UMTRI-83-1

EVALUATION OF HEAVY EQUIPMENT OPERATORS' SAFETY BELT RESTRAINT SYSTEM. PHASE II.

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16. Abstract
A proposed innovative restraint harness developed by U. S. Steel for the protection of heavy equipment operators was dynamically tested as Phase II of the restraint evaluation program. An impact sled was used for frontal and lateral testing, and a shaker platform was used to produce vertical jolts. An instrumented 50th percentile male Part 572 dummy simulated the equipment operator. The harness performance under these three test conditions was compared to the results obtained with a conventional lap belt. This report presents the data from the impact testing and makes recommendations for additional improvements to the harness system.

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I. Summary

This second phase of the study evaluated the proposed heavy equipment operator's safety belt restraint system under simulated dynamic conditions. Frontal, lateral, and vertical impacts were produced using the UMTRI impact sled and the shaker platform facilities. The performance of the proposed restraint was compared to the results obtained with conventional two-inch-wide lap belt webbing under identical conditions. This proposed harness offers a unique and promising approach to increasing restraint usage by heavy equipment operators, as detailed in the Phase I report. Further development to eliminate the problems found in Phase II impact testing is recommended.

The findings are summarized as follows:

- In frontal impacts, the proposed U. S. Steel restraints allowed greater pelvis and hip excursions than a conventional lap belt, but there was no difference in maximum head excursions.
- In lateral impacts, the proposed U. S. Steel restraint provided lesser pelvis and greater head excursions than a conventional lap belt.
- In vertical jolt impacts, there was no significant difference in performance between the proposed U. S. Steel restraint and a conventional lap belt.

II. Test Procedures and Results

A total of ten dynamic impact tests were conducted to evaluate the U. S. Steel restraint harness, six on the UMTRI impact sled and four on a vertical shaker platform. A conventional two-inch wide lap belt installation was used for comparison purposes.

The sled tests consisted of four frontal and two lateral impacts. The test platform consisted of a forklift seat attached to a fabricated frame. This assembly was rigidly fastened to the impact sled to simulate a typical operator seating configuration. Side and overhead high-speed movies were taken using Photosonics 1-B cameras operating at 1000 frames per second. A Polaroid Graph-Check sequence camera provided a "quick-look" at the restraint performance immediately after each test.

The shaker platform tests consisted of a single vertical jolt produced by a hydraulic servo system. This facility became available for use during the test program, and provided a more realistic simulation of vertical impacts experienced by equipment operators than could be produced on the sled. A fork lift seat attached to a frame was rigidly fastened to the shaker platform, similar to the impact sled setup.

A side view of the jolt test was recorded using a Photosonics 1-B camera operating at 1000 frames per second. A 50th percentile male Part 572 dummy instrumented with a triaxial accelerometer array mounted in its head and chest was used in these tests. GSE belt load cells were used to monitor belt webbing forces. These acceleration and force signals were recorded during each impact test on a Honeywell Model 7600 recorder.

Table 1 summarizes the impact sled testing of the proposed restraint system. Frontal tests were conducted at two different severity levels of approximately 18 mph at 30 g and 21 mph at 20 g. The higher velocity produced larger peak excursions of the knees and pelvis with either restraint system. The proposed restraint system gave a 75% greater pelvis excursion than the lap belt at 18 mph, and 120% greater excursions at 21 mph. Peak head excursions showed very little sensitivity to either restraint system or impact severity. The significantly higher peak head accelerations and HIC in tests 82S005 and 82S006 resulted from the dummy head's striking the legs. Head/leg interaction also occurred during test 82S002, but the lower test velocity lessened the effect.

Lateral tests were conducted at a severity level of 12 mph at 18 g. The proposed restraint system gave a 4% lower peak head excursion and a 9% greater peak pelvis excursion than the conventional two-inch lap belt, an insignificant difference.

Table II summarizes the vertical jolt testing on the shaker platform. The proposed restraint system and the conventional lap belt both provided the same degree of restraint on peak vertical excursions of the head and shoulders. Also, both restraint systems provided lesser peak vertical excursions than those produced when simulating an unrestrained operator.

Table I. Summary of Sled Test Results

Test Number:	82S001	82S002	82S003	82S004	82S005	82S006
Restraint System:	U.S. Steel	2" lap belt	U.S. Steel	2" lap belt	U.S. Steel	2" lap belt
Velocity: (mph)	18.2	18.5	11.9	12.0	21.2	21.1
Deceleration: (g)	29.8	30.0	18.8	18.4	20.3	20.9
Direction of Impact:	Frontal	Frontal	Lateral	Lateral	Frontal	Frontal
Maximum Excursions (inches)						
HEAD:	33.2	33.7	36.1	37.6	33.9	32.6
KNEES:	11.8	7.9	NA	NA	15.6	8.4
PELVIS:	10.9	6.2	9.7	8.9	15.2	6.9
Peak Belt Loads (pounds)						
RT:	1386	1631	601	578	1425	1992
LT:	1547	1628	32	357	1558	1632
Peak Resultant Accelerations (g)						
HEAD:	42	185	13	23	73	194
CHEST:	20	35	21	12	32	71
Head Injury Criteria (HIC):	309	652	30	135	976	1439

Table 11. Summary of Shaker Platform Results

Test Number	Restraint System	Peak Platform Deceleration (g)	Maximum Vertical Excursions (inches)		Peak Belt Loads (pounds)	
			Head	Shoulder	Rt	Lt
82S007	U. S. Steel	2.2	.9	1.7	66	67
82S008	U. S. Steel	1.6	1.0	2.0	65	64
82S009	None	2.5	1.9	2.6	--	--
82S010	2" lap belt webbing	2.8	1.3	1.8	86	75

III. Discussion

From the test results, the proposed restraint system appears to offer comparable protection to a conventional lap belt during lateral and vertical impacts, but allows excessive pelvic excursions during a frontal impact. Analysis of the frontal test high-speed movies suggests the higher excursions result from the ability of the short side belts to move fore-and-aft along the main belt loop. While this provides adjustability so the restraint will fit a wide range of operators, it also appears to feed in additional effective belt length during frontal impact.

To eliminate this condition, it may be necessary to eliminate or modify the adjustability feature of the short side belts along the main belt loop. Either stitching the side belts to the main loop or providing several shorter adjustment ranges should reduce the forward excursion of the occupant.

Another consideration is the proper length or tension adjustment of the short side belts. For all the impact tests, these were pretensioned between 12 to 15 pounds to provide consistent initial conditions. However, the short belts are not as easy to tension as a conventional lap belt, increasing the probability of misuse or non-use. A simplified tightening method for the side belts that could be easily performed by a restrained, seated operator should improve usage rates as well as impact performance.

For the vertical jolt tests, the proposed severity level of 7 mph at 6 g was not attained. The low excursion of the unrestrained operator would suggest retesting at the higher severity to obtain a better comparison of the two restraint systems.

A suspension-type seat could not be obtained in time for inclusion in the Phase II test program. However, this type of seat was recently evaluated on the UMTRI impact sled using a similar restraint harness. In a frontal impact the entire suspension-type seat rotated forward and remained permanently deformed in this position. This motion allowed the dummy to slide off the end of the seat cushion and submarine under the restraint. Because of the greater pelvis excursions produced by the proposed restraint system, the interaction with a suspension-type seat and the high potential for submarining should be investigated.

IV. Recommendations

To improve the impact performance of the proposed restraint system, emphasis should be placed on factors that reduce the pelvis and knee excursions during frontal impacts.

These include the following:

- Ensuring that installation of the harness attaching anchors will provide the recommended 50° ± 5° belt angle. Vertical attachments will significantly increase forward motion during impact.
- Provide an easily performed length adjustment for the short side belts to encourage operators to use the restraint in a correctly tensioned manner.
- Minimize or eliminate the fore-aft travel of the short side belts along the main loop. This adjustability feature unfortunately degrades frontal impact performance.

Additional testing should also be considered to evaluate the following:

- The effect of higher severity vertical impacts on restraint performance.
- The interaction of a suspension-type seat with the proposed restraint system to check for potential seat cushion override by the operator, resulting in submarining.
- The effectiveness of any alternative modifications to the proposed restraint system design.

V. Appendix

1. Test Data

Data are arranged in the following sequence for each impact test:

- Test summary
- Data Plots
- Setup Photograph
- Graph-Check Photograph
- Post-Test Photograph

Test Summary TEST 82S001

Test Setup

Test Facility: UMTRI Impact Sled

Impact Parameters

Velocity:	18.2 mph
Deceleration:	29.8 g, with trapezoidal waveform
Direction:	Frontal
Restraint System:	U. S. Steel

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -12 g	max = 9 g
R-L (Right-Left):	min = -11 g	max = 6 g
I-S (Inferior-Superior):	min = - 1 g	max = 41 g
Resultant	42 g	
HIC (Head Injury Criteria)	309 from 118 to 256 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -13 g	max = 9 g
R-L (Right-Left):	min = - 3 g	max = 5 g
I-S (Inferior-Superior):	min = - 1 g	max = 18 g
Resultant	20 g	

Peak belt loads

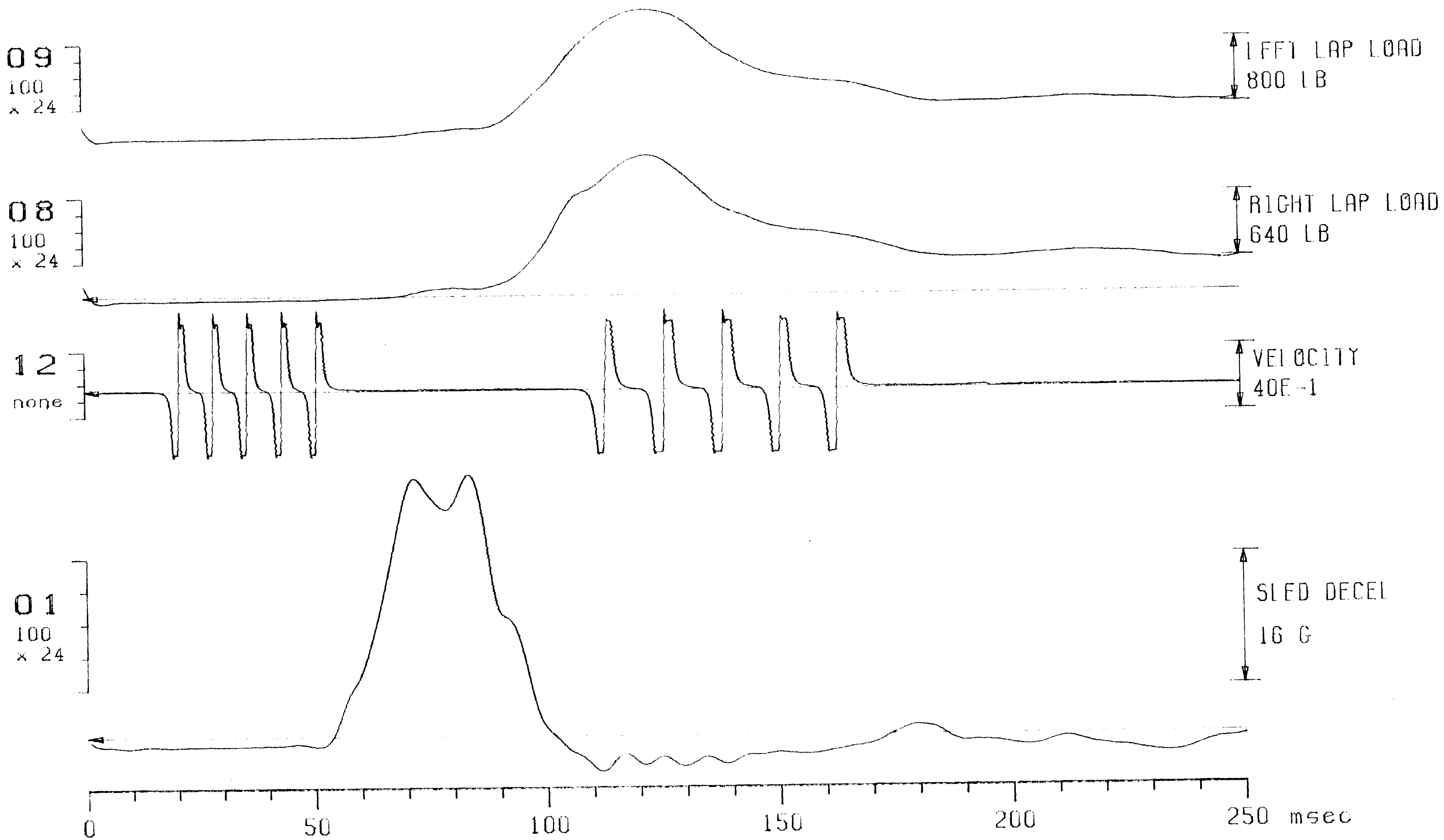
Right side:	1386 pounds
Left side:	1547 pounds

Maximum Excursions (from H. S. film analysis)

Head:	33.2 inches
Knees:	11.8 inches
Pelvis:	10.9 inches

Observations:

FILE # 43 256.00 ms = 2048 Pts / 8000 Hz 03:59:20 -04:03:54



H7: 178 ← A/D → SEAT-1 11/12/82 82S 001

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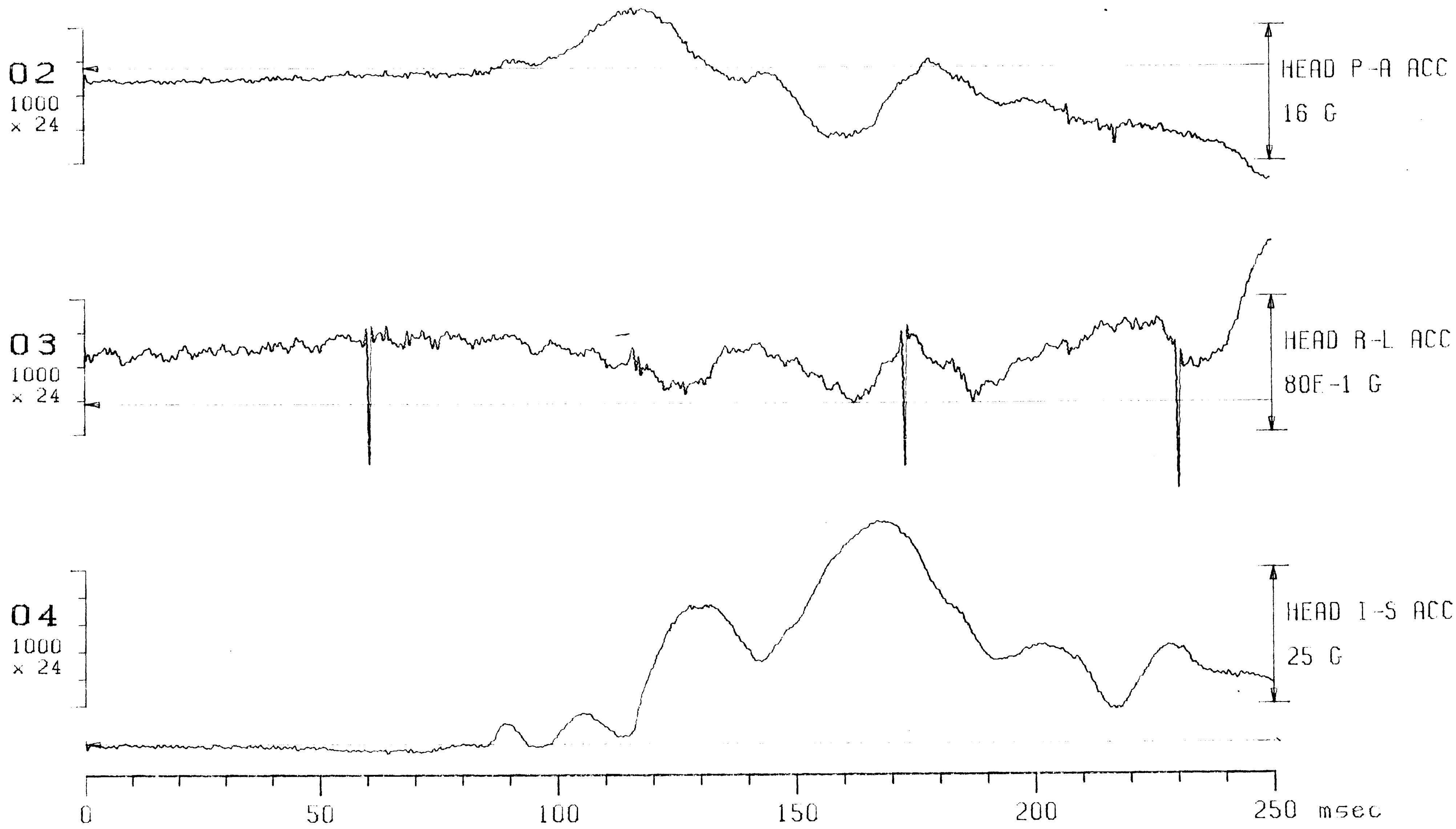

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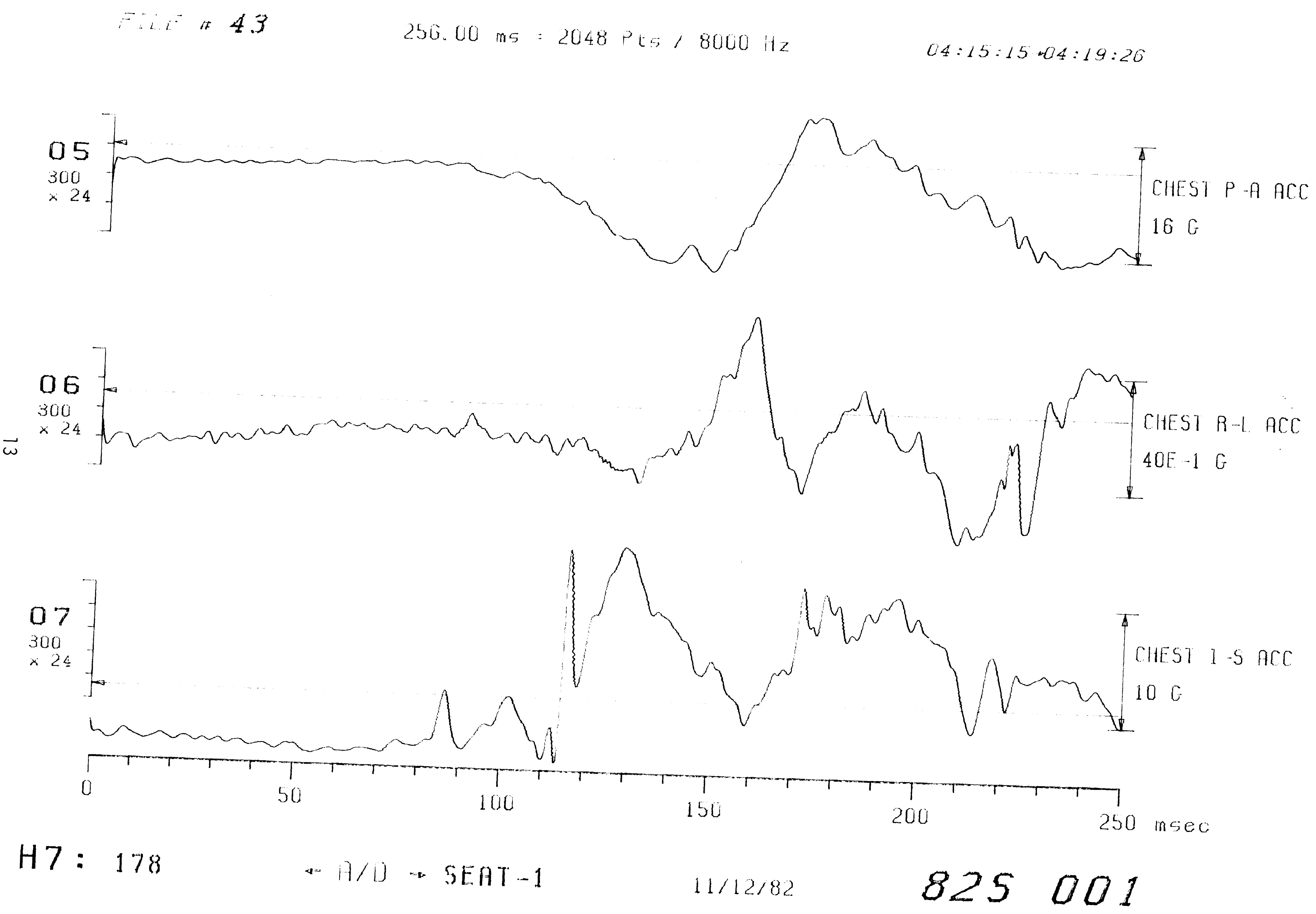
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256.00 ms : 2048 Pts / 8000 Hz
04:15:15-04:19:26
05
300
x 24
CHEST P-A ACC
16 G
06
300
x 24
CHEST R-L ACC
40E-1 G
07
300
x 24
CHEST I-S ACC
10 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/12/82
82S 001


82S001

82S001


82S001
A82S001


S001
A82S001

Test Summary TEST 82S002

Test Setup

Test Facility: UMTRI Impact Sled

Impact Parameters

Velocity:	18.5 mph
Deceleration:	30.0 g, with trapezoidal waveform
Direction:	Frontal

Restraint System: 2" lap belt webbing

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -138 g	max = 12 g		
R-L (Right-Left):	min = - 44 g	max = 85 g		
I-S (Inferior-Superior):	min = - 20 g	max = 93 g		
Resultant	185 g			
HIC (Head Injury Criteria)	652	from 149	to 216	ms

Peak chest accelerations

P-A (Posterior-Anterior)	min = -35 g	max = 6 g
R-L (Right-Left):	min = - 3 g	max = 4 g
I-S (Inferior-Superior):	min = - 3 g	max = 20 g
Resultant	35 g	

