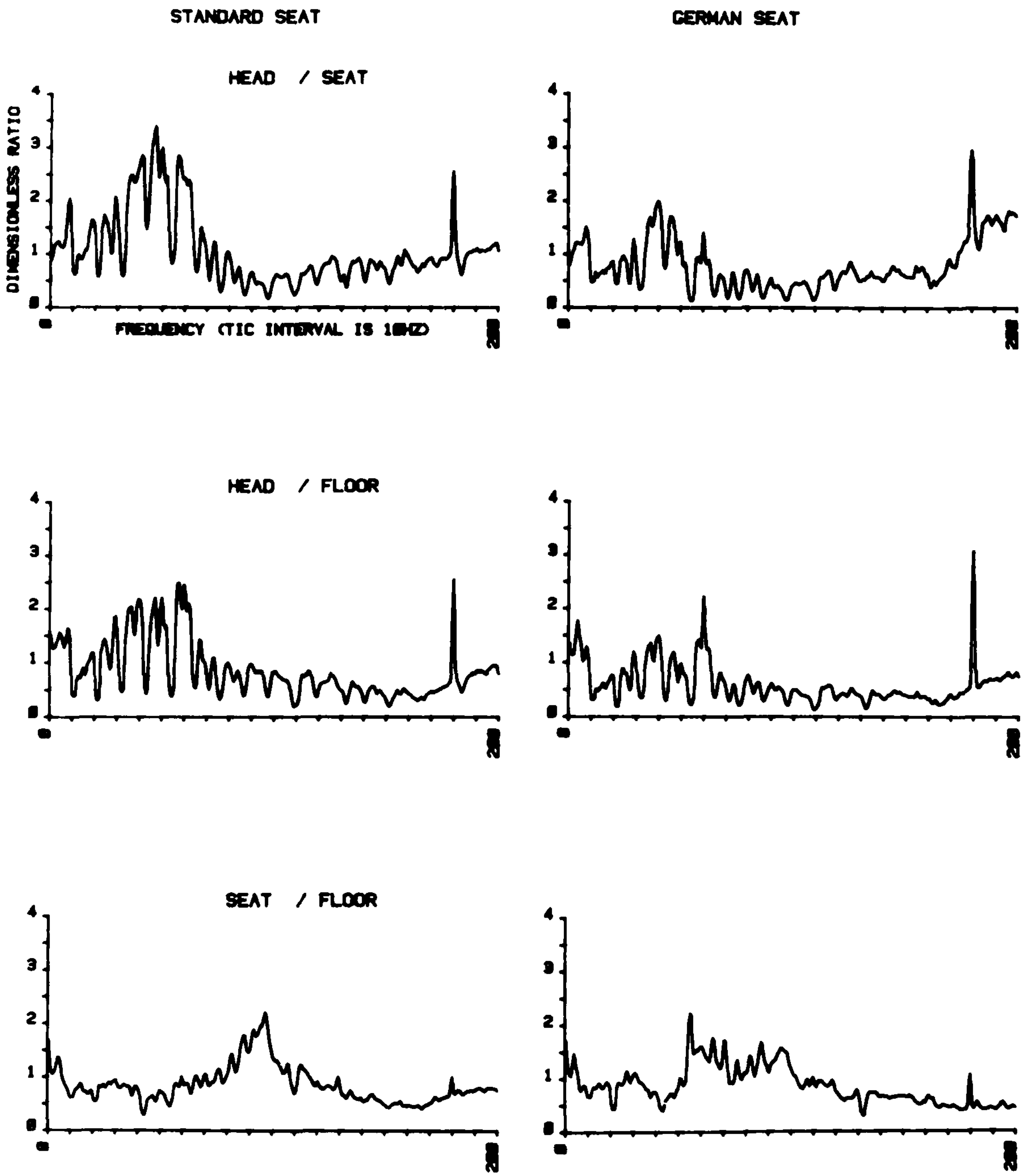


FIGURE E-4. Resultant Spectra, Pitch

APPENDIX F

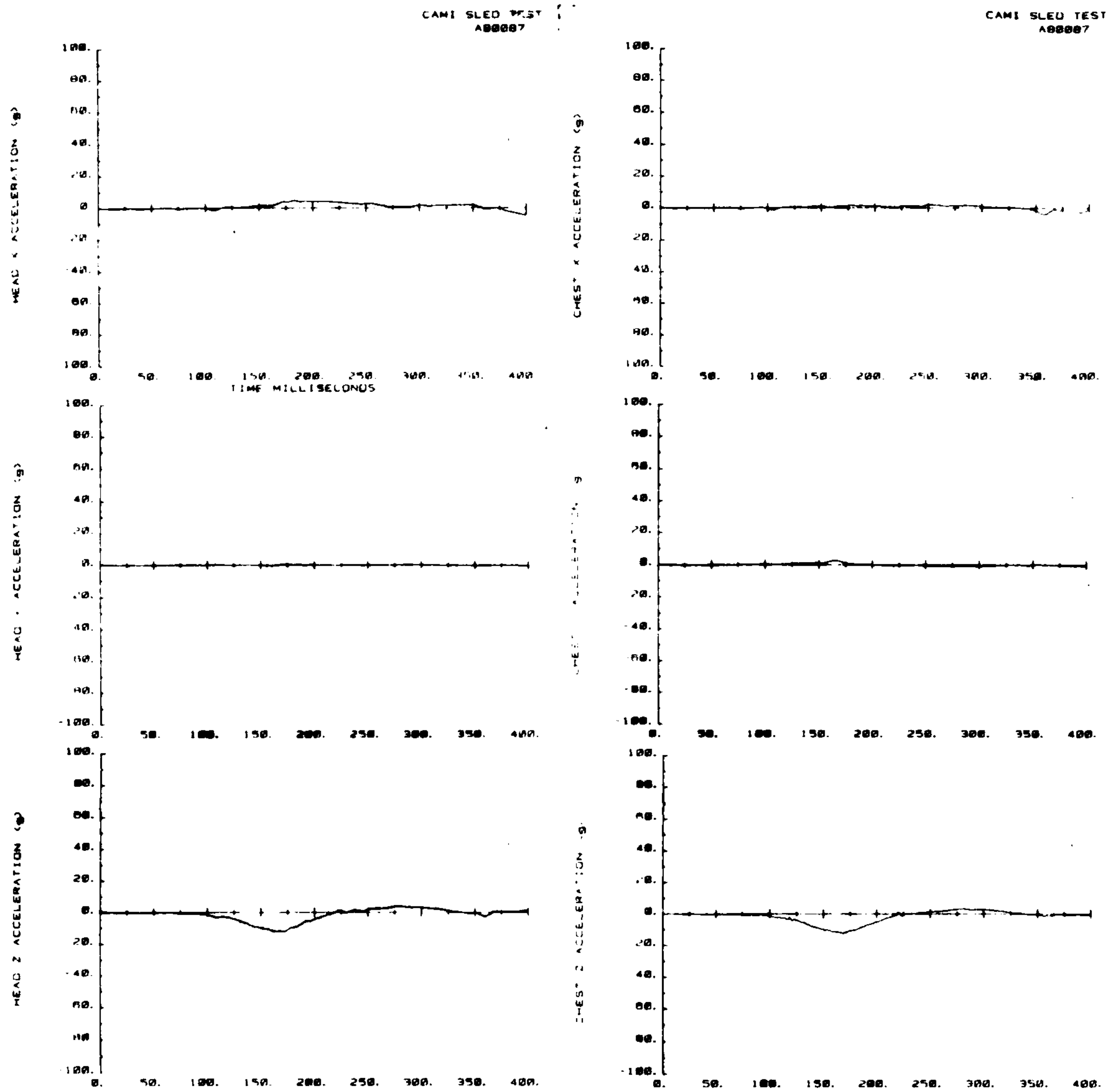
TRANSMISSIBILITY SPECTRA COMBINATION

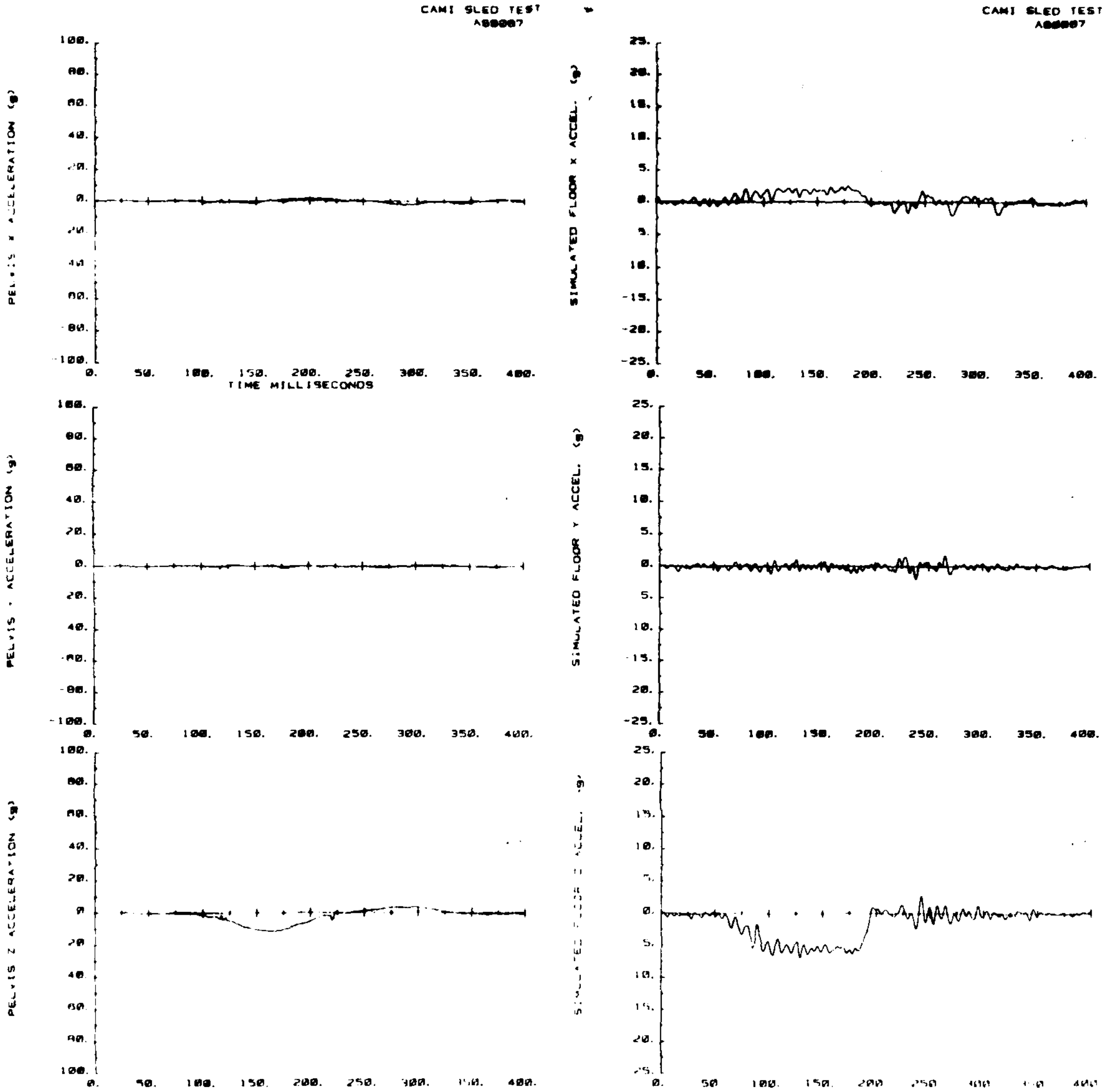

STANDARD SEAT
GERMAN SEAT
HEAD / SEAT
HEAD / FLOOR
SEAT / FLOOR
DIMENSIONLESS RATIO
FREQUENCY (TIC INTERVAL IS 10HZ)

