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Vertical Drop Test of a Narrow- Body Transport Fuselage Section With Overhead Stowage Bins

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16. Abstract <p>A 10-foot-long fuselage section from a Boeing 737-100 was dropped from a height of 14 feet, generating a final velocity at impact of 30 feet per second. The fuselage section was configured to simulate the load density at the maximum takeoff weight condition. The final weight of 8870 pounds included cabin seats, dummy occupants, overhead stowage bins with contents, and cargo compartment luggage. The fuselage section was instrumented with strain gages, accelerometers, and high-speed cameras. The fuselage section sustained severe deformation of the cargo compartment. The cargo compartment luggage influenced the manner in which the fuselage crushed, affecting the g forces experienced by the fuselage section and the pulse duration. The seat tracks experienced a vertical impact pulse of 15 g and a pulse duration of approximately 135 milliseconds. Although numerous fuselage structural members fractured during the test, a habitable environment was maintained for the occupants, and the impact was considered survivable. Both overhead stowage bins maintained their structural integrity and remained attached to the fuselage. The bins sustained up to 14 g vertical loading. Distribution of the loads among the bin supports was different in the dynamic versus static case.</p>					
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TABLE OF CONTENTS

	Page
EXECUTIVE SUMMARY	ix
INTRODUCTION	1
BACKGROUND	1
DESCRIPTION OF TEST FACILITY AND TEST FUSELAGE SECTION	1
Test Facility	1
Test Fuselage Section	3
Test Fuselage Section and Drop Test Platform Orientation	7
TEST INITIATION	7
INSTRUMENTATION	7
Fuselage	11
Overhead Storage Bins	11
Hitco Bin	13
Link Calibrations	14
Static Bin Calibrations	16
Calibration Results	17
Heath Tecna Bin	18
Support Calibrations	22
Static Bin Calibrations	22
Calibration Results	22
Anthropomorphic Test Dummies	24
Drop Test Platform	25
Visual Imaging	27
DATA ACQUISITION AND REDUCTION	28
Data Acquisition Systems	28
NEFF 490	28
EME DAS-48S	29
Data Collection	29

Data Reduction	30
DATA ANALYSIS	30
Time to Impact	30
Impact Velocity	31
Airframe Acceleration	31
Sidewall Vertical Accelerations	33
Seat Track Vertical Accelerations	36
Bin Analysis	39
Hitco Bin	40
Heath Tecna Bin	45
Drop Test Platform	51
Platform Load Cells	51
Platform Accelerations	52
Platform String Potentiometer Displacements	52
Anthropomorphic Test Dummies	52
RESULTS AND DISCUSSION	52
Fuselage Structure	52
Overhead Stowage Bins	54
Comparison of Dynamic and Static Loading—Hitco Bin	55
Load Capability	56
Comparison of Dynamic and Static Loading—Heath Tecna Bin	56
Load Capability	56
Seats	57
CONCLUSIONS	57
REFERENCES	59
APPENDICES	
A—Calibration Data	
B—Test Data	
C—Photographic Documentation	

LIST OF ILLUSTRATIONS

Figure		Page
1	Dynamic Drop Test Facility	2
2	Dynamic Drop Test Facility and Fuselage Section	3
3	Fuselage Section	4
4	Fuselage Section, Showing Cargo Door and Reinforcing Beam	4
5	Fuselage Section Seat Numbering Scheme	5
6	Sensor Location	12
7	Hitco Bin	13
8	Strain Gage Bridge Location—Tie Rod Link	13
9	Strain Gage Bridge Location—Support Link	14
10	Strain Gage Bridge Location—Strut Link	14
11	Calibration of the Hitco Links	15
12	Strut Link Angles	16
13	Heath Tecna Bin	19
14	Strain Gage Bridge Location—HT1 and HT3	19
15	Strain Gage Bridge Location—HT2 and HT4	19
16	Strain Gage Bridge Location—HT5 through HT9	20
17	Strain Gage Bridge Location—HT10 and HT11	20
18	Calibration of the Heath Tecna Supports	21
19	ATD Location—Right Side	24
20	ATD Location—Left Side	25
21	Drop Test Platform	26
22	Camera Locations	27
23	NEFF 490 Data Acquisition System	28
24	EME DAS-48S Data Acquisition System	29
25	Typical Sidewall Vertical Acceleration	32
26	Typical Sidewall Vertical Velocity Change	32
27	Typical Seat Track Vertical Acceleration	33
28	Typical Seat Track Vertical Velocity Change	33
29	Left Upper Sidewall Vertical Accelerations	34
30	Left Lower Sidewall Vertical Accelerations	34
31	Right Upper Sidewall Vertical Accelerations	35
32	Right Lower Sidewall Vertical Accelerations	35
33	Left Inner Seat Track Vertical Accelerations	37
34	Left Outer Seat Track Vertical Accelerations	37
35	Right Inner Seat Track Vertical Accelerations	38
36	Right Outer Seat Track Vertical Accelerations	38
37	Hitco Bin—Vertical Acceleration (20 Hz)	42
38	Hitco Bin—Vertical Acceleration (100 Hz)	43
39	Hitco Bin—Calculated Vertical Velocity	43
40	Hitco Bin—Total Vertical Load	44
41	Hitco Bin—Total Lateral Load	44
42	Hitco Bin—Total Longitudinal Load	45

43	Heath Tecna Bin—Vertical Acceleration (20 Hz)	48
44	Heath Tecna Bin—Vertical Acceleration (100 Hz)	48
45	Heath Tecna Bin—Calculated Vertical Velocity	49
46	Heath Tecna Bin—Total Vertical Load	49
47	Heath Tecna Bin—Total Lateral Load	50
48	Heath Tecna Bin—Total Longitudinal Load	50
49	Drop Test Platform—Total Reacted Load	51
50	Cargo Area Deformation	53
51	Left View—Buckle of the Fuselage Skin	54
52	Front View—Fractured Cargo Frames	54

LIST OF TABLES

Table		Page
1	Seat and Anthropomorphic Test Dummy Locations	5
2	Fuselage Section Weight	6
3	Data Acquisition Systems—Configurations and Sensor Location	8
4	Hitco Bin—Link Angles	17
5	Hitco Bin—Vector Components of the Reacted Loads	18
6	Hitco Bin—Vertical Influence Coefficients	18
7	Heath Tecna Bin—Support Angles	23
8	Heath Tecna Bin—Vector Components of the Reacted Loads	23
9	Heath Tecna Bin—Vertical Influence Coefficients	24
10	Impact Velocity	31
11	Sidewall Vertical Accelerations	36
12	Seat Track Vertical Accelerations	39
13	Hitco Bin—Measured Peak Load for Each Link	41
14	Hitco Bin—Vector Component Link Loads at Maximum Bin Loading	41
15	Hitco Bin—Comparison of Cal_m vs Measured Vertical Loads	42
16	Heath Tecna Bin—Measured Peak Load for Each Support	46
17	Heath Tecna Bin—Vector Component Support Loads at Maximum Bin Loading	46
18	Heath Tecna Bin—Comparison of Cal_m vs Measured Vertical Loads	47
19	Drop Test Platform—String Potentiometer Maximum Displacements	52
20	Anthropomorphic Test Dummy Data	52
21	Cargo Area—Fuselage Crush Measurements	53
22	Hitco Bin—Dynamic/Static Influence Coefficients	56
23	Heath Tecna Bin—Dynamic/Static Influence Coefficients	56
24	Seat Damage	57

EXECUTIVE SUMMARY

On November 29, 2000, the Federal Aviation Administration (FAA) conducted a vertical impact test of a narrow-body transport airplane fuselage section, which included two different types of in-service overhead stowage bins. The test was conducted at the FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey. The objective of the test was to evaluate the response behavior of the overhead stowage bin installations when subjected to a severe, but survivable, impact condition. Of particular interest was a comparison of the pretest static, steady-state forces that the bins were subjected to during their calibration versus the dynamic forces generated during the impact test.

A 10-foot-long fuselage section from a Boeing 737-100 was dropped from a height of 14 feet, thereby generating a final velocity at impact of 30 feet per second. This is consistent with the vertical velocity change found in the Seat Dynamic Performance Standard in Title 14 Code of Federal Regulations (CFR) Part 25 paragraph 25.562(b)(1). The fuselage section was configured to simulate the load density at the maximum takeoff weight condition. The final weight of 8870 pounds included cabin seats, dummy occupants, overhead stowage bins with contents, and cargo compartment luggage. The test fuselage section was instrumented with strain gages, accelerometers, and high-speed cameras.

The fuselage section sustained severe deformation of the cargo compartment, crushing approximately two feet. The cargo compartment luggage influenced the manner in which the fuselage crushed, affecting the g forces experienced by the fuselage section and the pulse duration. The seat tracks experienced a vertical impact pulse of approximately 15 g's and a pulse duration of approximately 135 msec. Although numerous fuselage structural members fractured during the test, a habitable environment was maintained for the occupants, and the impact was considered survivable.

Both overhead stowage bins maintained their structural integrity and remained attached to the fuselage. The bins sustained up to 14-g's vertical dynamic loading. These bins were able to support dynamic loads in excess of twice the static load certification requirements. A comparison of dynamic versus static vertical loading factors for all instrumented supports, using strain gage data and accelerometer data, showed good agreement. However, the distribution of the loads among the bin supports was different in the dynamic versus static case. The maximum loading that the critical bin supports experienced during the test did not exceed 70% of their failure load.

The seats experienced approximately 15-g's vertical loading. This was in excess of the seat's Technical Standard Order (TSO) static load rating. The seats experienced damage ranging from limited damage of the cross tubes and spreader tubes to fracture of the rear seat legs causing the seats to collapse.

INTRODUCTION

On November 29, 2000, the Federal Aviation Administration (FAA) conducted a vertical impact test of a narrow-body transport airplane fuselage section, which included two different types of in-service overhead stowage bins. The test was conducted at the FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey. The objective of the test was to evaluate the response behavior of the overhead stowage bins and supports when subjected to a severe, but survivable, impact condition. Of particular interest was a comparison of the pretest static, steady-state forces that the bins were subjected to during their calibration versus the dynamic forces generated during the impact test. Response data obtained from this test can also be used to validate analytical models and/or calibrate the models as necessary.

A 10-foot-long fuselage section from a Boeing 737-100 was dropped from a height of 14 feet to simulate an impact velocity of 30 feet/second. This is consistent with the vertical velocity change found in the Seat Dynamic Performance Standard in Title 14 Code of Federal Regulations (CFR) Part 25 paragraph 25.562(b)(1) [1]. The fuselage section was configured to simulate the load density at the maximum takeoff weight condition. The weight included cabin seats, dummy occupants, overhead stowage bins with contents, and cargo compartment luggage. Structural response data were obtained during impact from instrumentation installed on the fuselage structure, floor structure, and the overhead stowage bins.

BACKGROUND

The FAA developed a Crash Dynamics and Engineering Development Program [2]. This vertical drop test is one of a series of transport airframe section tests conducted in support of the FAA's program regarding the retention of cabin mass items. Tests included the longitudinal acceleration test of overhead stowage bins in a transport airframe section [3], the vertical drop test of a transport fuselage section with overhead stowage bins and auxiliary fuel tank onboard [4], and the longitudinal acceleration tests of overhead stowage bins and auxiliary fuel tank in a transport airplane airframe section [5 and 6]. All the tests were conducted under severe, but survivable impact conditions. The longitudinal test [3] identified the reaction of a transport airplane fuselage section and the overhead stowage bins. The vertical impact test [4] showed the reaction of the fuselage section, the onboard overhead stowage bins, and the double-wall auxiliary fuel tank system. The longitudinal test [5] is primarily a data report, which presented the structural response and interaction between a transport airplane fuselage section, overhead stowage bins, and conformable auxiliary fuel tank system while [6] is the analysis of the overhead stowage bins response to this test.

DESCRIPTION OF TEST FACILITY AND TEST FUSELAGE SECTION

TEST FACILITY.

The drop test facility is comprised of two 57-foot vertical steel towers connected at the top by a horizontal platform (figures 1 and 2). An electrically powered winch, mounted on the platform and attached to a re-eved hoisting cable, is used to raise and lower the test fuselage section. A sheave block assembly hanging from the free end of the re-eved cable is attached to a solenoid-operated release hook. The airplane is connected to the release hook by a cable/turnbuckle

assembly, which is bolted to the fuselage section at four locations. The maximum lifting capacity of the vertical drop test facility is 30,000 pounds. Located below the winch cable assembly and between the tower legs is a 15- by 36.5-foot wooden platform which rests upon steel I-beams and is supported by 12 load cells.