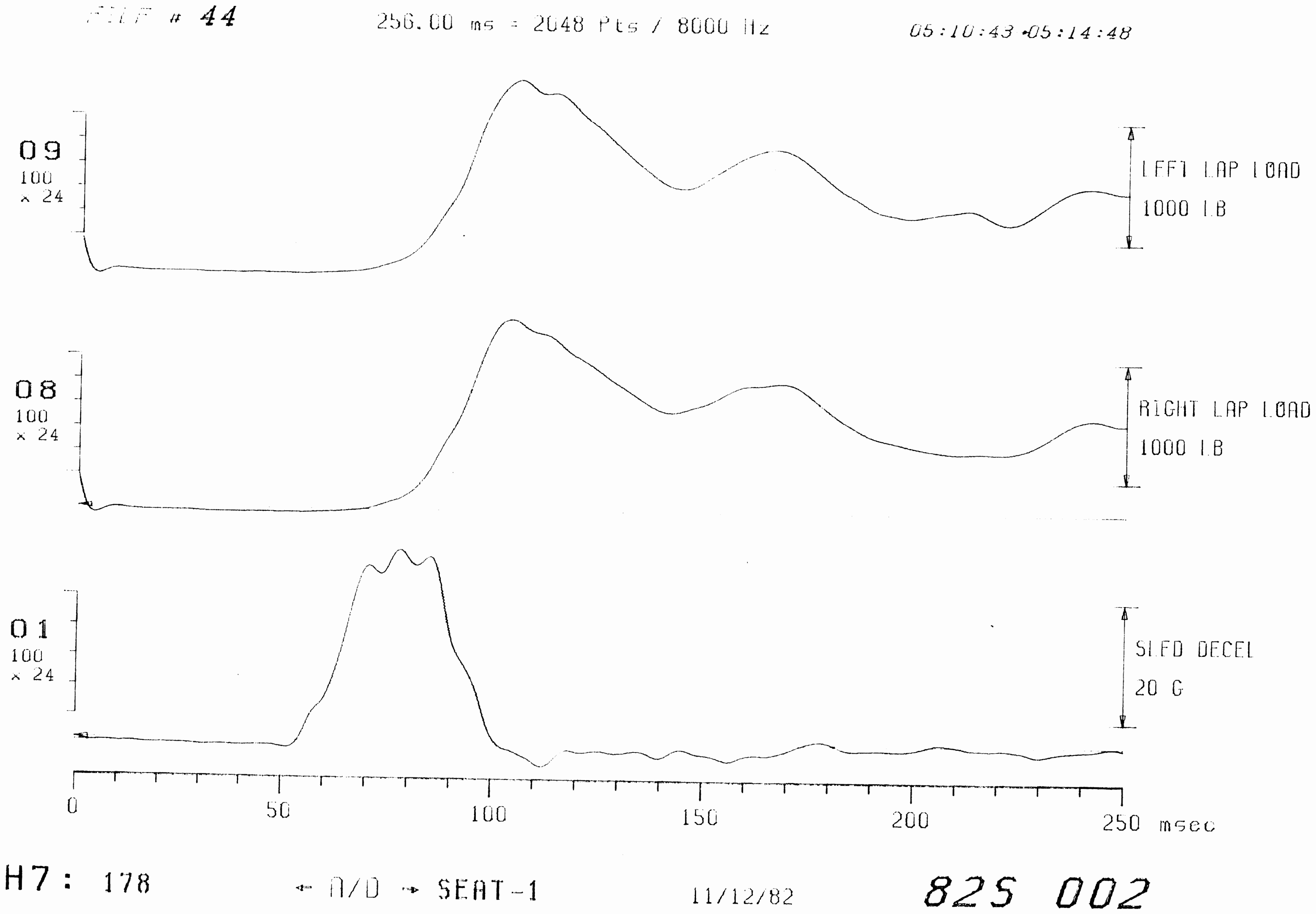
Peak belt loads

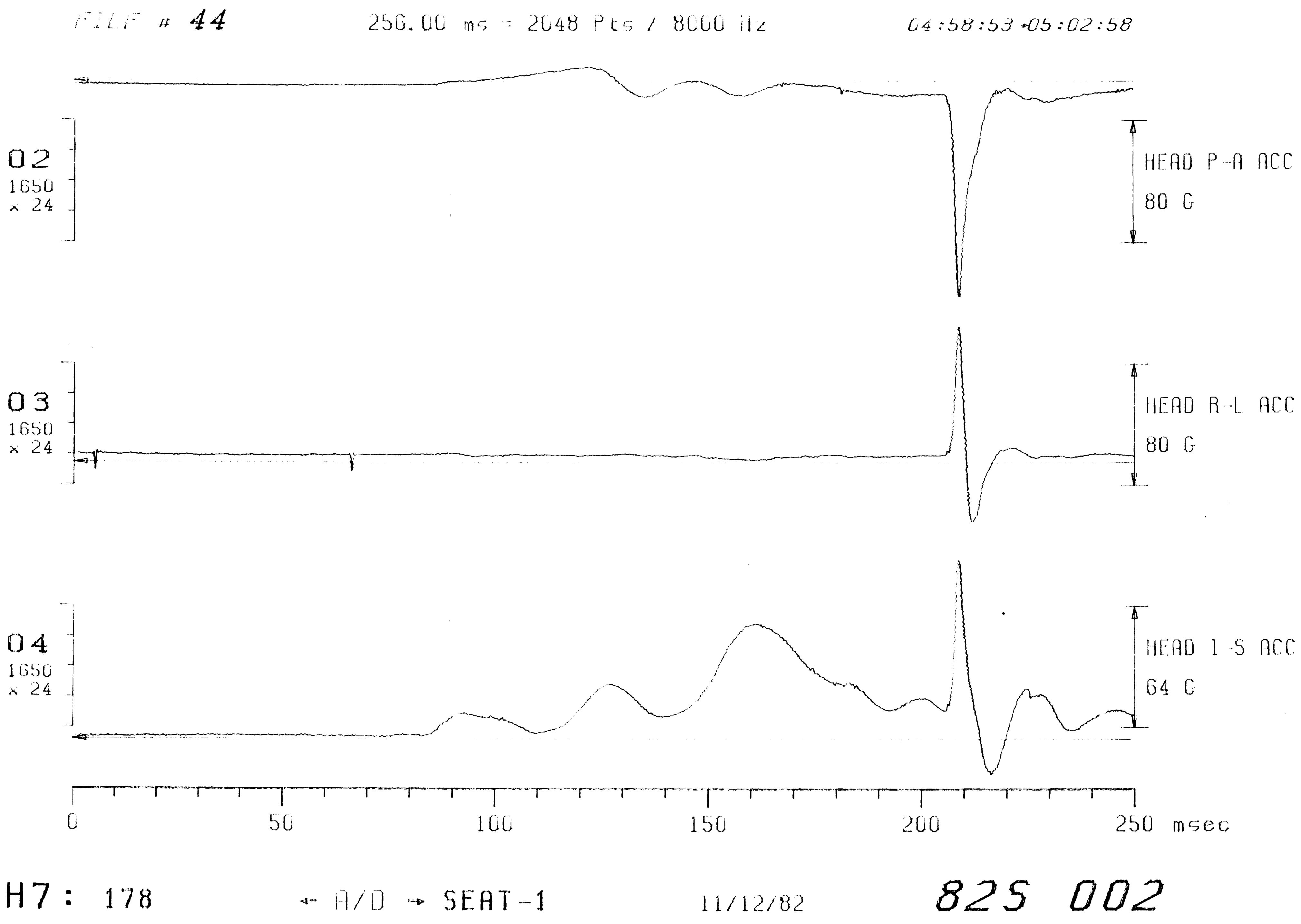
Right side:	1631 pounds
Left side:	1628 pounds

Maximum Excursions (from H. S. film analysis)

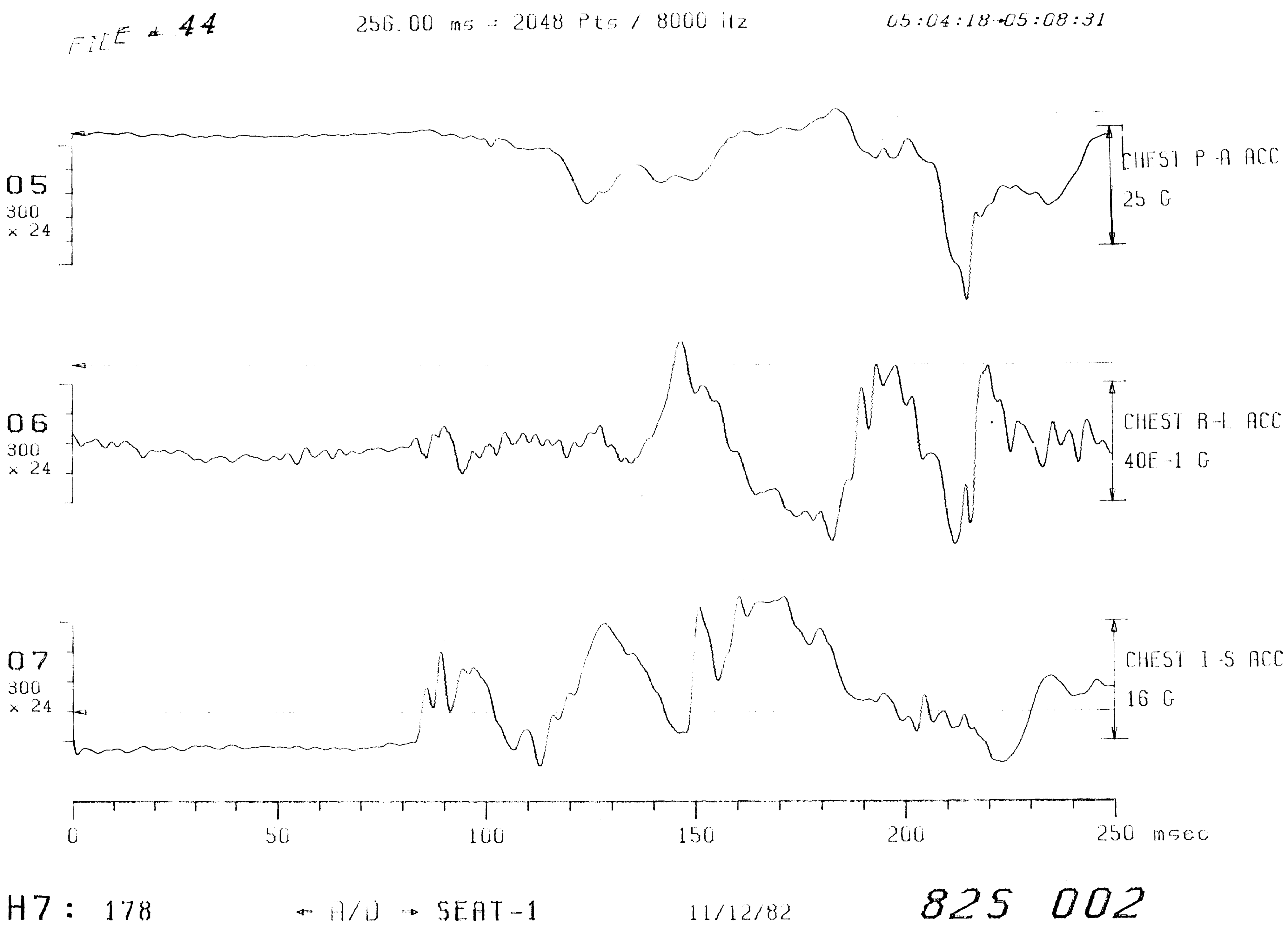
Head:	33.7 inches
Knees:	7.9 inches
Pelvis:	6.2 inches

Observations:


FILE # 44
256.00 ms = 2048 Pts / 8000 Hz
05:10:43 -05:14:48
09
100
x 24
LEFT LAP LOAD
1000 LB
08
100
x 24
RIGHT LAP LOAD
1000 LB
01
100
x 24
SLED DECEL
20 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/12/82
825 002



FILE # 44
256.00 ms = 2048 Pts / 8000 Hz
04:58:53-05:02:58
02
1650
x 24
HEAD P-A ACC
80 G
03
1650
x 24
HEAD R-L ACC
80 G
04
1650
x 24
HEAD I-S ACC
64 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/12/82
825 002


FILE # 44
256.00 ms = 2048 Pts / 8000 Hz
05:04:18→05:08:31
05
300
× 24
CHEST P-A ACC
25 G
06
300
× 24
CHEST R-L ACC
40E-1 G
07
300
× 24
CHEST I-S ACC
16 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/12/82
825 002


82S002

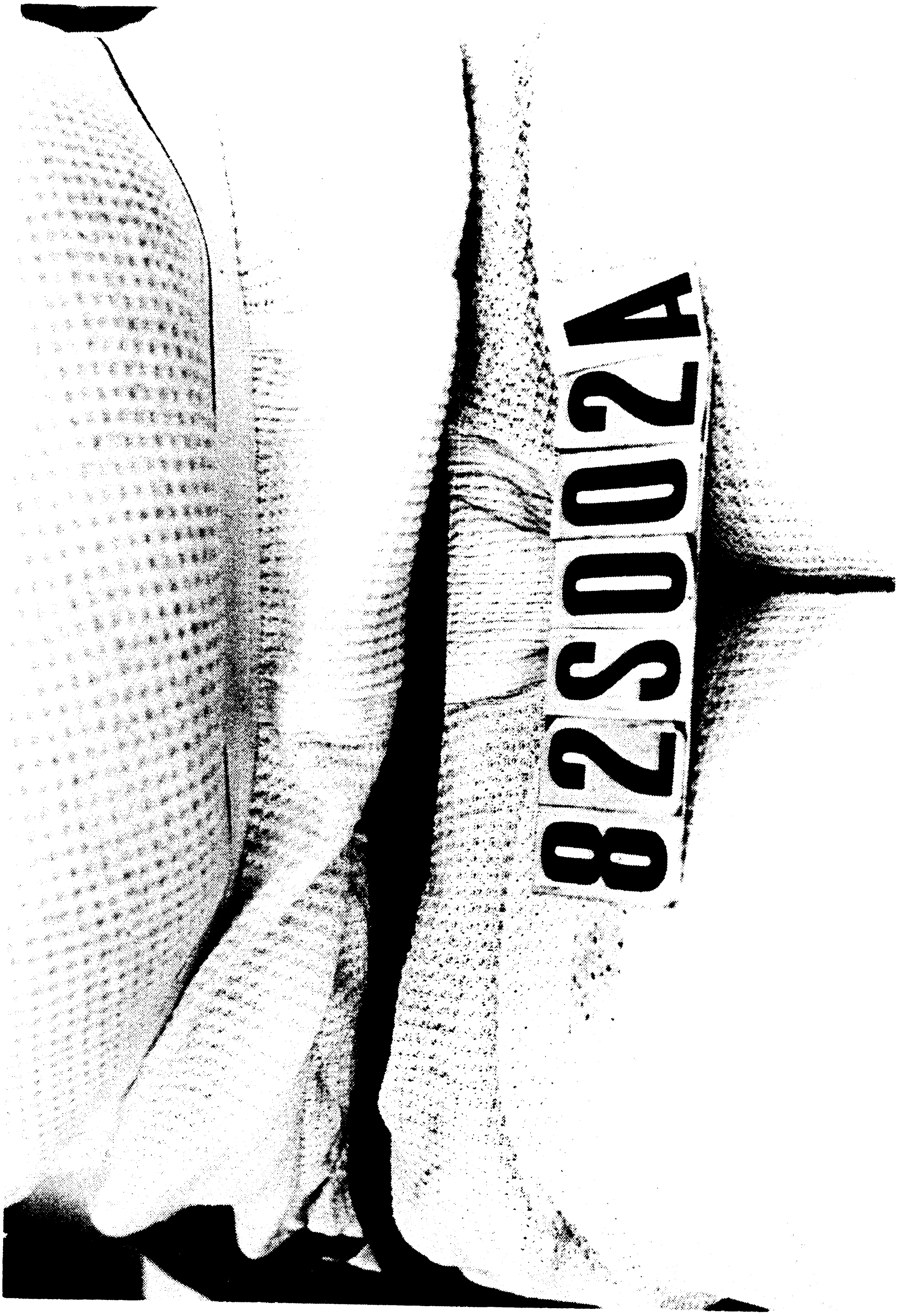
5 1

6 2

7 3

8 4

82S002


82S002A


A82S002


A82S002

Test Summary TEST 82S003

Test Setup

Test Facility: UMTRI Impact Sled

Impact Parameters

Velocity: 11.9 mph

Deceleration: 18.8 g, with trapezoidal waveform

Direction: Lateral

Restraint System: U. S. Steel

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = - 2 g	max = 4 g
R-L (Right-Left):	min = - 8 g	max = 10 g
I-S (Inferior-Superior):	min = -12 g	max = 1 g
Resultant	13 g	
HIC (Head Injury Criteria)	30 from 150 to 408 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = - 2 g	max = 1 g
R-L (Right-Left):	min = - 1 g	max = 5 g
I-S (Inferior-Superior):	min = -21 g	max = 2 g
Resultant	21 g	

Peak belt loads

Right side: 601 pounds

Left side: 32 pounds

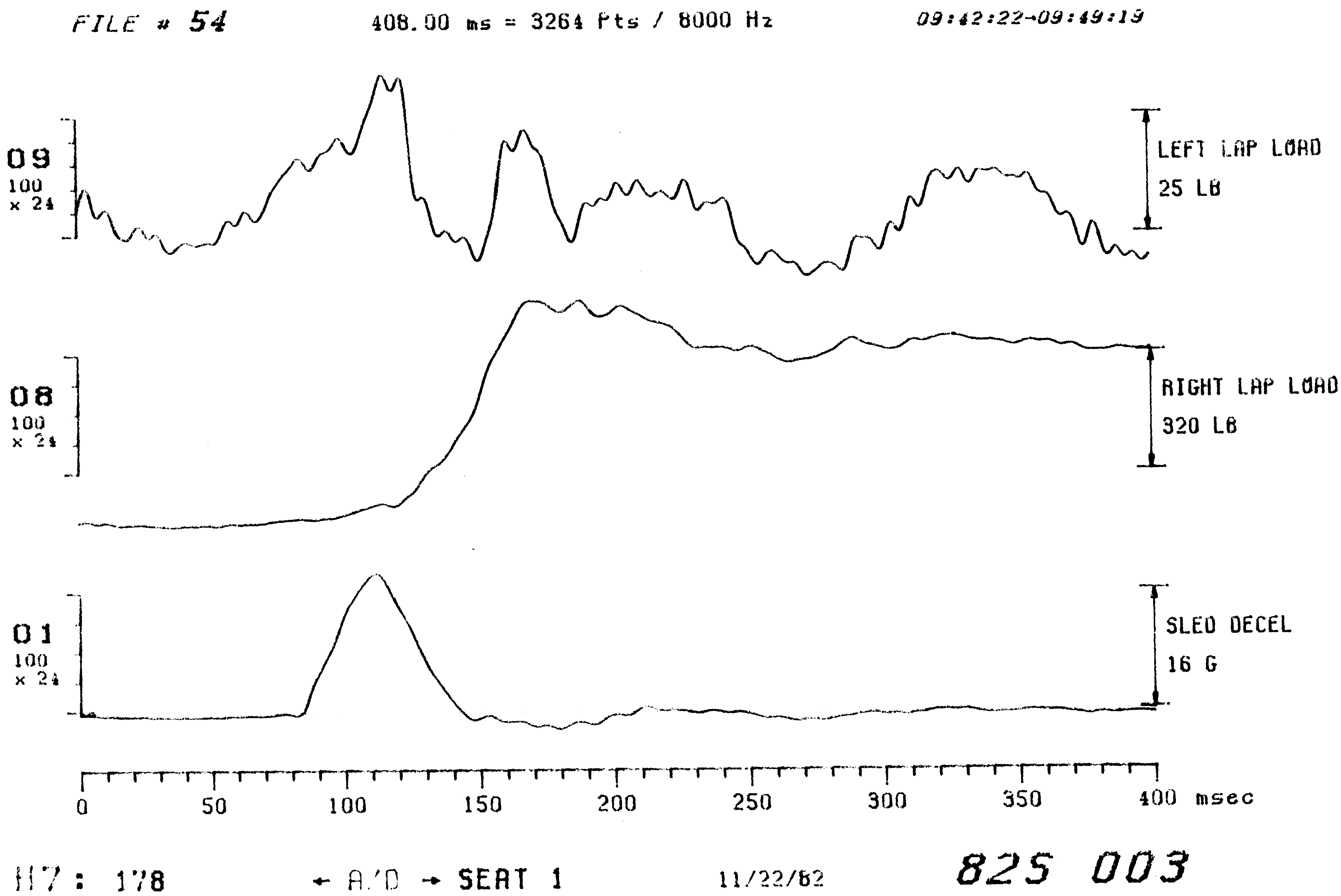
Maximum Excursions (from H. S. film analysis)

Head: 36.1 inches

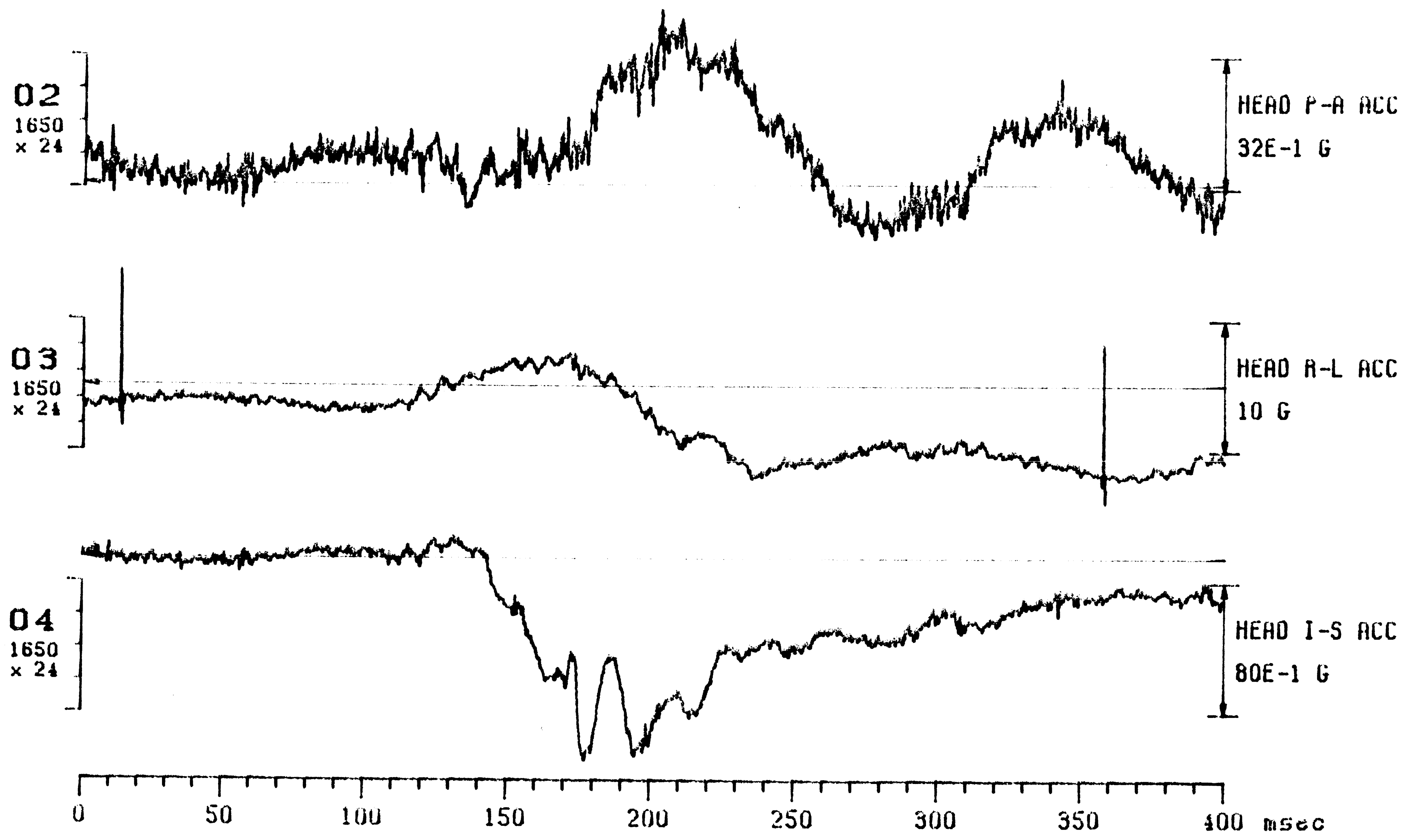
Knees: NA inches

Pelvis: 9.7 inches

Observations:


FILE # 54
408.00 ms = 3264 Pts / 8000 Hz
09:42:22-09:49:19
09
100
x 24
LEFT LAP LOAD
25 LB
08
100
x 24
RIGHT LAP LOAD
320 LB
01
100
x 24
SLED DECEL
16 G
0
50
100
150
200
250
300
350
400 msec
H7: 178
← A/D → SEAT 1
11/22/82
825 003