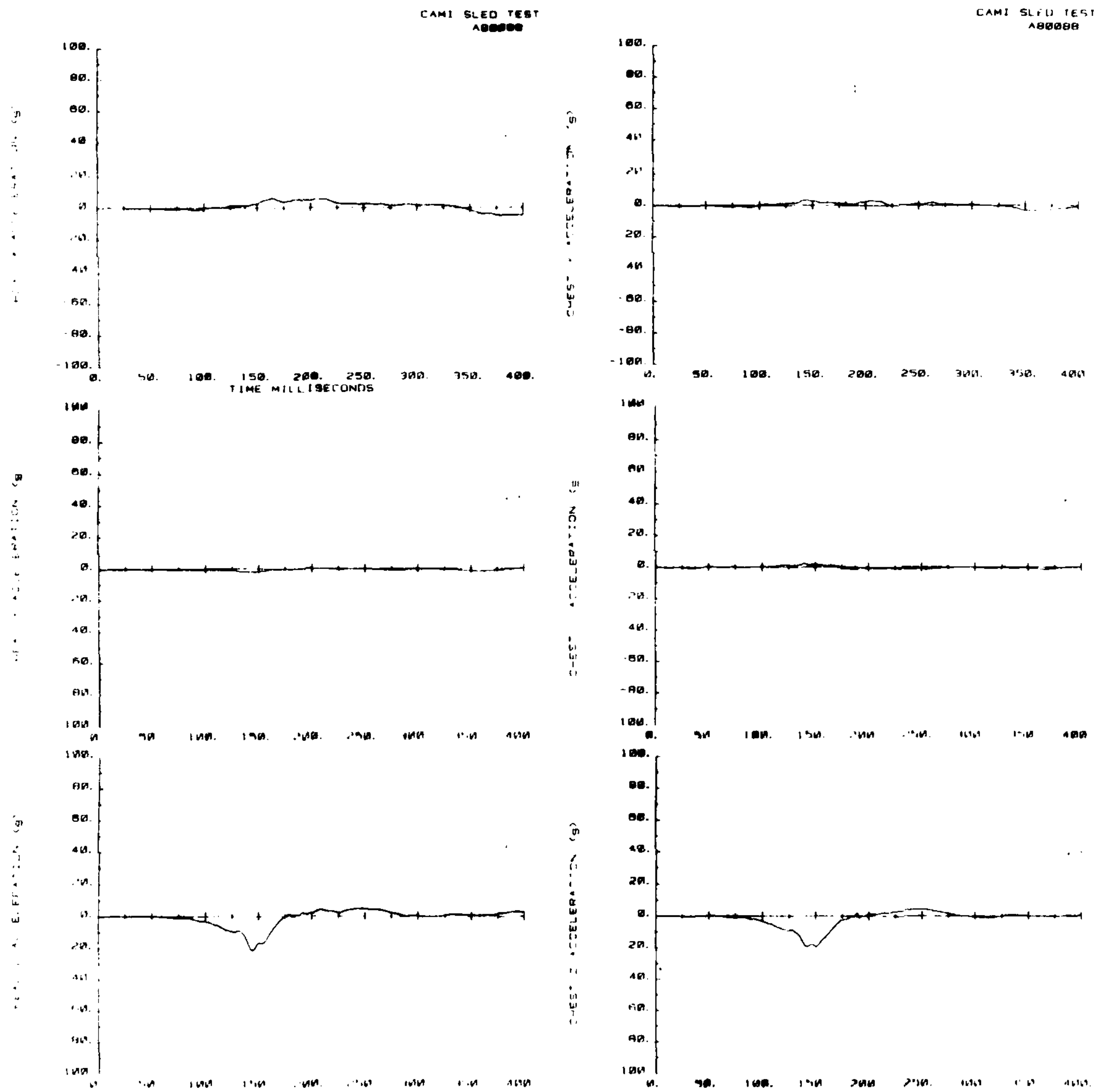
APPENDIX G

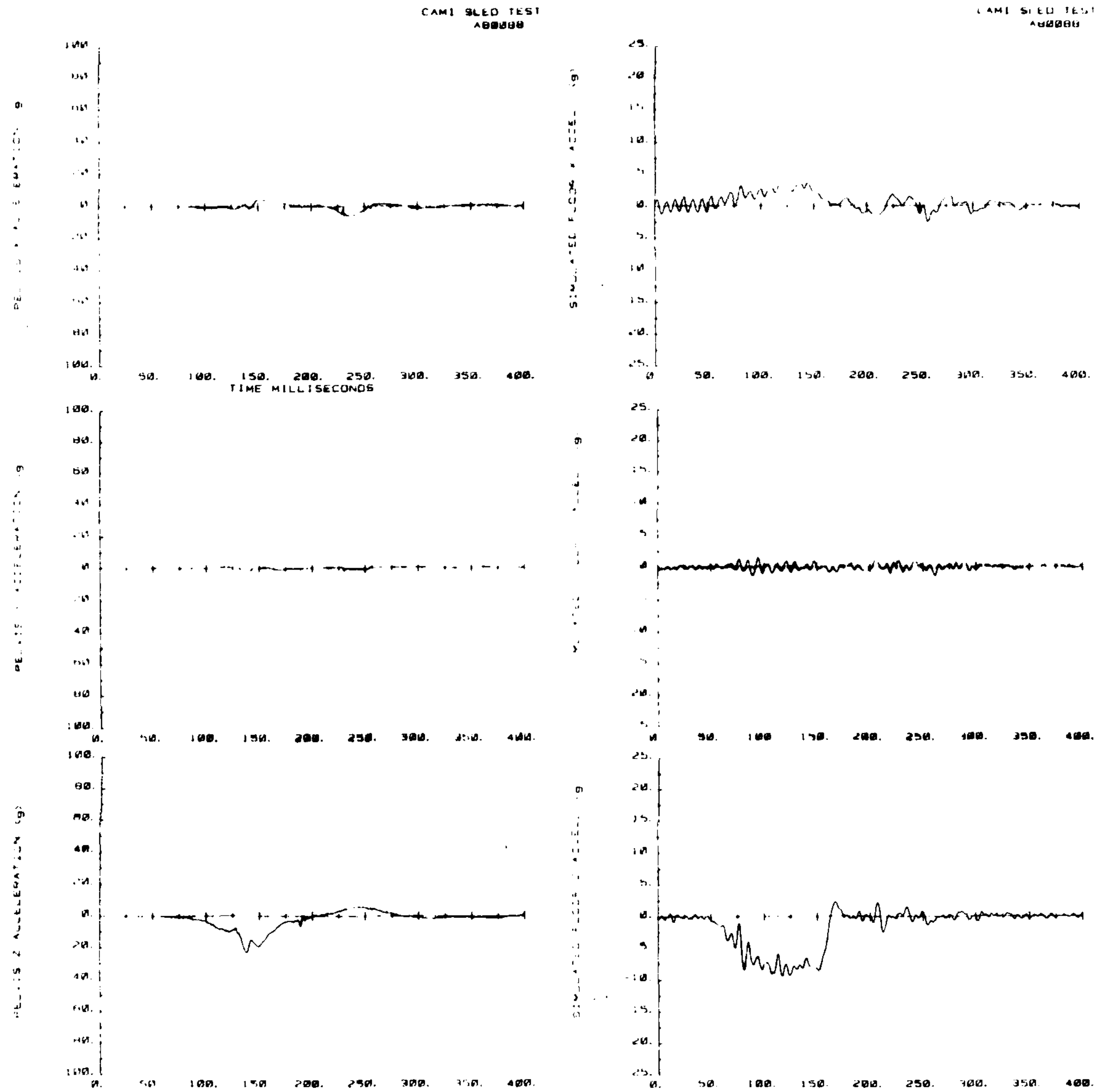
CAMI SLED TEST ACCELERATION VS TIME TRACES

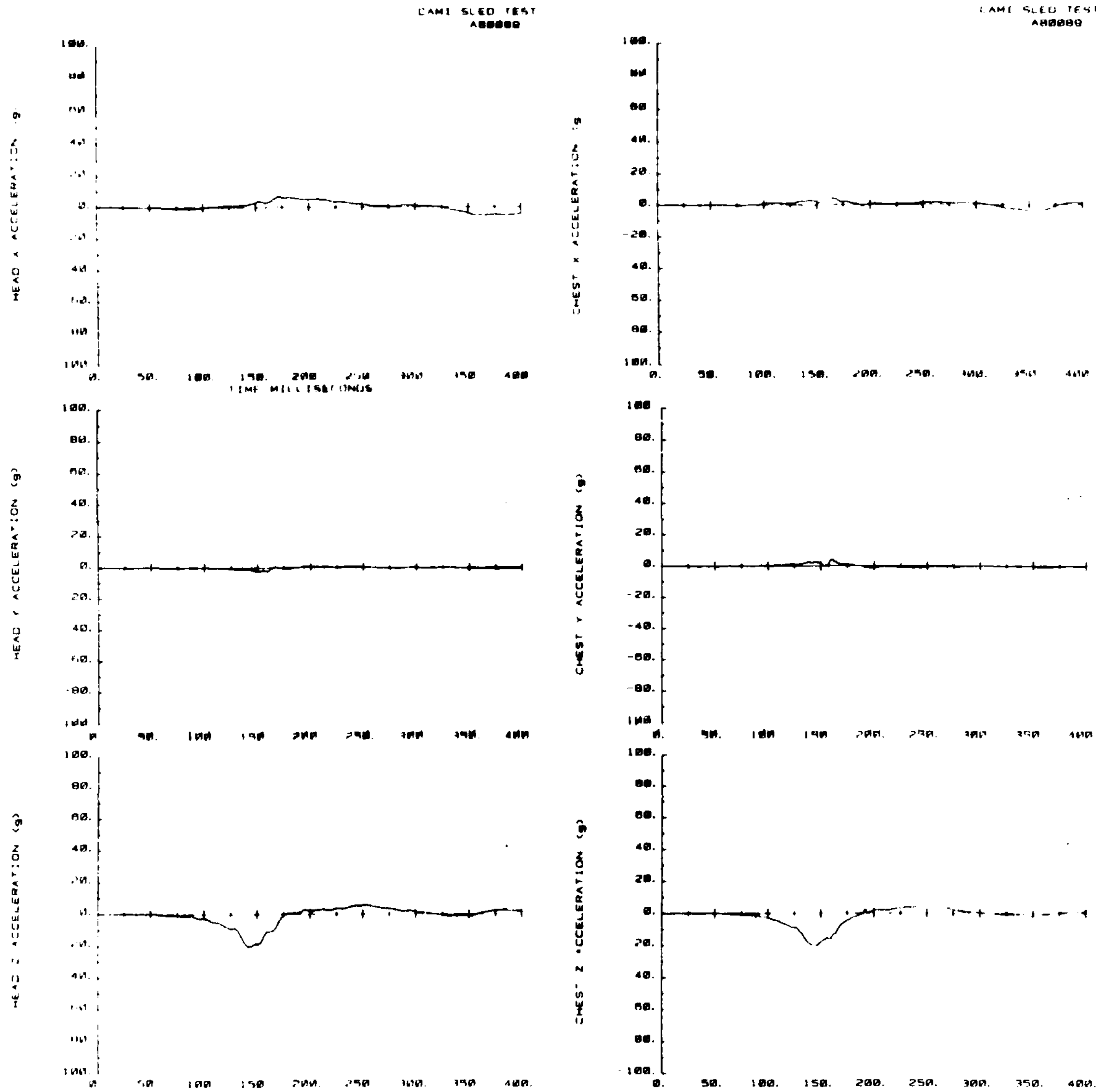
DESCRIPTION	TEST NO.	PAGE NO.
Head, chest, pelvis and simulated floor acceleration for x, y, and z directions	A80087	60
	A80088	62
	A80089	64
	A80090	66
	A80091	68
	A80092	70
	A80093	72
	A80094	74
	A80095	76
	A80096	78
	A80097	80
Sled X acceleration for each of 11 test runs	A80088-A80097	82


CAMI SLED TEST
A80087
HEAD X ACCELERATION (g)
CHEST X ACCELERATION (g)
TIME MILLISECONDS
HEAD Z ACCELERATION (g)


CAMI SLED TEST
CAMI SLED TEST
PELVIS X ACCELERATION (g)
SIMULATED FLOOR X ACCEL. (g)
TIME MILLISECONDS
SIMULATED FLOOR Y ACCEL. (g)
PELVIS Z ACCELERATION (g)

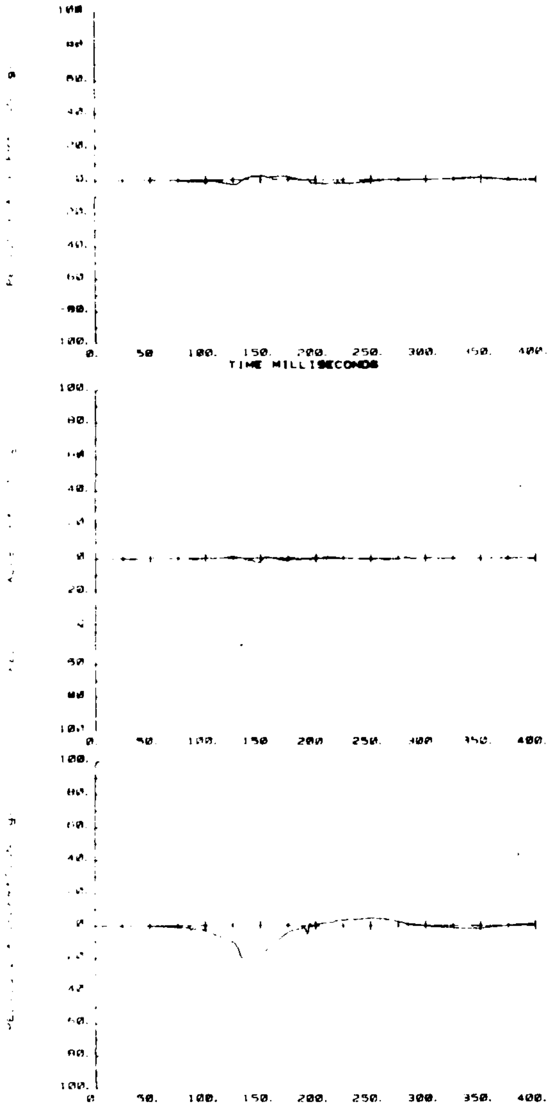

CAMI SLED TEST
CAMI SLED TEST
A80088
TIME MILLISECONDS
CHEST ACCELERATION (g)


CAMI SLED TEST
A80080
TIME MILLISECONDS
PELVIS Z ACCELERATION (g)