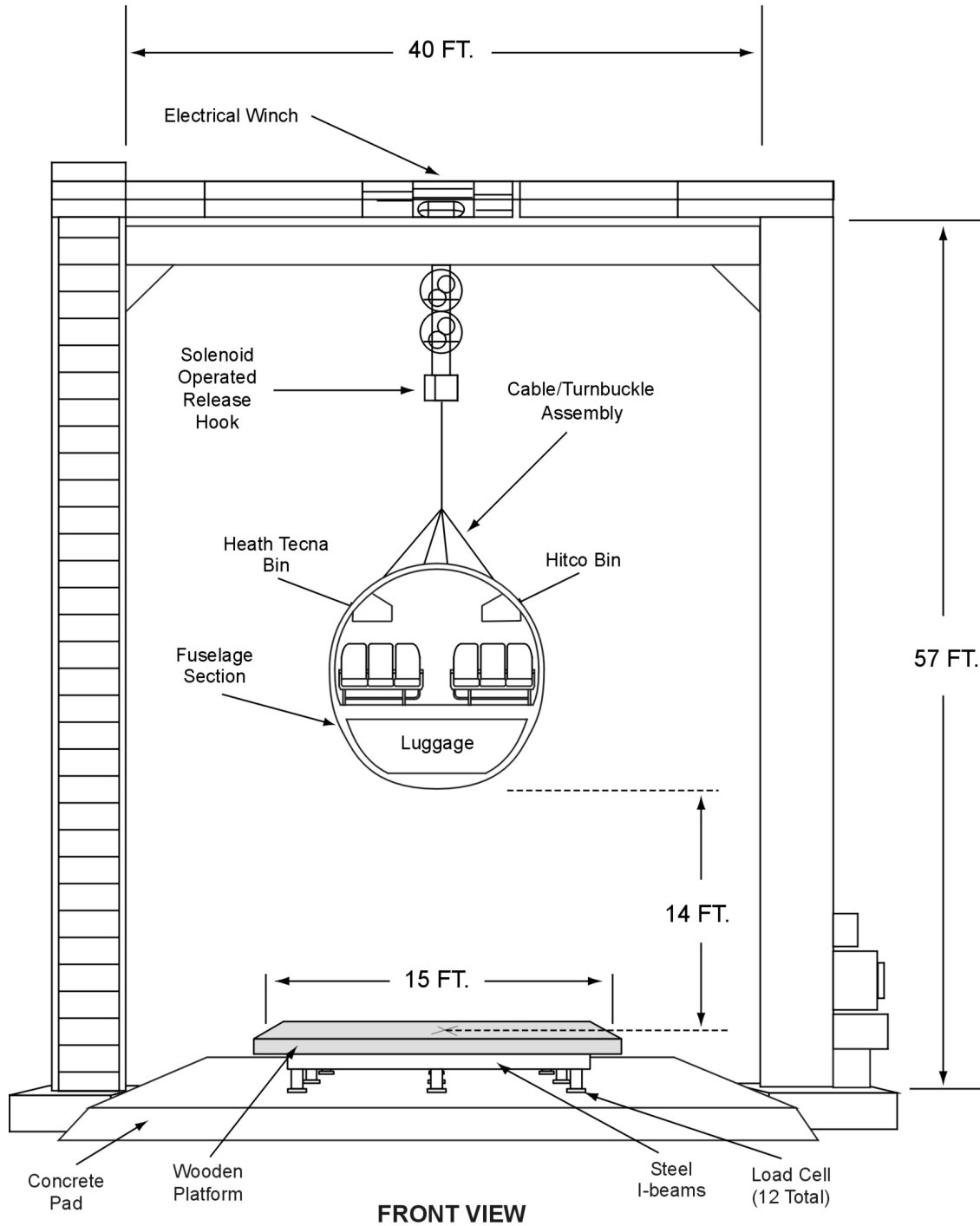


FIGURE 1. DYNAMIC DROP TEST FACILITY



FIGURE 2. DYNAMIC DROP TEST FACILITY AND TEST FUSELAGE SECTION

TEST FUSELAGE SECTION.

The fuselage section was a 10-foot section cut from fuselage station (FS) 380 to FS 500 of a Boeing 737-100 transport airplane (figure 3). The fuselage section included a below-floor cargo compartment with an access door located on the right (copilot) side (figure 4). The outer floor beams at each of end of the fuselage section were reinforced (figure 4) to minimize the open-end effects, i.e., to simulate the reaction that would be seen if an entire aircraft fuselage was tested. Nonstructural interior liners and insulation were removed from the fuselage section. The section was equipped with typical cabin seats, overhead stowage bins, and luggage.

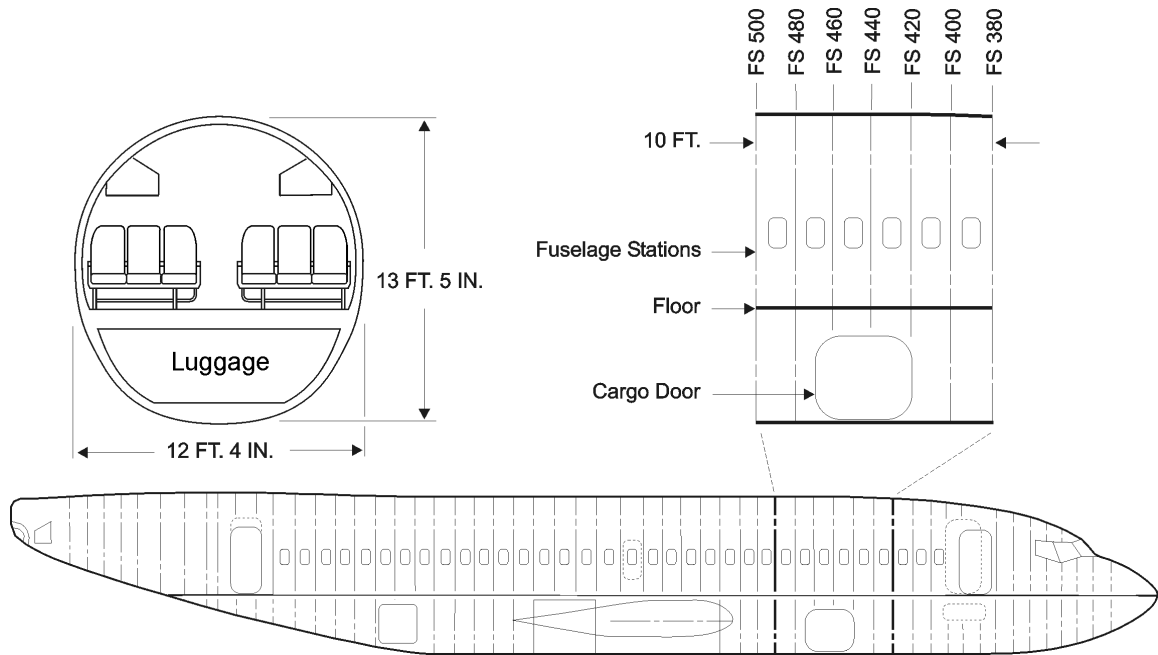


FIGURE 3. FUSELAGE SECTION
(From a Boeing 737-100 Airplane)

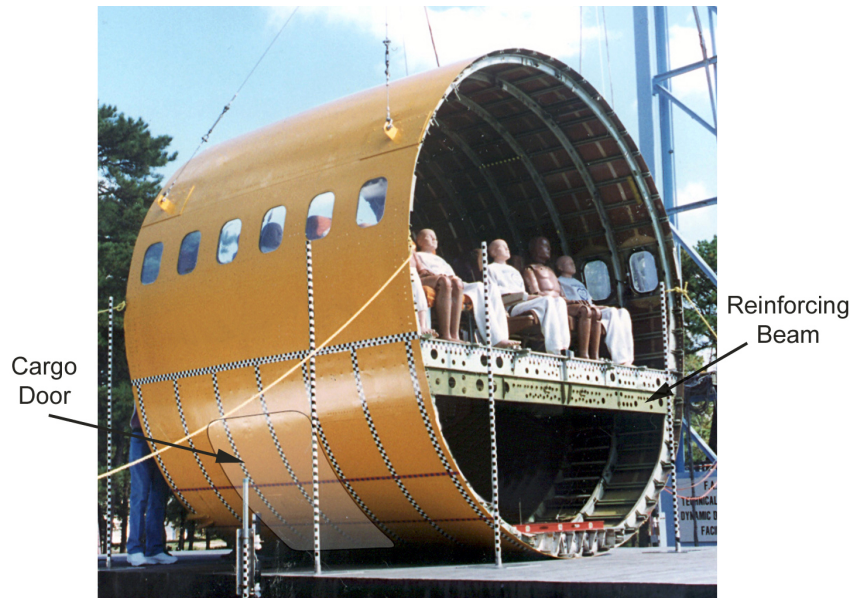


FIGURE 4. FUSELAGE SECTION, SHOWING CARGO DOOR AND
REINFORCING BEAM

The cabin section was configured with six triple cabin seats placed in three rows. Two different cabin seats were used in the test. UOP seats were installed on the right side, and Weber Aircraft seats were mounted on the left side. A 36-inch pitch was used on both sides. For the purpose of this report, the seats were numbered as shown in figure 5. All the seats were “9 g-rated seats” and contained a mannequin or an anthropomorphic test dummy (ATD). The ATDs are of the

Hybrid II type (14 CFR 25.572), manufactured to represent the 50th percentile male adult passenger. Table 1 gives the description of the seats and the ATD locations by fuselage station. The seats, dummies, and mannequins were used to achieve the desired fuselage section weight and provide comparative data to other tests; they were not of primary interest in this test.

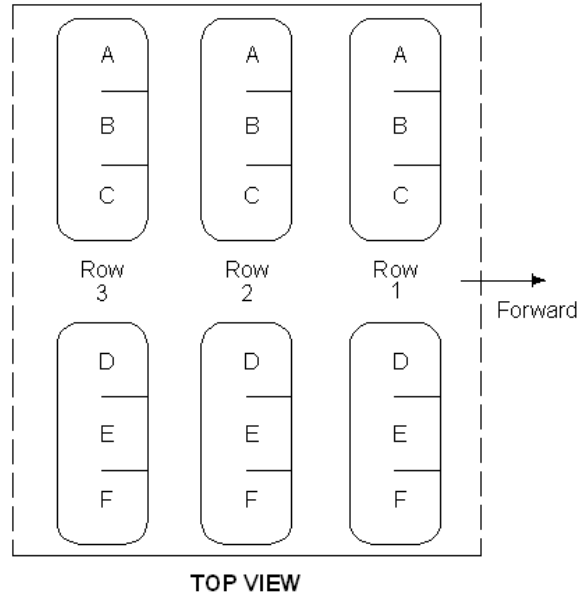


FIGURE 5. FUSELAGE SECTION SEAT NUMBERING SCHEME

TABLE 1. SEAT AND ANTHROPOMORPHIC TEST DUMMY LOCATIONS

Location	Seat Description	Seat Number	Occupants
FS 406 (Row 1)	Left Side Weber Aircraft Seat	A	Mannequin
		B	ATD #1
		C	Mannequin
	Right Side UOP Seat	D	Mannequin
		E	ATD #2
		F	Mannequin
FS 442 (Row 2)	Left Side Weber Aircraft Seat	A	Mannequin
		B	ATD #3
		C	Mannequin
	Right Side UOP Seat	D	Mannequin
		E	ATD #4
		F	Mannequin
FS 478 (Row 3)	Left Side Weber Aircraft Seat	A	Mannequin
		B	ATD #5
		C	Mannequin
	Right Side UOP Seat	D	Mannequin
		E	ATD #6
		F	Mannequin

Two different types of 60-inch overhead stowage bins were installed in the cabin. A Hitco bin was mounted on the left side between FS 409 and FS 469 and a Heath Tecna bin was mounted on the right side between FS 415 and FS 475. Both bins were loaded with plywood ballast to achieve their placarded maximum weight and centers of gravity (CG). Two Personal Service Units (PSUs)—control panels for lights, air, etc.—were attached under each bin. The loaded weight of the Hitco and Heath Tecna bins were 257 and 176 lbs, respectively. The bin doors were latched and strapped shut to ensure the bin contents remained inside the bins during the impact. The bins were instrumented with accelerometers and the support attachments were instrumented with strain gage bridges. Both of these sensors are discussed in the instrumentation section of this report.

The cargo area contained 98 bags of luggage, which were evenly distributed by weight. The luggage was held in place by cargo nets that were secured in the forward/aft sections of the fuselage. The luggage was also held down by cargo straps, which were mounted to the cargo floor, thus preventing any movement during free fall.

The test fuselage section also contained four high-speed cameras.

The total weight of the test fuselage section was 8870 pounds. The individual item weights are presented in table 2.

TABLE 2. FUSELAGE SECTION WEIGHT

Item	Weight (lb)	Quantity	Total (lb)
ATD	170	6	1020
Mannequin	161	12	1932
Cameras	22	4	88
UOP Seat	80	3	240
Weber Aircraft Seat	68	3	204
Heath Tecna Bin (empty)	56	1	56
Hitco Bin (empty)	57	1	57
Heath Tecna Bin Contents	120	1	120
Hitco Bin Contents	200	1	200
Fuselage	1360	1	1360
Luggage	3229	1	3229
Camera Mount	70	2	140
Switch box	7	1	7
Miscellaneous	217	1	217
Total			8870

TEST FUSELAGE SECTION AND DROP TEST PLATFORM ORIENTATION.

The test fuselage section and the drop test platform were centered below the release hook. The coordinate systems for both were referenced while standing in and looking toward the front of the test fuselage section. The fuselage coordinate system is per manufacturer's specifications. Locations correspond to the distance (inches) from the reference. Thus, FS 420 is denoted as being located +420 inches from the reference point (near the front of the aircraft) along the longitudinal (x axis). Distances measured in the lateral direction (left -y and right +y) are referenced from the longitudinal centerline. The relative height is referenced from the surface of the cabin floor (above floor +z, below -z). The reference point for the platform is the intersection of the geometric center of its length and width and the surface of the platform (corresponding to the x, y, and z axes, respectively). Positive directions are forward (+x), right (+y), and up (+z).