FILE # 54 408.00 ms = 3264 Pts / 8000 Hz 10:11:58-10:19:33



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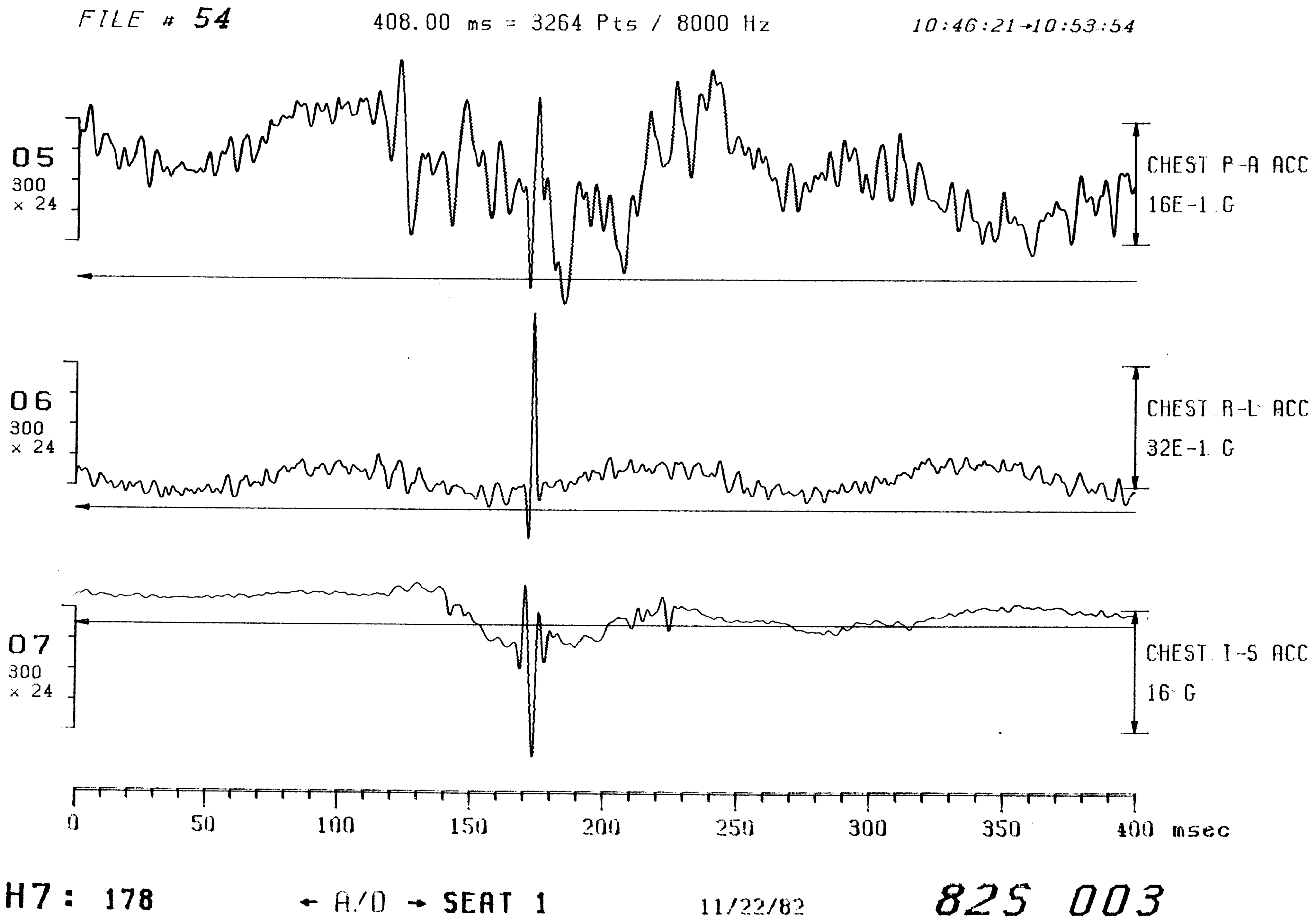
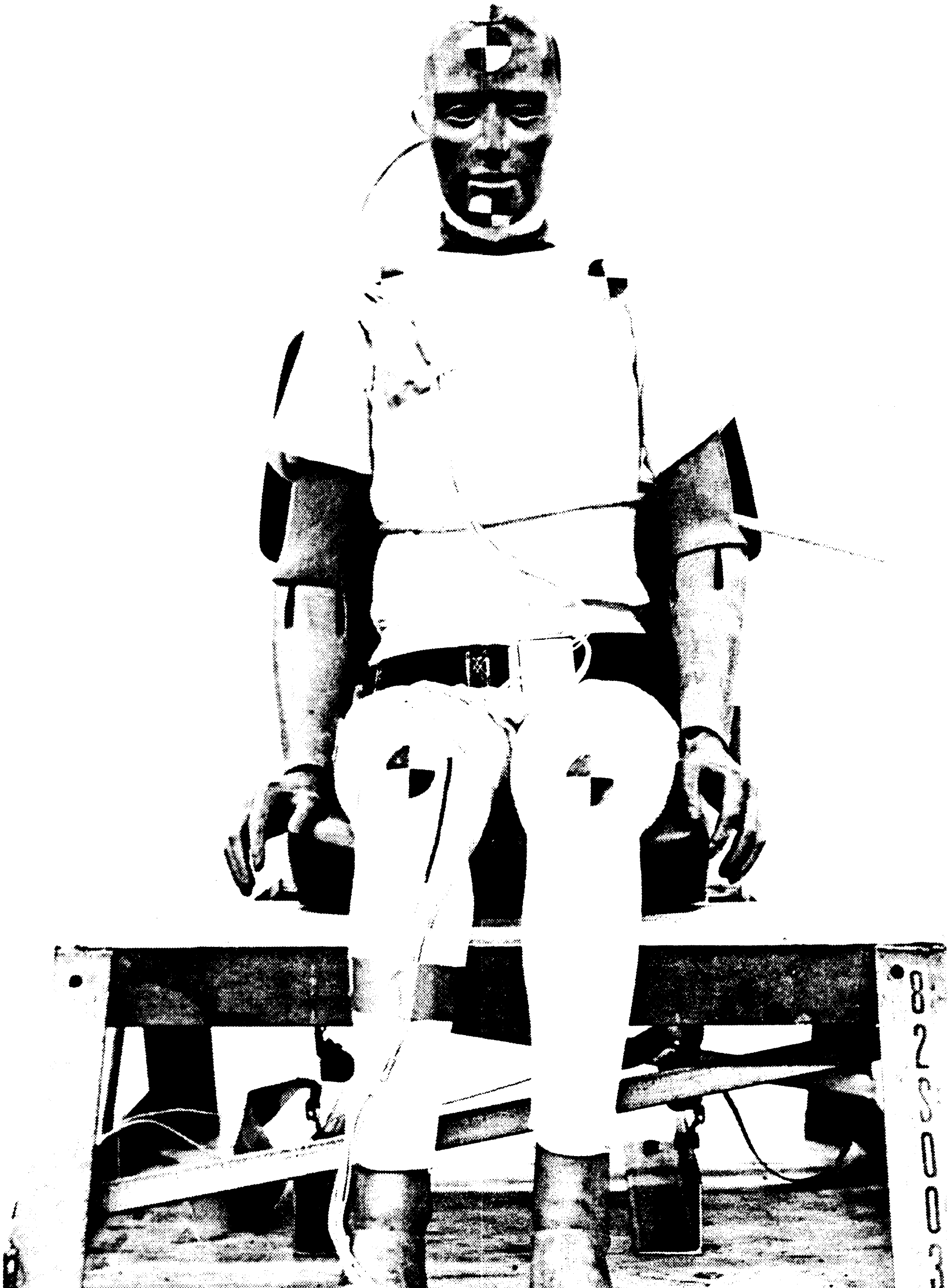


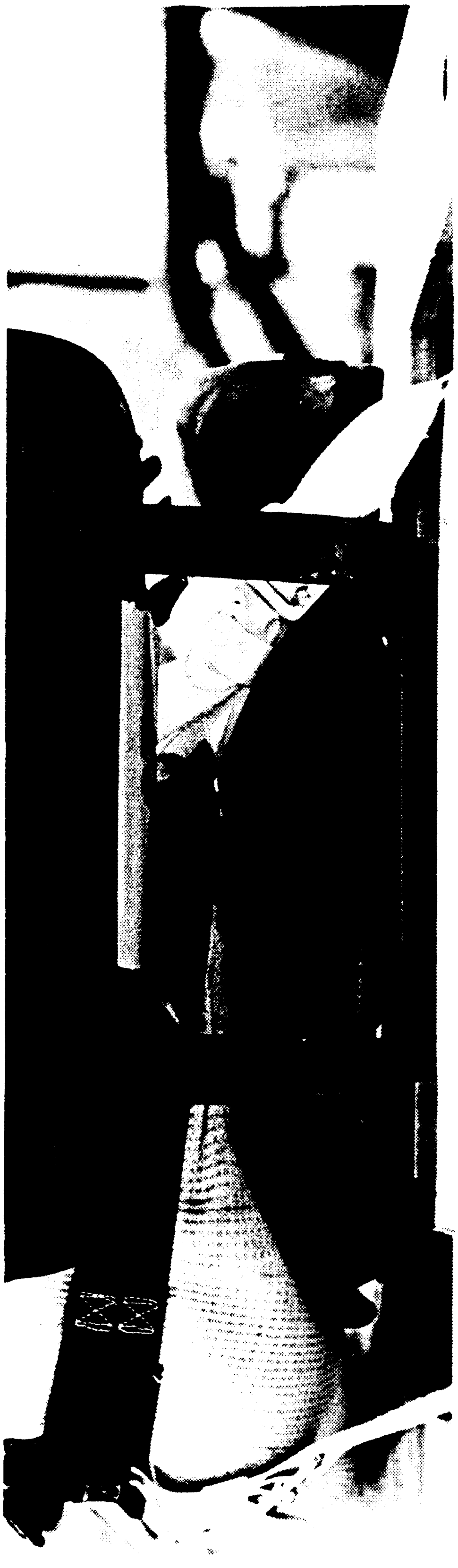
FILE # 54
408.00 ms = 3264 Pts / 8000 Hz
10:46:21→10:53:54
05
300
× 24
CHEST P-A ACC
16E-1 G
06
300
× 24
CHEST R-L ACC
32E-1 G
07
300
× 24
CHEST I-S ACC
16 G
0
50
100
150
200
250
300
350
400 msec
H7: 178
← A/D → SEAT 1
11/22/82
825 003


82S003


82S003


82S003


82S003A
82S003




82S003A


82S003A

Test Summary TEST 82S004

Test Setup

Test Facility: UMTRI Impact Sled

Impact Parameters

Velocity:	12.0 mph
Deceleration:	18.4 g, with trapezoidal waveform
Direction:	Lateral
Restraint System:	2" lap belt webbing

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = 0 g	max = 1 g
R-L (Right-Left):	min = - 6 g	max = 7 g
I-S (Inferior-Superior):	min = -23 g	max = 2 g
Resultant	23 g	
HIC (Head Injury Criteria)	135 from 147 to 376 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = - 3 g	max = 3 g
R-L (Right-Left):	min = - 5 g	max = 1 g
I-S (Inferior-Superior):	min = -11 g	max = 1 g
Resultant	12 g	

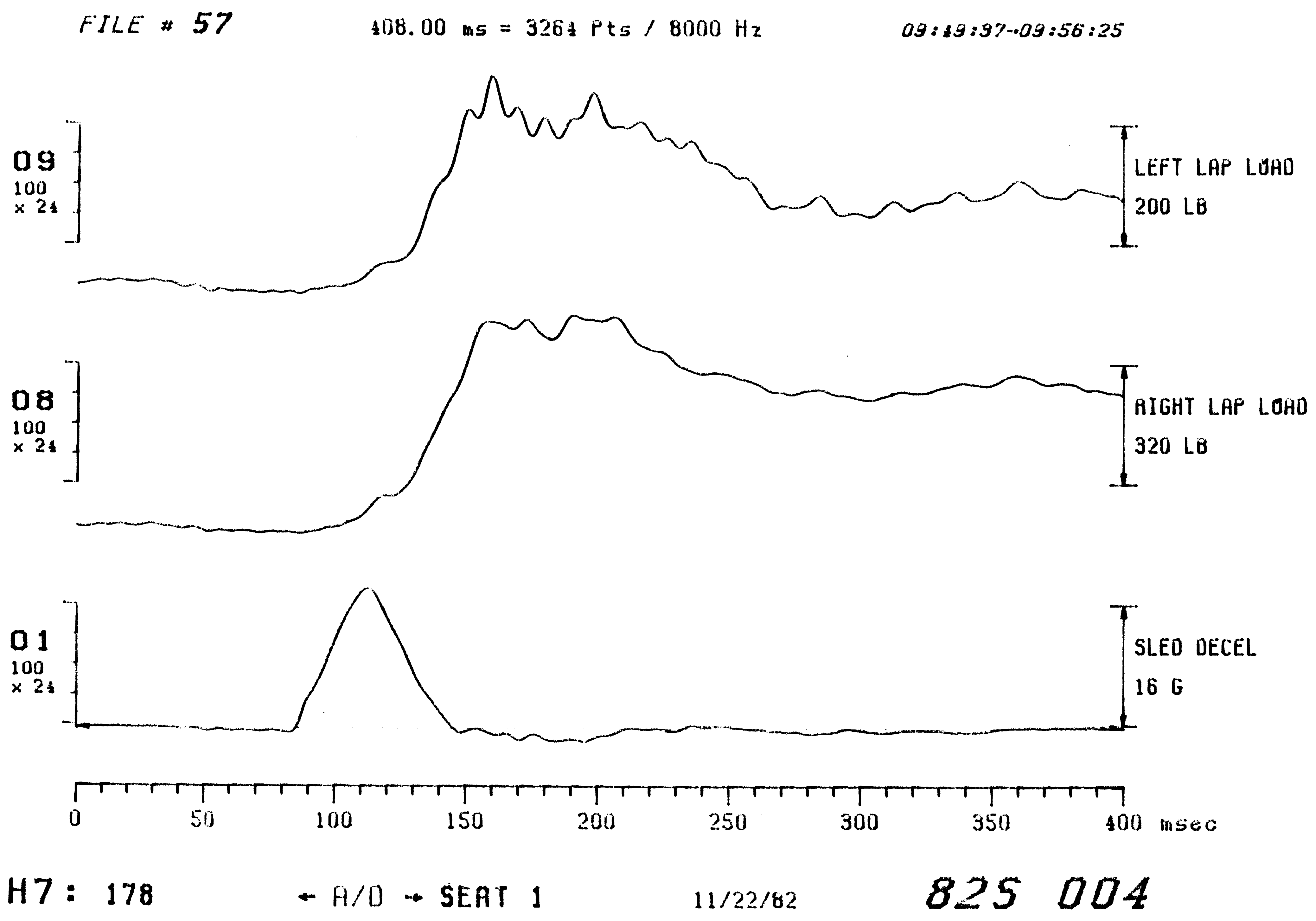
Peak belt loads

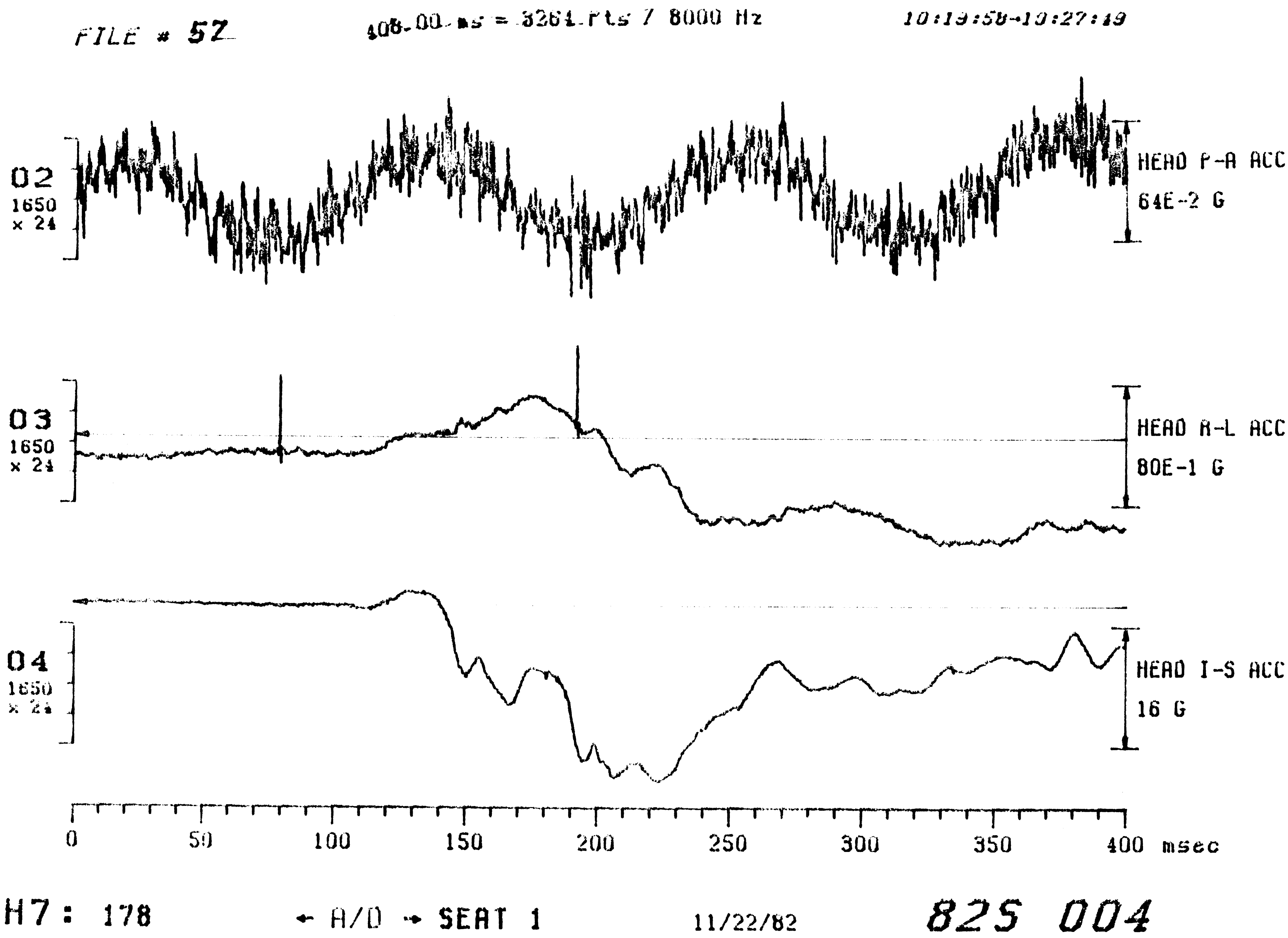
Right side:	578 pounds
Left side:	357 pounds

Maximum Excursions (from H. S. film analysis)

Head:	37.6 inches
Knees:	NA inches
Pelvis:	8.9 inches

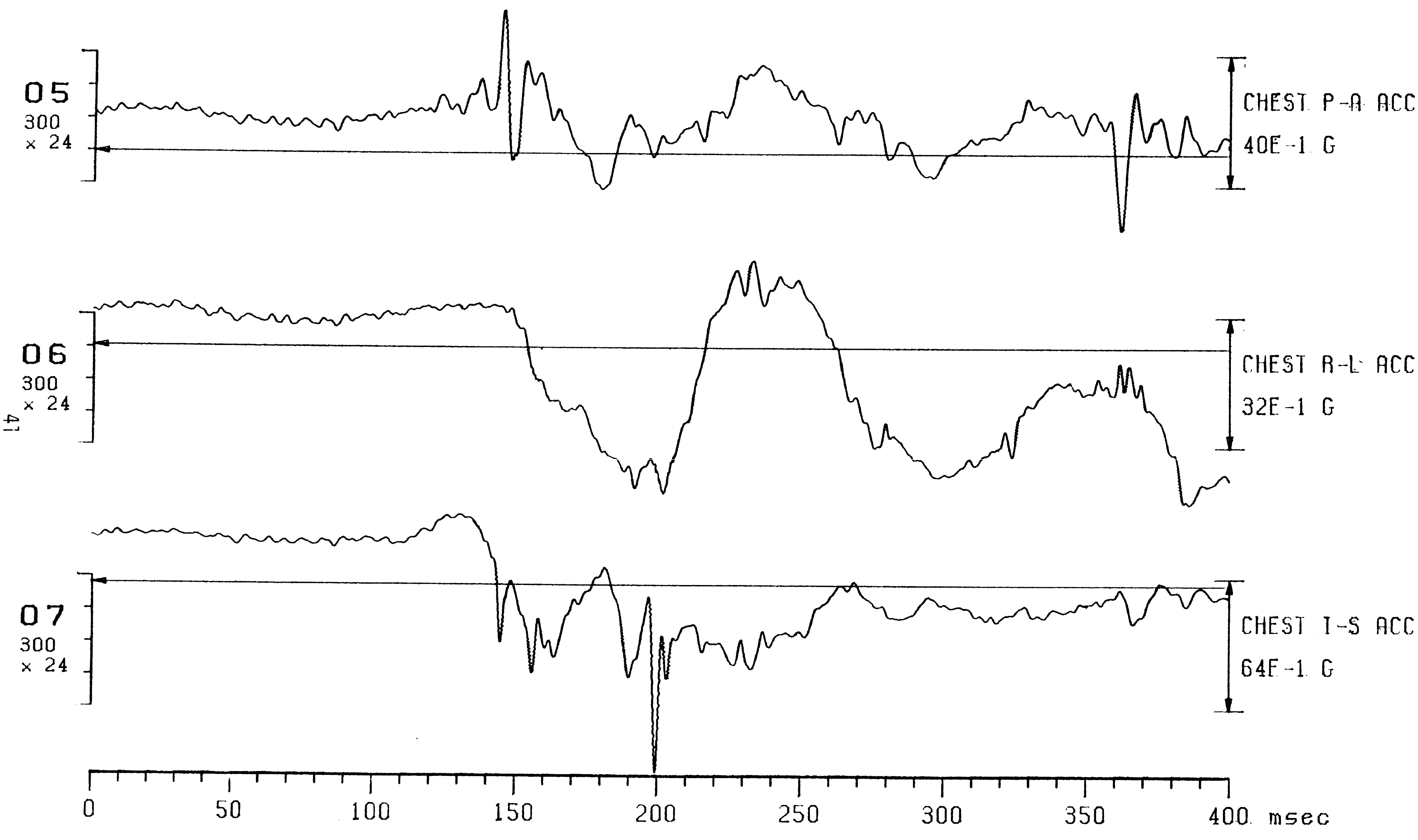
Observations:


FILE # 57
408.00 ms = 3264 Pts / 8000 Hz
09:49:37--09:56:25
09
100
x 24
LEFT LAP LOAD
200 LB
08
100
x 24
RIGHT LAP LOAD
320 LB
01
100
x 24
SLED DECEL
16 G
0
50
100
150
200
250
300
350
400 msec
H7: 178
← A/D → SEAT 1
11/22/82
825 004

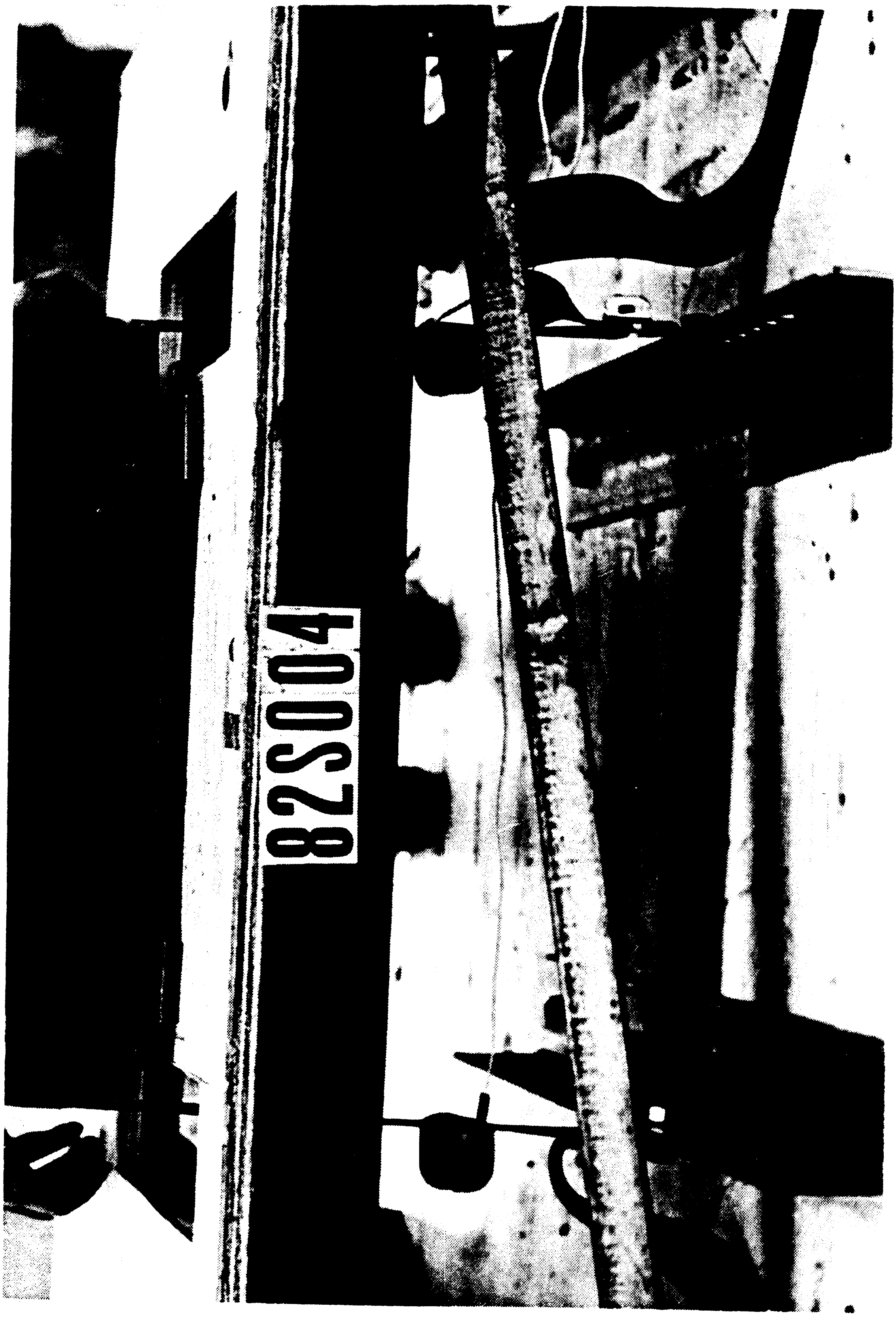


FILE # 57
408.00 ms = 3264 Pts / 8000 Hz
10:19:58-10:27:49
02
1650
x 24
HEAD P-A ACC
64E-2 G
03
1650
x 24
HEAD R-L ACC
80E-1 G
04
1650
x 24
HEAD I-S ACC
16 G
0
50
100
150
200
250
300
350
400 msec
H7: 178
← A/D → SEAT 1
11/22/82
82S 004