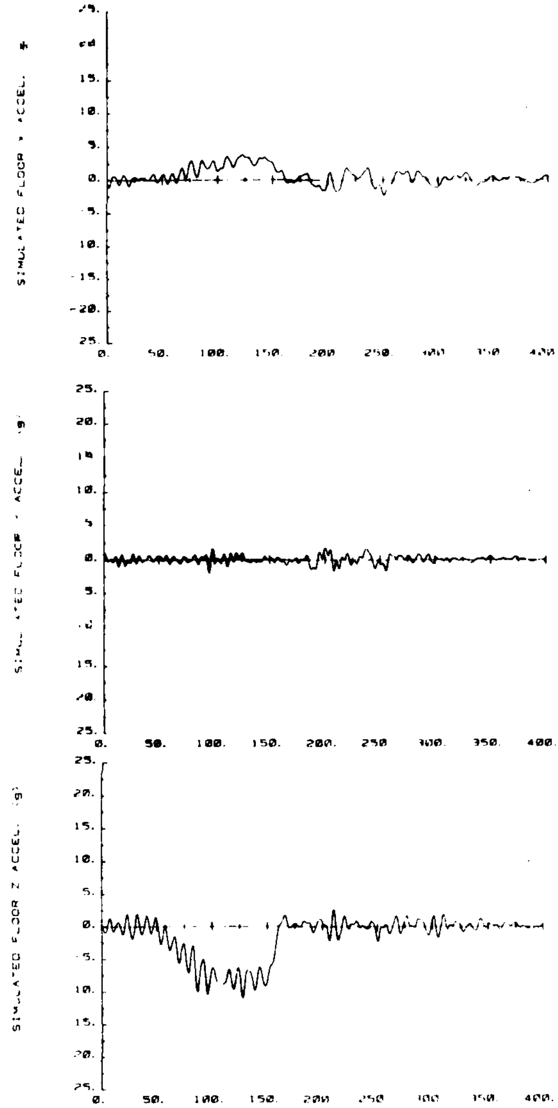


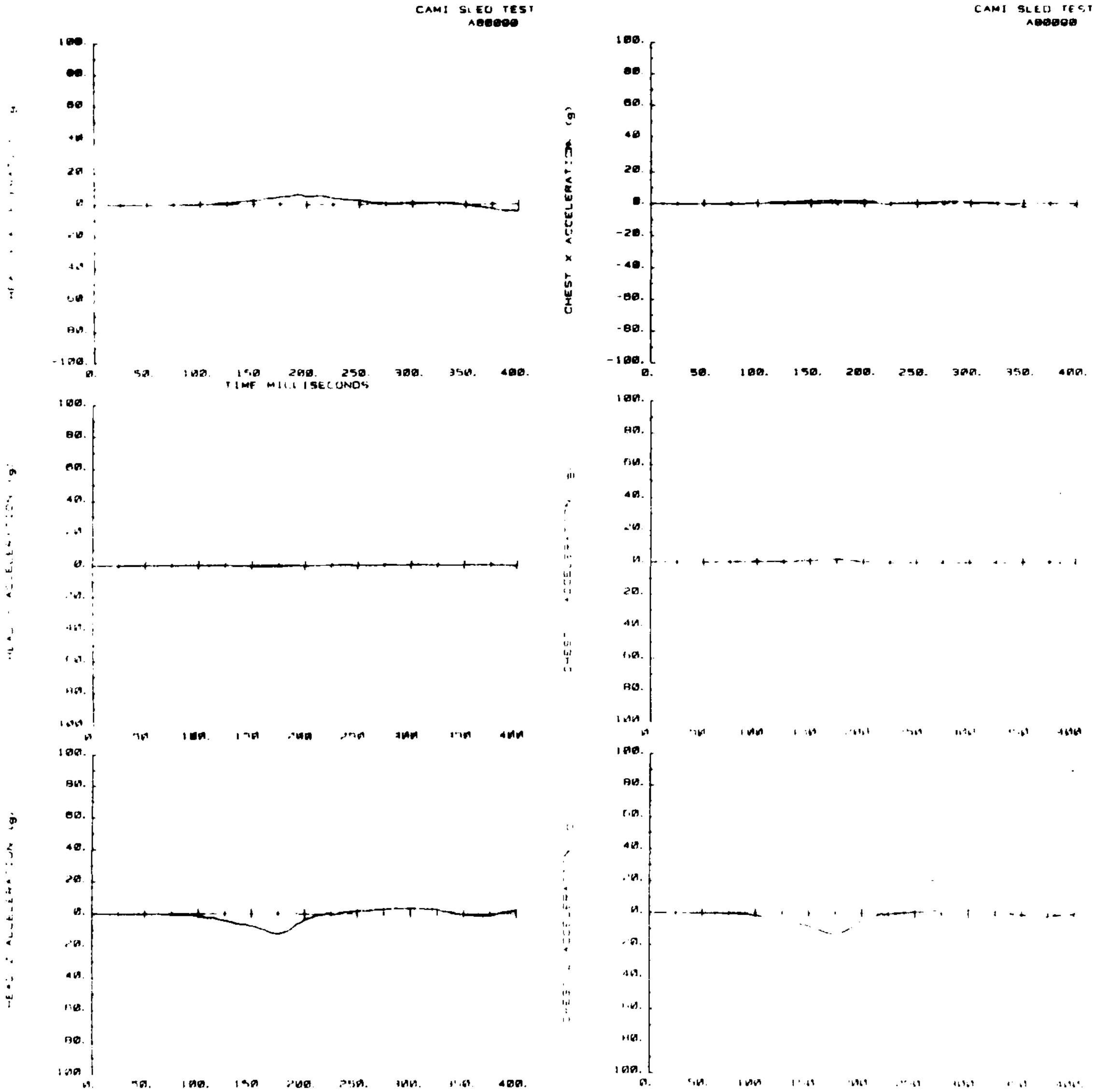
CAMI SLED TEST
A80089
CAMI SLED TEST
A80089
HEAD X ACCELERATION (g)
CHEST X ACCELERATION (g)
TIME MILLISECONDS
HEAD Y ACCELERATION (g)
CHEST Y ACCELERATION (g)
HEAD Z ACCELERATION (g)
CHEST Z ACCELERATION (g)
0. 50. 100. 150. 200. 250. 300. 350. 400.