TEST INITIATION

Prior to the test, the four supporting cable/turnbuckle assemblies were adjusted to level the fuselage forward/aft and left/right. The data acquisition systems were started and the test fuselage section was raised 14 feet above the surface of the platform (measured from the bottom of the fuselage). Four guide ropes, manned by members of the drop test team, steadied the airplane while it hung above the platform. When the test fuselage section was steady and level, the automatic timing sequence was started. The high-speed film cameras and video cameras were activated and two seconds later, the test fuselage section was released. The wind prior to and during the test was calm.

INSTRUMENTATION

The descriptions and locations of all 127 sensors used during the test are listed in table 3. All the sensors were oriented to measure vertical reactions unless otherwise noted.

TABLE 3. DATA ACQUISITION SYSTEMS—CONFIGURATIONS AND
SENSOR LOCATION

Channel	Description	Sensor Mfg-Model	Unit	Location		
NEFF 490				X	Y	Z
101	FS 400 L Upper SW	Endevco 7231C-750	g's	400	-53	73
102	FS 400 L Lower SW	Endevco 7231C-750	g's	400	-68	12
103	FS 418 L Inner ST	Endevco 7231C-750	g's	418	-23	1
104	FS 418 L Outer ST	Endevco 7231C-750	g's	418	-44	1
105	FS 400 R Upper SW	Endevco 7231C-750	g's	400	58	67
106	FS 400 R Lower SW	Endevco 7231C-750	g's	400	68	12
107	FS 418 R Inner ST	Endevco 7231C-750	g's	418	23	1
108	FS 418 R Outer ST	Endevco 7231C-750	g's	418	44	1
109	FS 440 L Upper SW	Endevco 7231C-750	g's	440	-53	73
110	FS 440 L Lower SW	Endevco 7231C-750	g's	440	-68	12
111	FS 443 L ATD #3 Loadcell	R. Denton 1708	lbs	443	-36	24
112	FS 443 L ATD #3 Accel	Endevco 7231C-750	g's	443	-36	20
113	Platform Loadcell #4A	Interface 1231BMZ	lbs	72	-60	-32
114	Platform Loadcell #5A	Interface 1241BMZ	lbs	72	0	-32
115	Platform Loadcell #6A	Interface 1231 BMZ	lbs	72	60	-32
201	FS 440 R Upper SW	Endevco 7231C-750	g's	440	58	67
203	FS 440 R Lower SW	Endevco 7231C-750	g's	440	68	12
204	HT Bin Aft Accel	Endevco 7231C-750	g's	474	52	69
205	FS 452 R Outer ST X-Dir	Endevco 7231C-750	g's	452	44	1
206	FS 452 R Outer ST Y-Dir	Endevco 7231C-750	g's	452	44	1
207	FS 452 R Outer ST	Endevco 7231C-750	g's	472	44	1
208	FS 452 R Inner ST	Endevco 7231C-750	g's	452	23	1
209	FS 452 L Outer ST X-Dir	Endevco 7231C-750	g's	452	-44	1
210	FS 452 L Outer ST Y-Dir	Endevco 7231C-750	g's	452	-44	1
211	FS 452 L Outer ST	Endevco 7231C-750	g's	452	-44	1
212	FS 452 L Inner ST	Endevco 7231C-750	g's	452	-23	1
213	Platform Loadcell #7A	Interface 1231BMZ	lbs	-72	-60	-32
214	Platform Loadcell #8A	Interface 1241 BMZ	lbs	-72	0	-32
215	Platform Loadcell #9A	Interface 1231 BMZ	lbs	-72	60	-32
216	FS 480 L Upper SW	Endevco 7231C-750	g's	480	53	73
217	FS 480 L Lower SW	Endevco 7231C-750	g's	480	68	12
218	FS 484 L Outer ST	Endevco 7231C-750	g's	484	-44	1
219	FS 484 L Inner ST	Endevco 7231C-750	g's	484	-23	1
220	FS 480 R Upper SW	Endevco 7231C-750	g's	480	53	73
221	FS 480 R Lower SW	Endevco 7231C-750	g's	480	68	12
222	FS 484 R Inner ST	Endevco 7231C-750	g's	484	23	1
223	FS 484 R Outer ST	Endevco 7231C-750	g's	484	44	1
224	H9 Vertical Support Link	Strain Gage Bridge	lbs	480	-47	77
225	H10 Lateral Support Link	Strain Gage Bridge	lbs	480	-50	74
226	H11 Strut Link	Strain Gage Bridge	lbs	430	-48	75
227	H Bin Aft Accel	Endevco 7231C-750	g's	468	-35	73

TABLE 3. DATA ACQUISITION SYSTEMS—CONFIGURATIONS AND
SENSOR LOCATION (Continued)

Channel	Description	Sensor Mfg-Model	Unit	Location		
				X	Y	Z
NEFF 490						
228	H Bin Forward Accel	Endevco 7231C-750	g's	410	-35	65
229	H Bin Center Accel X-Dir	Endevco 7231C-750	g's	439	-35	65
230	H Bin Center Accel Y-Dir	Endevco 7231C-750	g's	439	-35	65
231	H Bin Center Accel	Endevco 7231C-750	g's	439	-35	73
301	HT7 CH A	Strain Gage Bridge	lbs	440	51	73
302	HT7 CH B	Strain Gage Bridge	lbs	440	53	70
303	HT8 CH A	Strain Gage Bridge	lbs	460	51	73
304	HT8 CH B	Strain Gage Bridge	lbs	460	53	70
305	HT9 CH A	Strain Gage Bridge	lbs	480	51	73
306	HT9 CH B	Strain Gage Bridge	lbs	480	53	70
307	HT10 CH A	Strain Gage Bridge	lbs	443	52	72
308	HT10 CH B	Strain Gage Bridge	lbs	445	52	72
309	HT10 CH C	Strain Gage Bridge	lbs	444	52	72
310	HT11 CH A	Strain Gage Bridge	lbs	449	52	72
311	HT11 CH B	Strain Gage Bridge	lbs	451	52	72
312	HT11 CH C	Strain Gage Bridge	lbs	450	52	72
313	HT Bin Center Accel	Endevco 7231C-750	g's	445	52	64
314	HT Bin Center Accel X-Dir	Endevco 7231C-750	g's	445	52	64
315	HT Bin Center Accel Y-Dir	Endevco 7231C-750	g's	445	52	64
401	HT Bin Forward Accel	Endevco 7231C-750	g's	416	52	69
402	IRIG Generator	True Time	volts	-	-	-
407	Windspeed Anemometer	Micro Response 2031	mph	-	-	-
409	FS-500 R Lower SW	Endevco 7231C-750	g's	500	70	12
413	FS-500 L Lower SW	Endevco 7231C-750	g's	500	-70	12
414	FS-380 L Inner ST	Endevco 7231C-750	g's	380	-23	1
415	FS-380 R Inner ST	Endevco 7231C-750	g's	380	23	1
416	H1 Tierod Link	Strain Gage Bridge	lbs	413	-32	84
417	H2 Tierod Link	Strain Gage Bridge	lbs	472	-32	86
418	H3 Vertical Support Link	Strain Gage Bridge	lbs	400	-47	77
419	H4 Lateral Support Link	Strain Gage Bridge	lbs	400	-49	74
420	H5 Vertical Support Link	Strain Gage Bridge	lbs	420	-47	77
421	H6 Lateral support Link	Strain Gage Bridge	lbs	420	-49	74
422	H7 Vertical Support Link	Strain Gage Bridge	lbs	460	-47	77
423	H8 Lateral Support Link	Strain Gage Bridge	lbs	460	-49	74
424	HT3 Aft Strut	Strain Gage Bridge	lbs	415	32	79
425	HT2 Forward Mating Support	Strain Gage Bridge	lbs	415	32	84
426	HT1 Forward Strut	Strain Gage Bridge	lbs	475	32	79
427	HT4 Aft Mating Support	Strain Gage Bridge	lbs	475	32	84
428	HT5 CH A	Strain Gage Bridge	lbs	400	51	73
429	HT5 CH B	Strain Gage Bridge	lbs	400	53	70
430	HT6 CH A	Strain Gage Bridge	lbs	420	51	73
431	HT6 CH B	Strain Gage Bridge	lbs	420	53	70

TABLE 3. DATA ACQUISITION SYSTEMS—CONFIGURATIONS AND
SENSOR LOCATION (Continued)

Channel	Description	Sensor Mfg-Model	Unit	Location		
DAS-48S				X	Y	Z
1	Platform Accel #1	Endevco 2262A-200	g's	217	-60	-204
2	Platform String Pot #1	Celesco PT 101-0020	inches	206	-60	-23/-38
3	Platform Loadcell #1B	Sensotec 41	lbs	218	-60	-32
4	Platform Accel #2	Endevco 2262A-200	g's	217	0	-204
5	Platform String Pot #2	Celesco PT 101-0020	inches	206	0	-23/-38
6	Platform Loadcell #2B	Sensotec 41	lbs	218	0	-32
7	Platform Accel #3	Endevco 2262A-200	g's	217	60	-132
8	Platform String Pot #3	Celesco PT 101-0040	inches	206	60	-23/-38
9	Platform Loadcell #3B	Sensotec 41	lbs	218	60	-32
10	Platform Accel #4	Endevco 2262A-200	g's	71	-60	-132
11	Platform String Pot #4	Celesco PT 101-0020	inches	72	-48	-23/-38
12	Platform Loadcell #4B	Interface 1231BMZ	lbs	72	-60	-32
13	Platform Accel #5	Endevco 2262A-200	g's	71	0	-132
14	Platform String Pot #5	Celesco PT 101-0020	inches	60	0	-23/-38
15	Platform Loadcell #5B	Interface 1241BMZ	lbs	72	0	-32
16	Platform Accel #6	Endevco 2262A-200	g's	71	60	-132
17	Platform String Pot #6	Celesco PT 101-0020	inches	72	48	-23/-38
18	Platform Loadcell #6B	Interface 1231BMZ	lbs	72	60	-32
19	Platform Accel #7	Endevco 2262A-200	g's	71	-60	-132
20	Platform String Pot #7	Celesco PT 101-0020	inches	-72	-48	-23/-38
21	Platform Loadcell #7B	Interface 1231BMZ	lbs	-72	-60	-32
22	Platform Accel #8	Endevco 2262A-200	g's	-72	0	-132
23	Platform String Pot #8	Celesco PT 101-0020	inches	-60	0	-23/-38
24	Platform Loadcell #8B	Interface 1241 BMZ	lbs	-72	0	-32
25	Platform Accel #9	Endevco 2262A-200	g's	71	60	-132
26	Platform String Pot #9	Celesco PT 101-0020	inches	-72	48	-23/-38
27	Platform Loadcell #9B	Interface 1231 BMZ	lbs	-72	60	-32
28	Platform Accel #10	Endevco 2262A-200	g's	-217	-60	-132
29	Platform String Pot #10	Celesco PT 101-0020	inches	-206	-60	-23/-38
30	Platform Loadcell #10B	Sensotec 41	lbs	-218	-60	-32
31	Platform Accel #11	Endevco 2262A-200	g's	-217	0	-132
32	Platform String Pot #11	Celesco PT 101-0020	inches	-206	0	-23/-38
33	Platform Loadcell #11B	Sensotec 41	lbs	-218	0	-32
34	Platform Accel #12	Endevco 2262A-200	g's	-217	60	-132
35	Platform String Pot #12	Celesco PT 101-0020	inches	-206	60	-23/-38
36	Platform Loadcell #12B	Sensotec 41	lbs	-218	60	-32
37	Platform String Pot #13	Celesco PT 101-0020	inches	0	0	-23/-38
38	FS 406 L ATD #1 Loadcell	R. Denton 1708	lbs	406	-36	24
39	FS 406 L ATD #1 Accel	Endevco 7231C-750	g's	406	-36	20
40	FS 406 R ATD #2 Loadcell	R. Denton 1707	lbs	406	36	24
41	FS 406 R ATD #2 Accel	Endevco 7231C-750	g's	406	36	20
42	FS 442 R ATD #4 Loadcell	Endevco 7231C-750	lbs	442	36	24
43	FS 442 R ATD #4 Accel	Endevco 7231C-750	g's	442	36	20
44	FS 478 L ATD #5 Loadcell	R. Denton 1708	lbs	478	-36	24

TABLE 3. DATA ACQUISITION SYSTEMS—CONFIGURATIONS AND
SENSOR LOCATION (Continued)

Channel	Description	Sensor Mfg-Model	Unit	Location		
DAS-48S				X	Y	Z
45	FS 478 L ATD #5 Accel	Endevco 7231C-750	g's	478	-36	20
46	FS 478 R ATD #6 Loadcell	R. Denton 1708	lbs	478	36	24
47	FS 478 R ATD #6 Accel	Endevco 7231C-750	g's	478	36	20
48	IRIG Generator	True Time	volts	-	-	-
D1	Hook Release Contact Switch			440	-	-
D2	Forward Contact Switch			380	-	
D3	Aft Contact Switch			500	-	

Note: Sensor excitation voltage equals 10 volts. See "Test Fuselage Section and Drop Test Platform Orientation" for details on each coordinate system. All the sensors were oriented to measure vertical reactions unless otherwise noted.