FILE # 57   408.00 ms = 3264 Pts / 8000 Hz   10:54:31→11:01:32



H7: 178   ← A/D → SEAT 1   11/22/82   825 004


82S004


82S004


82S004A


82S004A


82S004A

Test Summary TEST 82S005

Test Setup

Test Facility: UMTRI Impact Sled

Impact Parameters

Velocity:	21.2 mph
Deceleration:	20.3 g, with trapezoidal waveform
Direction:	Frontal
Restraint System:	U. S. Steel

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -50 g	max = 6 g
R-L (Right-Left):	min = - 9 g	max = 42 g
I-S (Inferior-Superior):	min = -57 g	max = 0 g
Resultant	73 g	
HIC (Head Injury Criteria)	976 from 118 to 228 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -27 g	max = 1 g
R-L (Right-Left):	min = - 7 g	max = 23 g
I-S (Inferior-Superior):	min = -25 g	max = 3 g
Resultant	32 g	

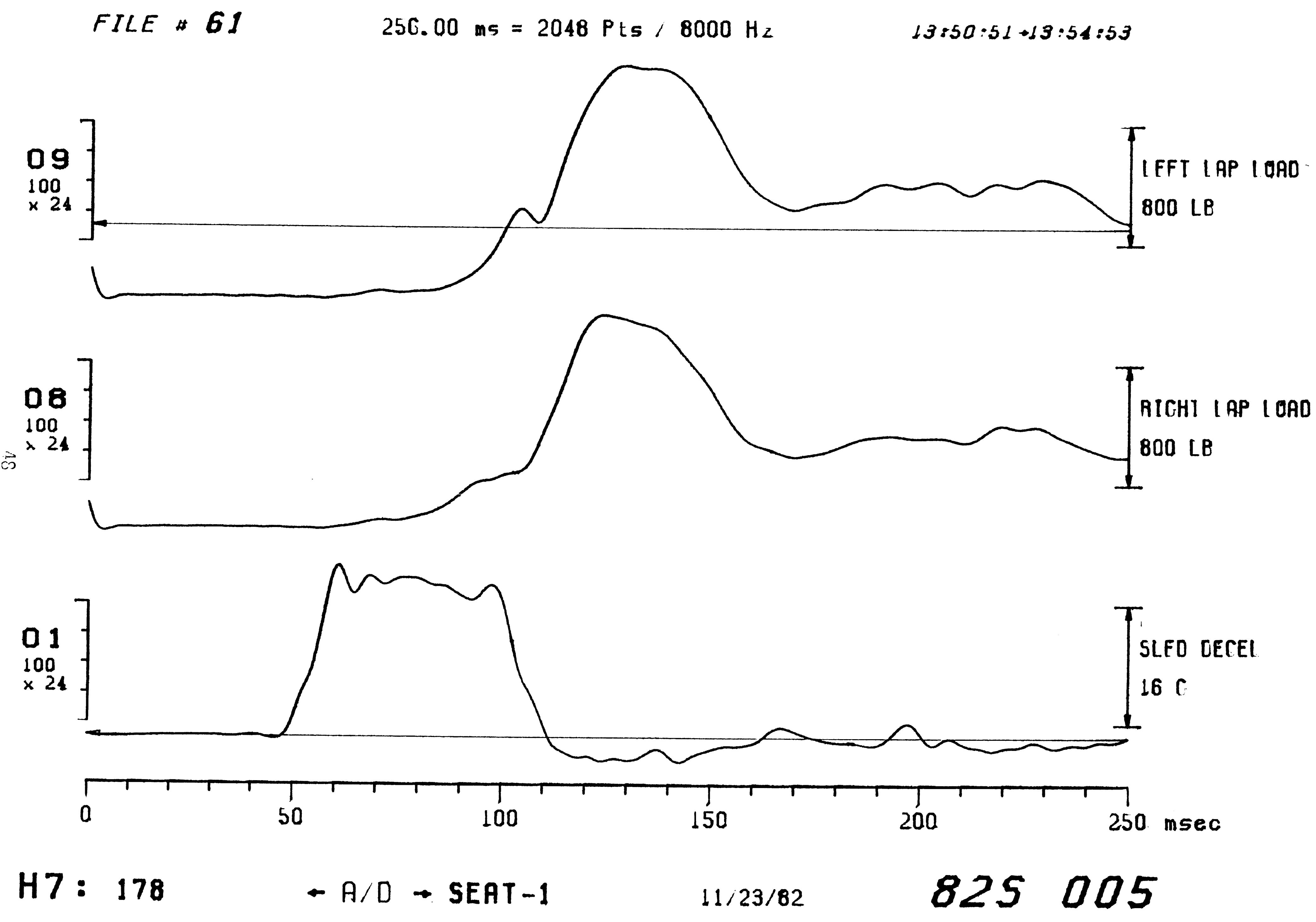
Peak belt loads

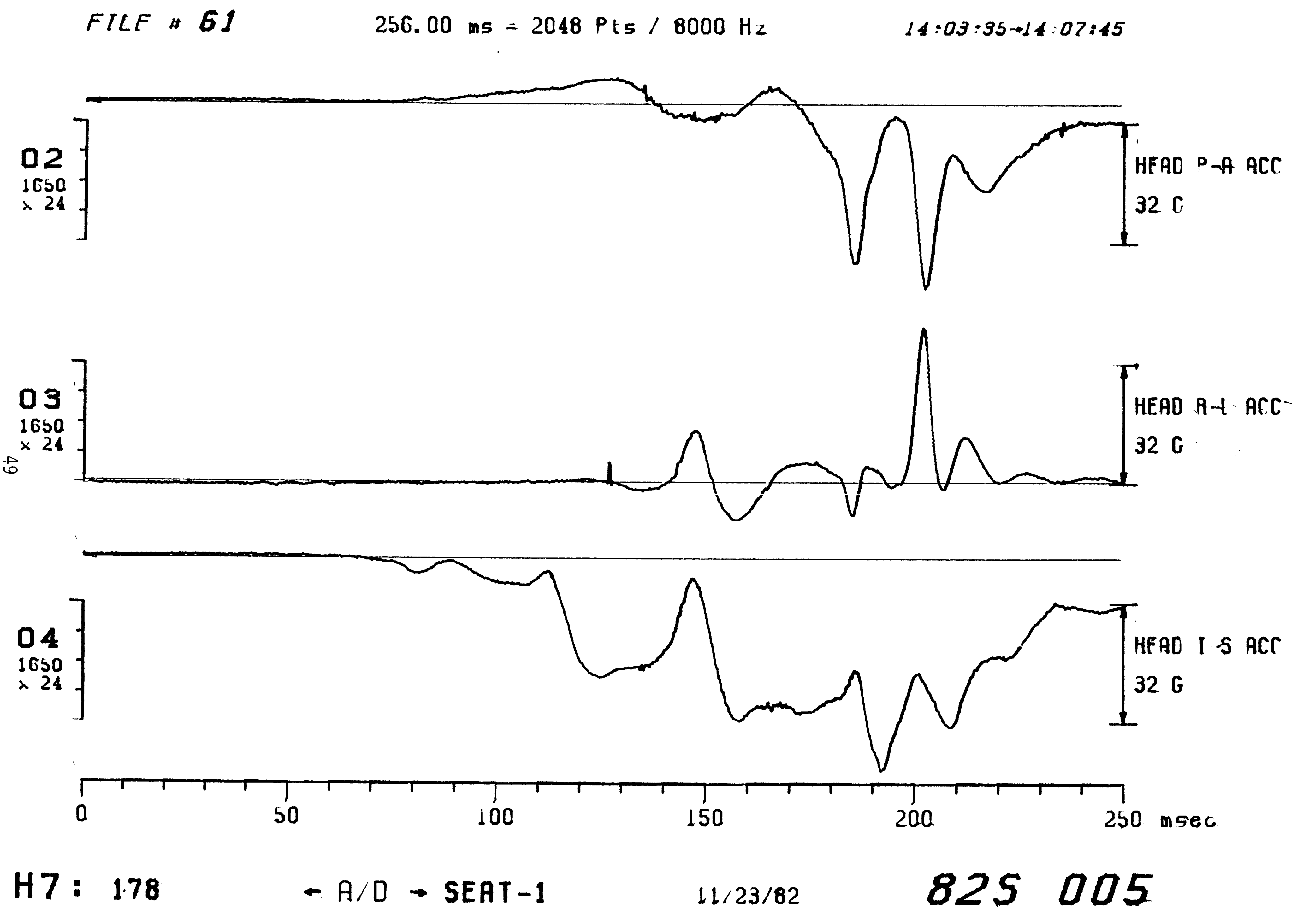
Right side:	1425 pounds
Left side:	1558 pounds

Maximum Excursions (from H. S. film analysis)

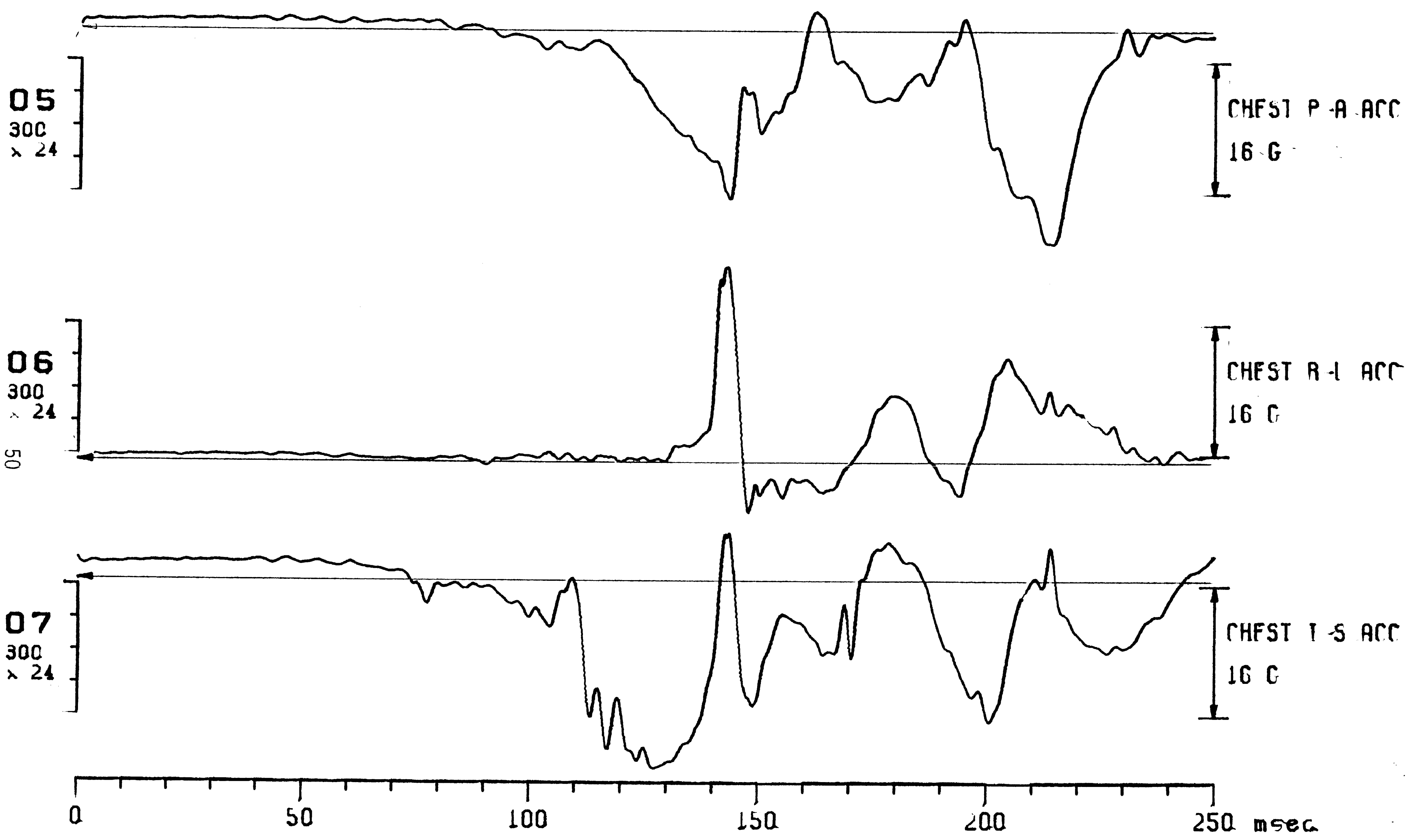
Head:	33.9 inches
Knees:	15.6 inches
Pelvis:	15.2 inches

Observations:


FILE # 61
256.00 ms = 2048 Pts / 8000 Hz
13:50:51 → 13:54:53
09
100
x 24
LEFT LAP LOAD
800 LB
08
100
x 24
RIGHT LAP LOAD
800 LB
01
100
x 24
SLED DECEL
16 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/23/82
82S 005

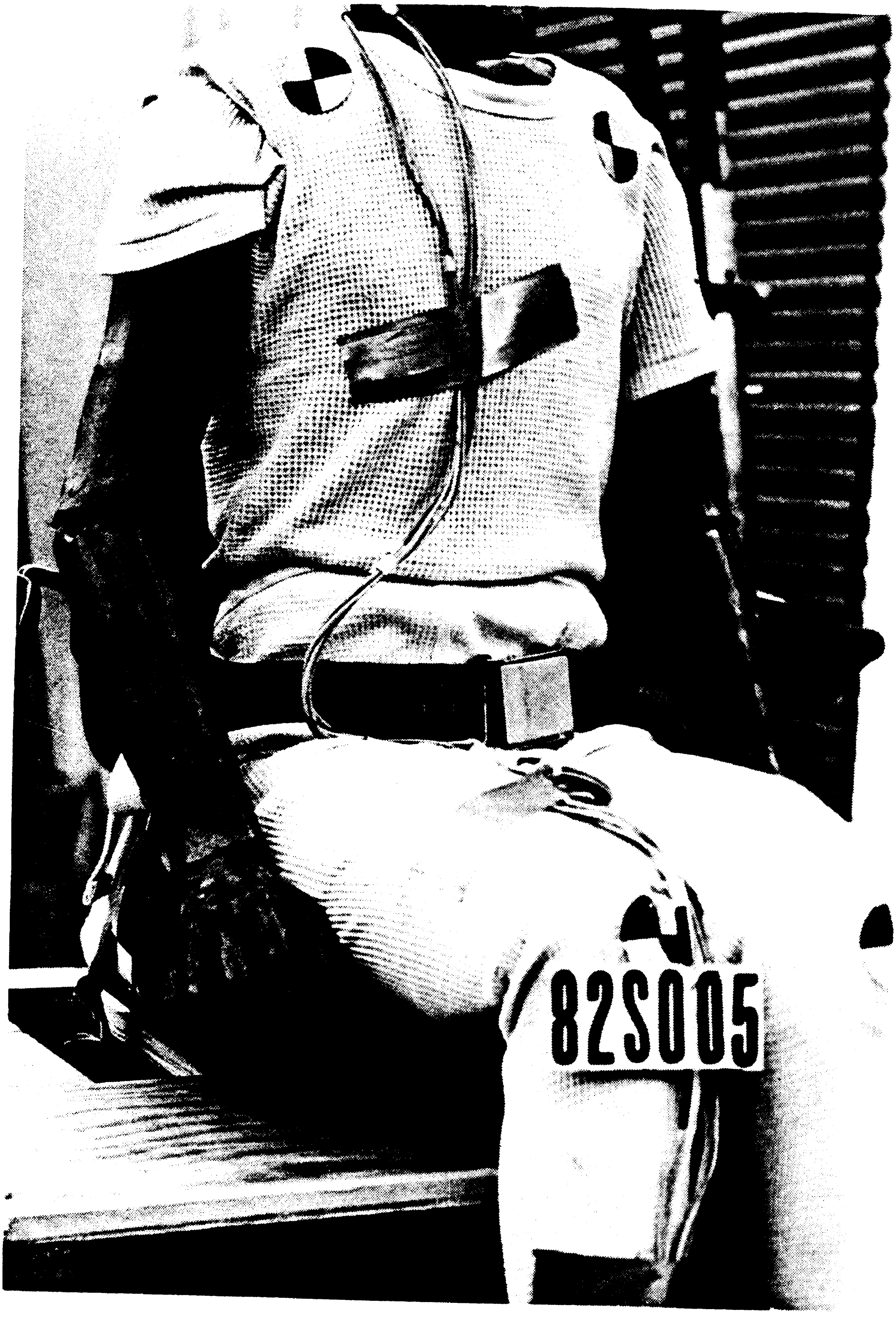

FILE # 61
256.00 ms = 2048 Pts / 8000 Hz
14:03:35→14:07:45
02
1650
x 24
HEAD P-A ACC
32 G
03
1650
x 24
HEAD A-L ACC
32 G
04
1650
x 24
HEAD I-S ACC
32 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/23/82
825 005

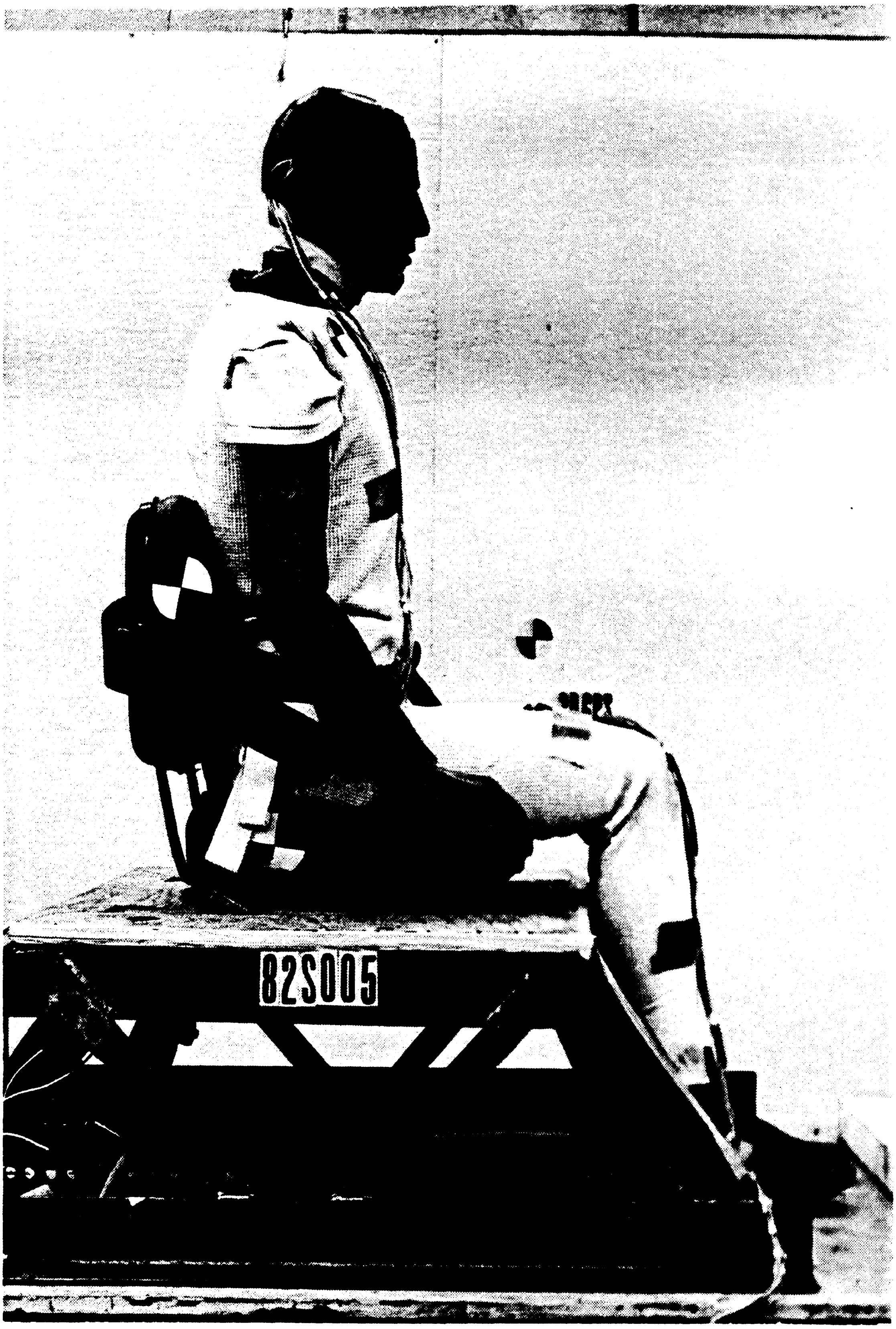
FILE # 61   256.00 ms = 2048 Pts / 8000 Hz   14:14:49-14:18:55

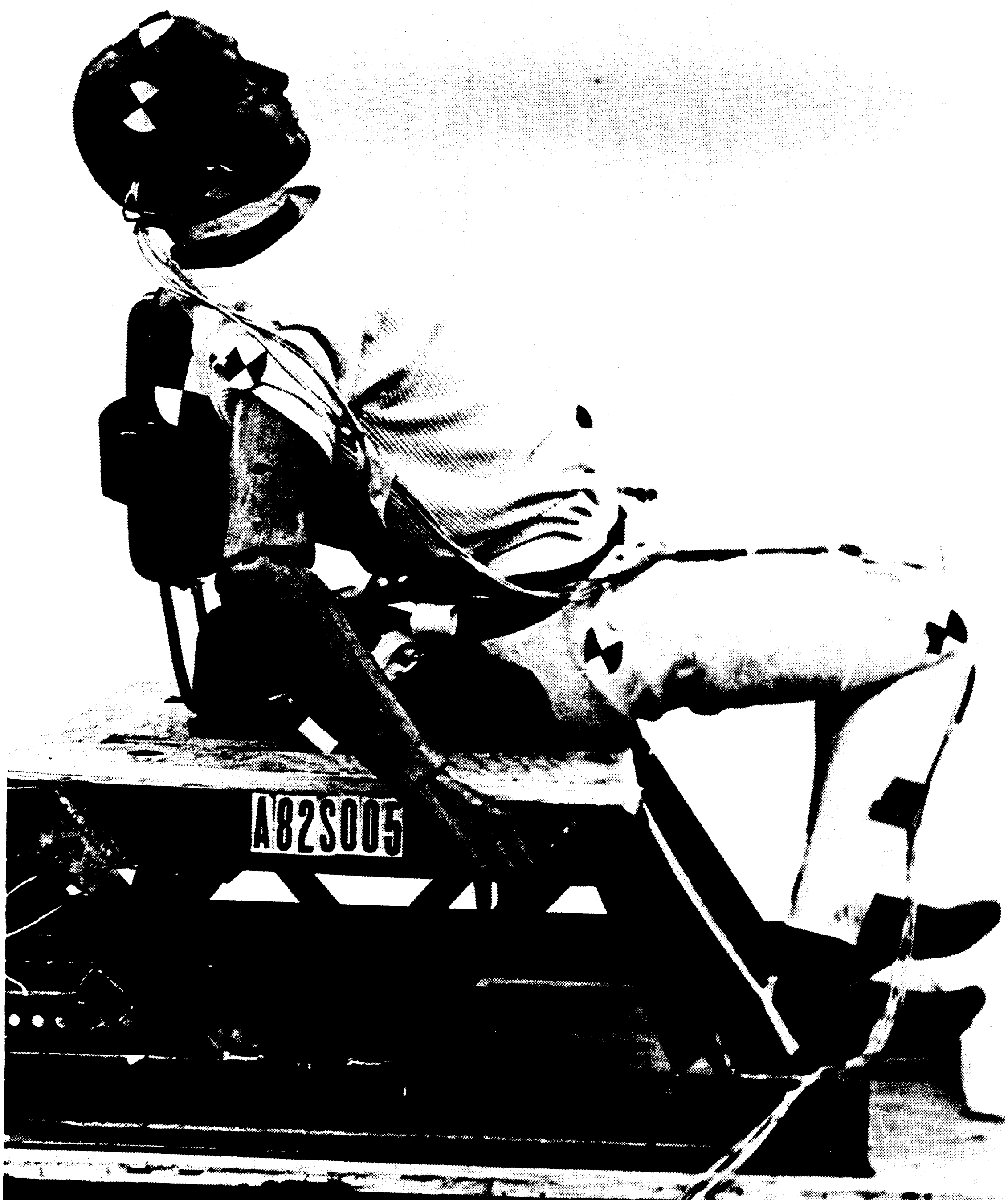


H7: 178   ← A/D → SEAT-1   11/23/82   825 005

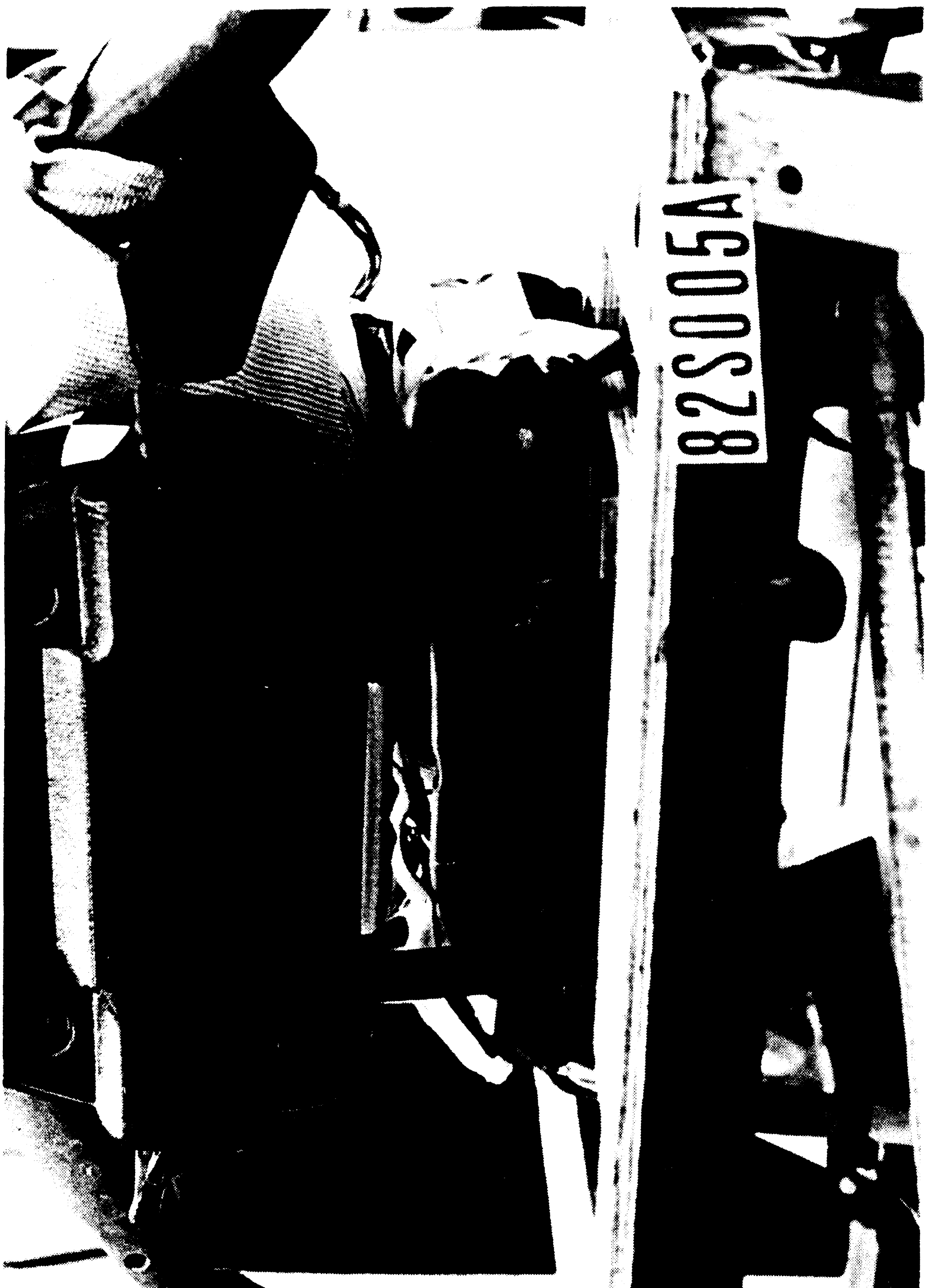

82S005


82S005


82S005


A82S005


82S005A


82S005A


82S005A

Test Summary TEST 82S006

Test Setup

Test Facility: UMTRI Impact Sled

Impact Parameters

Velocity:	21.1 mph
Deceleration:	20.9 g, with trapezoidal waveform
Direction:	Frontal
Restraint System:	2" lap belt webbing