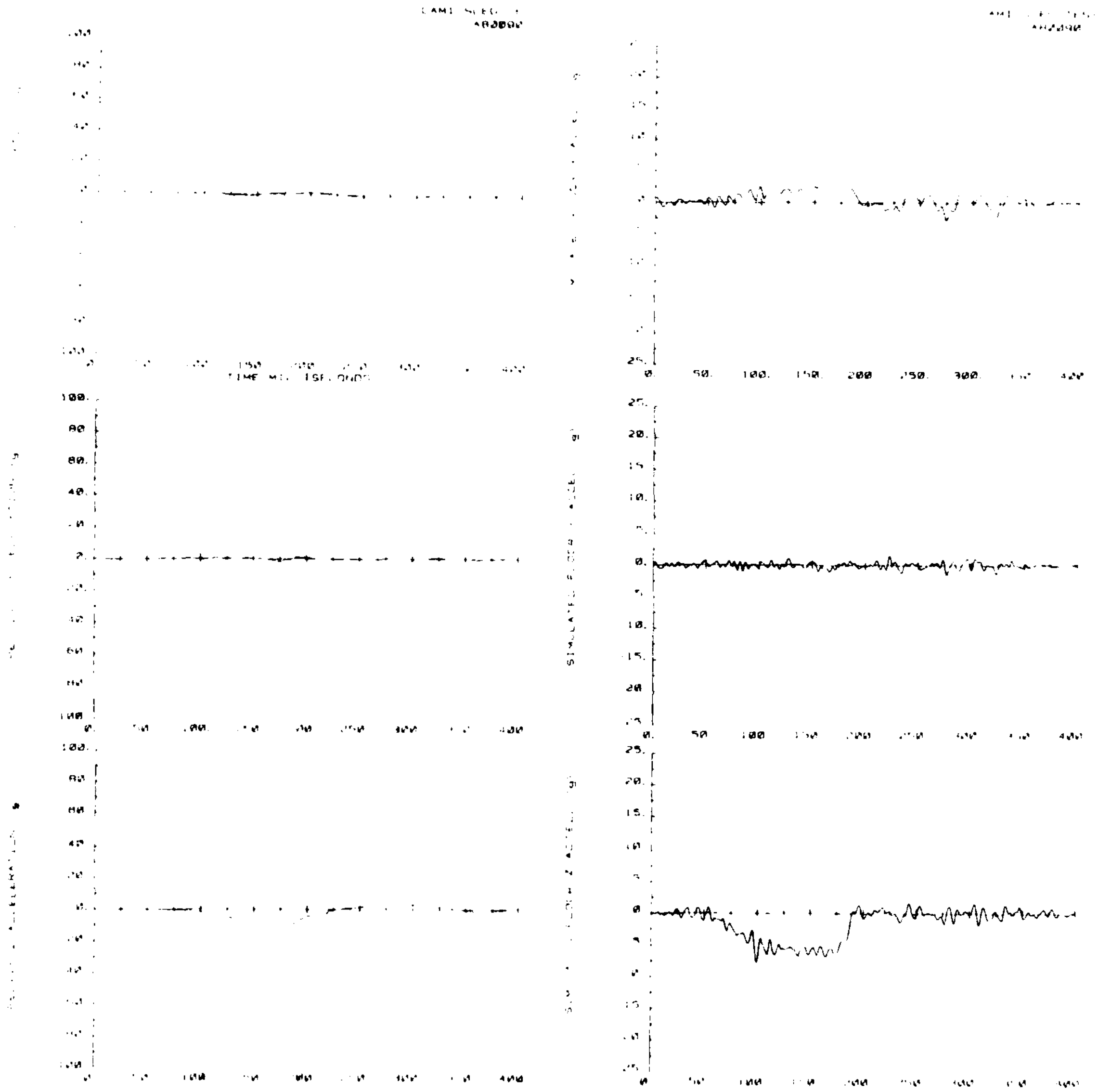
CAMI SLED TEST
AR0080

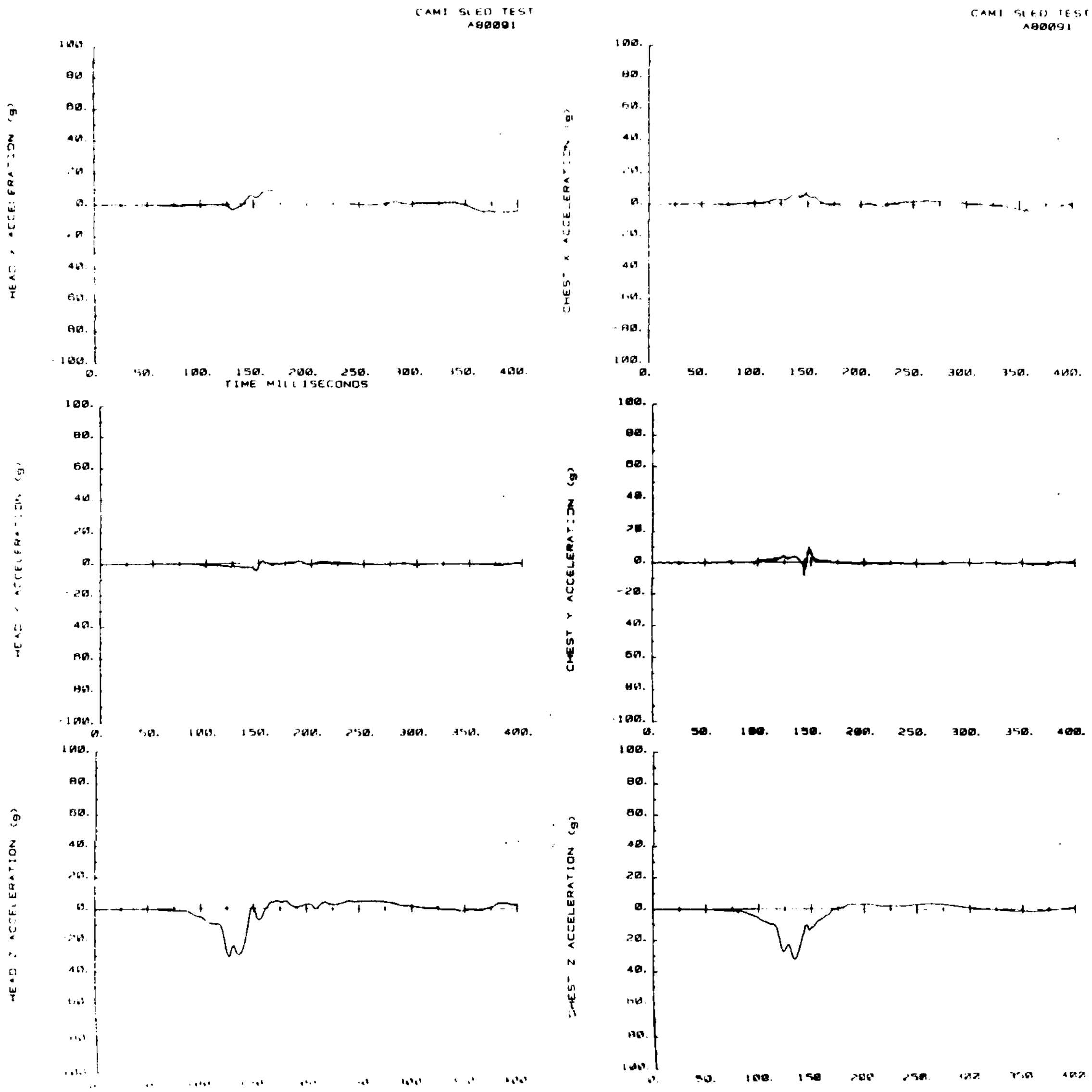


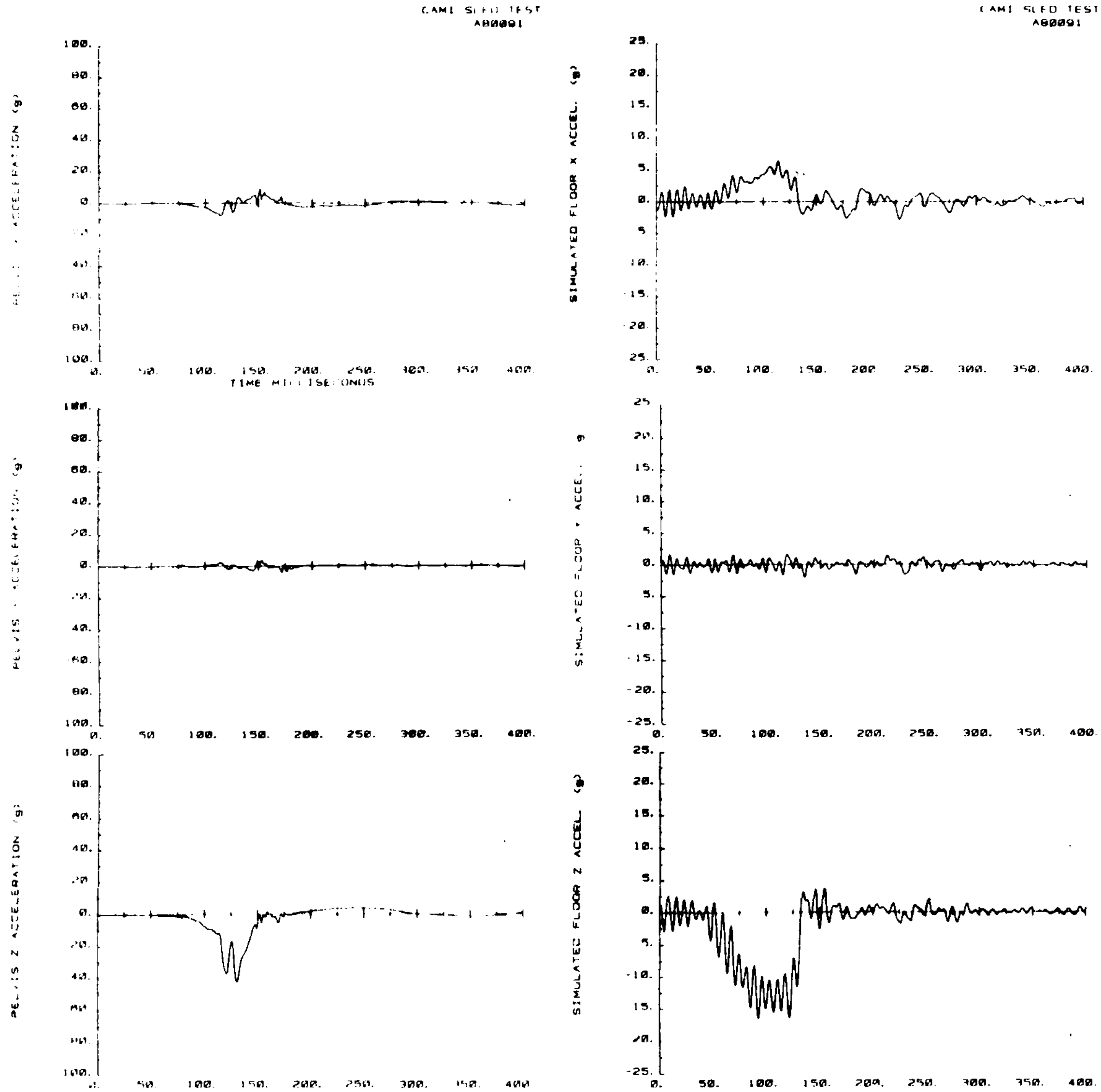
CAMI SLED TEST
AR0089

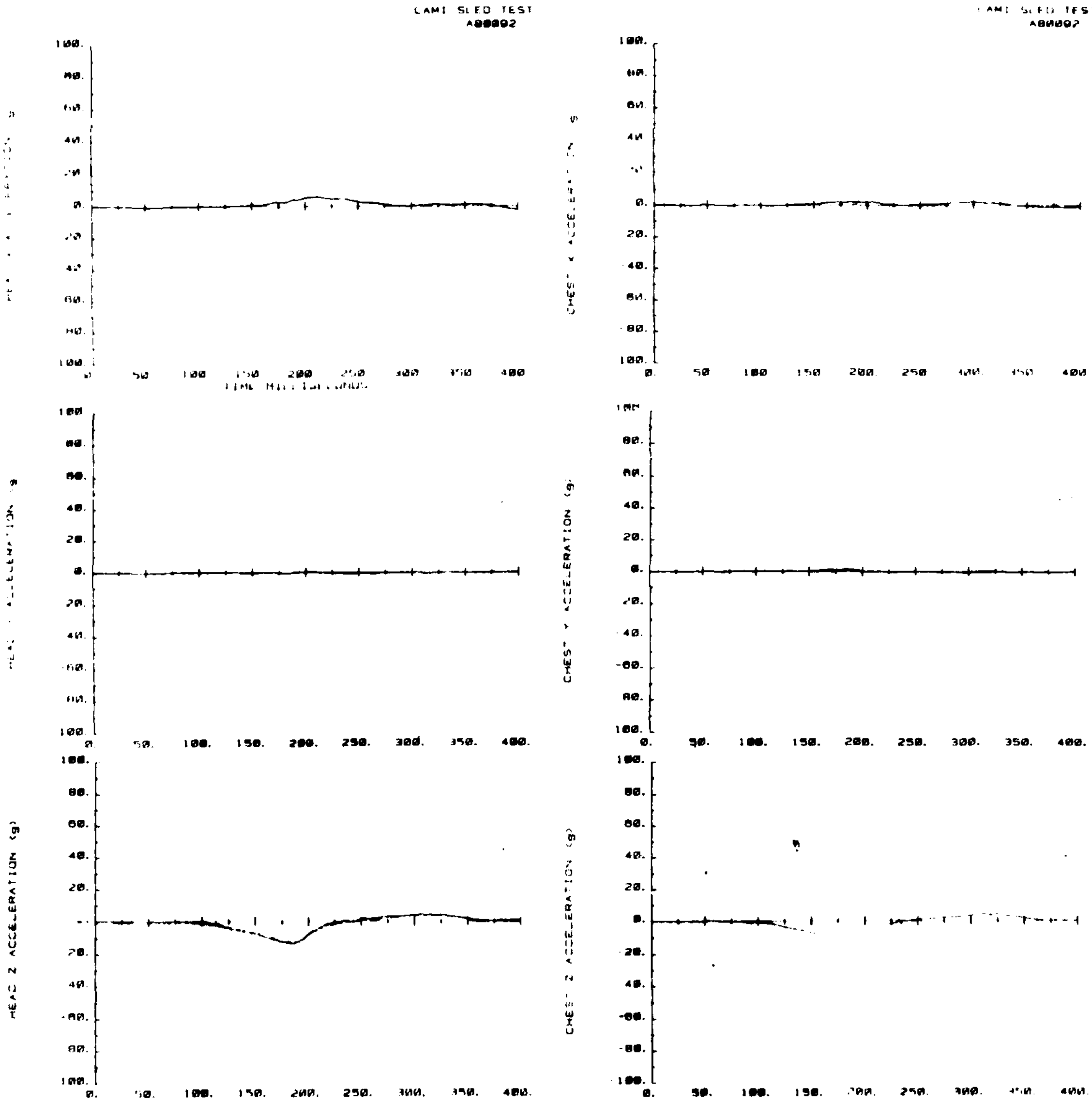


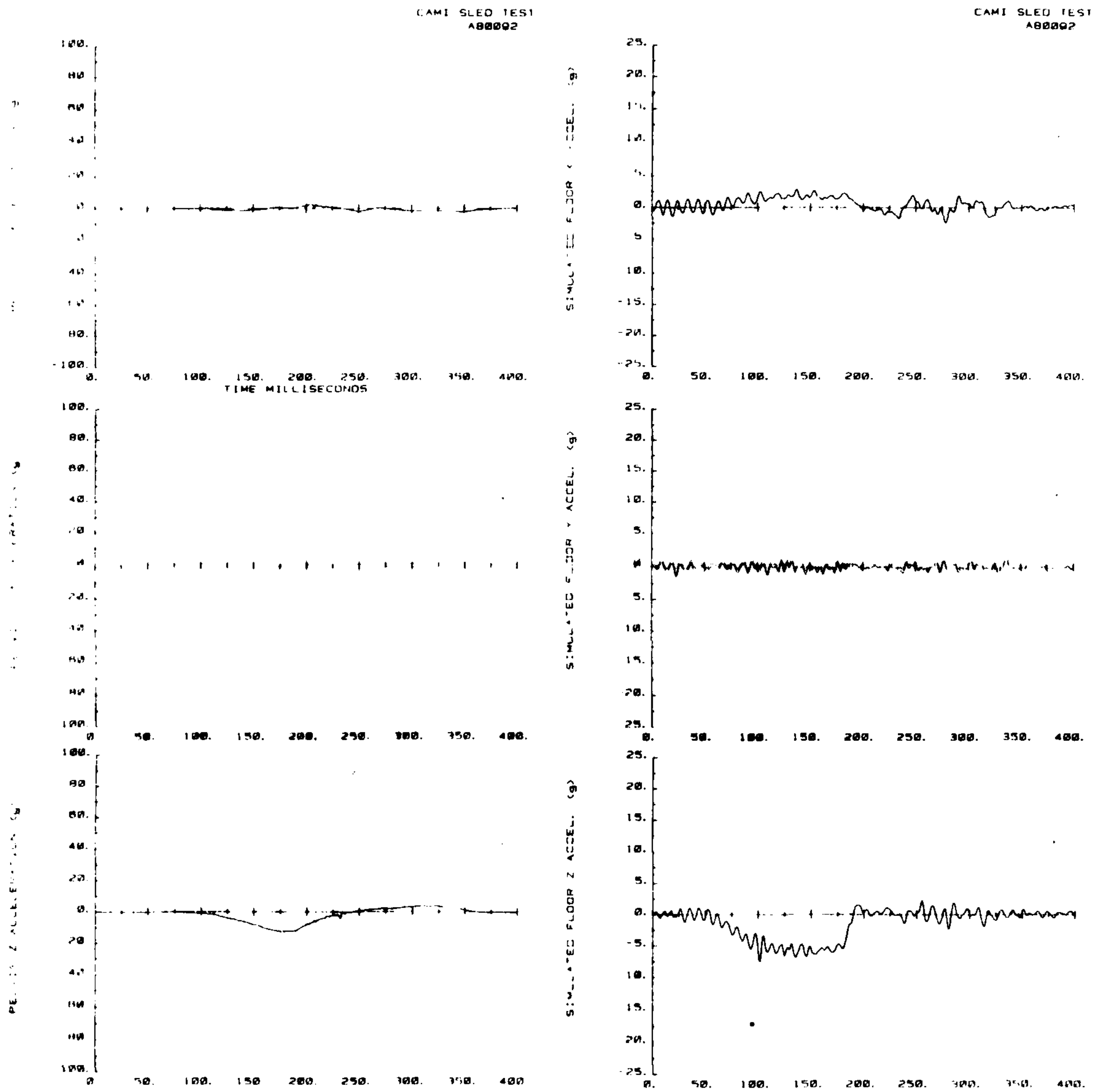

CAMI SLED TEST
A00000
CAMI SLED TEST
A00000
CHEST X ACCELERATION (g)
TIME MILLISECONDS

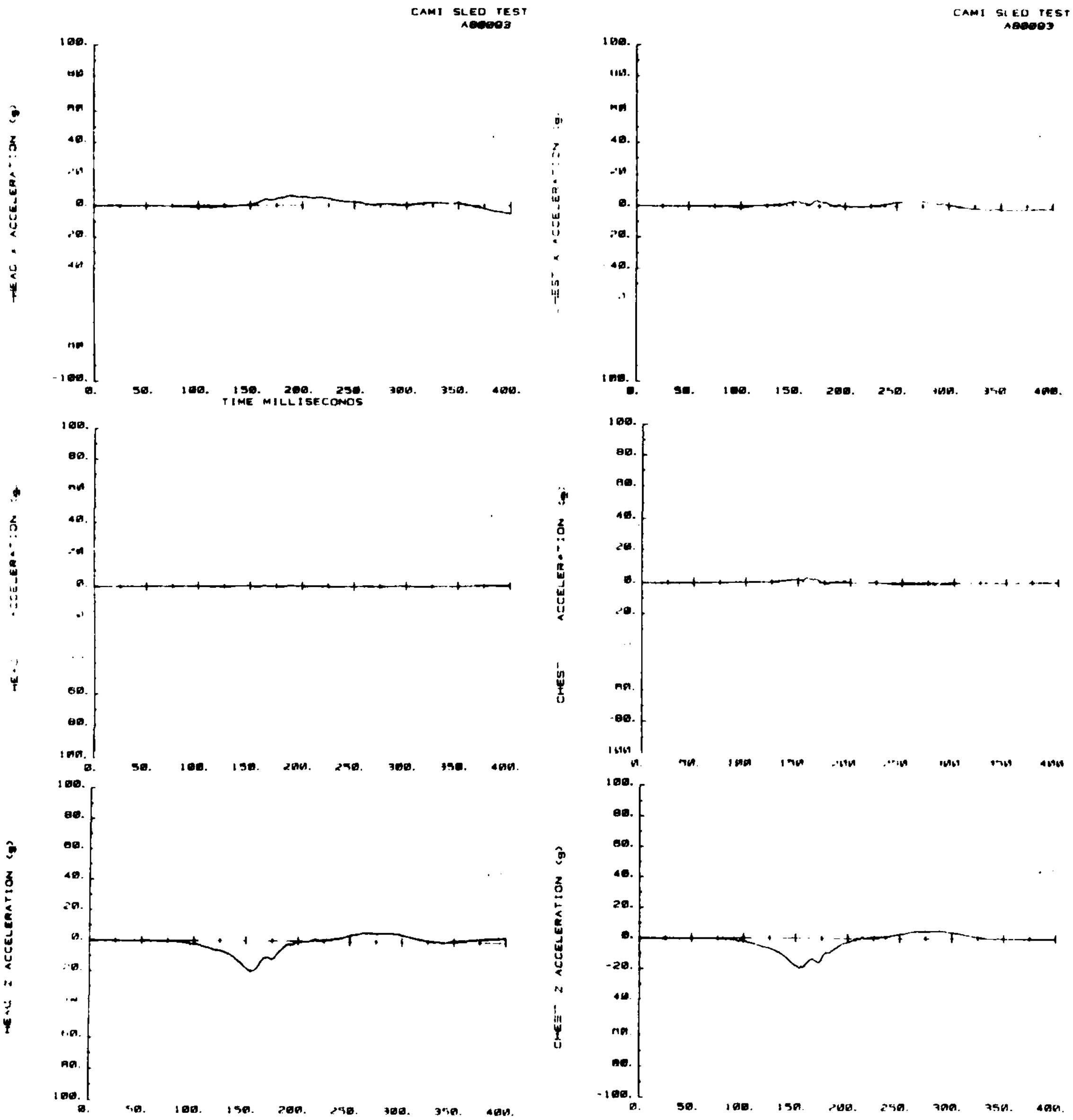


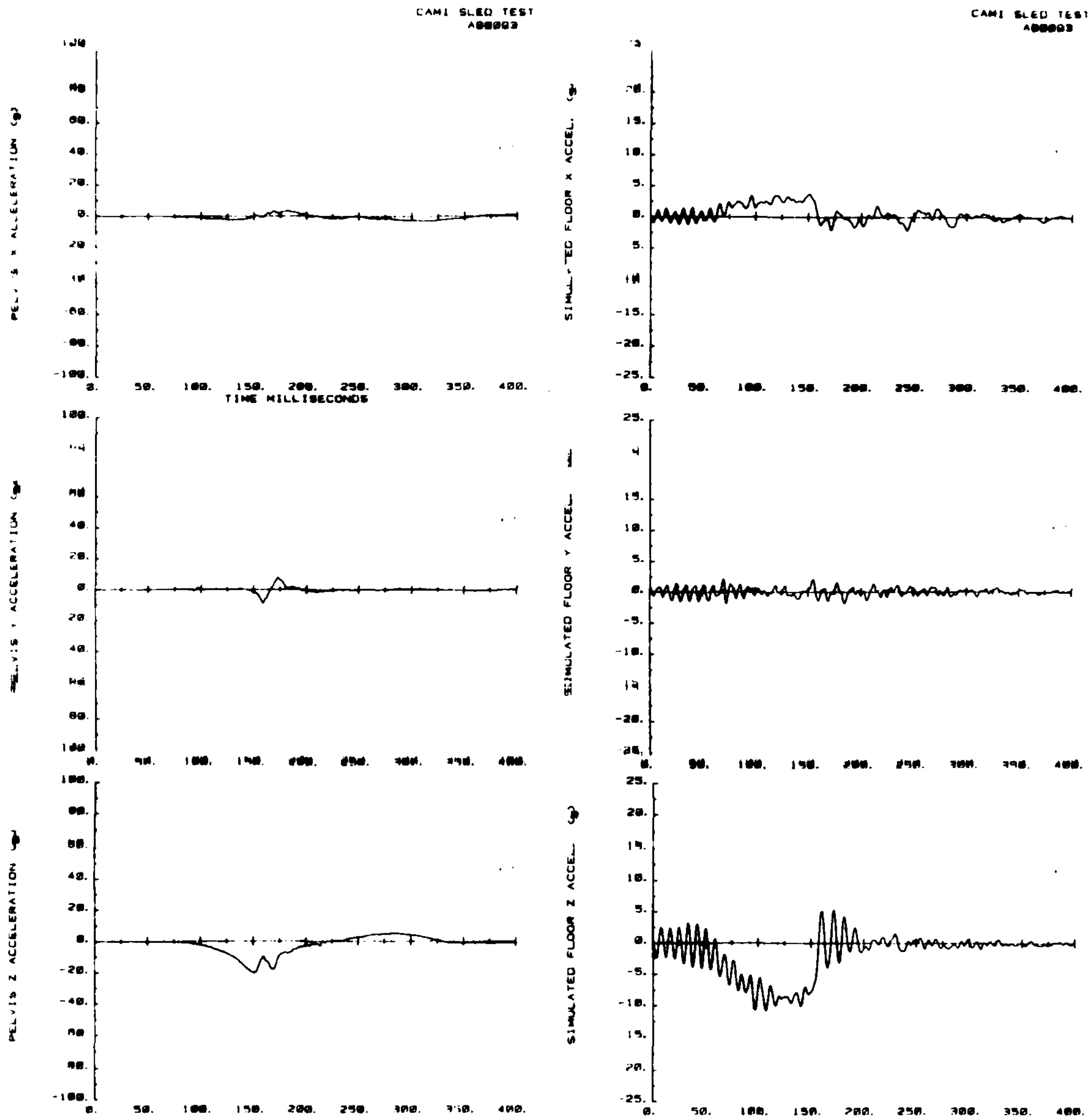

CAMI SLED TEST
A80091
CAMI SLED TEST
A80091
HEAD X ACCELERATION (g)
CHEST X ACCELERATION (g)
TIME MILLISECONDS
HEAD Y ACCELERATION (g)
CHEST Y ACCELERATION (g)