ST = Seat Track

L = Left C = Center R = Right
SW = Side Wall

H = Hitco Bin
HT = Heath Tecna Bin

FUSELAGE.

The fuselage instrumentation for this test included 32 Endevco model 7231C-750 accelerometers (figure 6) and three contact switches. Accelerometers in the cabin area were located on the sidewall frame sections. They were mounted at two locations, the lower level at 12 inches above the floor. The upper accelerometers were located near the overhead stowage bin mounting brackets at either 64 or 70 inches above the floor. Accelerometers were also mounted to the seat tracks at various locations throughout the cabin. Contact switches were used to determine the elapsed time between hook release and the impact of the fuselage onto the drop test platform. One contact switch was mounted to the release hook and two were mounted to the bottom of the fuselage.

OVERHEAD STOWAGE BINS.

Instrumented bin support brackets were used to measure and characterize the reaction of the bins. Critical supports were instrumented with strain gages configured and calibrated as load cells. Two types of calibrations were performed: a support calibration and a static bin calibration. The support calibration was conducted on each support to determine the sensitivity of each strain gage bridge. The sensitivity coefficients were programmed into the data acquisition systems so that the data was recorded as load data and not as an analog voltage. The static calibration of the bin installation was conducted to provide data for a force balance analysis in the vertical, lateral, and longitudinal directions. The static bin calibration was also conducted to determine the static influence coefficient of each bin support. The static influence coefficient is the relative load of the support in response to an applied static load in the vertical direction. The resulting influence coefficients provided the basis for the comparison of the bin reactions under static and dynamic loading.

Five accelerometers were mounted on each bin to measure accelerations and characterize the dynamic response of the bins. One accelerometer was attached to each end of the bin to measure acceleration in the vertical direction. Three accelerometers were mounted to the bottom of the bin in a triaxial configuration.

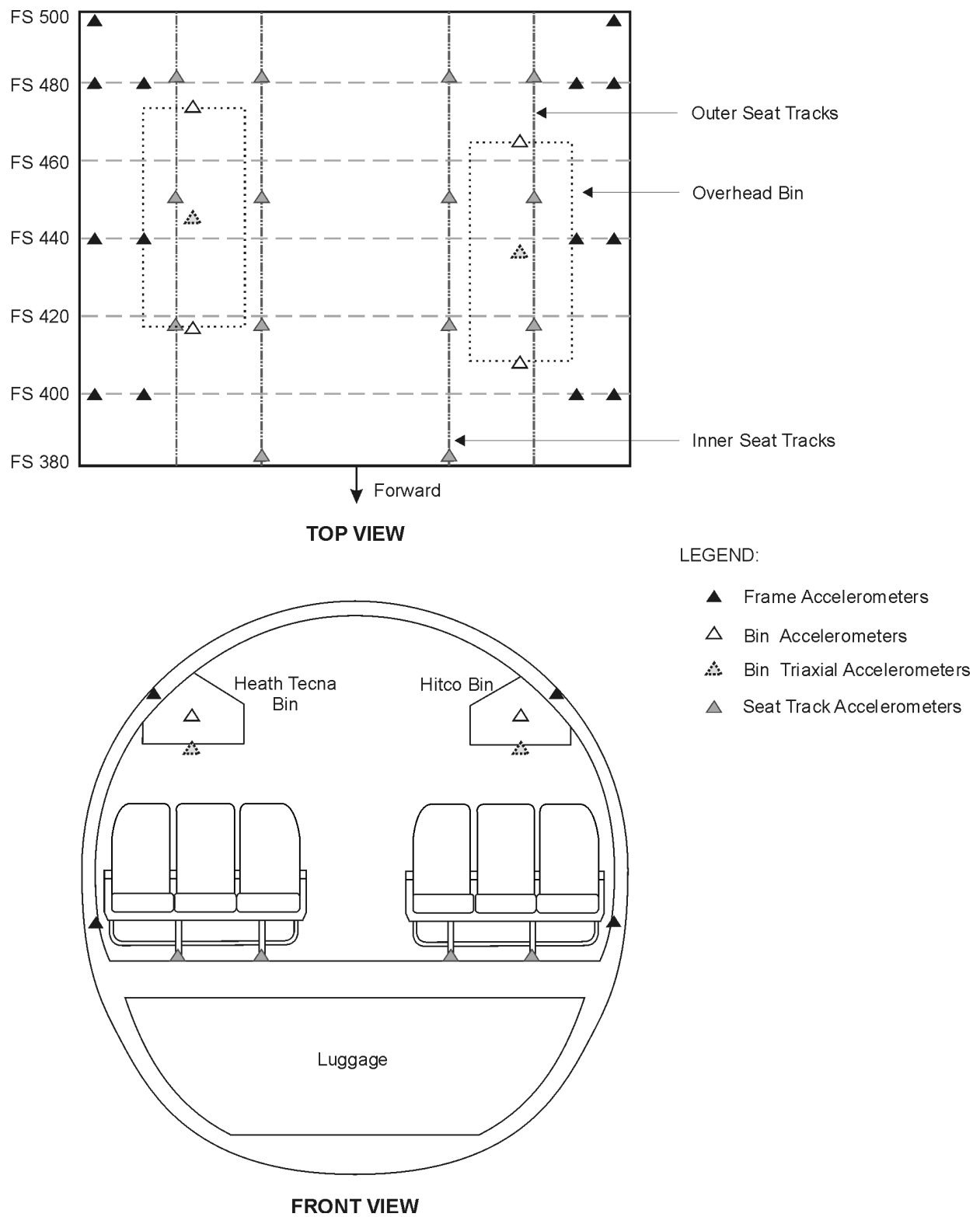


FIGURE 6. SENSOR LOCATION

Bin loading in the vertical, lateral, and longitudinal directions was determined by summing the vector components of each instrumented support. The bin-mounted accelerometers were used to determine the inertial loading in the vertical, lateral, and longitudinal directions. The inertial loads were then used to verify the measured loads of the instrumented bin supports.

HITCO BIN. The Hitco bin was secured to the aircraft by 11 instrumented support links (figure 7). Two tie rods (H1 and H2) and four support links (H3, H5, H7, and H9) were oriented primarily in the vertical direction. The four support links (H4, H6, H8, and H10) were oriented primarily in the lateral direction. The strut link (H11) was oriented primarily to react to loads in the longitudinal direction.

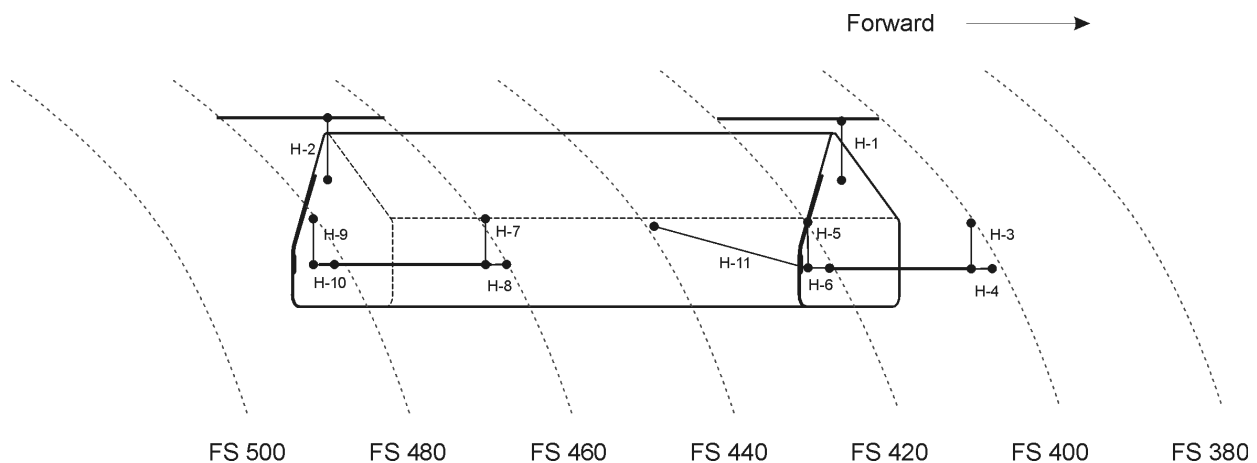


FIGURE 7. HITCO BIN

Figures 8, 9, and 10 show representative links and their corresponding strain gage bridge locations. Figure 11 shows the links, strain gage bridge locations, and calibration information. The strain gage bridges for these links were installed to measure axial loading only.

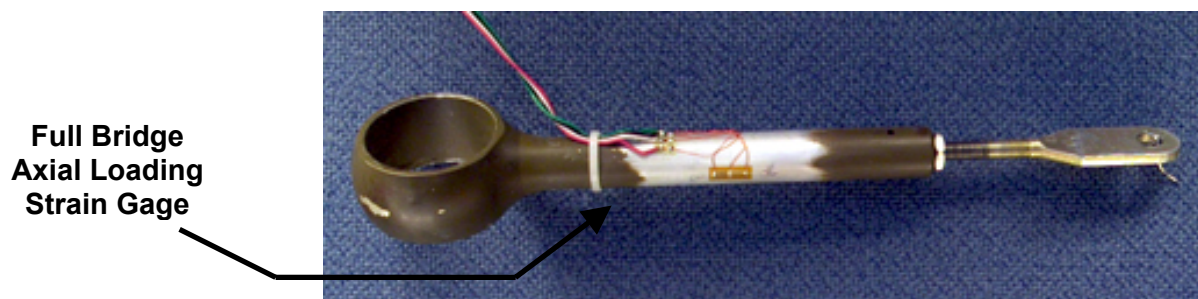


FIGURE 8. STRAIN GAGE BRIDGE LOCATION—TIE ROD LINK

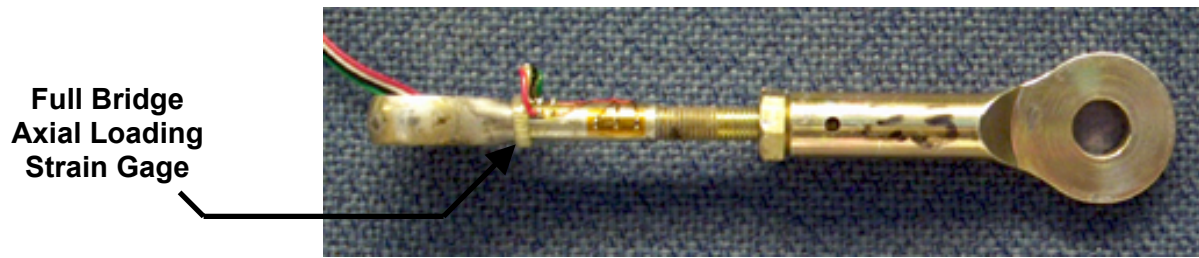


FIGURE 9. STRAIN GAGE BRIDGE LOCATION—SUPPORT LINK

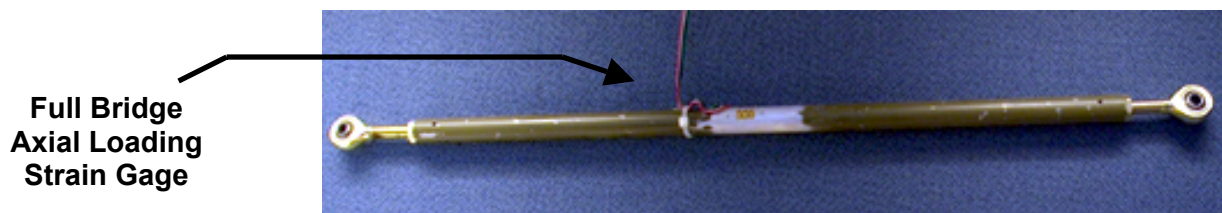


FIGURE 10. STRAIN GAGE BRIDGE LOCATION—STRUT LINK

Link Calibrations. The links were calibrated using a Material Testing System (MTS) machine. The links were fixtured to the MTS machine (see figures A-1 to A-3 in appendix A) and cycled through their calibration range, along their principal load path (figure 11). The load was applied incrementally, allowed to stabilize, and data was collected. The link was unloaded, the bolts that secured the support were loosened, and the process repeated two more times. Figures A-4 to A-14 show a representative calibration curve for each link. The data was consistent for all three calibrations. A linear best-fit curve was used to calculate the sensitivity coefficient, nonlinearity, and hysteresis for each link. A nominal value for each link is listed in table A-1.

A posttest check was conducted to determine the linearity of the tie rods (H1 and H2), for the load experienced by the support during the test. The supports were loaded to -600 lbs and +1250 lbs. The results, shown in figures A-15 and A-16, indicate linearity throughout the range.