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -97 g	max = 11 g
R-L (Right-Left):	min = -139 g	max = 14 g
I-S (Inferior-Superior):	min = -95 g	max = 7 g
Resultant	194 g	
HIC (Head Injury Criteria)	1439 from 119 to 226 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -66 g	max = 12 g
R-L (Right-Left):	min = -11 g	max = 17 g
I-S (Inferior-Superior):	min = -33 g	max = 45 g
Resultant	71 g	

Peak belt loads

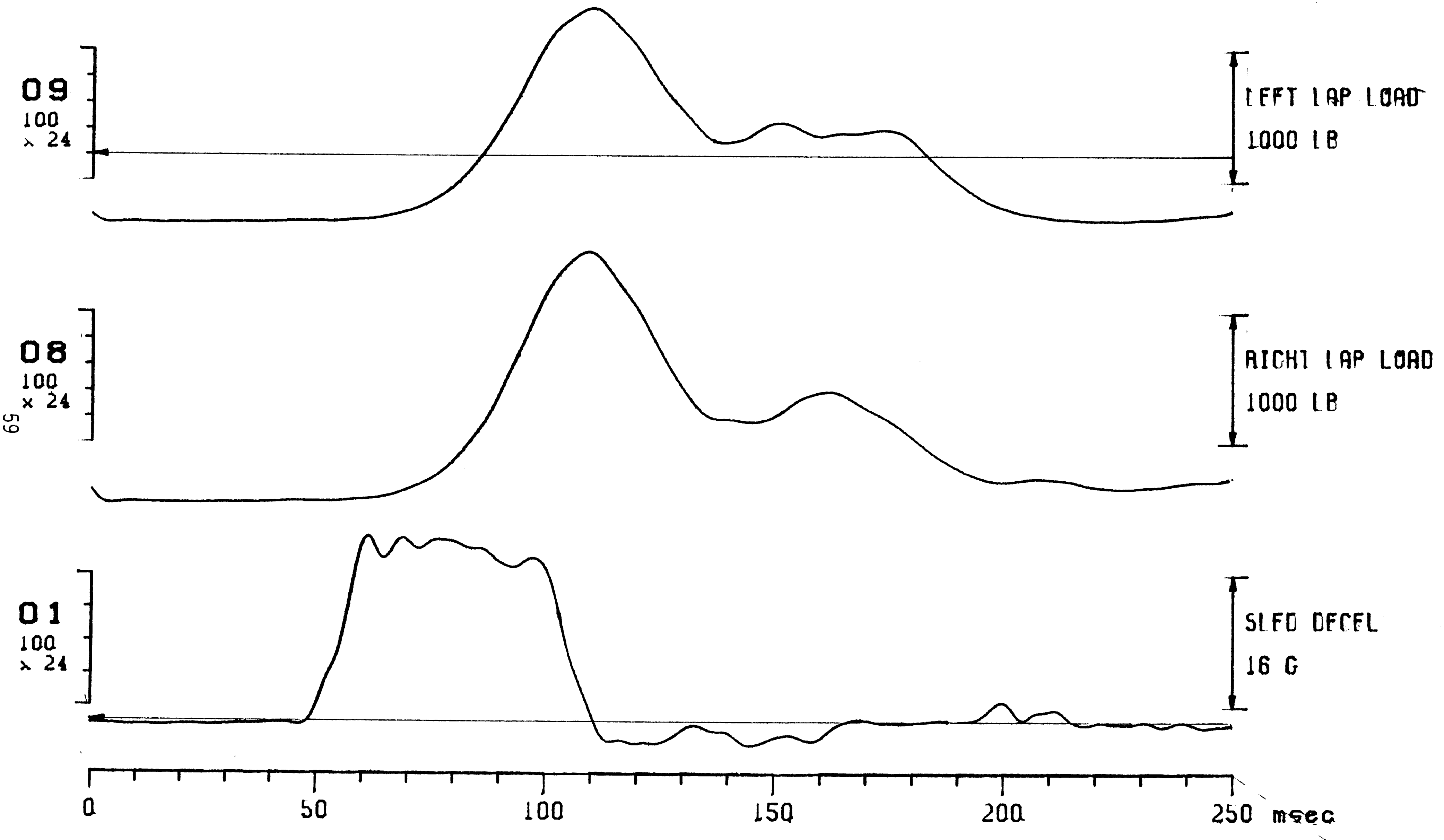
Right side:	1922 pounds
Left side:	1632 pounds

Maximum Excursions (from H. S. film analysis)

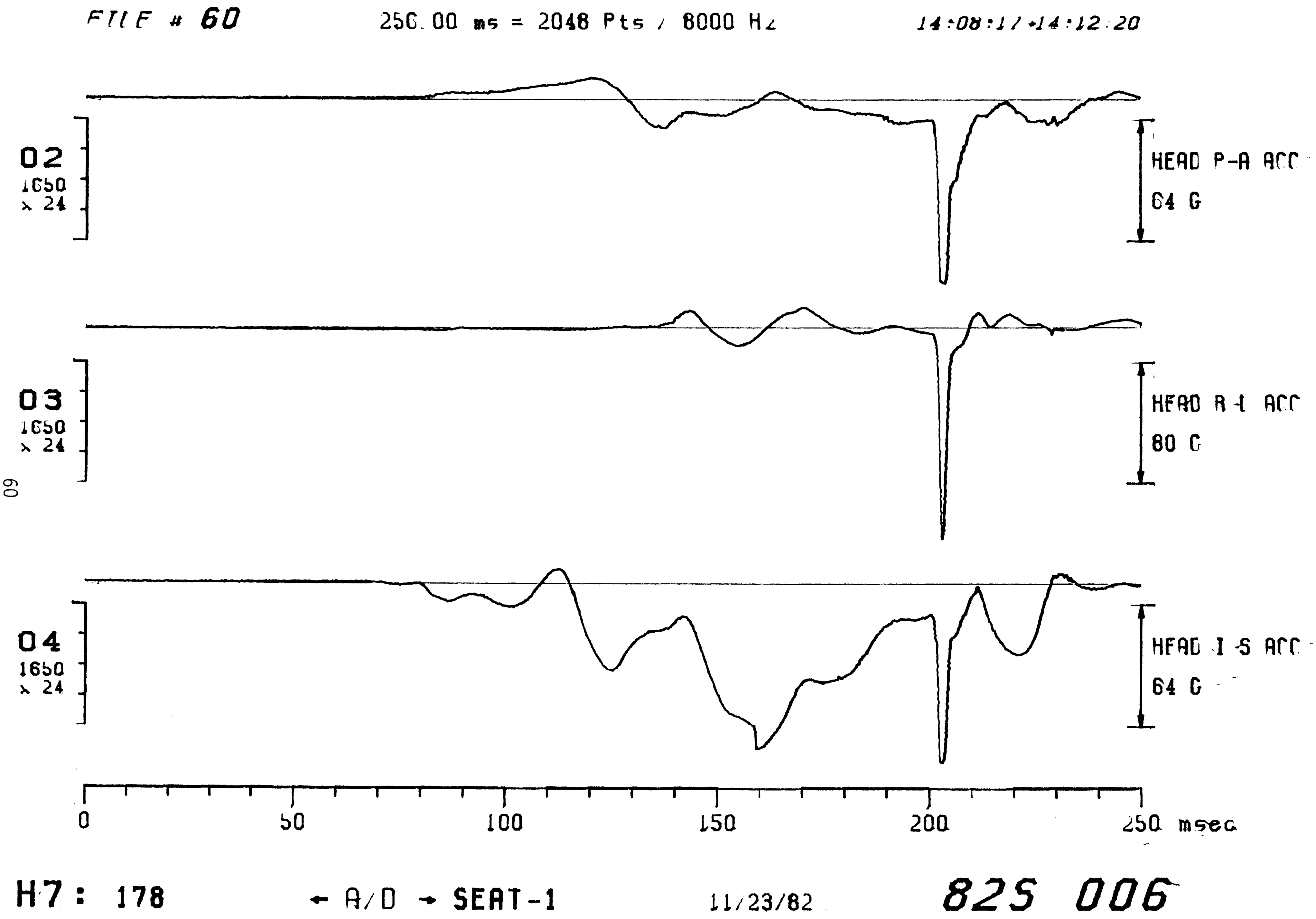
Head:	32.6 inches
Knees:	8.4 inches
Pelvis:	6.9 inches

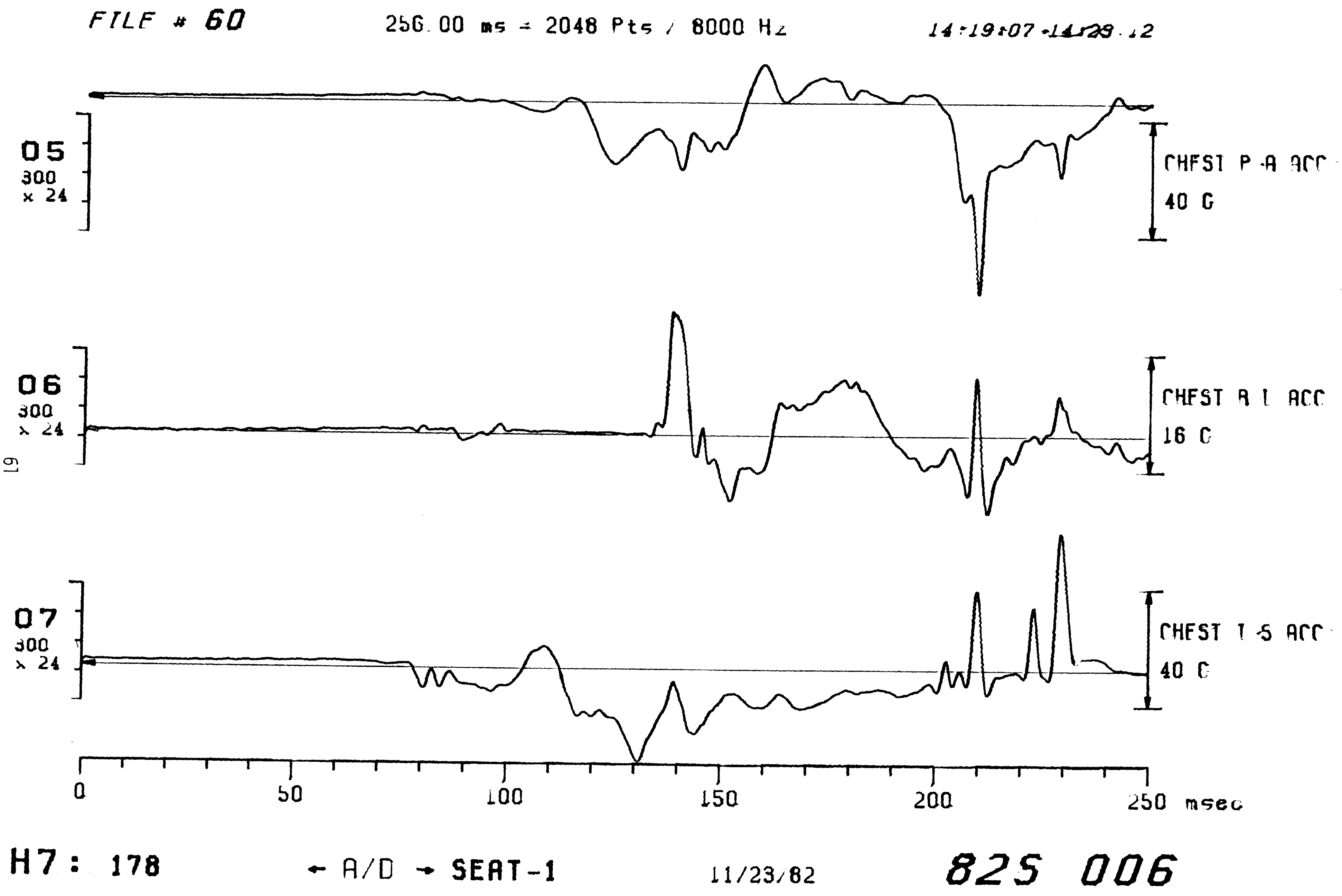
Observations:

FILE # 60 256.00 ms = 2048 Pts / 8000 Hz 13:55:05 →13:59:11



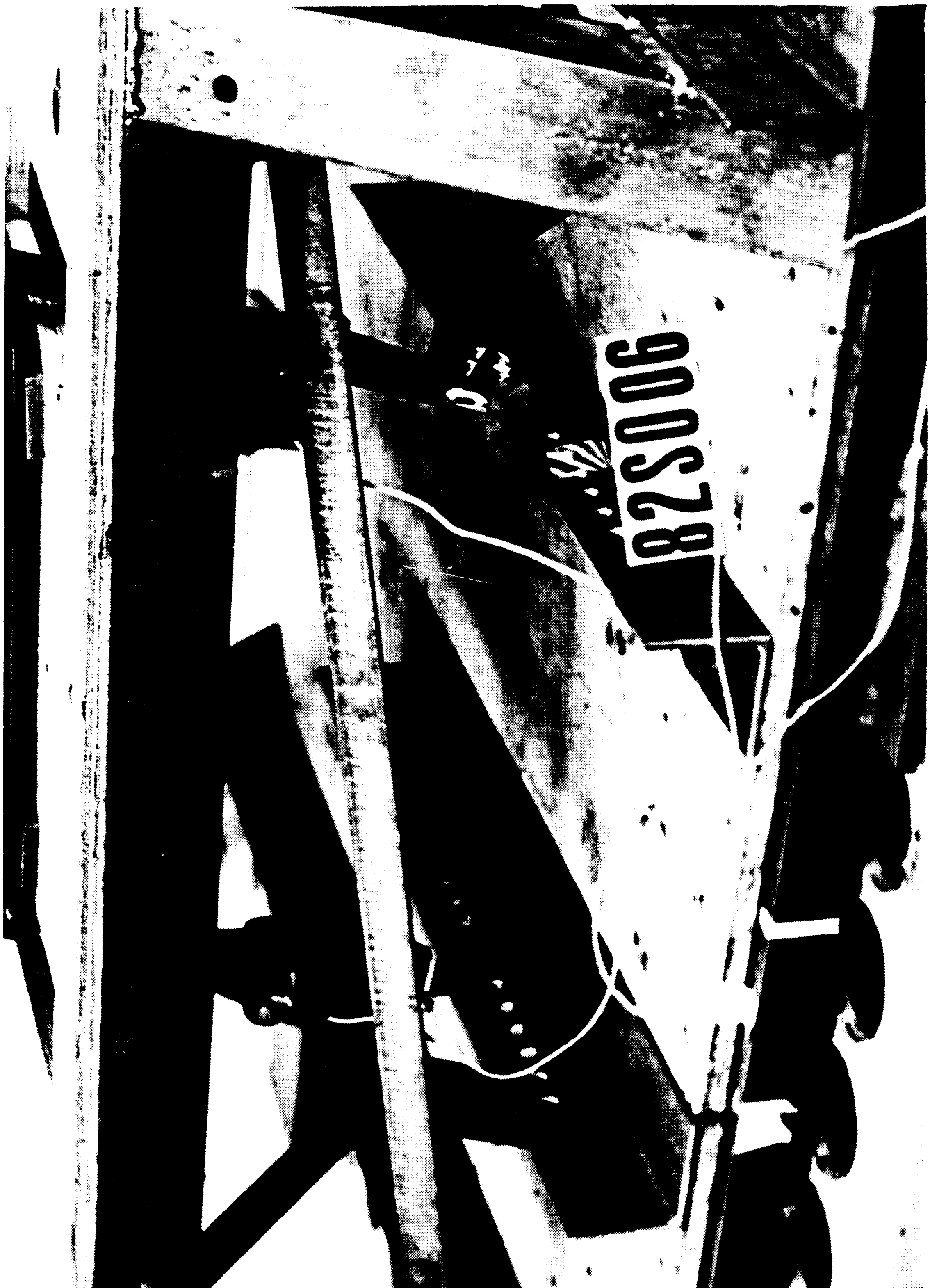
H7: 178 ← A/D → SEAT-1 11/23/82 825 006

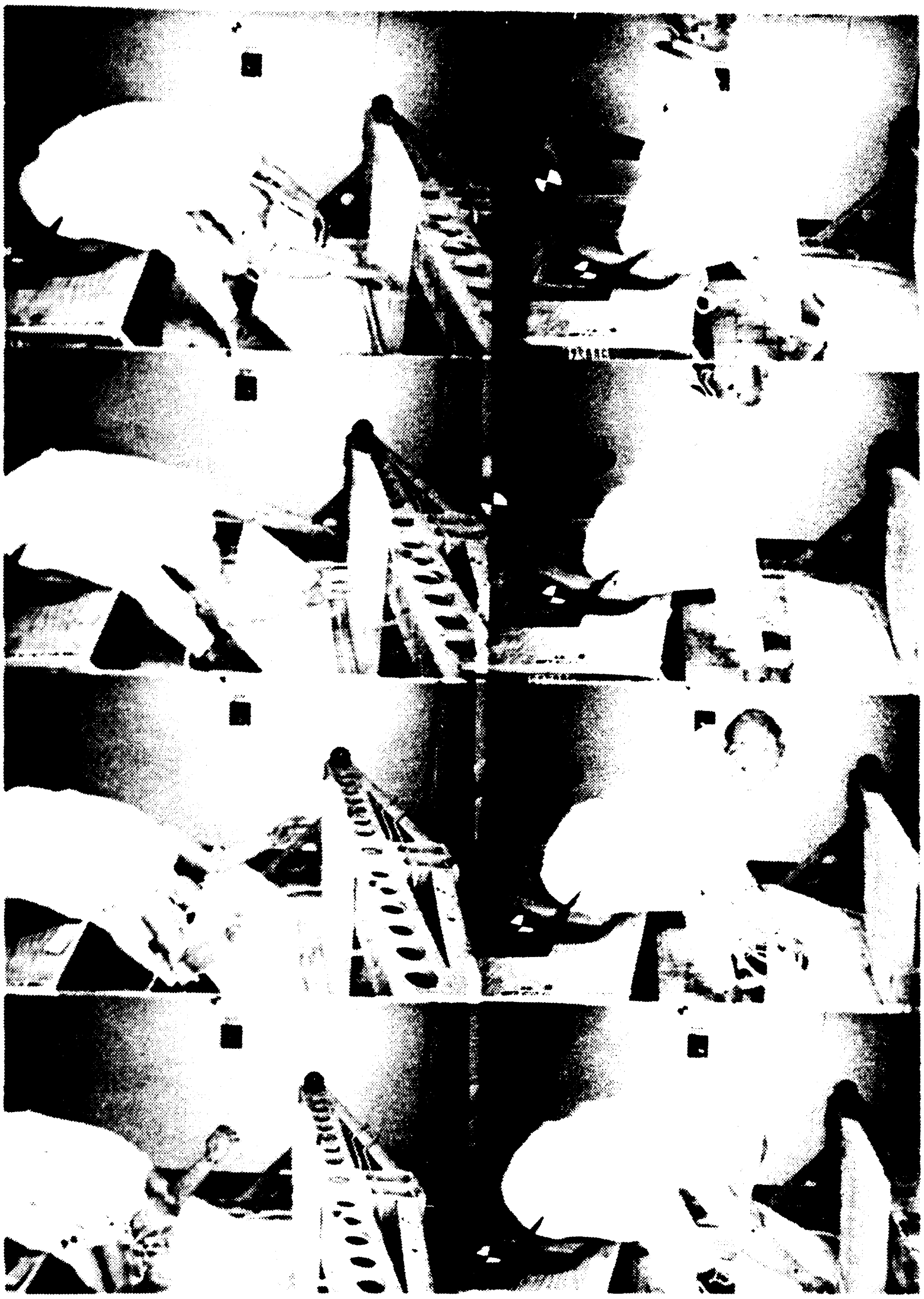

FILE # 60
250.00 ms = 2048 Pts / 8000 Hz
14:08:17-14:12:20
02
1650
x 24
HEAD P-A ACC
64 G
03
1650
x 24
HEAD R-L ACC
80 G
04
1650
x 24
HEAD I-S ACC
64 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/23/82
82S 006


FILE # 60
256.00 ms = 2048 Pts / 8000 Hz
14:19:07 14:23.12
05
300
x 24
CHEST P-A ACC
40 G
06
300
x 24
CHEST R-L ACC
16 G
07
300
x 24
CHEST I-S ACC
40 G
0
50
100
150
200
250 msec
H7: 178
← A/D → SEAT-1
11/23/82
825 006


82S006


82S006


82S006



5 1

6 2

7 3

8 4

82S 006


82SJ006A


82S006A

Test Summary TEST 82S007

Test Setup

Test Facility: Vertical Shaker Platform

Impact Parameters

Platform Motion: Upward jolt and return

Pulse Shape: Triangular displacement waveform

Peak Platform Acceleration: 2.2 g

Restraint System: U. S. Steel Restraint Harness

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -2 g	max = 1 g
R-L (Right-Left):	min = -2 g	max = 1 g
I-S (Inferior-Superior):	min = -3 g	max = 6 g
Resultant	6 g	
HIC (Head Injury Criteria)	1 from 97 to 614 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -1 g	max = 1 g
R-L (Right-Left):	min = 0 g	max = 0 g
I-S (Inferior-Superior):	min = -3 g	max = 7 g
Resultant	7 g	