HEAD Z ACCELERATION (g)
CHEST Z ACCELERATION (g)

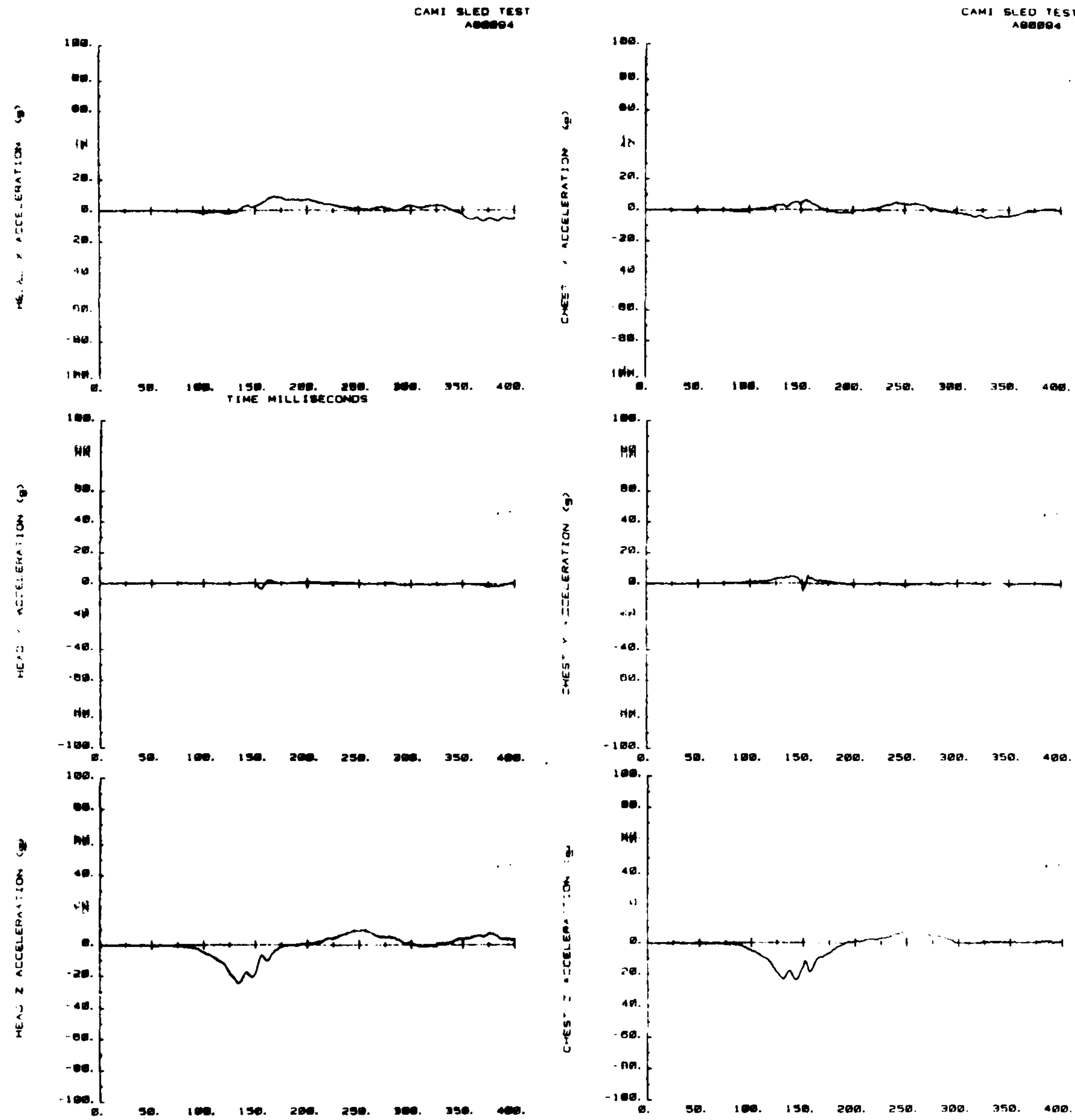

CAMI SLED TEST
AB0091
CAMI SLED TEST
AB0091
SIMULATED FLOOR X ACCEL. (g)
SIMULATED FLOOR Z ACCEL. (g)
PELVIS Z ACCELERATION (g)
0. 50. 100. 150. 200. 250. 300. 350. 400.

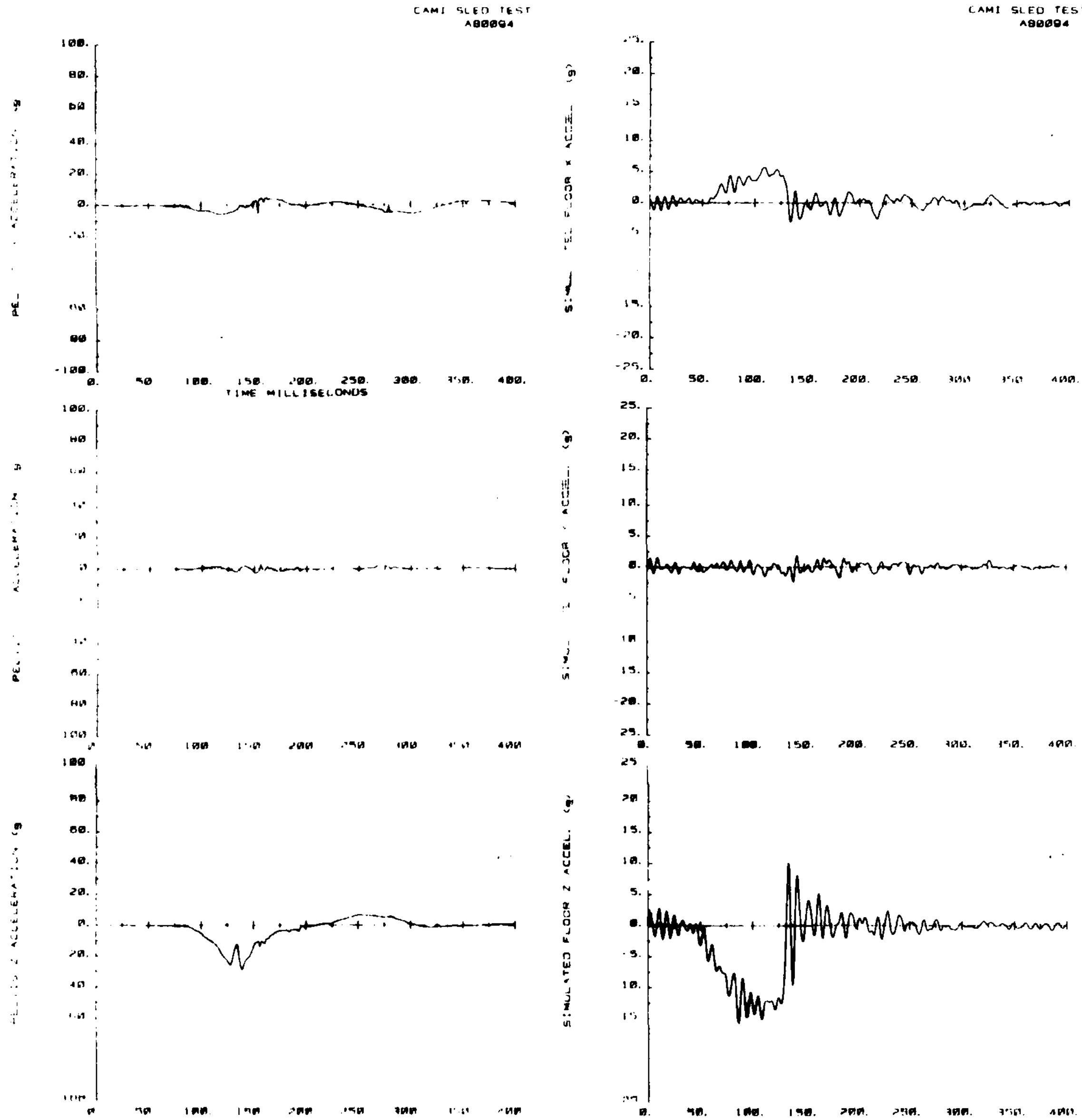

LAMI SLED TEST
A80002
HEAD Z ACCELERATION (g)
CHEST Z ACCELERATION (g)
CHEST Y ACCELERATION (g)
TIME MILLISECONDS

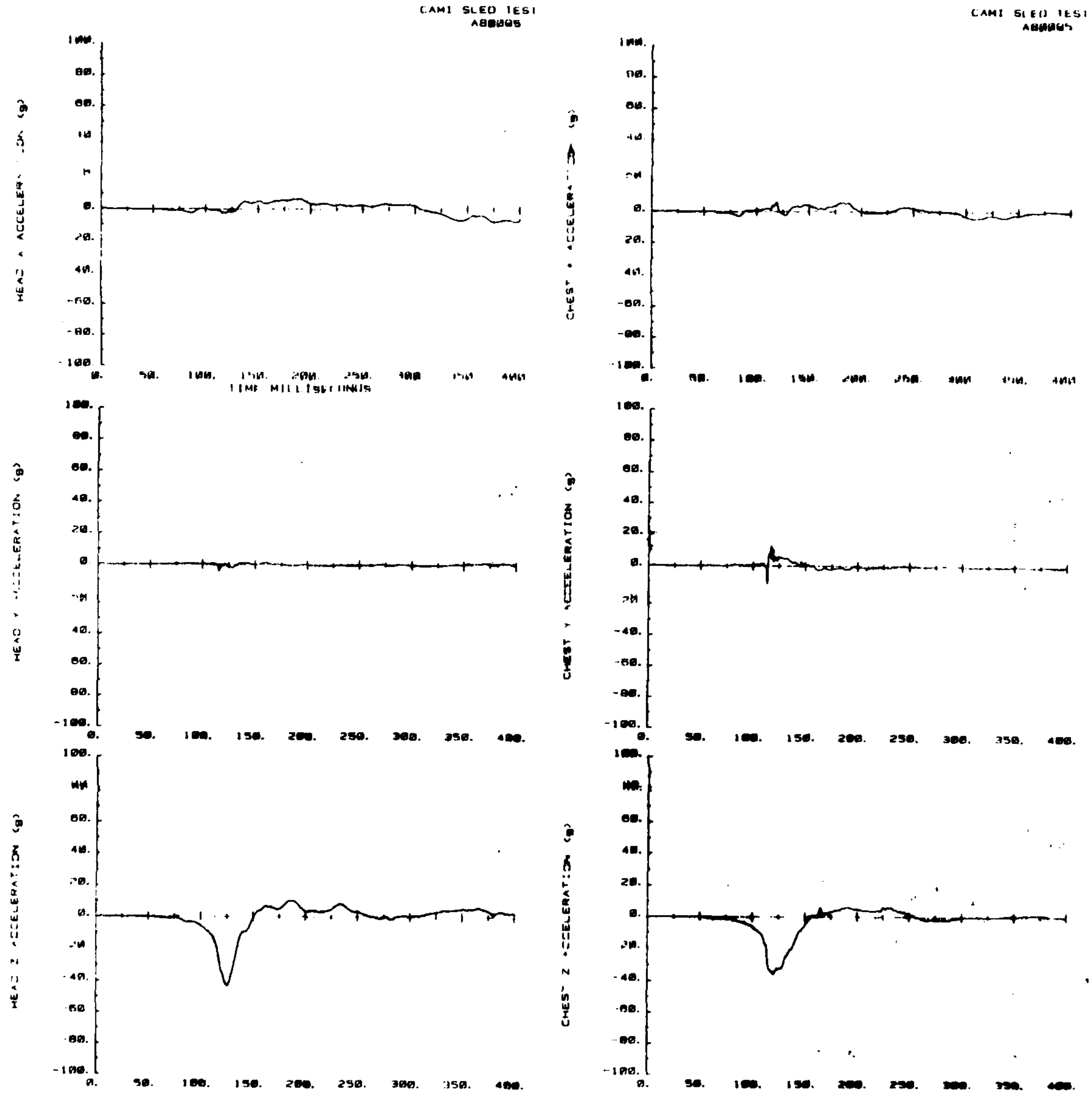

CAMI SLED TEST
A80002
CAMI SLED TEST
A80002
TIME MILLISECONDS
SIMULATED FLOOR Y ACCEL. (g)
SIMULATED FLOOR Z ACCEL. (g)