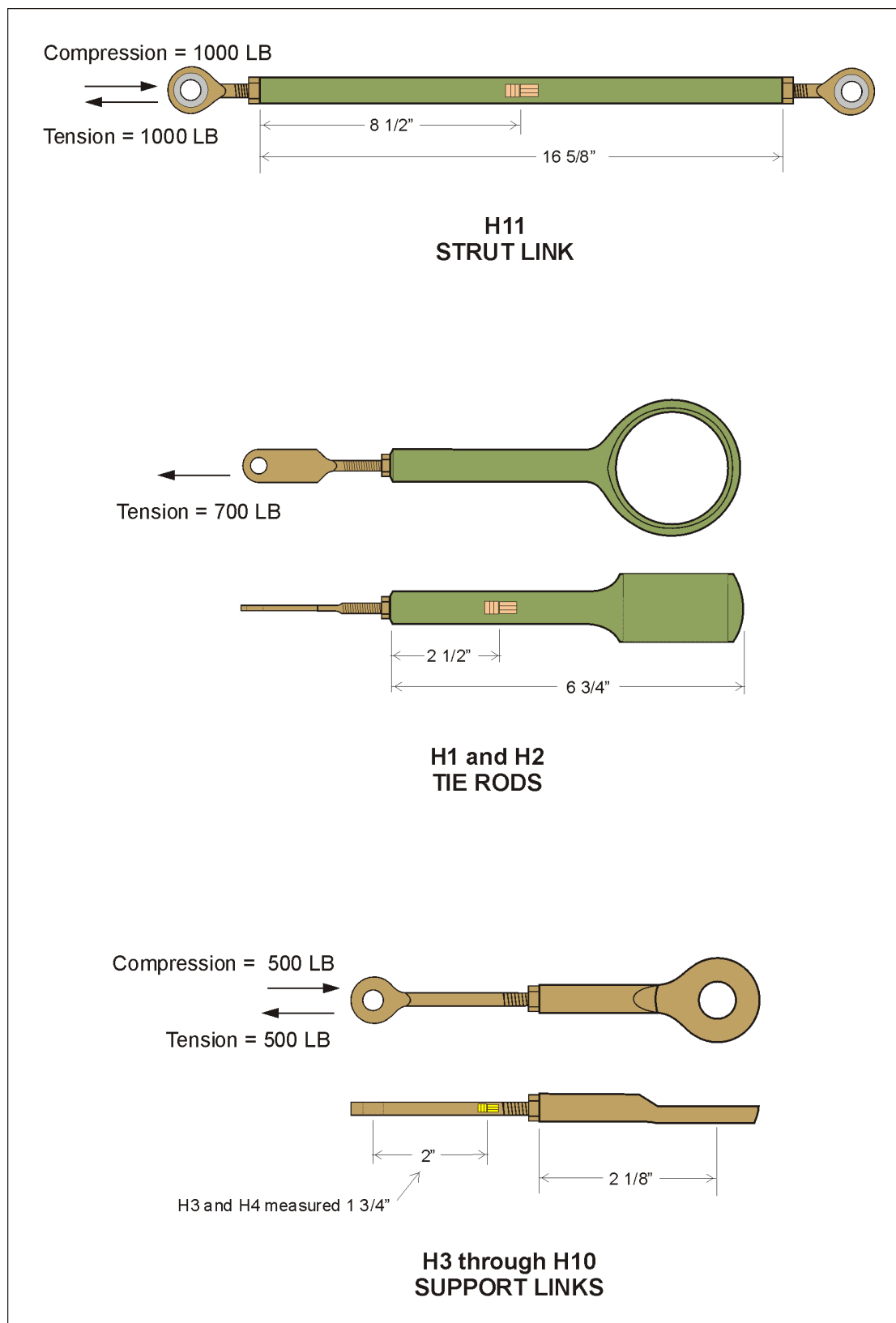


FIGURE 11. CALIBRATION OF THE HITCO LINKS

Static Bin Calibrations. Three identical static calibrations were performed on the Hitco bin to determine if the calibrations were within acceptable limits for static equilibrium, and to determine the influence coefficient for each support link. Prior to loading the bin, the angle of each link was measured with respect to the x, y, and z axes of the fuselage section. The bin was then symmetrically loaded in increments of 200 lbs until a load of 1000 lbs was reached. This represents a 5-g (1057-lb) static loading. The bin was then symmetrically unloaded in 200 lb increments. The angle of each of the links and the corresponding load data were recorded at each increment. A force balance analysis was then performed to compare the sum of the vector component loads (along each of the axes) to the applied load. The following equations were used.

Links H1 through H10

$$F_z = F(\sin \alpha) \quad (1)$$

$$F_y = F(\cos \alpha) \quad (2)$$

$$F_x = 0 \quad (3)$$

Strut Link H11

$$F_z = F(\sin \alpha) \quad (4)$$

$$F_y = F(\cos \alpha)(\sin \beta) \quad (5)$$

$$F_x = F(\cos \alpha)(\cos \beta) \quad (6)$$

where F_x , F_y , and F_z are the vector component loads in the x, y, and z directions, respectively. F is the measured (reacted) load, α is the angle between the principal load axis (link axis) and the horizontal plane, and β is the angle between the projection of the principal load axis on the horizontal plane and the x axis (figure 12).

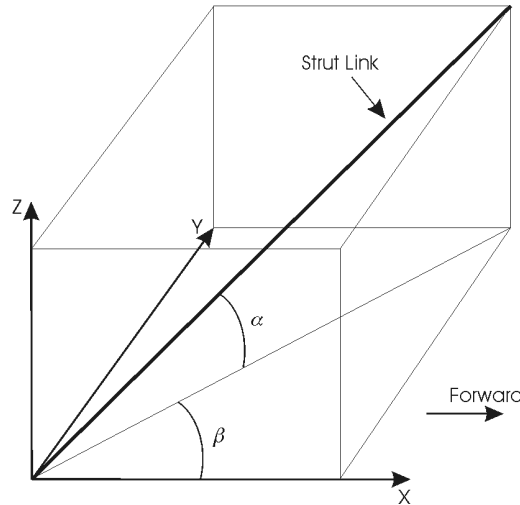


FIGURE 12. STRUT LINK ANGLES

The influence coefficient (I_s), in the z direction, was calculated by dividing the vertical component load (F_z) of each support link by the total vertical component load ($\sum F_z$) using the equation

$$I_s = \frac{F_z}{\sum F_z} \quad (7)$$

Calibration Results. The measured angles recorded from the three static calibrations were identical, and equal to the initial readings (table 4). The measured and resolved loads for the three calibrations are shown in tables A-2 to A-4. The averaged results for the force balance analysis showing the resolved reacted loads are presented in table 5. The averaged results for the z direction influence coefficients at an applied nominal load of 1000 lbs are listed in table 6. These influence coefficients were used in the analysis section of the report. Similar values were obtained at all applied loads.

TABLE 4. HITCO BIN—LINK ANGLES

Support	Angle α (Degree)	Angle β (Degree)
H1	93	--
H2	89	--
H3	82	--
H4	175	--
H5	84	--
H6	183	--
H7	94	--
H8	183	--
H9	87	--
H10	173	--
H11	13	17

TABLE 5. HITCO BIN—VECTOR COMPONENTS OF THE REACTED LOADS

Support	Load (lbs) Vertical (z) Direction	Load (lbs) Lateral (y) Direction	Load (lbs) Longitudinal (x) Direction
H1	355	19	----
H2	305	-5	----
H3	58	-8	----
H4	0	2	----
H5	105	-11	----
H6	-2	32	----
H7	112	8	----
H8	1	-15	----
H9	64	-3	----
H10	0	-2	----
H11	-5	-20	-58
Vector load	993	-5	-58
Applied load	1000	0	0
Difference	-7	-5	-58

TABLE 6. HITCO BIN—VERTICAL INFLUENCE COEFFICIENTS

Support	Influence Coefficient
H1	0.358
H2	0.307
H3	0.059
H4	0.000
H5	0.105
H6	-0.002
H7	0.113
H8	0.001
H9	0.064
H10	0.000
H11	-0.005

HEATH TECNA BIN. The Heath Tecna bin was secured to the aircraft by 11 instrumented supports (figure 13). The supports and the locations of their strain gages are shown in figures 14 to 17. Two vertically mounted struts (HT1 and HT3) and mating supports (HT2 and HT4) were paired and connected in series. These supports were oriented primarily in the vertical direction. The struts were attached to the ends of the bin, and their mating supports were indirectly attached to the fuselage.

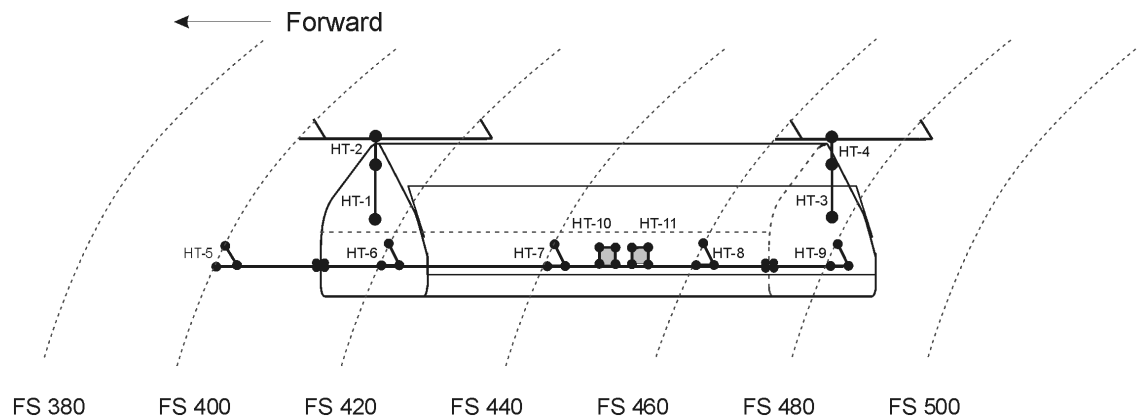


FIGURE 13. HEATH TECNA BIN

Supports HT5 to HT9 provide for vertical and lateral loading. These supports were mounted to the fuselage frame sections and to a support rail, which was attached to the bin. The bin was attached to the rail at two locations, one adjacent to HT6, and the other between HT8 and HT9. Supports HT10 and HT11 were attached to the rail and to a flange that straddled two frame sections. The primary function of these supports was to react the longitudinal loading of the bin.



FIGURE 14. STRAIN GAGE BRIDGE LOCATION—HT1 AND HT3

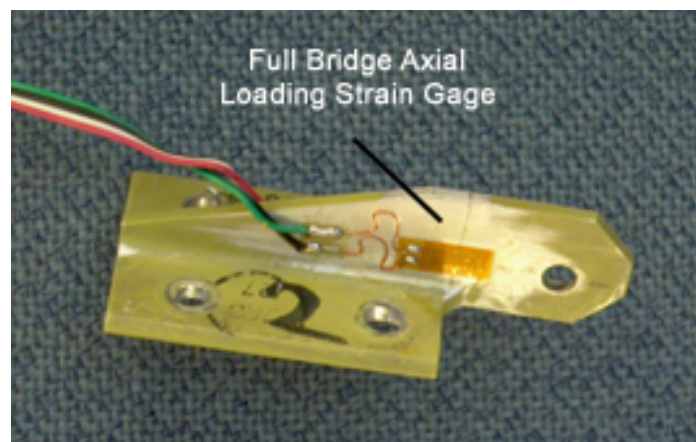


FIGURE 15. STRAIN GAGE BRIDGE LOCATION—HT2 AND HT4



FIGURE 16. STRAIN GAGE BRIDGE LOCATION—HT5 THROUGH HT9

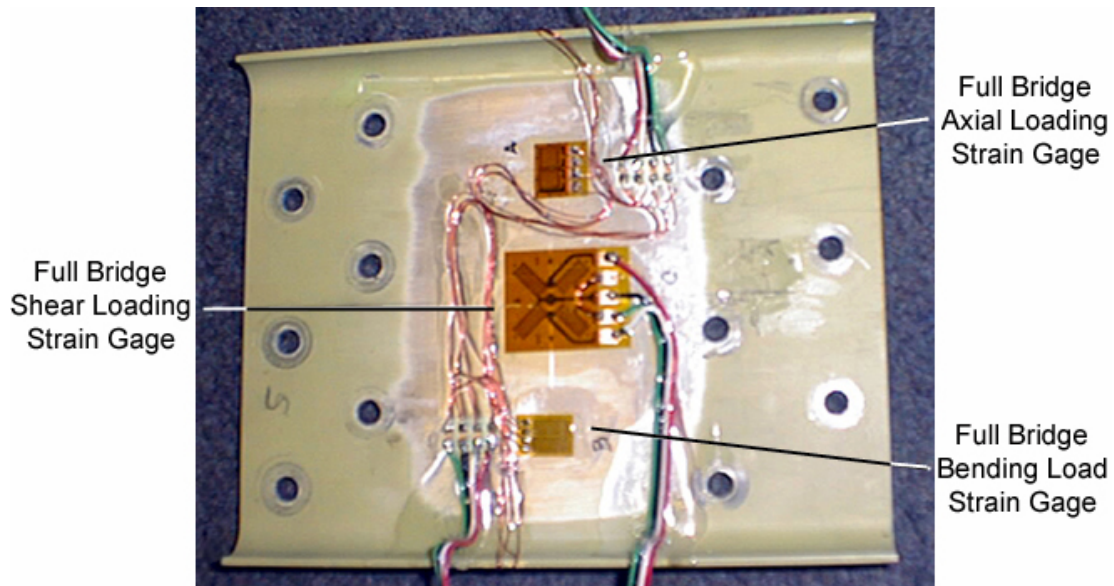


FIGURE 17. STRAIN GAGE BRIDGE LOCATION—HT10 AND HT11

Figure 18 shows representative supports and their strain gage locations, associated angles, and calibration information. All supports were configured to measure axial loading. In addition, supports HT10 and HT11 were configured to measure bending loads (HT10B and HT11B) and shear loads (HT10C and HT11C). HT10B and HT11B were used to determine bending loads during static conditions.