Peak belt loads

Right side: 66 pounds

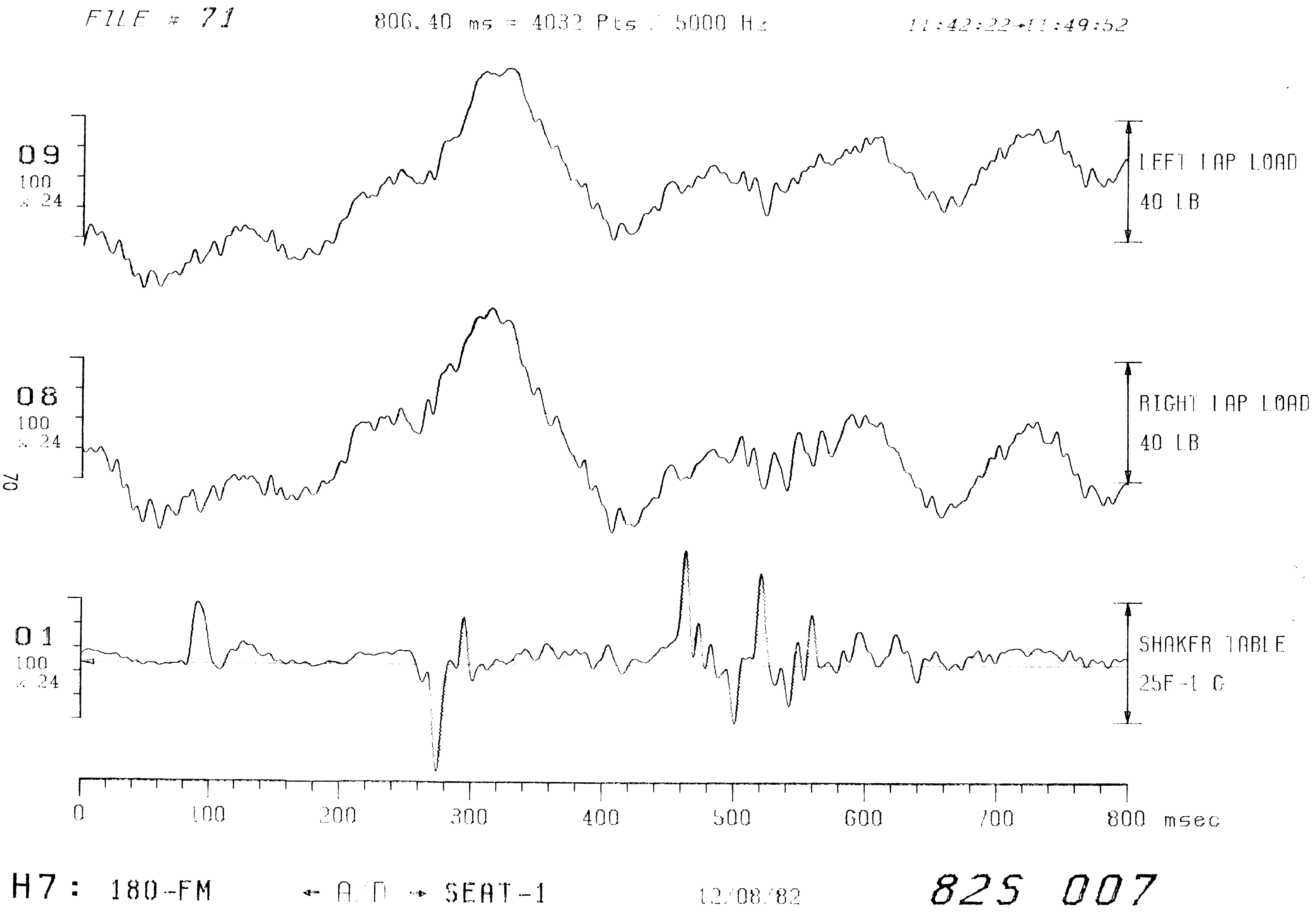
Left side: 67 pounds

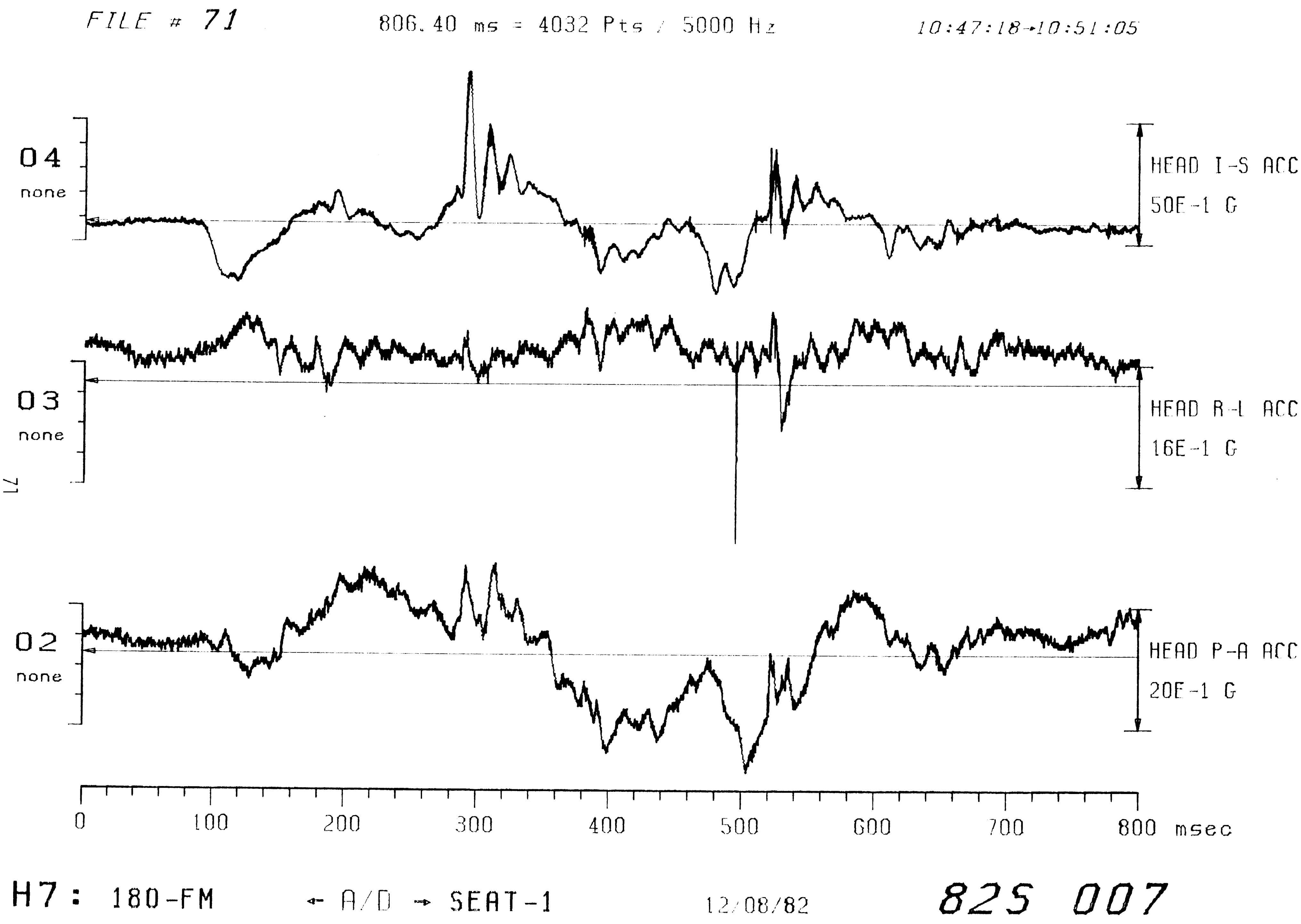
Maximum Excursions (from H. S. film analysis)

Head: .9 inches

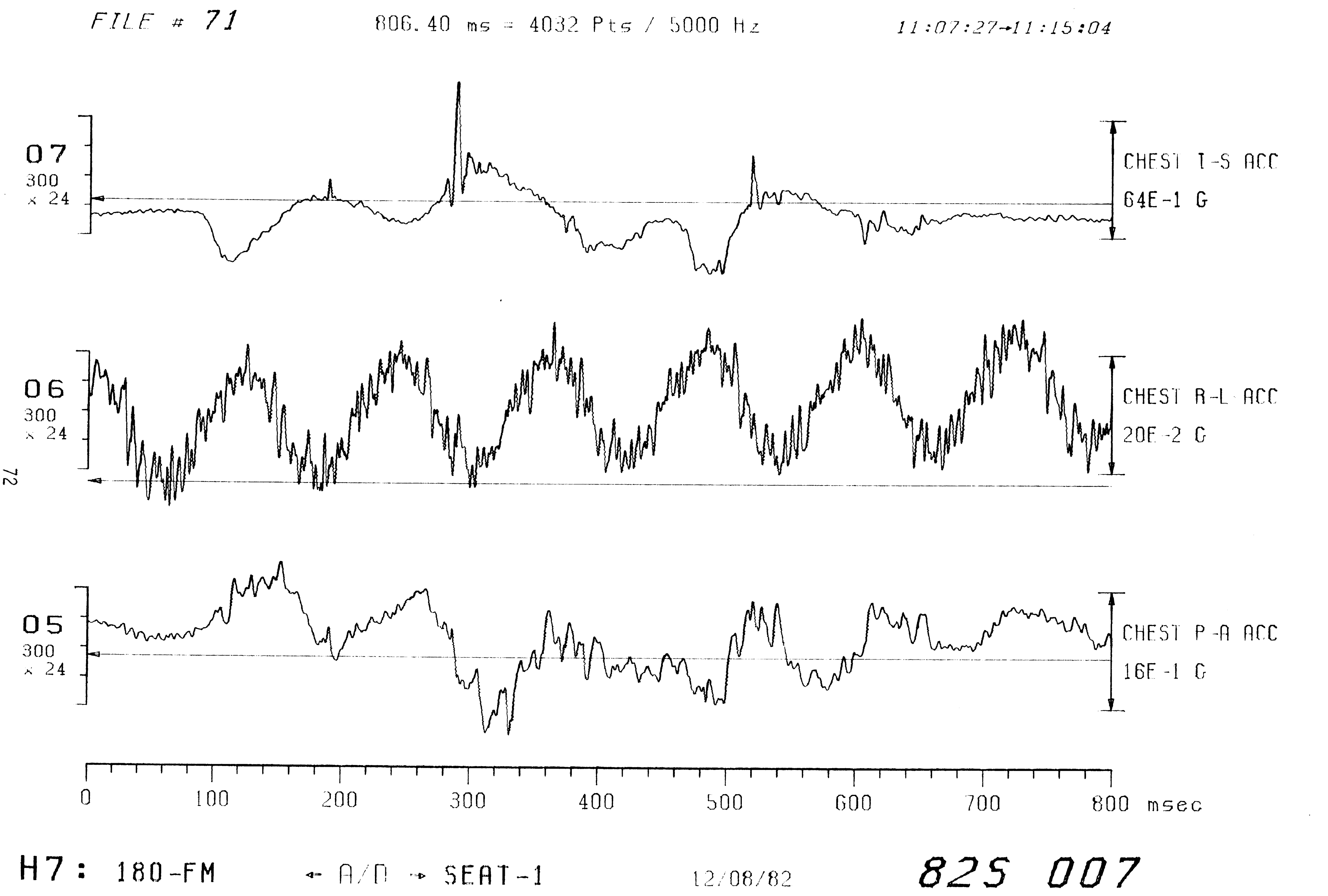
Shoulder: 1.7 inches

Observations:

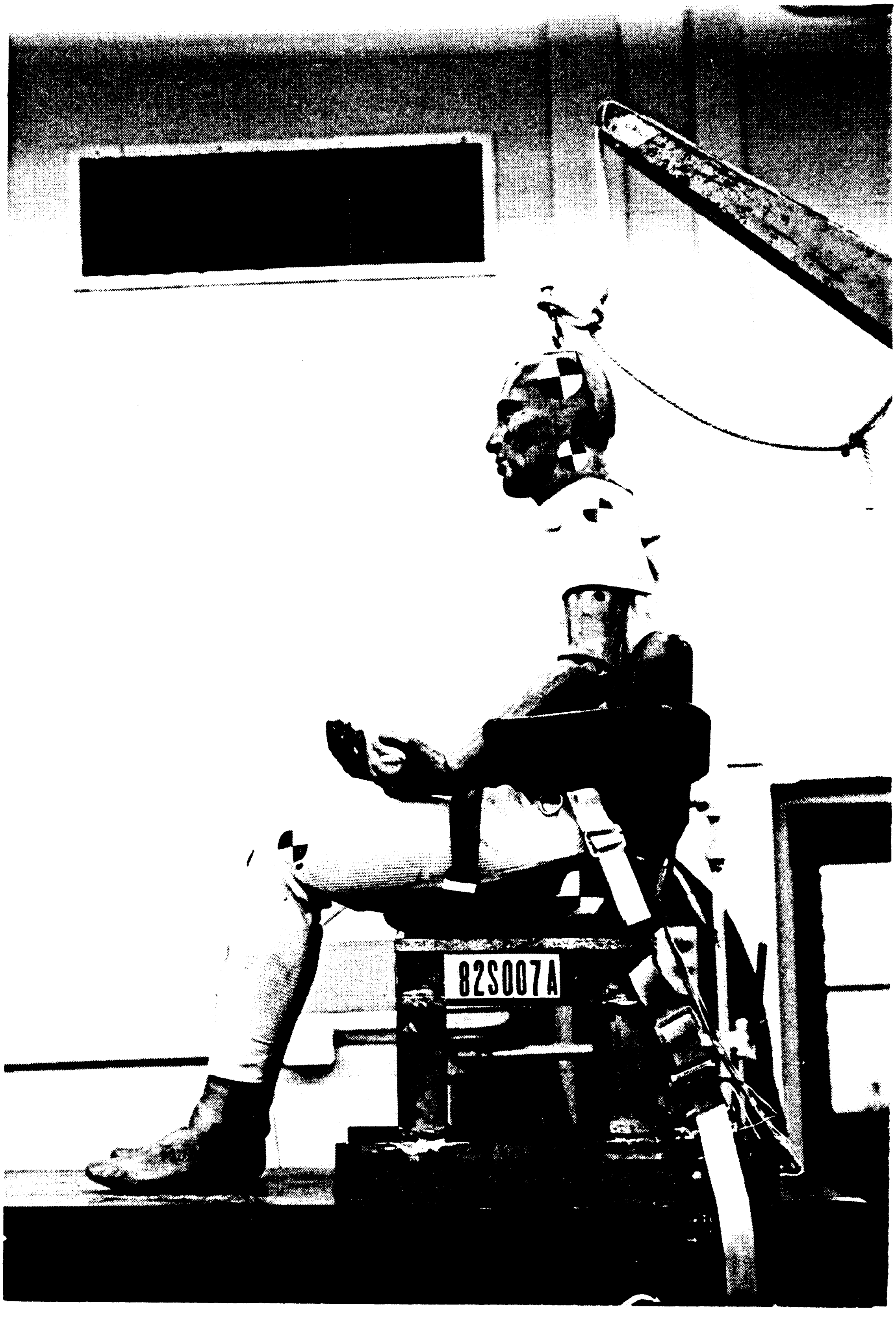

FILE # 71
806.40 ms = 4032 Pts / 5000 Hz
11:42:22→11:49:52
09
100
x 24
LEFT LAP LOAD
40 LB
08
100
x 24
RIGHT LAP LOAD
40 LB
01
100
x 24
SHAKER TABLE
25F-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
825 007



FILE # 71
806.40 ms = 4032 Pts / 5000 Hz
10:47:18→10:51:05
04
none
HEAD I-S ACC
50E-1 G
03
none
HEAD R-L ACC
16E-1 G
02
none
HEAD P-A ACC
20E-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
82S 007


FILE # 71
806.40 ms = 4032 Pts / 5000 Hz
11:07:27→11:15:04
07
300
x 24
CHEST I-S ACC
64E-1 G
06
300
x 24
CHEST R-L ACC
20E-2 G
05
300
x 24
CHEST P-A ACC
16E-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
825 007


82S007


82S007A

Test Summary TEST 82S008

Test Setup

Test Facility: Vertical Shaker Platform

Impact Parameters

Platform Motion: Upward jolt and return
Pulse Shape: Triangular displacement waveform
Peak Platform Acceleration: 1.6 g

Restraint System: U. S. Steel Restraint Harness

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -2 g	max = 1 g
R-L (Right-Left):	min = -2 g	max = 1 g
I-S (Inferior-Superior):	min = -3 g	max = 5 g
Resultant	5 g	
HIC (Head Injury Criteria)	1 from 133 to 575 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -2 g	max = 1 g
R-L (Right-Left):	min = -1 g	max = 0 g
I-S (Inferior-Superior):	min = -3 g	max = 6 g
Resultant	6 g	

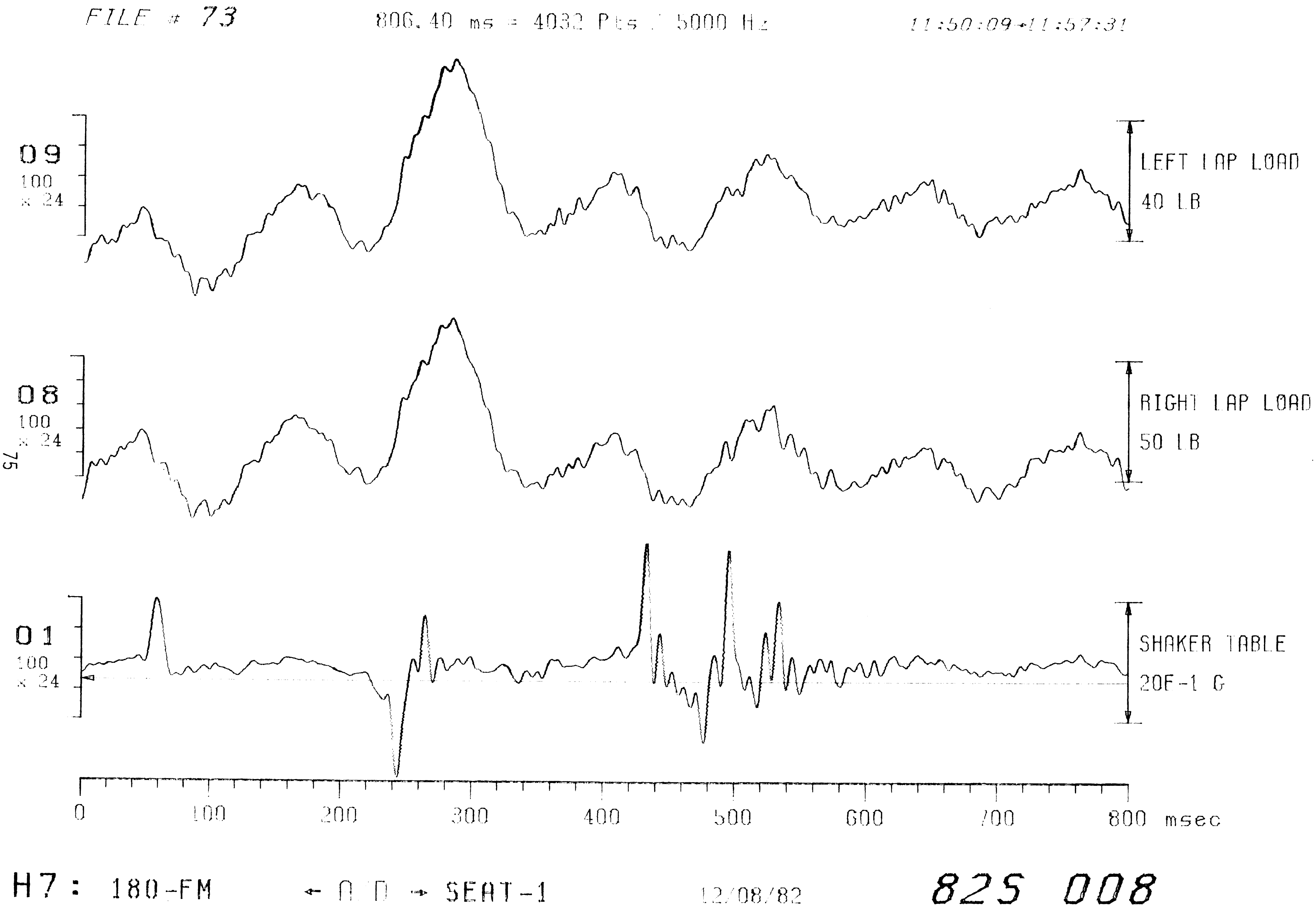
Peak belt loads

Right side: 65 pounds
Left side: 64 pounds

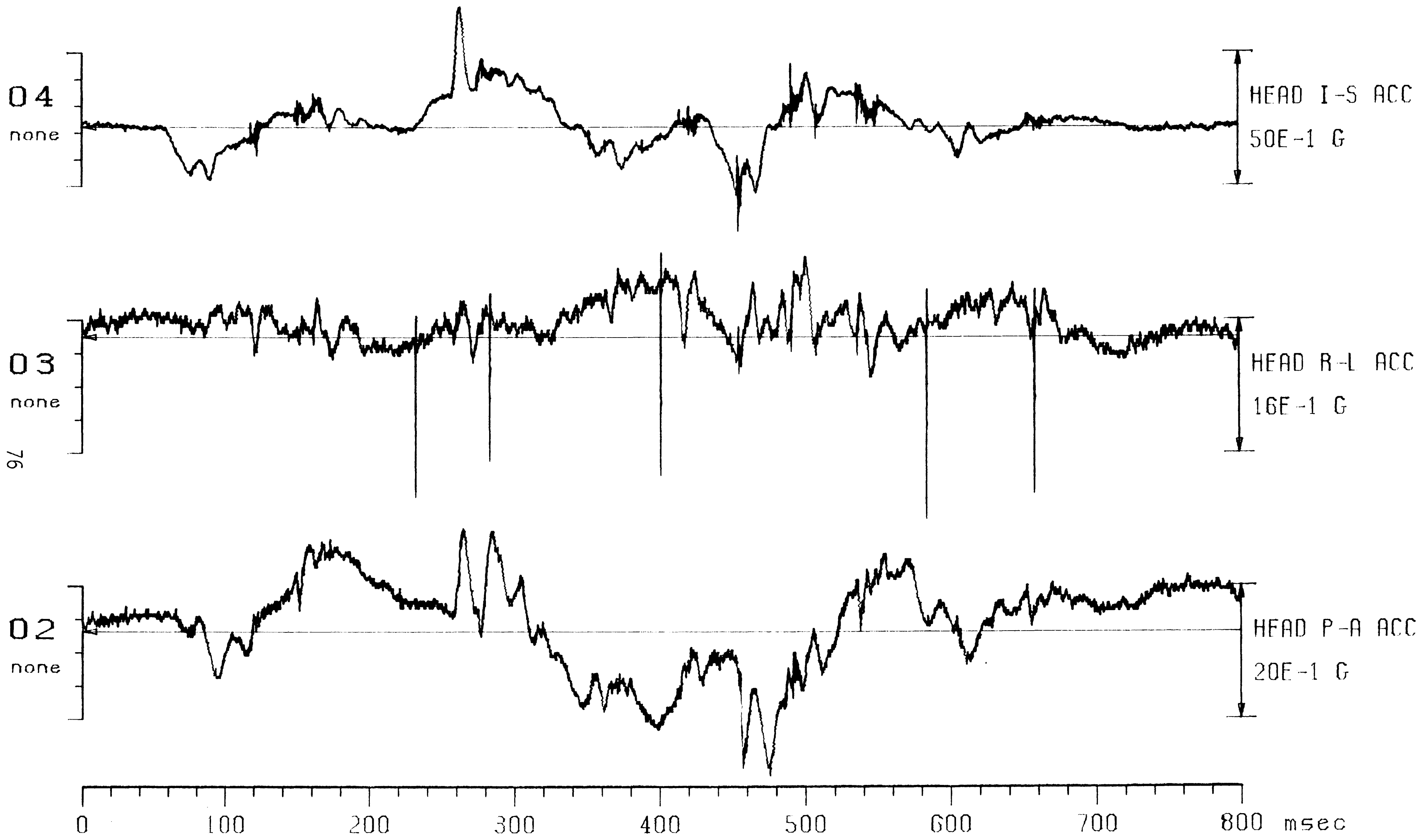
Maximum Excursions (from H. S. film analysis)