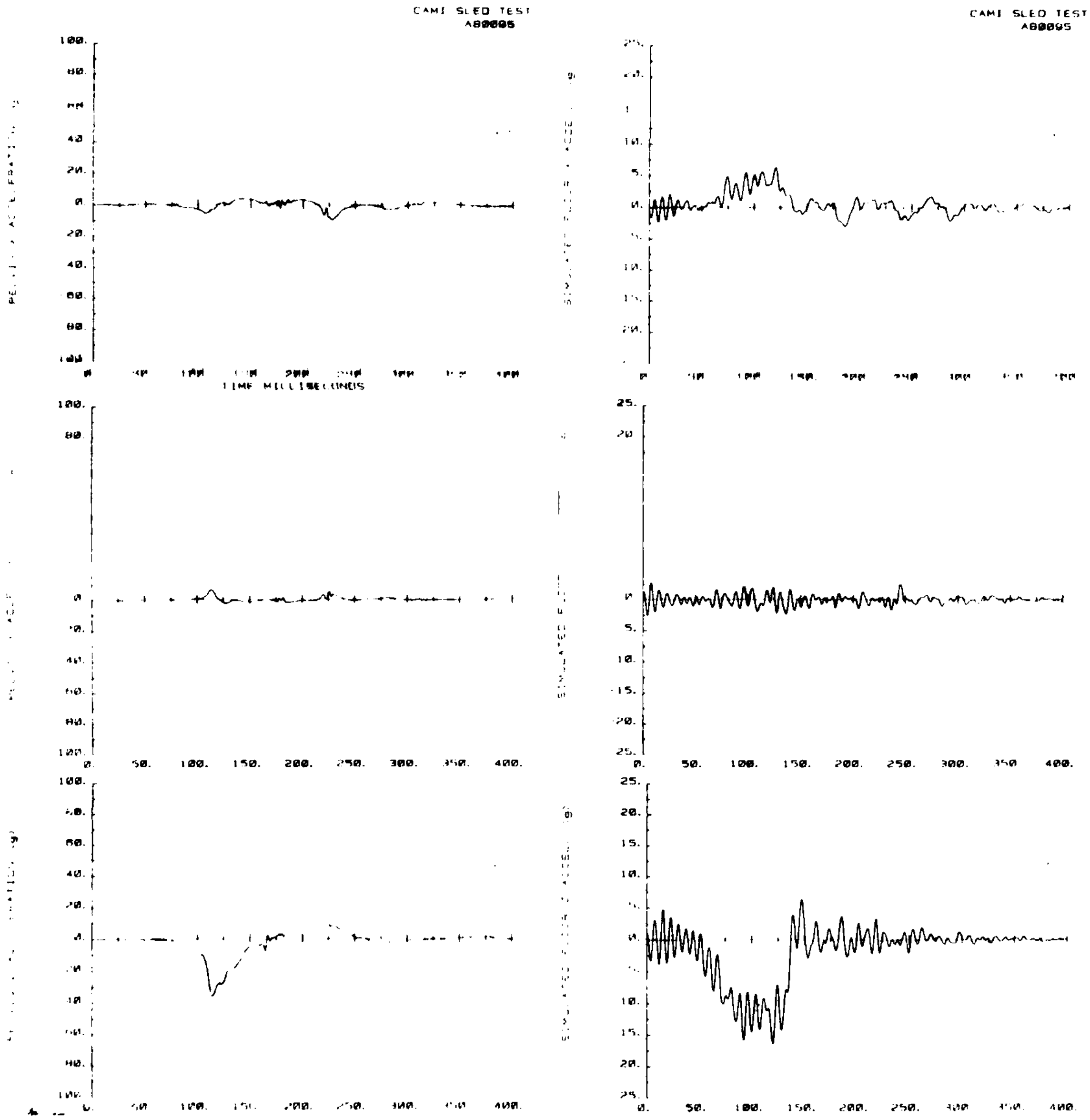

CAMI SLED TEST
A00003
CAMI SLED TEST
A00003
HEAD X ACCELERATION (g)
CHEST X ACCELERATION (g)
TIME MILLISECONDS
CHEST Y ACCELERATION (g)
HEAD Z ACCELERATION (g)
CHEST Z ACCELERATION (g)

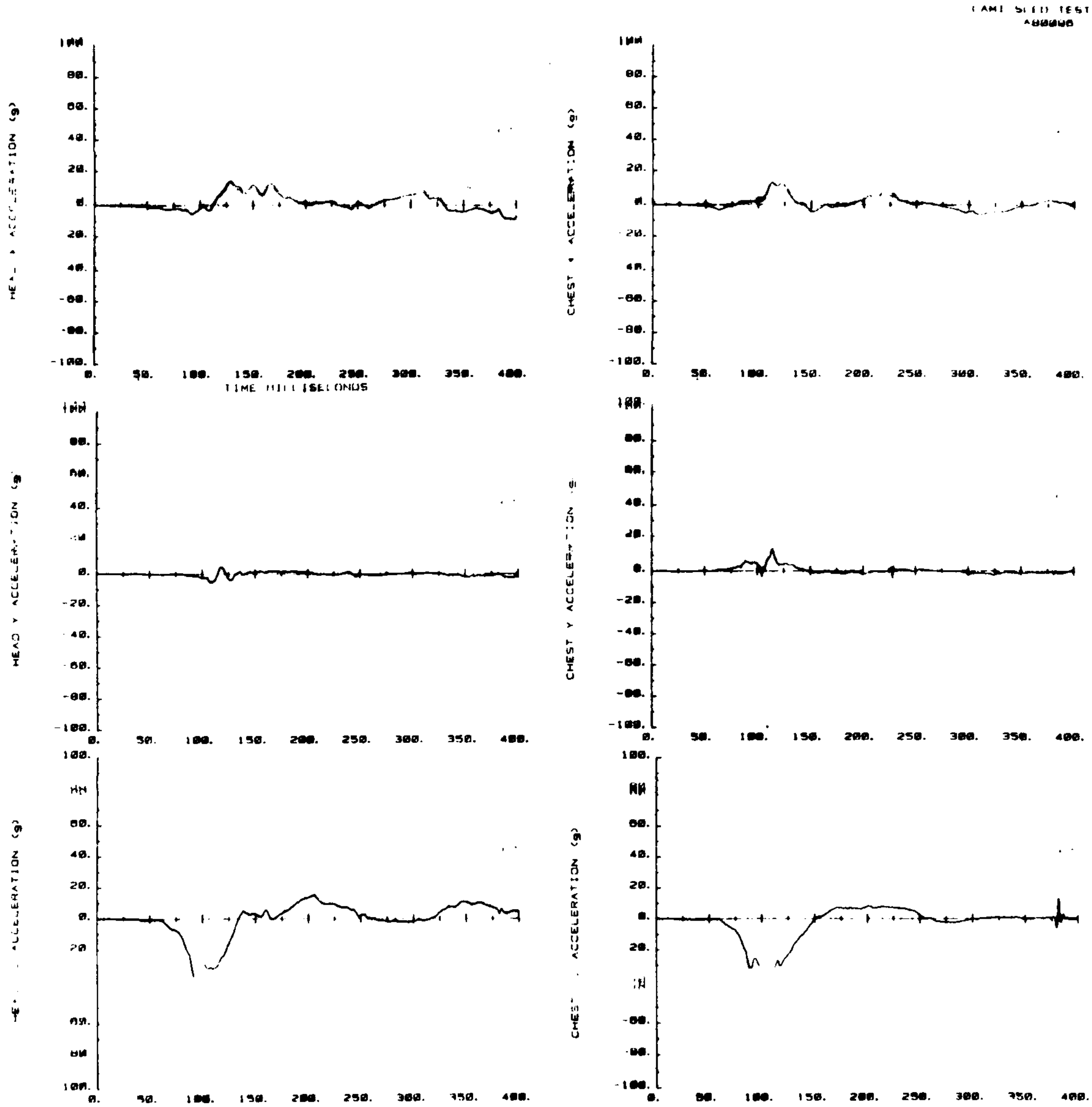

CAMI SLED TEST
A08003
PELVIS X ACCELERATION (g)
TIME MILLISECONDS
PELVIS Y ACCELERATION (g)
PELVIS Z ACCELERATION (g)
SIMULATED FLOOR X ACCEL. (g)
SIMULATED FLOOR Y ACCEL.
SIMULATED FLOOR Z ACCEL. (g)

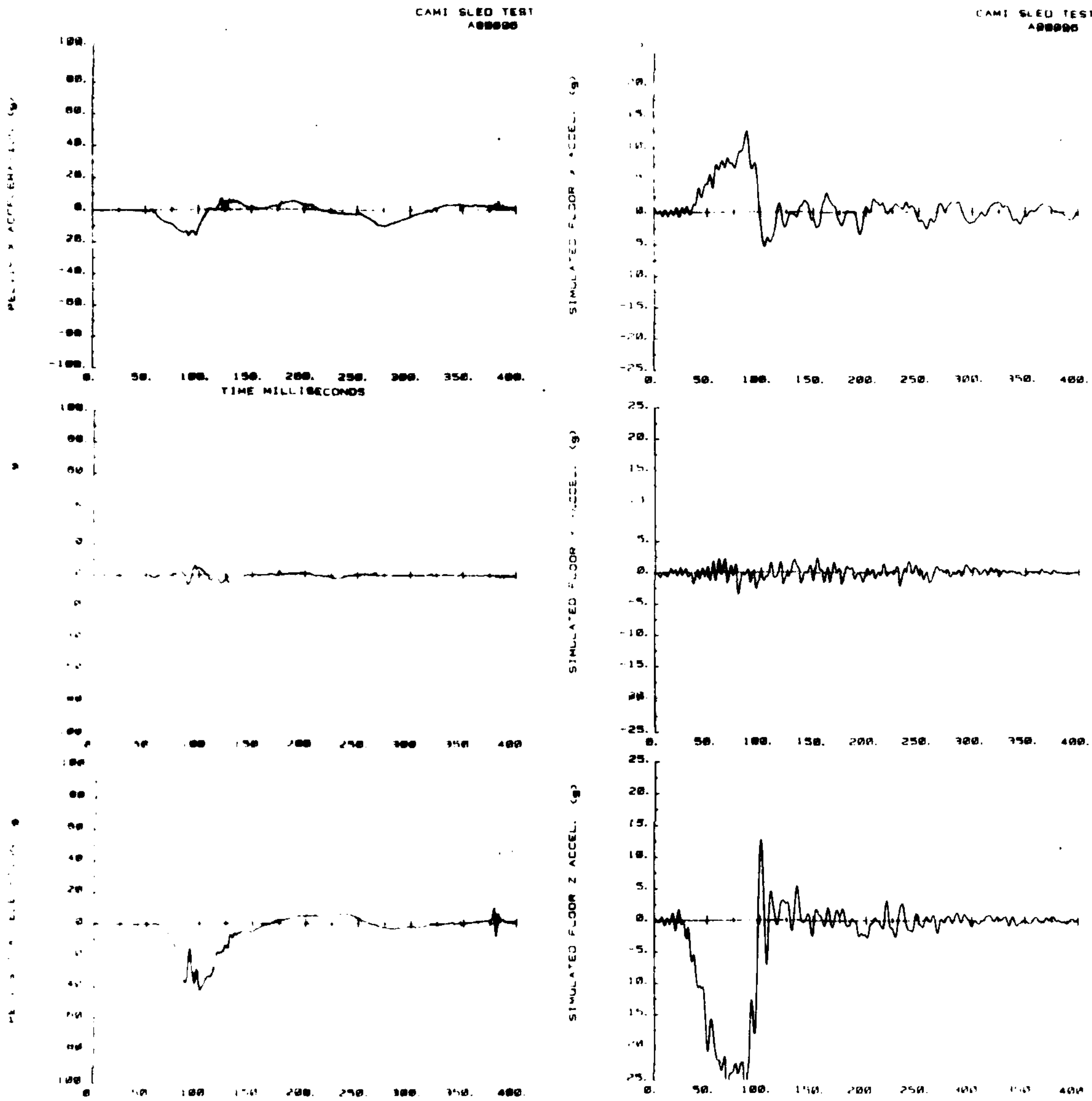

CAMI SLED TEST
A00004
CAMI SLED TEST
A00004
HEAD X ACCELERATION (g)
CHEST X ACCELERATION (g)
TIME MILLISECONDS
HEAD Y ACCELERATION (g)
CHEST Y ACCELERATION (g)
HEAD Z ACCELERATION (g)
CHEST Z ACCELERATION (g)


CAMI SLED TEST
A80094
CAMI SLED TEST
A80094
TIME MILLISECONDS
SIMULATED FLOOR Z ACCEL. (g)