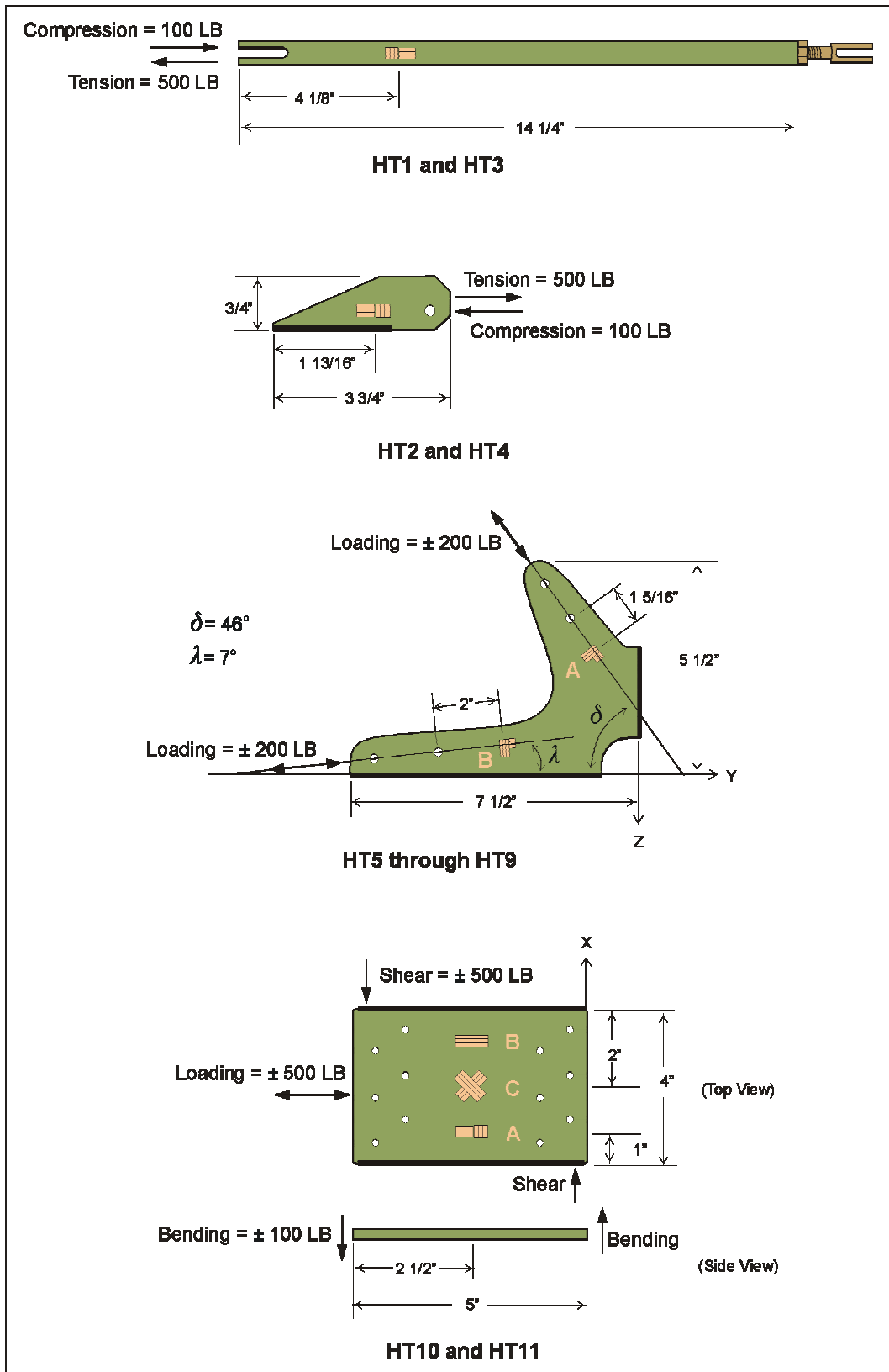


FIGURE 18. CALIBRATION OF THE HEATH TECNA SUPPORTS

Support Calibrations. The supports were calibrated using an MTS machine. The supports were fixtured to the MTS machine (figures A-17 to A-21) and cycled through their calibration range, along their principal load path (figure 18). The load was applied incrementally, allowed to stabilize, and data was collected. The support was then unloaded, the bolts that secured the support were loosened, and the process repeated two more times. During the calibration of supports HT5 to HT9, channels A and B were measured to determine if any unwanted cross talk existed. None was observed. Figures A-22 to A-41 show a representative calibration curve for each support. The data was consistent for all three calibrations. A linear best-fit curve was used to determine the sensitivity coefficient, nonlinearity, and hysteresis for each support. A nominal value for each supported is listed in table A-5.

A posttest check was conducted to determine the linearity of the struts (HT1 and HT3) and their mating supports (HT2 and HT4), for the load experienced by the support during the test. The supports were checked from -100 lbs to +1250 lbs. The results, shown in figures A-42 to A-45, still indicate linearity throughout their range.

Static Bin Calibrations. Three identical static calibrations were performed on the Heath Tecna bin to determine if the calibrations were within acceptable limits for static equilibrium and to determine the influence coefficients. Prior to loading the bin, the angle of each support was measured with respect to the x, y, and z axes of the fuselage section. The bin was then symmetrically loaded in increments of 100 lbs until a load of 600 lbs was reached. This represents a 5-g (656-lb) static loading. The bin was then symmetrically unloaded in 100 lb increments. The load and angle of the supports was recorded at each increment. A force balance analysis was then performed to compare the sum of the vector component loads (along each of the axes) to the applied load. The following equations were used.

Supports HT1 through HT11

$$F_z = F(\sin \alpha) \quad (8)$$

$$F_y = F(\cos \alpha) \quad (9)$$

$$F_x = 0 \quad (10)$$

Supports HT10C and HT11C

$$F_x = F \quad (11)$$

where F_x , F_y , and F_z are the vector component loads in the x, y, and z directions, respectively, F is the measured (reacted) load, and α is the angle between the principal load axis and the horizontal plane.

Calibration Results. The measured angles recorded from the three static calibrations were identical, and equal to the initial readings (table 7). The measured and resolved loads for the three calibrations are shown in tables A-6 to A-8. The averaged results for the force balance analysis showing the resolved reacted loads are presented in table 8. The z direction influence coefficients at an applied nominal load of 600 lbs are listed in table 9. These influence

coefficients were used in the analysis section of the report. Similar values were obtained at all applied loads.

TABLE 7. HEATH TECNA BIN—SUPPORT ANGLES

Support	Angle α (Degree)
HT1	85
HT2	85
HT3	90
HT4	90
HT5A	46
HT5B	7
HT6A	46
HT6B	7
HT7A	46
HT7B	7
HT8A	46
HT8B	7
HT9A	46
HT9B	7
HT10A	37
HT11A	37

TABLE 8. HEATH TECNA BIN—VECTOR COMPONENTS OF THE REACTION LOADS

Support	Load (lbs) Vertical (z) Direction	Load (lbs) Lateral (y) Direction	Load (lbs) Longitudinal (x) Direction
HT1	202	18	----
HT2	184	0	----
HT3	204	18	----
HT4	180	0	----
HT5A	40	38	----
HT5B	-3	-25	----
HT6A	73	71	----
HT6B	-5	-38	----
HT7A	18	17	----
HT7B	-1	-10	----
HT8A	46	44	----
HT8B	-4	-29	----
HT9A	70	68	----
HT9B	-6	-49	----
HT10A	-8	-10	----
HT10C	----	----	-6
HT11A	-13	-17	----
HT11C	----	----	-36
Vector load*	614	96	-42
Applied load	600	0	0
Difference	14	96	-42

*Note: Does not include HT2 and HT4 in total.

TABLE 9. HEATH TECNA BIN—VERTICAL INFLUENCE COEFFICIENTS

Support	Influence Coefficient
HT1	0.329
HT2	0.332
HT3	0.299
HT4	0.294
HT5A	0.064
HT5B	-0.005
HT6A	0.119
HT6B	-0.008
HT7A	0.029
HT7B	-0.002
HT8A	0.074
HT8B	-0.006
HT9A	0.115
HT9B	-0.010
HT10A	-0.012
HT10C	-----
HT11A	-0.021
HT11C	-----

ANTHROPOMORPHIC TEST DUMMIES.

There were six 50th percentile Hybrid II ATDs (14 CFR 25.572) onboard. All ATDs were instrumented with load cells (Denton model 1708) to measure spinal column axial loading in the lumbar area. Endevco model 7231C-750 accelerometers were also used to measure g forces in the pelvic region. The ATDs were located in the center seats (B and E) of each triple bench at FS 406, 442, and 478 as noted in table 1 and shown in figures 19 and 20.



FIGURE 19. ATD LOCATION—RIGHT SIDE



FIGURE 20. ATD LOCATION—LEFT SIDE

DROP TEST PLATFORM.

The wooden portion of the platform consisted of 205 wooden planks (15 feet long, 2 inches thick, and 20 inches high). The planks were placed side by side forming a 15-foot-wide, 10-inch-high and 36.5-foot-long platform. The planks were bolted together using connected steel rods running the length of the platform. The wooden platform rested on a framework of 12-inch steel I-beams that rested on 12 load cells. The total weight of the platform prior to the test was 40,274 lbs.

The drop test platform rested on 12 load cells (6 Sensotec model 41, 4 Interface model 1231, and 2 Interface model 1241) with load capacities of 50,000, 100,000, and 200,000 pounds, respectively. All platform load cells were dual-output, denoted as channels A and B. The load cell locations are shown in figure 21. Prior to the drop test, the platform was leveled and the tare weight electronically zero-balanced. The platform load cells were used to measure the impact loads and determine their distribution. The reaction forces generated during the impact of the test fuselage section may then be determined.

Twelve Endevco model 2262A-200 accelerometers were mounted to the bottom of the platform to characterize the platform response to the impact (figure 21). Platform response was measured because of the potential influence it may have on fuselage accelerometer readings.

Seven Celesco model PT101 string potentiometers and six Celesco model PT8101 string potentiometers were attached to the bottom of the platform to measure platform displacement (figure 21).

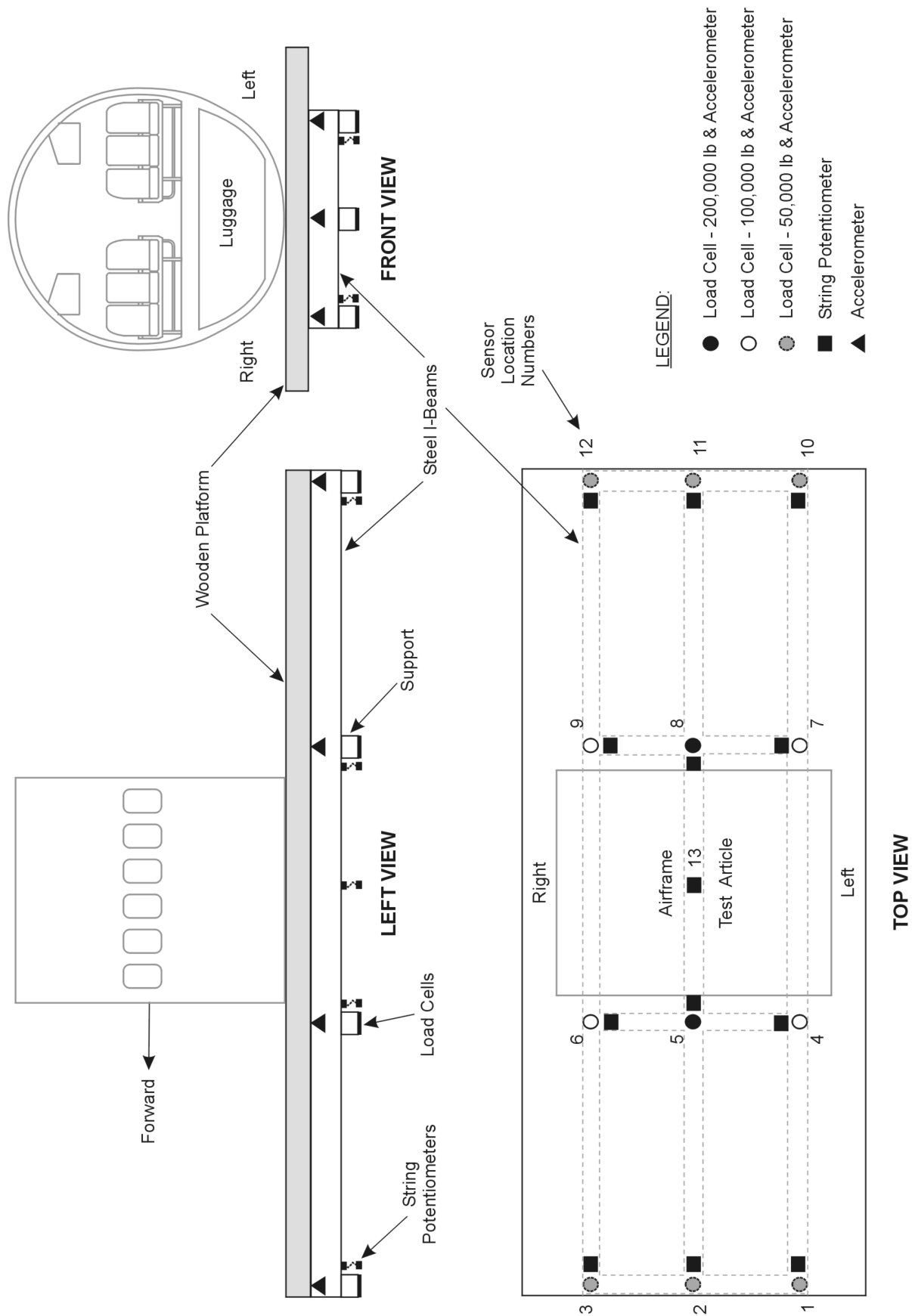


FIGURE 21. DROP TEST PLATFORM

VISUAL IMAGING.