Head: 1.0 inches
Shoulder: 2.0 inches

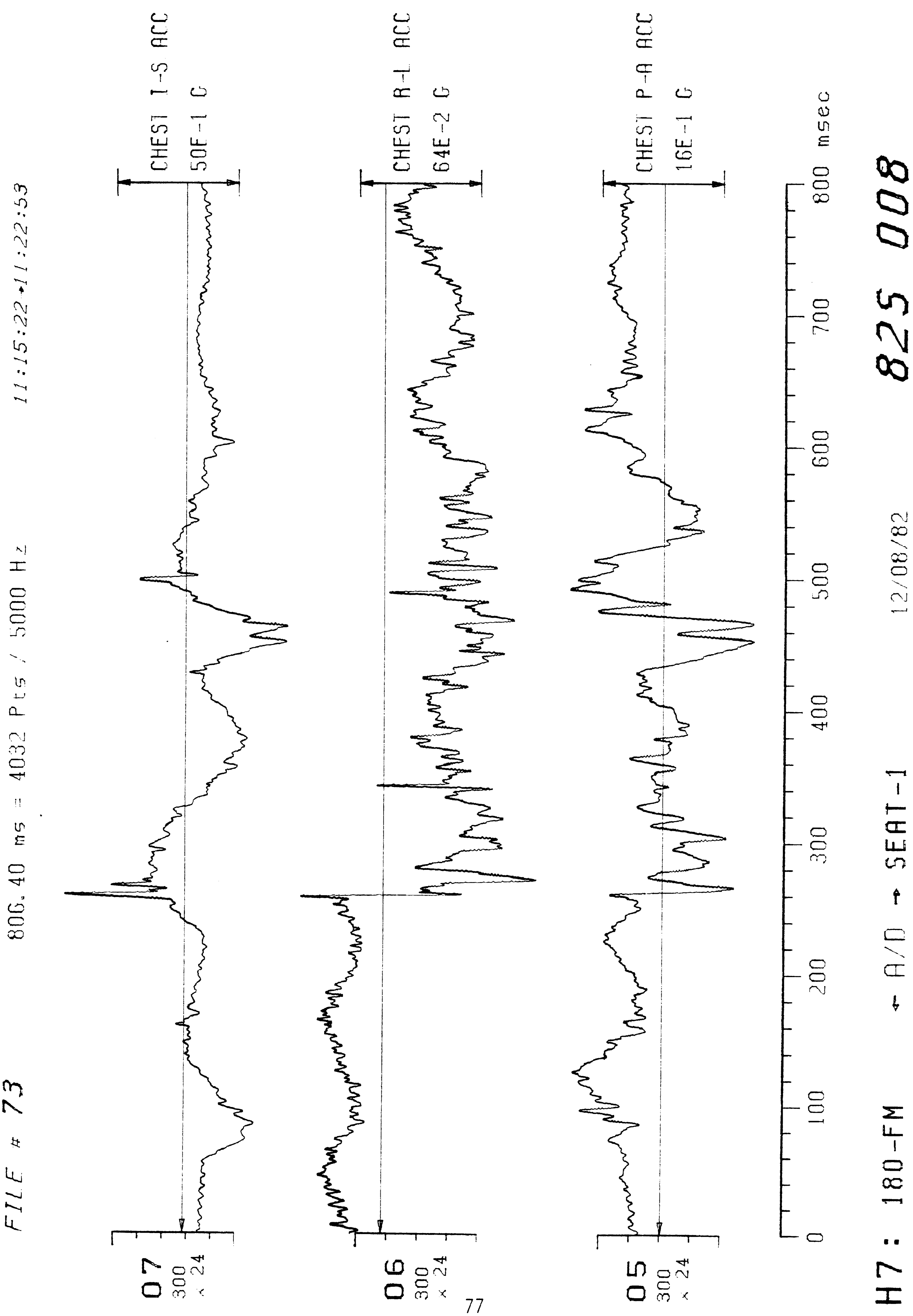
Observations:

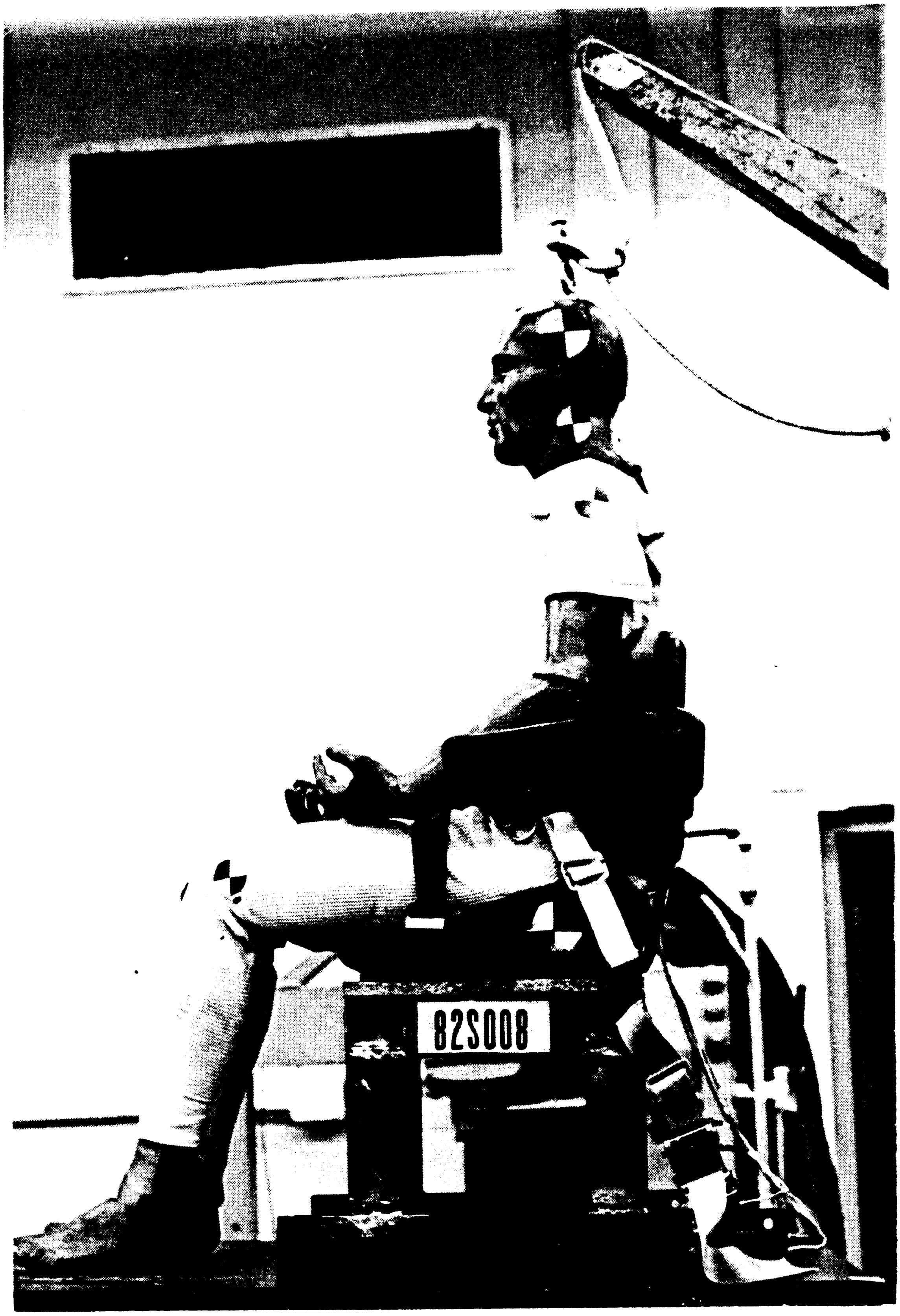

FILE # 73
806.40 ms = 4032 Pts / 5000 Hz
11:50:09→11:57:31
09
100
x 24
LEFT LAP LOAD
40 LB
08
100
x 24
RIGHT LAP LOAD
50 LB
01
100
x 24
SHAKER TABLE
20F-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A D → SEAT-1
12/08/82
82S 008

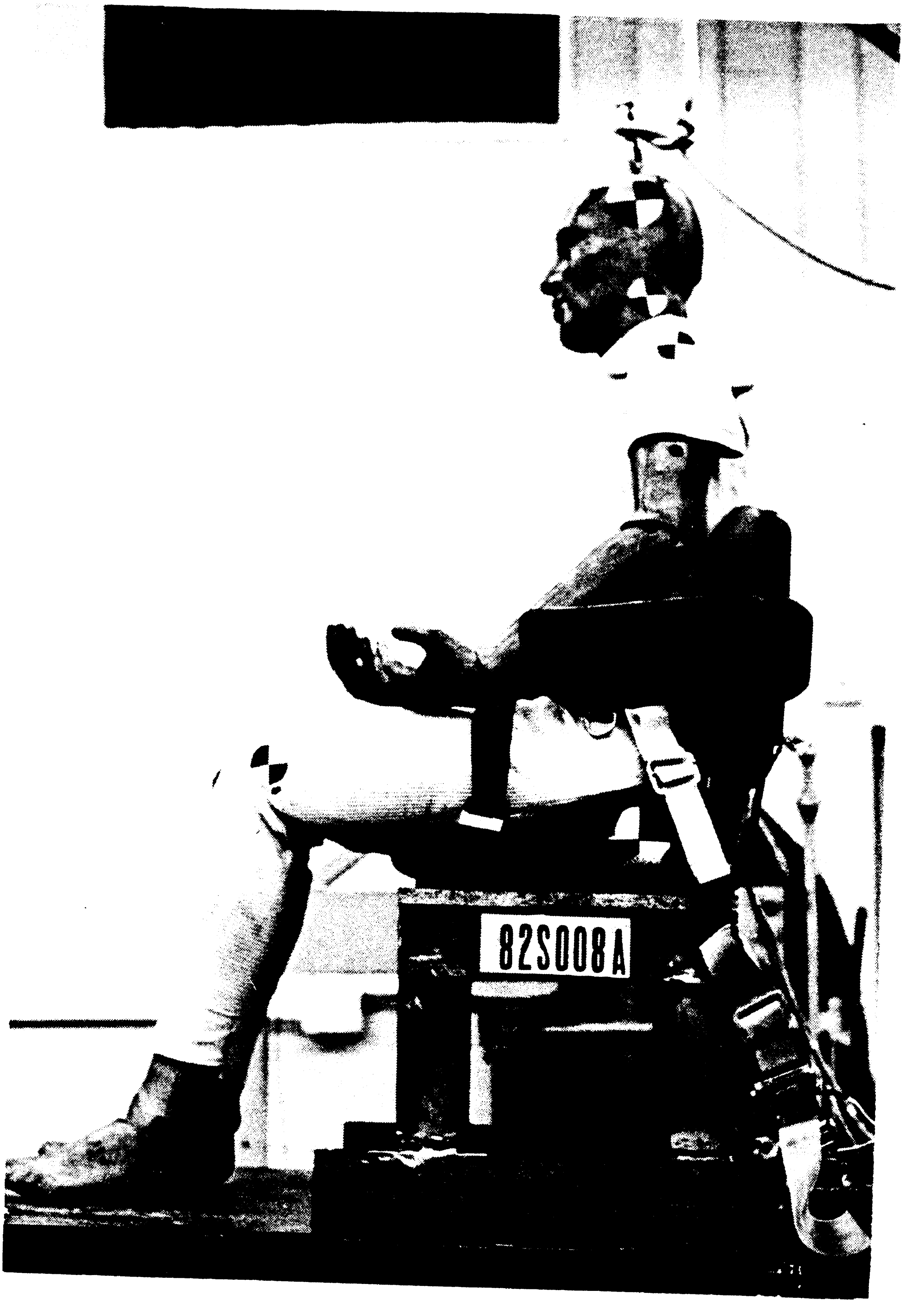
FILE # 73   806.40 ms = 4032 Pts / 5000 Hz   10:51:23→10:55:12



H7: 180-FM   ← A/D → SEAT-1   12/08/82   82S 008


FILE # 73
806.40 ms = 4032 Pts / 5000 Hz
11:15:22→11:22:53
CHEST I-S ACC
50E-1 G
CHEST R-L ACC
64E-2 G
CHEST P-A ACC
16E-1 G
07
300
x 24
06
300
x 24
05
300
x 24
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
825 008


82S008


82S008A

Test Summary

TEST 82S009

Test Setup

Test Facility: Vertical Shaker Platform

Impact Parameters

Platform Motion: Upward jolt of 5.7 inches and return in 370 ms

Pulse Shape: Triangular displacement waveform

Peak Platform Acceleration: 2.5 g

Restraint System: None

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -4 g	max = 1 g
R-L (Right-Left):	min = -2 g	max = 1 g
I-S (Inferior-Superior):	min = -7 g	max = 2 g
Resultant	7 g	
HIC (Head Injury Criteria)	1 from 442 to 482 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -2 g	max = 1 g
R-L (Right-Left):	min = 0 g	max = 1 g
I-S (Inferior-Superior):	min = 8 g	max = 3 g
Resultant	8 g	

Peak belt loads

Right side: ____ pounds

Left side: ____ pounds

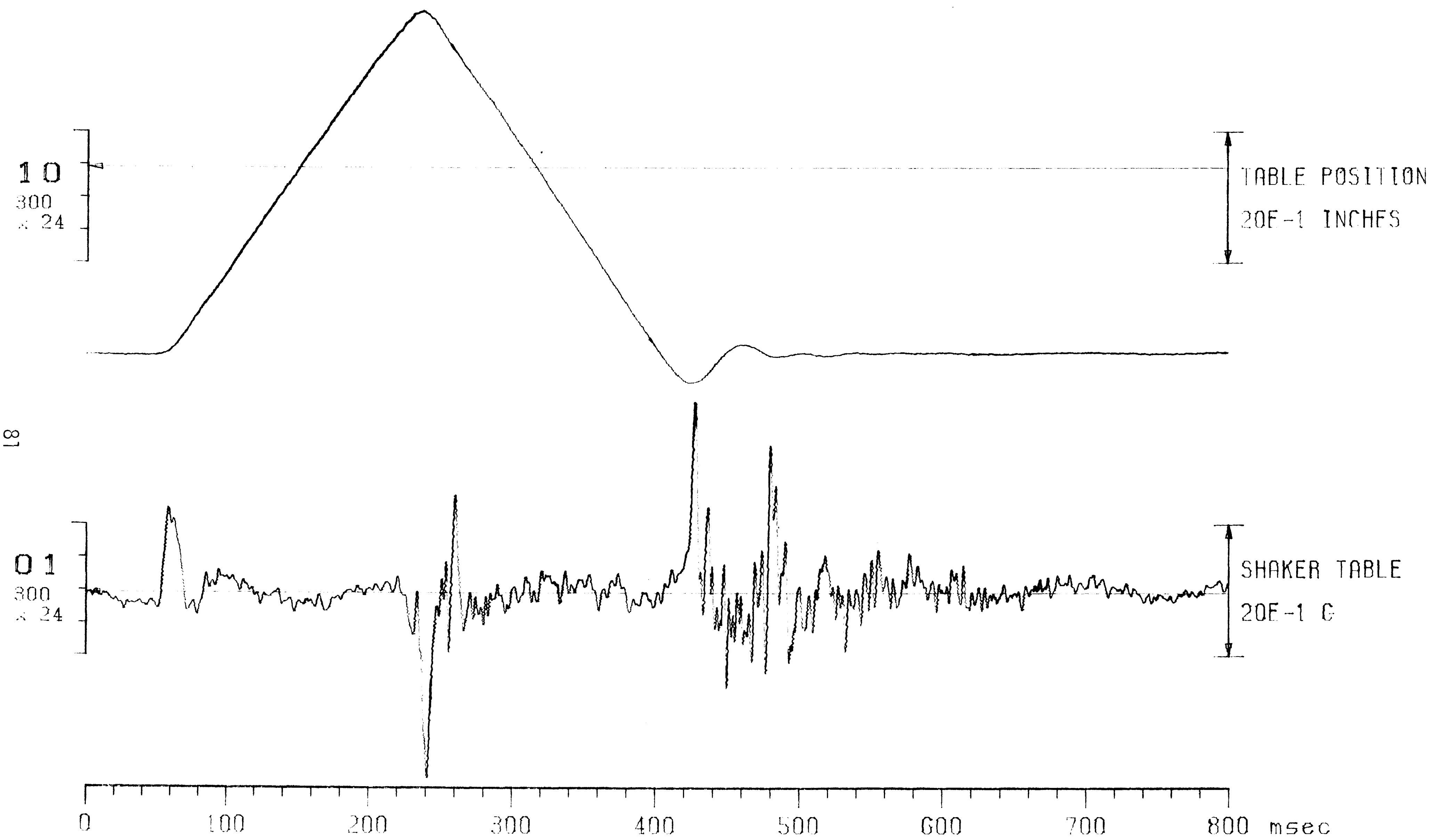
Maximum Excursions (from H. S. film analysis)

Head: 1.9 inches

Shoulder: 2.6 inches

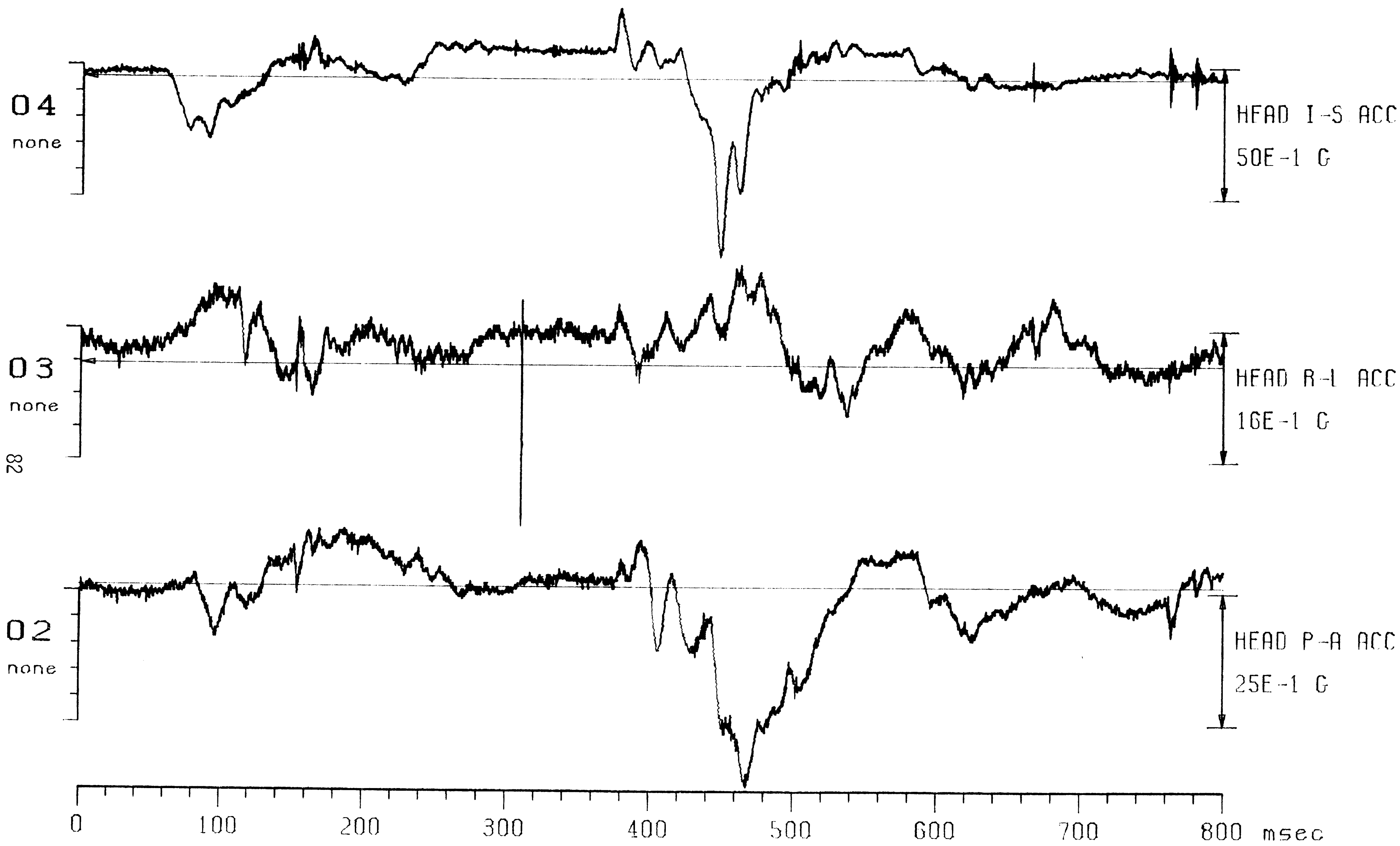
Observations:

FILE # 72   806.40 ms = 4032 Pts / 5000 Hz   12:33:42→12:38:51



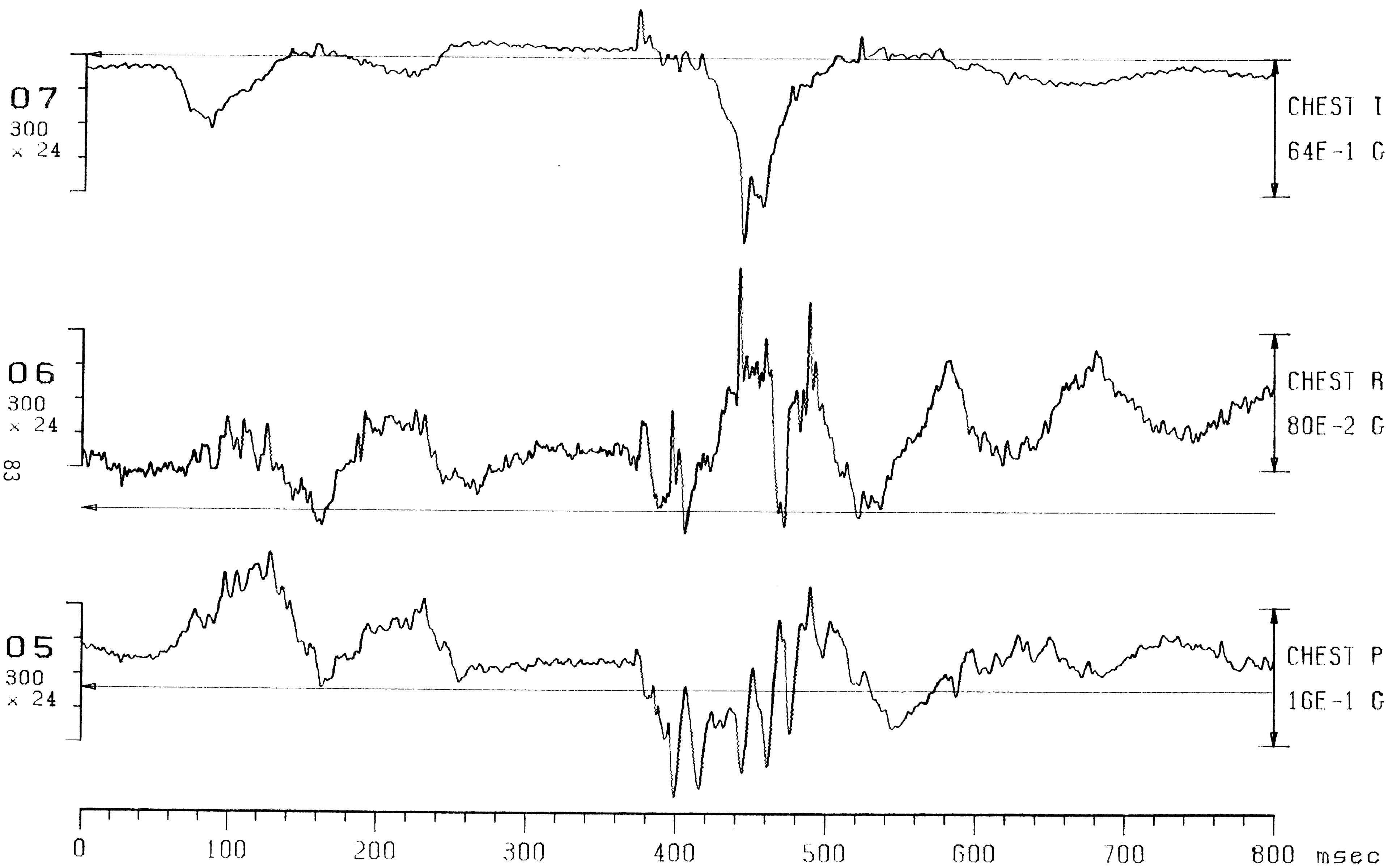
H7: 180-FM   ← A/D → 180   12/08/82   825 009