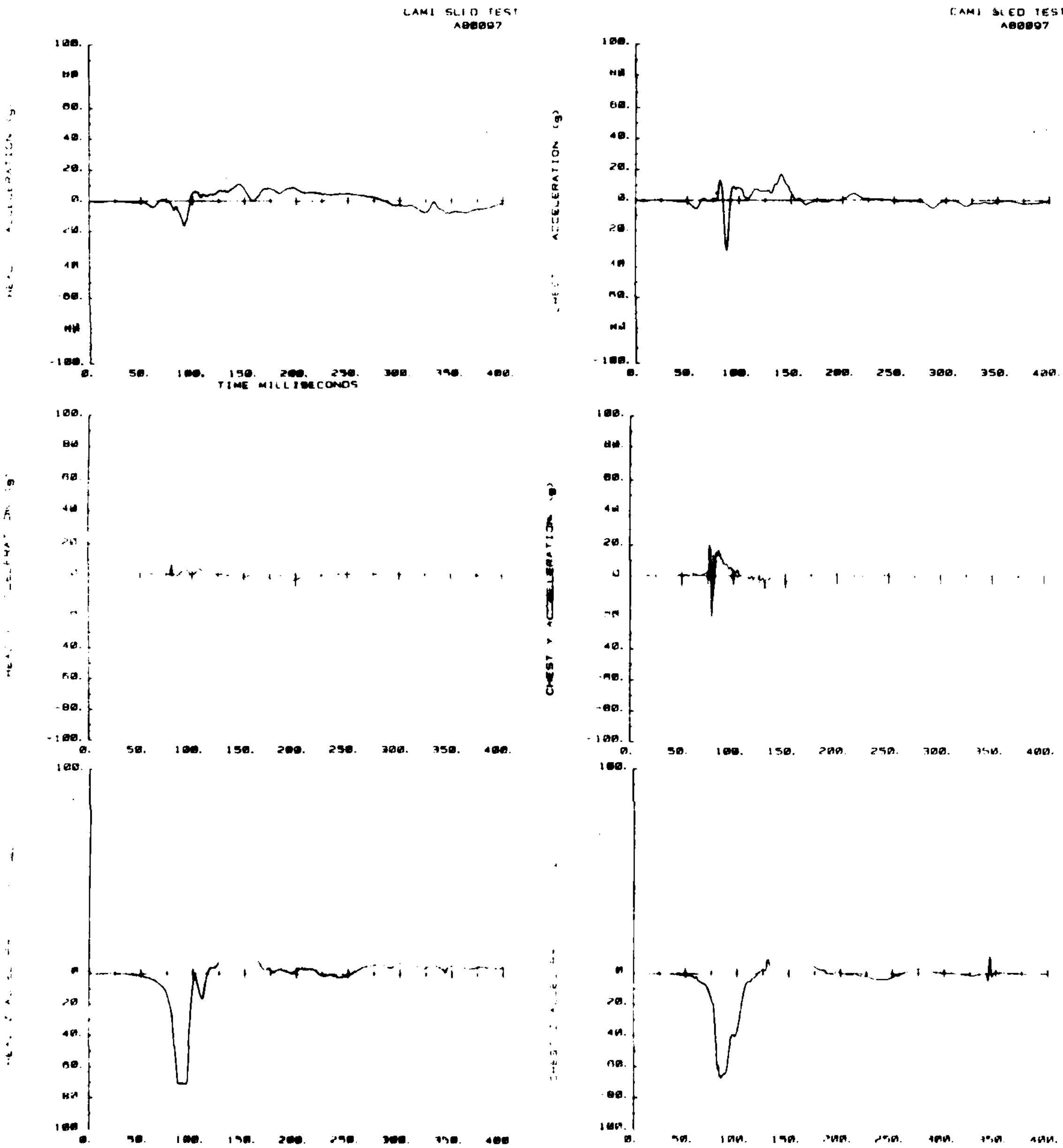

CAMI SLED TEST
CAMI SLED TEST

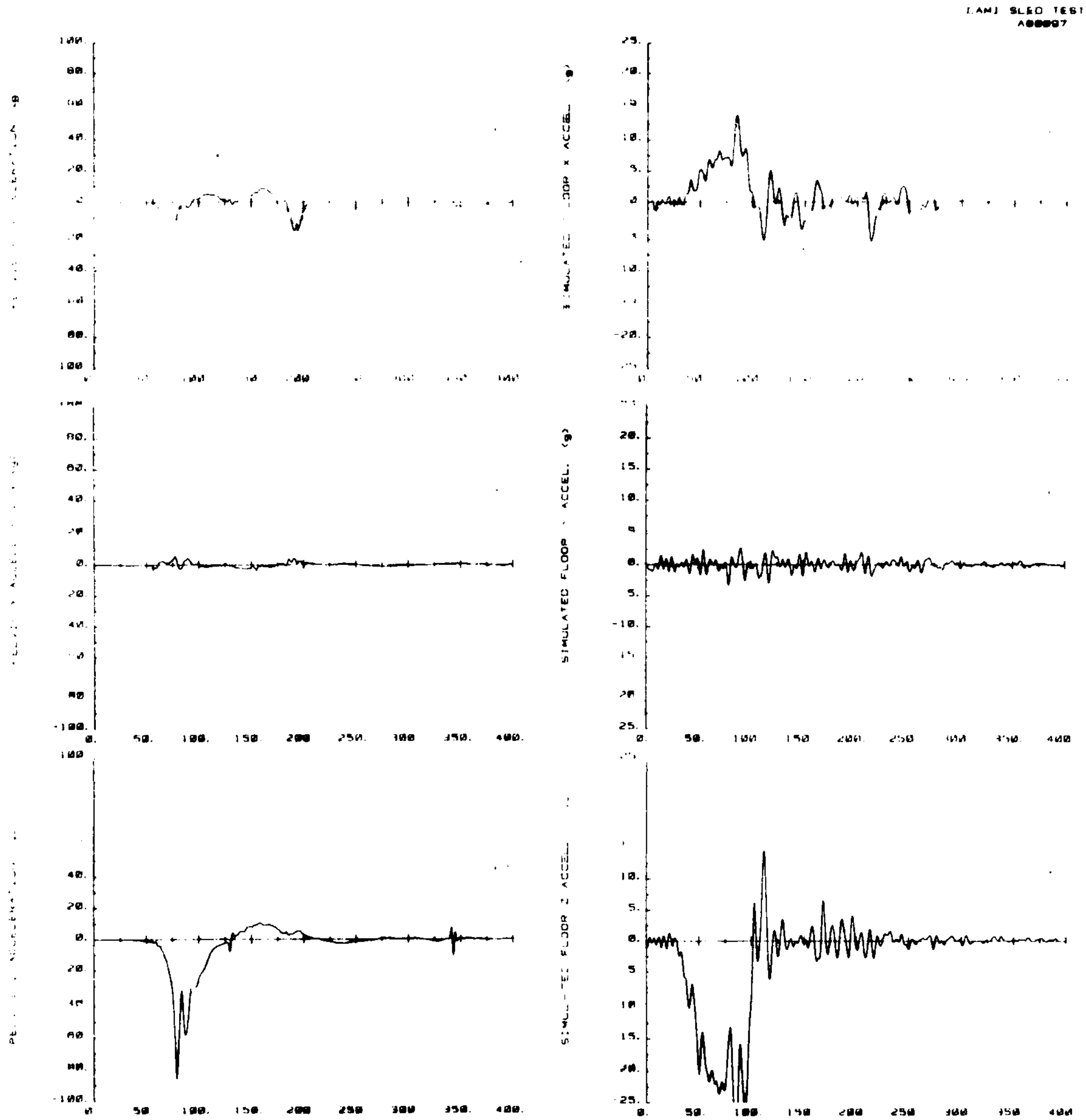

CAMI SLED TEST
A80095
CAMI SLED TEST
A80095
TIME MILLISECONDS

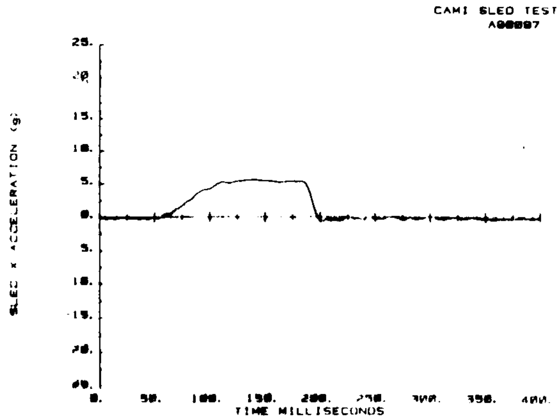


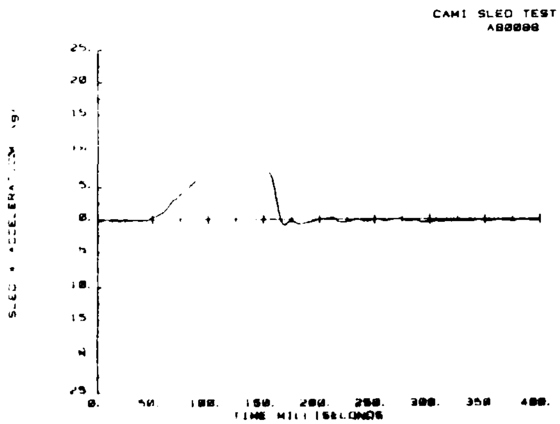


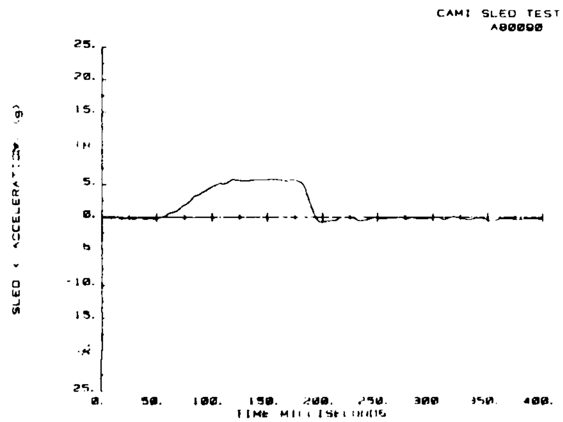
CAMI SLED TEST
A00000
CAMI SLED TEST
A00000
TIME MILLISECONDS
SIMULATED FLOOR Z ACCEL. (g)

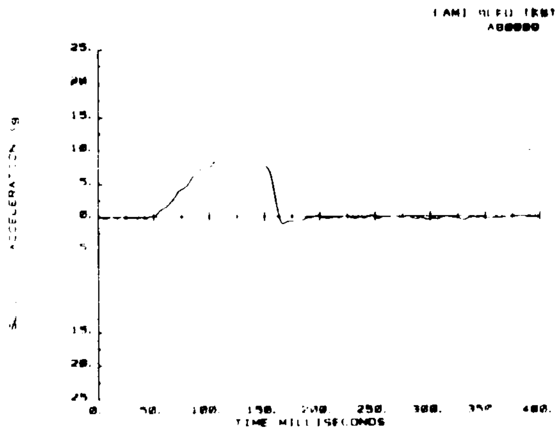

CAMI SLED TEST
A80097
TIME MILLISECONDS
CHEST ACCELERATION (g)
CHEST Y ACCELERATION (g)

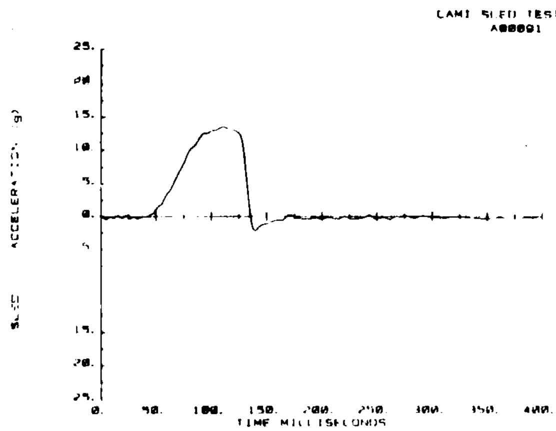

CAMI SLED TEST
A00007
SIMULATED FLOOR Z ACCEL.