Eleven high-speed (H/S) film cameras (500 frames per second) were used to record the test. Four of the cameras were onboard the test fuselage section to record the reaction of the bin supports. The remaining seven cameras were located around the exterior of the fuselage section and provided overall coverage of the fuselage section and areas of interest. All the cameras recorded date and time information, which was supplied by a satellite-based time code receiver. This allowed for the precision time stamping of each frame of film and provided a means to synchronize the time among all cameras as well as the recorded data. Seven standard video cameras (30 frames per second) were also located around the exterior of the fuselage section to provide overall coverage of the test. Camera locations are shown in figure 22. Two event bulbs were also used to indicate hook release.

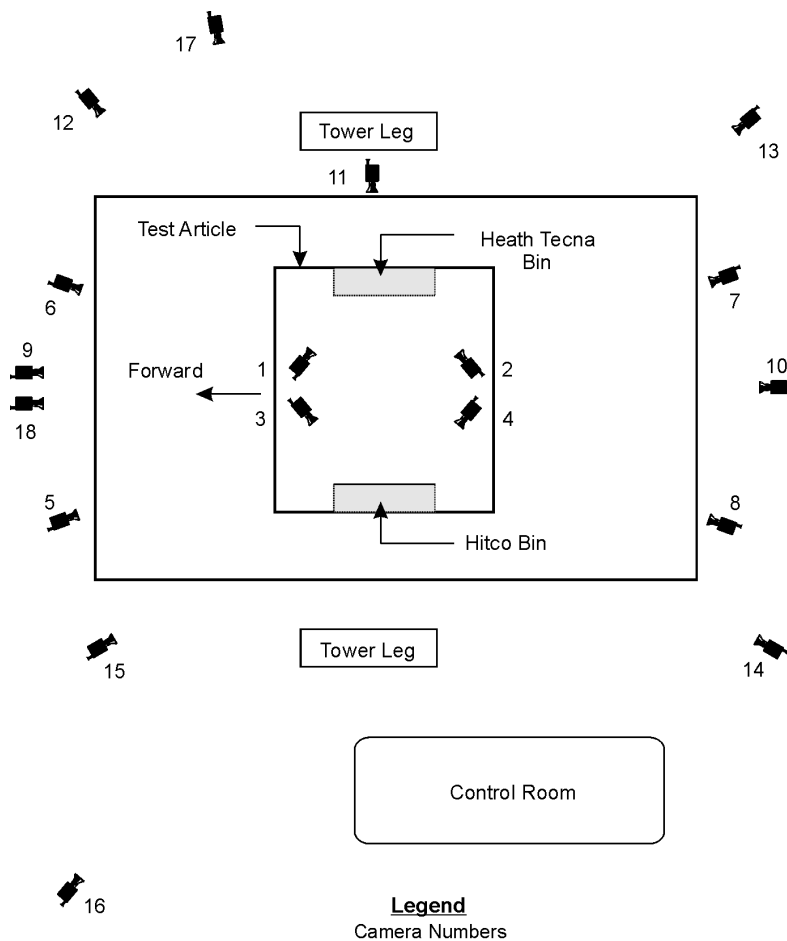


FIGURE 22. CAMERA LOCATIONS

DATA ACQUISITION AND REDUCTION

DATA ACQUISITION SYSTEMS.

A Neff 490 and an EME DAS-48S, data acquisition system were used to collect test data. They were controlled by two independent personal computers (PC). A pulse generated by a satellite based time code receiver was used to synchronize the two systems to the high-speed film.

NEFF 490. The NEFF 490 (figure 23) is a high-speed data acquisition system with the capability to sample and record data at sampling rates of up to 100 kHz per channel. The system consists of 92 channels. Each channel includes a 12-bit analog-to-digital (A/D) converter, a six-pole Bessel anti-alias filter with four programmable cutoff frequencies (100, 200, 1000, and 2000 Hz). Analog input is fed to a differential input amplifier with 12 programmable gain steps. Full-scale range inputs are selectable from ± 5 mV to ± 10.24 V.



FIGURE 23. NEFF 490 DATA ACQUISITION SYSTEM

For this test, the system was set to sample and record 77 channels of data simultaneously at 10,000 samples per second per channel. All data channels were prefiltered at a cutoff frequency of 1 kHz. The data was collected and stored in 512 Kbytes of onboard memory. Test data were then transferred to a PC by an IEEE-488 interface for further analysis. The full-scale range for each channel was selected based upon the expected output of the sensor.

EME DAS-48S. The EME DAS-48S (figure 24) is a high-speed, small, flexible, rugged portable data acquisition system. The system can acquire analog and digital data at rates up to 20 kHz per channel. The system consists of 48 analog channels and 24 digital channels. All channels were simultaneously sampled. The system has a 12-bit A/D converter and a six-pole Butterworth anti-alias filter with a programmable cutoff frequency (from 10 Hz to 20 kHz). Analog input is fed to a differential input amplifier with variable gain of 1 to 1000. The maximum input voltage is ± 2.5 volts.

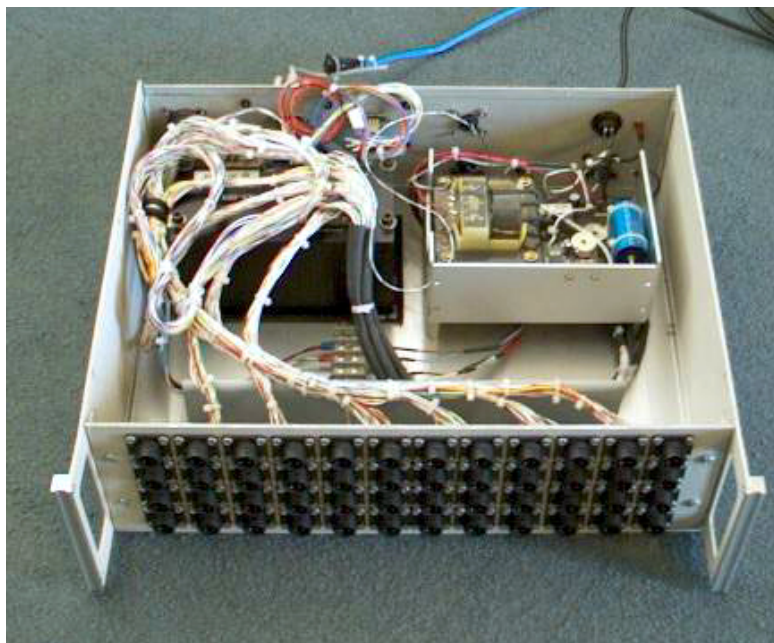


FIGURE 24. EME DAS-48S DATA ACQUISITION SYSTEM

For this test, the system was set to sample and record 48 channels of analog data and three channels of digital data. A sampling rate of 7500 was used (versus 10,000 for the Neff 490) due to a software limitation. All data channels were prefiltered at a cutoff frequency of 1 kHz. The data was collected and stored in 32 megabytes of onboard memory. Test data were then transferred to a PC by an RS-232/422 interface for further analysis. The gain value for each channel was selected based upon the expected output of the sensor.

DATA COLLECTION.

Before the test, the bridge output voltage for each channel's sensor was zero-balanced to compensate for any variation in the zero state of the sensor. The channels were then calibrated. All phases of balancing the bridge output voltage, calibrating the channels, measuring sensitivity,

and determining conversion coefficients for calculating engineering units were controlled by the data acquisition system software based upon user inputs.

The two systems were programmed to collect data in a pretrigger mode, a technique that allows the continuous sampling and storing of data in a buffer prior to the test trigger. The two data systems collected and saved the data 2 seconds prior to and 8 seconds after hook separation. The data acquisition systems were enabled prior to the hoisting of the fuselage section, thus insuring that data would be collected in the event of an inadvertent hook release. A Bowen 10-channel sequencer, was used to initiate the test sequence, including hook release, and controlled all the video, camera equipment, and accessories.

DATA REDUCTION.

DSP Development Corporation's DADiSP data analysis software was used to analyze the data.

For the purposes of this test, time zero (T_0) was defined as the moment of impact as observed on the high-speed film and confirmed via the recorded data. This time was November 29, 2000, at 18:30:13.284.

An SAE J211 class 600 (1000 Hz) digital filter [7] was used to filter the ATD load cell data. An SAE J211 class 60 (100 Hz) digital filter was used to filter all the other sensor data. However, the use of this filter did not provide adequate filtering to determine the fundamental accelerometer pulse shape. Posttest analysis of the fuselage and bin acceleration data indicated that the data exhibited large swings in value. These swings greatly influenced the pulse shape and amplitude, yet had a minimum affect on the fuselage and bin structural response. A 20-Hz digital filter was designed using SAE J211 guidelines to remove unwanted signals and provide the needed pulse definition. The use of this filter [8] was justified by showing that the integrated filtered pulse yielded the same velocity value as the unfiltered data and 100-Hz filtered data. Twenty-Hz filtered accelerometer data was used for the sidewall, seat tracks, and bin accelerations unless otherwise noted.

DATA ANALYSIS

TIME TO IMPACT.

The theoretical free-fall time of the airplane, 0.933 second, was calculated using the equation

$$t = \sqrt{\frac{2h}{g}} \quad (12)$$

where t is time, h is the drop test distance (14 ft), and g is the acceleration due to gravity (32.2 ft/sec^2). The measured free-fall time was the elapsed time between closure of the hook contact switch and the earliest closure of either the forward or aft bottom fuselage-mounted contact switch. A time of 0.935 and 0.936 second was calculated for the switches respectively. The times of the two contact switches indicate that the fuselage section was relatively level, at the time of impact with the drop test platform.

IMPACT VELOCITY.

The theoretical impact velocity was determined by the kinematic equation

$$v_t = \sqrt{2gh} \quad (13)$$

where v_t is the final theoretical velocity, g is the acceleration due to gravity, and h is the drop test distance. Using this equation, the theoretical impact velocity is 30 ft/sec.

The calculated velocity was determined by the kinematic linear motion equation

$$v_b - v_0 = gt \quad (14)$$

where v_b is the final calculated velocity, v_0 is the initial velocity (0 ft/sec), g is the acceleration due to gravity, and t is the measured free-fall time. Using this equation, the calculated impact velocity was 30 ft/sec.

Table 10 shows the drop test velocities obtained using the different methodologies.

TABLE 10. IMPACT VELOCITY

Methodology	Velocity (ft/sec)
Theoretical	30
Calculated	30

AIRFRAME ACCELERATION.

Airframe acceleration data are presented in two groups: sidewall vertical accelerations and seat track vertical accelerations. Airframe accelerometer locations are shown in table 3. For comparison, airframe acceleration data were filtered with 100 and 20 Hz filters. The filtered data can be found in appendix B. Typical sidewall and seat track accelerations and velocity changes are shown in figures 25 through 28.

Airframe data is given in terms of four parameters: pulse duration (Δt), maximum acceleration (G_{max}), peak acceleration (G_{peak}), and time of peak acceleration (t_{peak}). The G_{max} values were computed based on an idealized triangular pulse assumption

$$G_{max} = 2 \frac{\Delta V}{\Delta t} \quad (15)$$

where Δt is the difference between the start and stop times of the integration interval, and ΔV is the velocity change determined by integrating the acceleration data during Δt . All accelerations are in the vertical direction unless otherwise noted.

The fundamental impact pulse (20-Hz data) represents the overall impact response. The primary impact pulse represents the most significant pulse within the fundamental impact response.