FILE # 72 806.40 ms = 4032 Pts / 5000 Hz 10:55:39→10:59:16

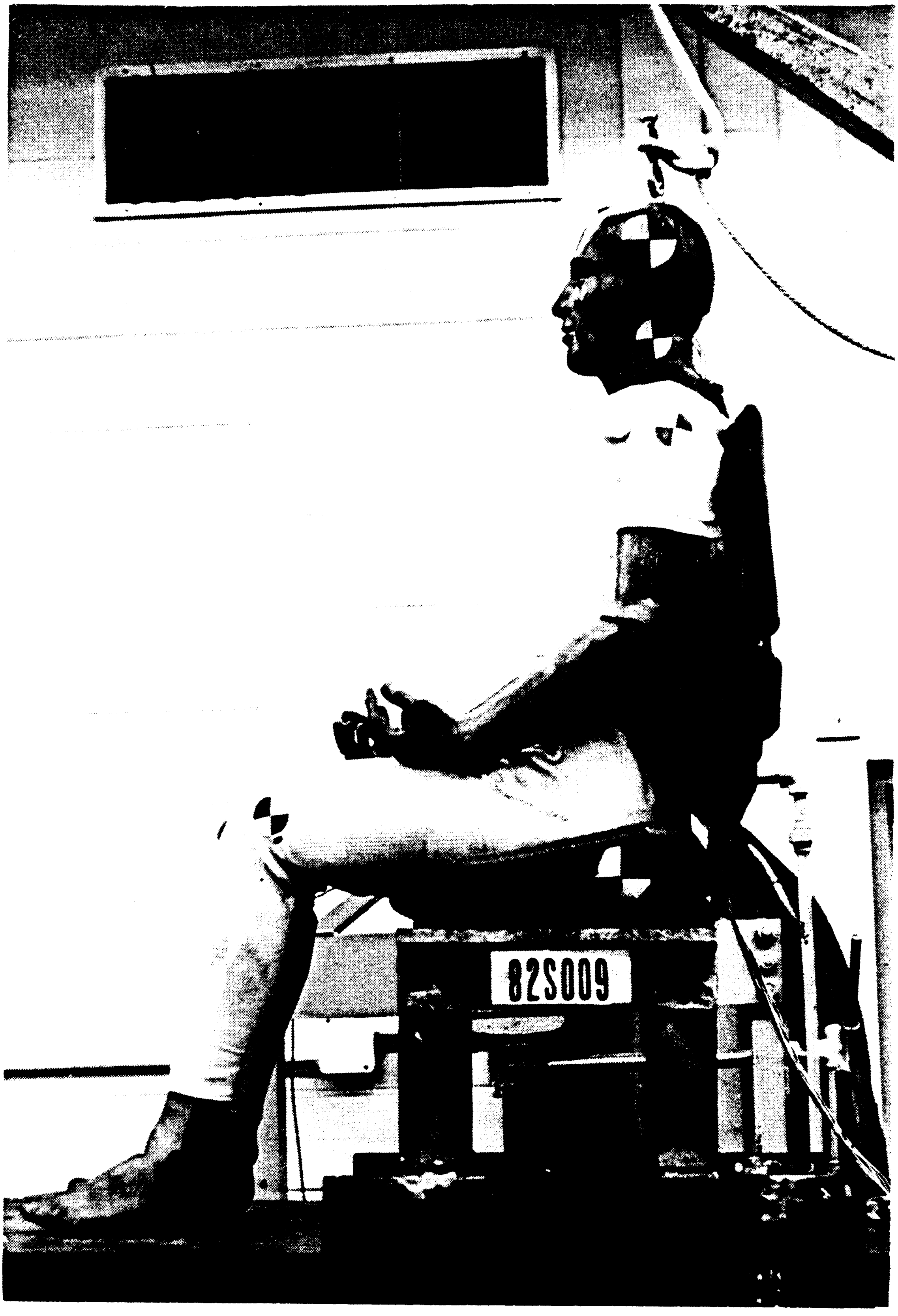


H7: 180-FM ← A/D → SEAT-1 12/08/82 825 009

FILE # 72 806.40 ms = 4032 Pts / 5000 Hz 11:23:12→11:30:28



H7: 180-FM ← A/D → SEAT-1 12/08/82 825 009


82S009


82S009A

Test Summary — TEST 82S010

Test Setup

Test Facility: Vertical Shaker Platform

Impact Parameters

Platform Motion: Upward jolt of 5.7 inches and return in 370 ms

Pulse Shape: Triangular displacement waveform

Peak Platform Acceleration: 2.8 g

Restraint System: 2 inch wide lap belt webbing

Test Results

Peak head accelerations

P-A (Posterior-Anterior):	min = -2 g	max = 1 g
R-L (Right-Left):	min = -2 g	max = 1 g
I-S (Inferior-Superior):	min = -3 g	max = 4 g
Resultant	4 g	
HIC (Head Injury Criteria)	1 from 44 to 543 ms	

Peak chest accelerations

P-A (Posterior-Anterior)	min = -2 g	max = 1 g
R-L (Right-Left):	min = 0 g	max = 1 g
I-S (Inferior-Superior):	min = -4 g	max = 4 g
Resultant	5 g	

Peak belt loads

Right side: 86 pounds

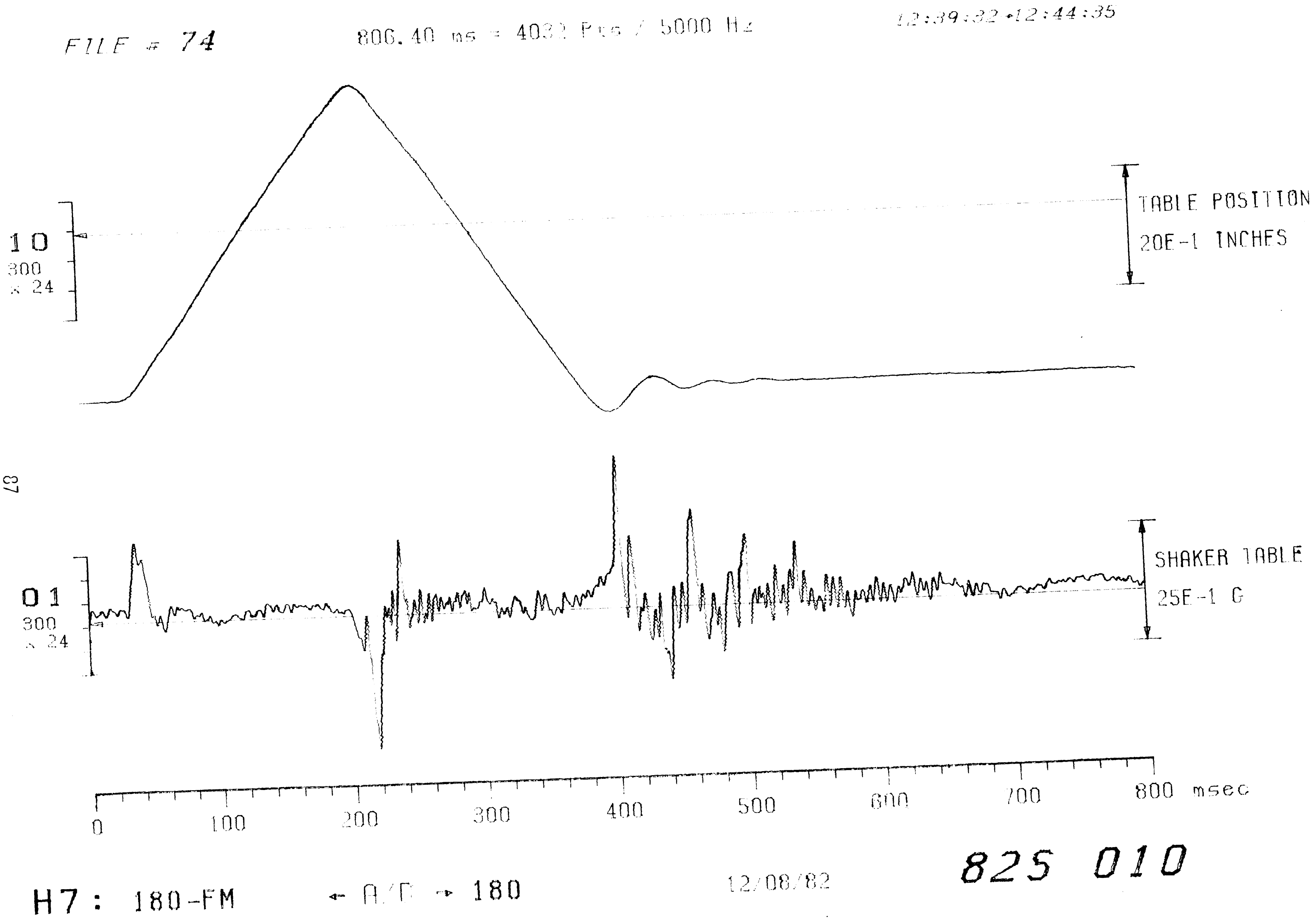
Left side: 75 pounds

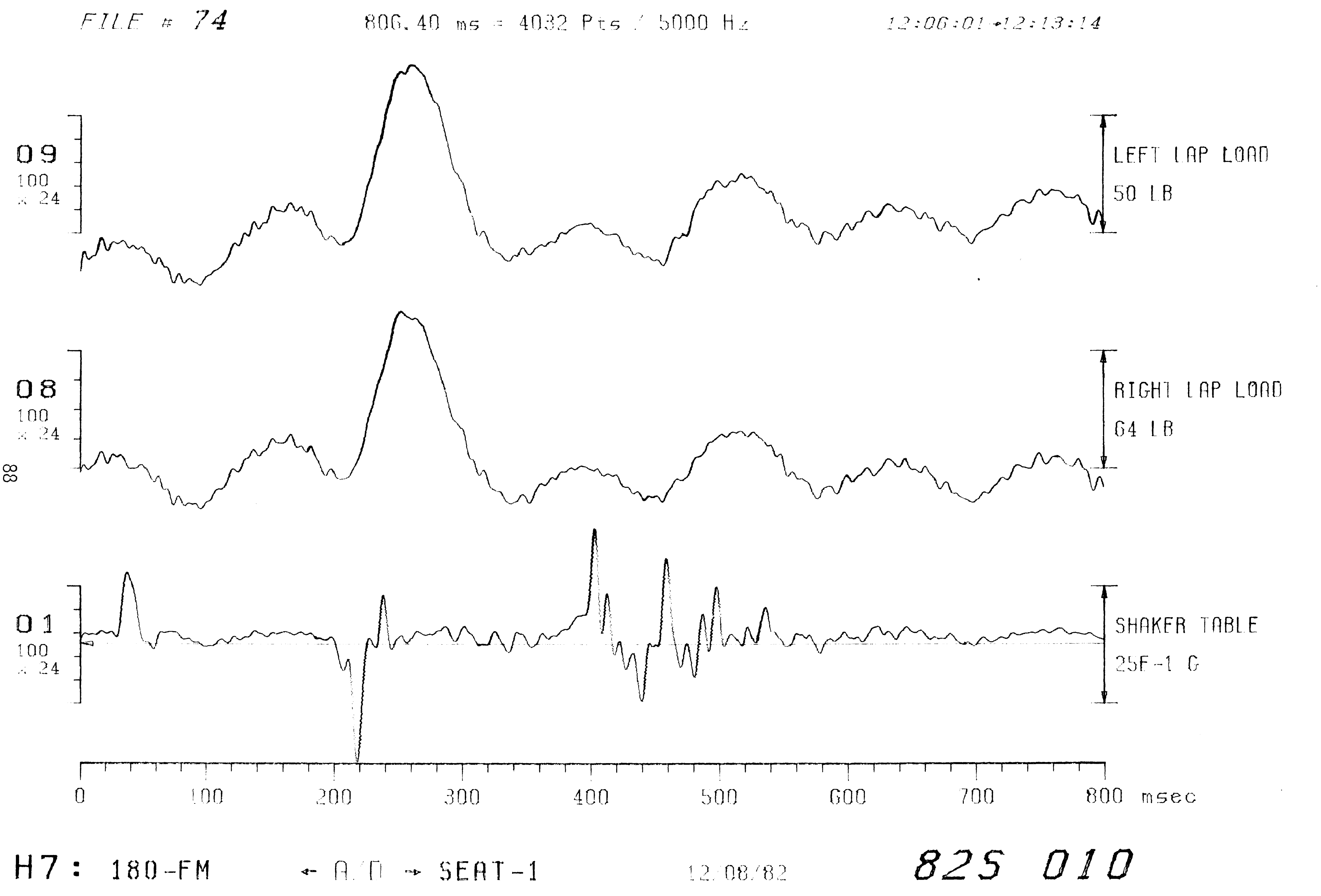
Maximum Excursions (from H. S. film analysis)

Head: 1.3 inches

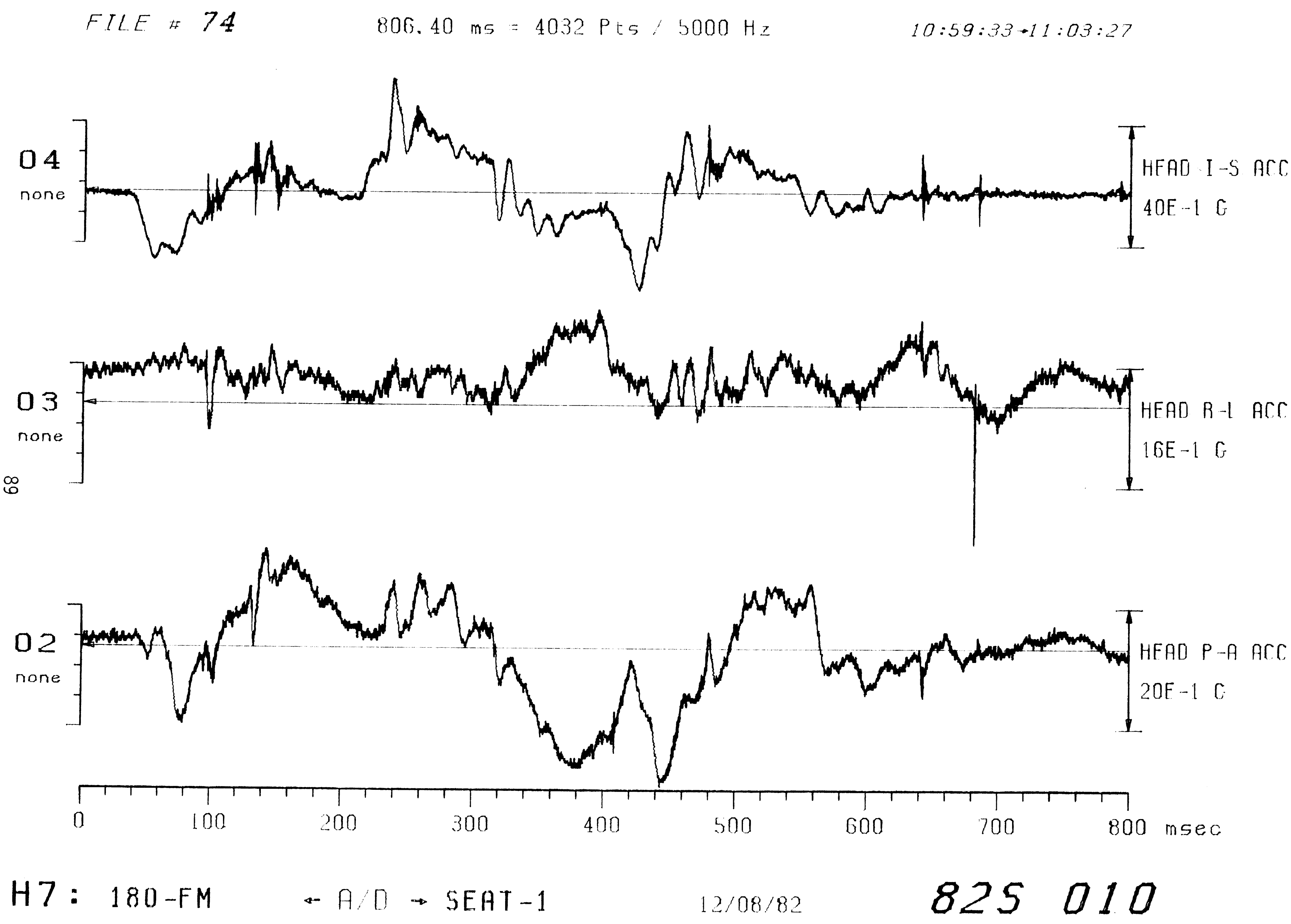
Shoulder: 1.8 inches

Observations:

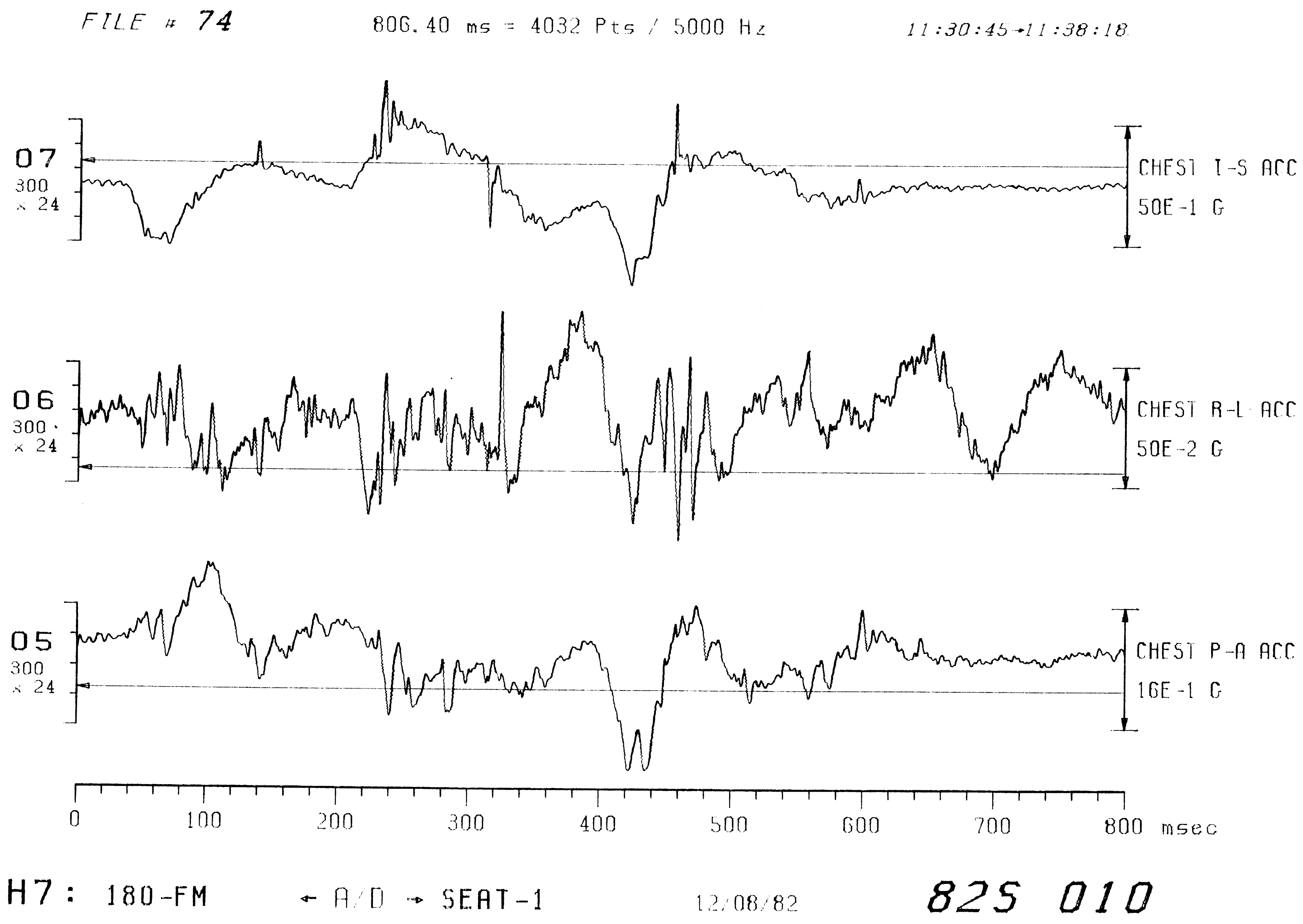

FILE # 74
806.40 ms = 4032 Pts / 5000 Hz
12:39:32 +12:44:35
TABLE POSITION
20E-1 INCHES
10
300
x 24
SHAKER TABLE
25E-1 G
01
300
x 24
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → 180
12/08/82
825 010

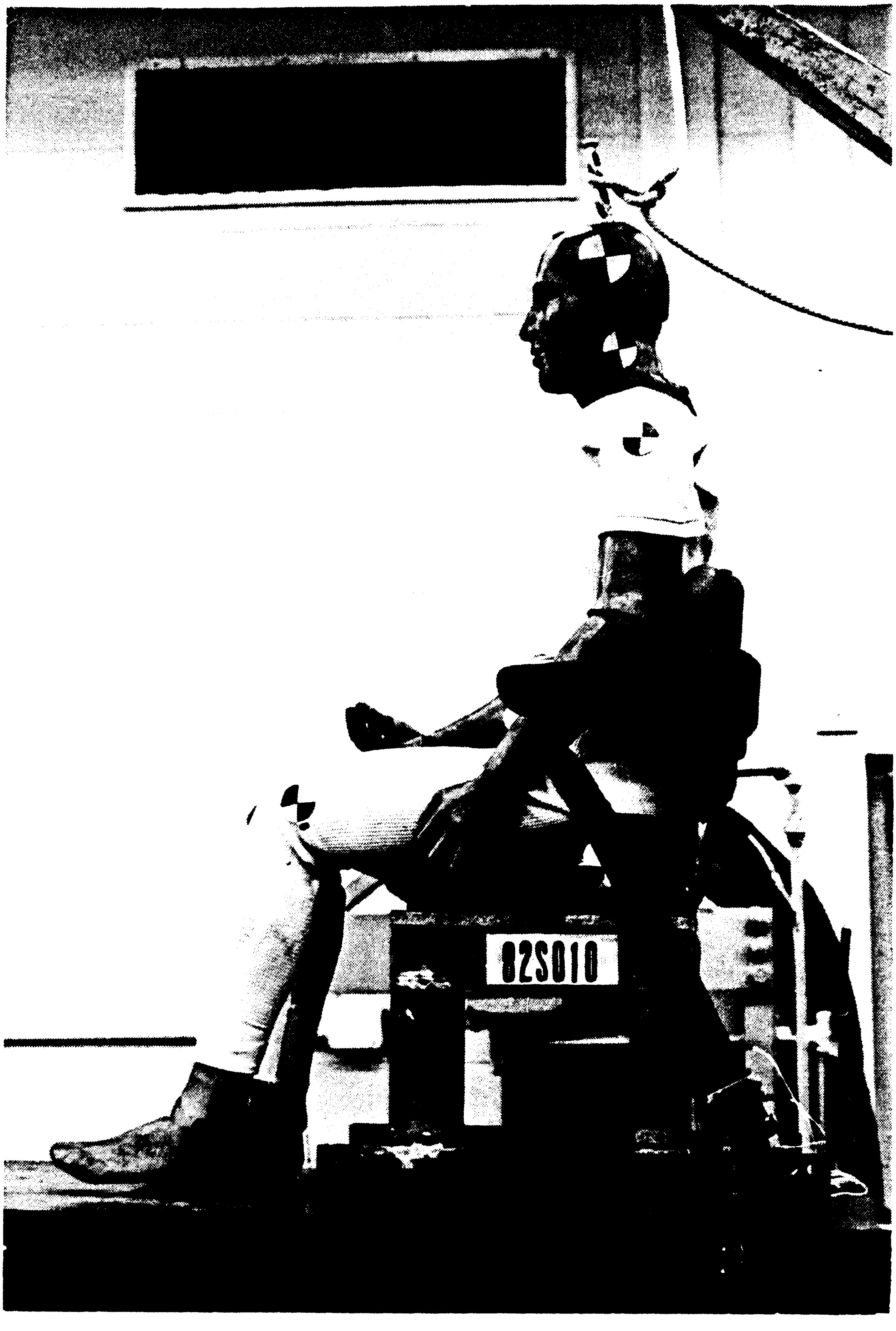


FILE # 74
806.40 ms = 4032 Pts / 5000 Hz
12:06:01→12:13:14
09
100
x 24
LEFT LAP LOAD
50 LB
08
100
x 24
RIGHT LAP LOAD
64 LB
01
100
x 24
SHAKER TABLE
25F-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
82S 010



FILE # 74
806.40 ms = 4032 Pts / 5000 Hz
10:59:33→11:03:27
04
none
HEAD I-S ACC
40E-1 G
03
none
HEAD R-L ACC
16E-1 G
02
none
HEAD P-A ACC
20E-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
825 010


FILE # 74
806.40 ms = 4032 Pts / 5000 Hz
11:30:45→11:38:18
07
300
× 24
CHEST I-S ACC
50E-1 G
06
300
× 24
CHEST R-L ACC
50E-2 G
05
300
× 24
CHEST P-A ACC
16E-1 G
0
100
200
300
400
500
600
700
800 msec
H7: 180-FM
← A/D → SEAT-1
12/08/82
825 010


82S010


82S010A