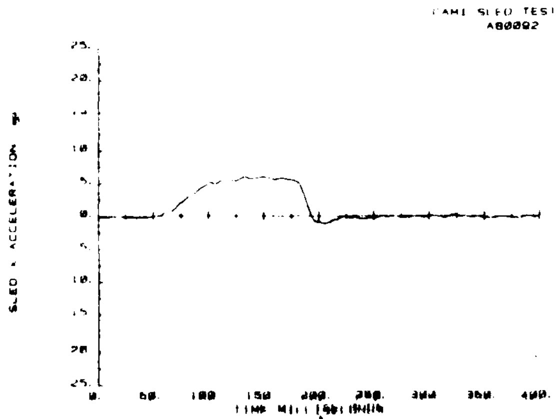

CAMI SLED TEST
SLED X ACCELERATION (g)
TIME MILLISECONDS


CAMI SLED TEST
TIME MILLISECONDS

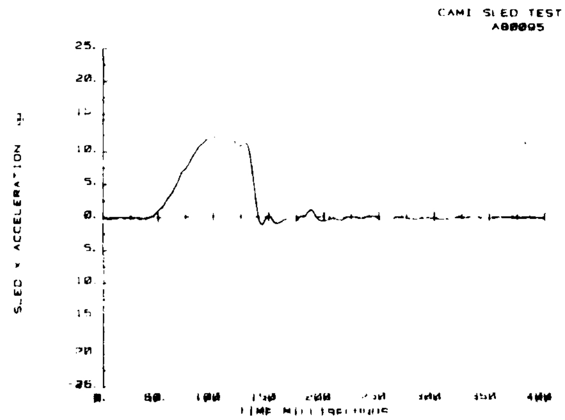

CAMI SLED TEST
TIME MILLISECONDS


TIME MILLISECONDS

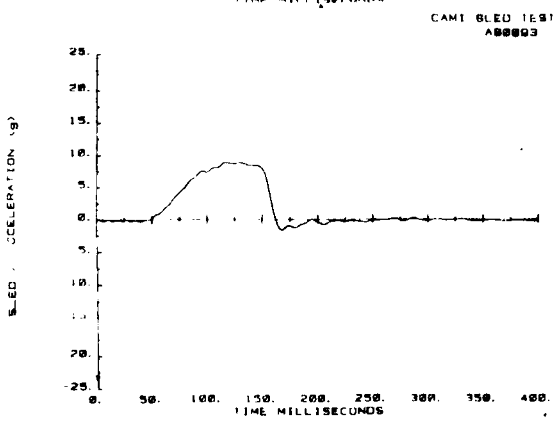

CAMI SLED TEST
TIME MILLISECONDS



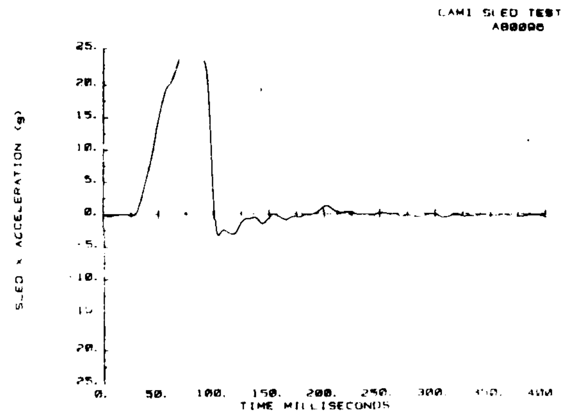
CAMI SLED TEST
A80002
SLED X ACCELERATION
TIME MILLISECONDS



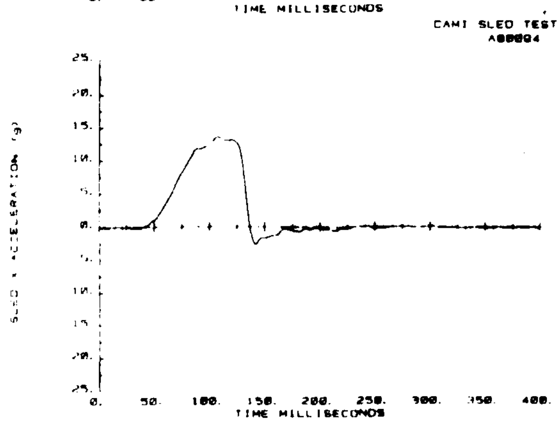
CAMI SLED TEST
A80005
SLED X ACCELERATION



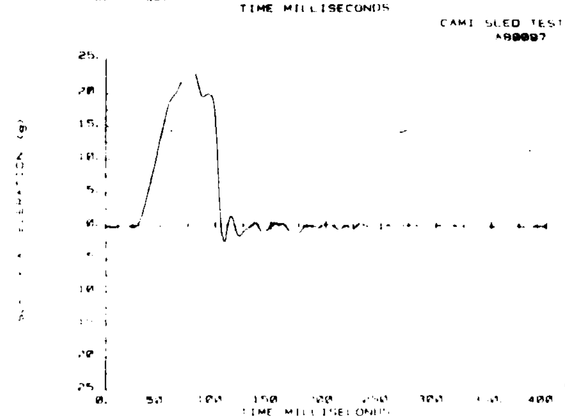
CAMI SLED TEST
A80003
TIME MILLISECONDS



CAMI SLED TEST
A80006
SLED X ACCELERATION (g)
TIME MILLISECONDS



CAMI SLED TEST
A80004
TIME MILLISECONDS



CAMI SLED TEST
A80007

APPENDIX H

LIST OF TRADE NAME EQUIPMENT

Columbia Research Laboratories
McDade Blvd., and Bullens La.
Woodlyn, PA 19094

Model 510-TX piezoelectric accelerometer

Electronic Associates, Inc.
185 Monmouth Parkway
West Long Branch, NJ 07764

Mini-AC analog computer

S.E. Labs (EMI) Ltd.
North Feltham Trading Estate
Feltham, Middlesex, England

EMI 7000M tape recorder

Endevco
Rancho Viejo Road
San Juan Capistrano, CA 92675

Model VT-3 Pad
Model 4470 Signal Conditioning System
Model 4825A accelerometer simulator

Entran Devices, Inc.
145 Paterson Avenue
Little Falls, NJ 07424

Model E6AL-125-10D ultraminiature accelerometer

Hewlett-Packard
P.O. Box 105005
450 Interstate North Parkway
Atlanta, GA 30348

9825S Desk top computer

Kistler Instrument Corp.
75 John Glenn Tr.
Amherst, NY 14120

Kaig-Swiss charge amplifier

Metraplex Corporation
Berkshire Industrial Park
Building 3
Bethel, CT 06801

Model 300 multiplexer
Model 340D strain guage conditioner

Nicolet Instrument Corporation
5225 Verona Rd.
Madison, WI 53711

660 FFT analyzer
160C data recorder

Systron-Donner Corp.
1 Systron Drive
Concord, CA 94518

Model 8150 time code generator

INITIAL DISTRIBUTION

Defense Technical Information Center
Cameron Station
Alexandria, VA 22314 (12)

Under Secretary of Defense for
Research and Engineering
ATTN: Military Assistant for
Medical and Life Sciences
Washington, D. C. 20301 (1)

Uniformed Services University
of the Health Sciences
4301 Jones Bridge Road
Bethesda, MD 20014 (1)

Commander
US Army Medical Research and
Development Command
ATTN: SGRD-RMS/Ms. Madigan
Fort Detrick
Frederick, MD 21701 (5)

Redstone Scientific Information
Center
ATTN: DRDMI-TBD
US Army Missile R&D Command
Redstone Arsenal, AL 35809 (1)

US Army Yuma Proving Ground
Technical Library
Yuma, AZ 85634 (1)

US Army Aviation Engineering
Flight Activity
ATTN: DAVTE-M (Technical Library)
Edwards AFB, CA 93523 (1)

US Army Combat Developments
Experimentation Command
Technical Library
HQ, USACDEC
Box 22
Fort Ord, CA 93941 (1)

Aeromechanics Laboratory
US Army Research & Technology Lab
Ames Research Center, M/S 215-1
Moffett Field, CA 94035 (1)

Sixth United States Army
ATTN: SMA
Presidio of San Francisco
California 94129 (1)

Director
Army Audiology & Speech Center
Walter Reed Army Medical Center
Forest Glen Section, Bldg 156
Washington, D.C. 20012 (1)

Harry Diamond Laboratories
Scientific & Technical Information
Offices
2800 Powder Mill Road
Adelphi, MD 20783 (1)

US Army Ordnance Center & School
Library, Bldg 3071
ATTN: ATSL-DOSL
Aberdeen Proving Ground, MD
21005 (1)

US Army Environmental Hygiene
Agency Library, Bldg E2100
Aberdeen Proving Ground, MD
21010 (1)

Technical Library
Chemical Systems Laboratory
Aberdeen Proving Ground, Md
21010 (1)

US Army Materiel Systems
Analysis Agency
ATTN: Reports Distribution
Aberdeen Proving Ground, MD
21005 (1)

Director
Naval Biosciences Laboratory
Naval Supply Center, Bldg 844
Oakland, CA 94625 (1)

Naval Air Systems Command
Technical Library AIR 9500
RM 278 Jefferson Plaza II
Department of the Navy
Washington, DC 20361 (1)

US Navy
Naval Research Laboratory Library
Code 1433
Washington, DC 20375 (1)

US Navy
Naval Air Development Center
Technical Information Division
Technical Support Department
Warminster, PA 18974 (1)

Human Factors Engineering Division
Aircraft & Crew Systems Technology
Directorate
Naval Air Development Center
Warminster, PA 18974 (1)

US Navy
Naval Research Laboratory Library
Shock & Vibration Information Center
Code 8404
Washington, DC 20375 (1)

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Sciences Division
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800 N. Quincy Street
Arlington, VA 22217 (1)

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National Naval Medical Center
Bethesda, MD 20014 (1)

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ATTN: George Kydd
Code 60B1
Warminster, PA 18974 (1)

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P.O. Box 29407
New Orleans, LA 70189 (1)

FAA Civil Aeromedical Institute
ATTN: Library
Box 25082
Oklahoma City, OK 73125 (1)

Department of Defence
R.A.N. Research Laboratory
P.O. Box 706
Darlinghurst, N.S.W. 2010
Australia (1)

Canadian Society of Avn Med
c/o Academy of Medicine, Toronto
ATTN: Ms. Carmen King
288 Bloor Street West
Toronto, Ontario M5S 1V8
Canada (1)

COL F. Cadigan
DAO-AMLOUS B
Box 36, US Embassy
FPO New York 09510 (1)

Officer Commanding
School of Opnl & Aerospace Medicine
DCIEM
PO Box 2000
1133 Sheppard Avenue West
Downsview, Ontario M3M 3B9
Canada (1)

Dr. E. Hendler
Code 6003
Naval Air Development Center
Warminster, PA 18974 (1)

Commander
US Army Transporation School
ATTN: ATSP-TD-ST
Fort Eustis, VA 23604 (1)

National Defence Headquarters
101 Colonel By Drive
Ottowa, Ontario K1A 0K2
Canada
ATTN: DPM (1)

Commander
US Army Troop Support & Aviation
Materiel Readiness Command
ATTN: DRSTS-W
St Louis, MO 63102 (1)

Commander
US Army Aviation R&D Command
ATTN: DRDAV-E
4300 Goodfellow Blvd
St. Louis, MO 63166 (1)

Director
US Army Human Engineering Laboratory
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Aberdeen Proving Ground, MD
21005 (1)

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US Army Aviation R&D Command
ATTN: Library
4300 Goodfellow Blvd
St. Louis, MO 63166 (1)

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US Army Health Services Command
ATTN: Library
Fort Sam Houston, TX 78234 (1)

Commandant
US Army Academy of Health Sciences
ATTN: Library
Fort Sam Houston, TX 78234 (1)

Commander
US Army Airmobility Laboratory
ATTN: Library
Fort Eustis, VA 23604 (1)

Air University Library
(AUL/LSE)
Maxwell AFB, AL 36112

US Air Force Flight Test Center
Technical Library, Stop 238
Edwards AFB, CA 93523 (1)

Colonel Stanley C. Knapp
US Central Command
CCSG MacDill AFB, FL 33608 (1)

US Air Force Armament Development
& Test Center
Technical Library
Eglin AFB, FL 32542 (1)

US Air Force Institute of Technology
(AFIT/LDE)
Bldg 640, Area B
Wright-Patterson AFB, OH 45433 (1)

US Air Force Aerospace Medical
Division
School of Aerospace Medicine
Aeromedical Library/TSK-4
Brooks AFB, TX 78235 (1)

Director of Professional Services
Office of the Surgeon General
Department of the Air Force
Washington, DC 20314 (1)

Human Engineering Division
Air Force Aerospace Medical
Research Laboratory
ATTN: Technical Librarian
Wright Patterson AFB, OH 45433 (1)

US Navy
Naval Weapons Center
Technical Library Division
Code 2333
China Lake, CA 93555

US Navy
Naval Aerospace Medical Institute
Library
Bldg 1953, Code 012
Pensacola, FL 32508 (1)

US Navy
Naval Submarine Medical Research Lab
Medical Library, Naval Submarine Base
Box 900
Groton, CT 06340 (1)

Staff Officer, Aerospace Medicine
RAF Staff
British Embassy
3100 Massachusetts Avenue, NW
Washington, DC 20008 (1)

Commander
US Army Medical Research Institute
of Chemical Defense
Aberdeen Proving Ground, MD
21010 (1)

Commander
Naval Air Development Center
ATTN: Code 6022 (Mr. Brindle)
Warminster, PA 18974

Director
Ballistic Research Laboratory
ATTN: DRDAR-TSB-S (STINFO)
Aberdeen Proving Ground, MD
21005 (2)

US Army Research & Development
Technical Support Activity
Fort Monmouth, NJ 07703 (1)

Commander/Director
US Army Combat Surveillance &
Target Acquisition Laboratory
ATTN: DELCS-D
Fort Monmouth, NJ 07703 (1)

US Army Avionics R&D Activity
ATTN: DAVAA-O
Fort Monmouth, NJ 07703

US Army White Sands Missile Range
Technical Library Division
White Sands Missile Range
New Mexico 88002 (1)

Chief
Benet Weapons Laboratory
LCWSL, USA ARRADCOM
ATTN: DRDAR-LCB-TL
Watervliet Arsenal
Watervliet, NY 12189 (1)

US Army Research & Technology Labs
Propulsion Laboratory MS 77-5
NASA Lewis Research Center
Cleveland, OH 44135 (1)

US Army Field Artillery School
Library
Snow Hall, Room 16
Fort Sill, OK 73503 (1)

US Army Dugway Proving Ground
Technical Library
Bldg 5330
Dugway, UT 84022 (1)

US Army Material Development &
Readiness Command
ATTN: DRCSG
5001 Eisenhower Avenue
Alexandria, VA 22333 (1)

US Army Foreign Science &
Technology Center
ATTN: DRXST-IS1
220 7th Street, NE
Charlottesville, VA 22901 (1)

Commander
US Army Training & Doctrine Command
ATTN: ATCD
Fort Monroe, VA 23651 (2)

Commander
US Army Training & Doctrine Command
ATTN: Surgeon
Fort Monroe, VA 23651 (1)

US Army Research & Technology Labs
Structures Laboratory Library
NASA Langley Research Center
Mail Stop 266
Hampton, VA 23665 (1)

Commander
10th Medical Laboratory
ATTN: DEHE (Audiologist)
APO New York 09180 (1)

Commander
US Army Natick R&D Laboratories
ATTN: Technical Librarian
Natick, MA 01760 (1)

Commanding Officer
404 Maritime Training Squadron
Canadian Forces Base, Greenwood
Greenwood, NS BOP 1NO
Canada
ATTN: Aeromed Training Unit
       WO P. Handy or Capt
       S. Olsen   (1)

Canadian Forces Medical Liaison
  Officer
Canadian Defence Liaison Staff
2450 Massachusetts Ave, NW
Washington, DC 20008   (1)

Canadian Airline Pilot's Assn
Maj. J. Soutendam (Ret)
1300 Steeles Avenue East
Brampton, Ontario L6T 1A2
Canada   (1)

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