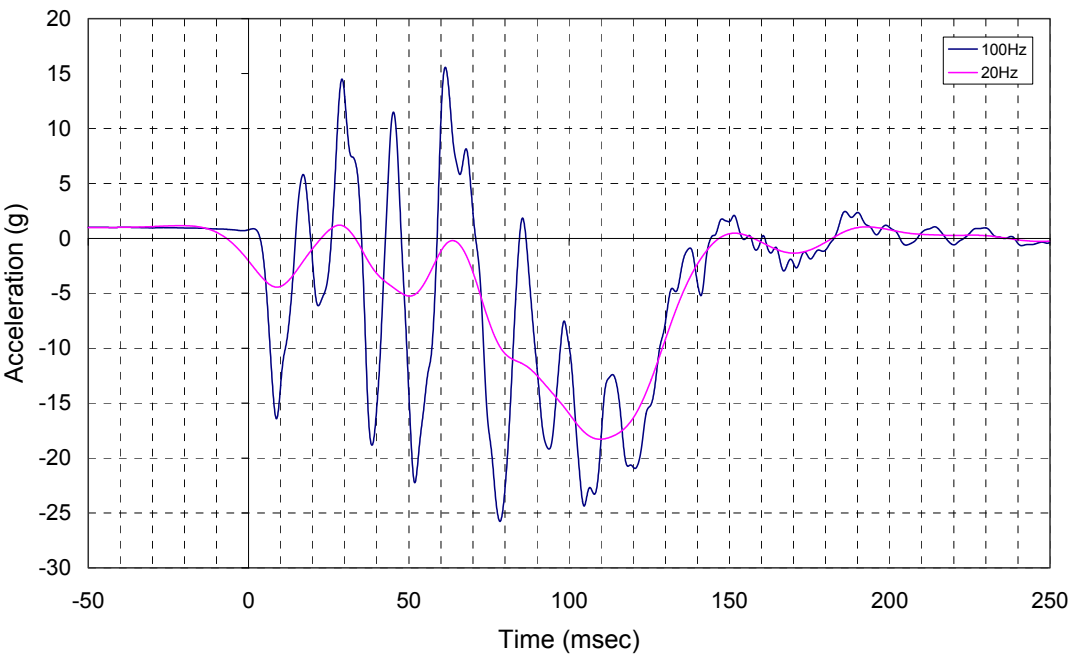


FIGURE 25. TYPICAL SIDEWALL VERTICAL ACCELERATION

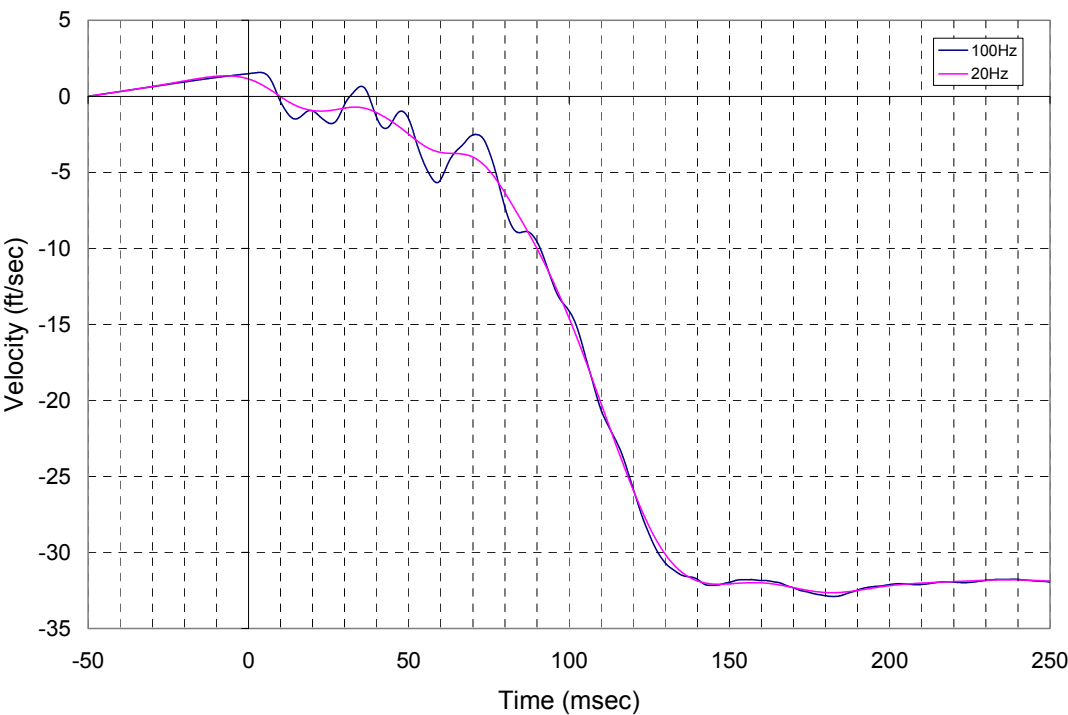


FIGURE 26. TYPICAL SIDEWALL VERTICAL VELOCITY CHANGE

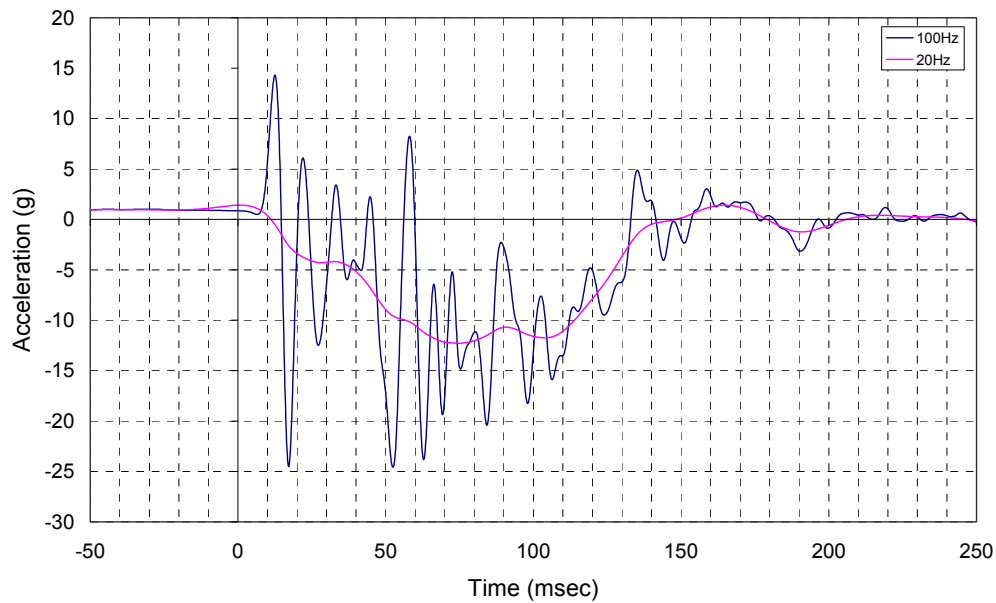


FIGURE 27. TYPICAL SEAT TRACK VERTICAL ACCELERATION

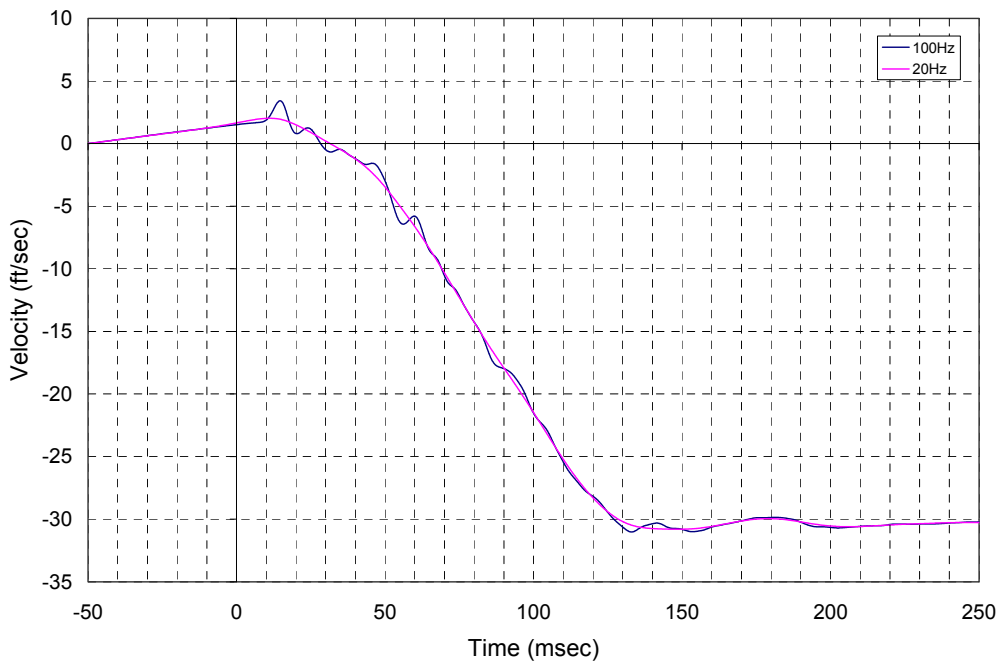


FIGURE 28. TYPICAL SEAT TRACK VERTICAL VELOCITY CHANGE

SIDEWALL VERTICAL ACCELERATIONS. The sidewall accelerations are presented in four groups: left upper accelerations, left lower accelerations, right upper accelerations, and right lower accelerations. The graphs of each group are shown in figures 29 to 32. (Note that the left lower sidewall accelerometer at FS 440 and the right upper sidewall accelerometer at FS 480 are

suspect since acceleration data show reverse direction reaction and unreasonable values. Therefore, the acceleration data at those locations were not used.)

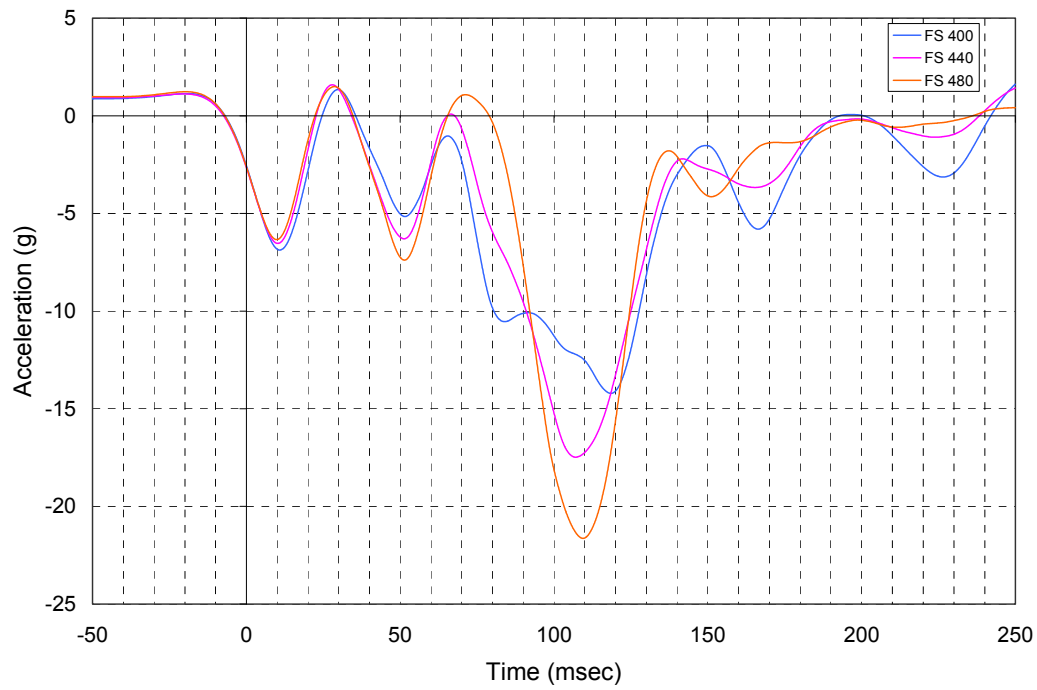


FIGURE 29. LEFT UPPER SIDEWALL VERTICAL ACCELERATIONS (20 Hz)

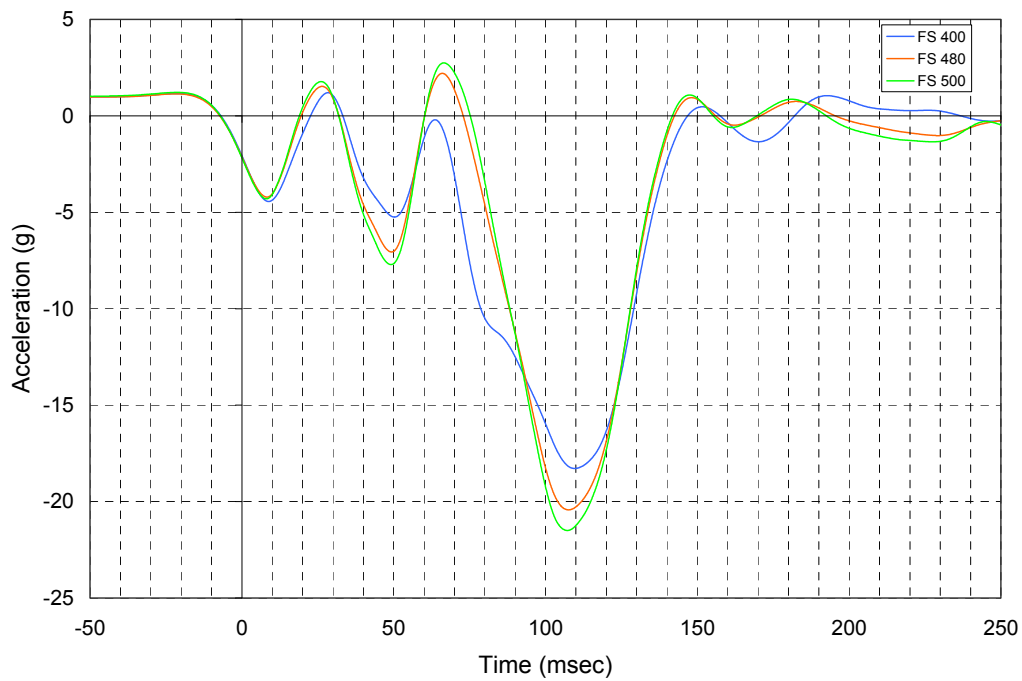


FIGURE 30. LEFT LOWER SIDEWALL VERTICAL ACCELERATIONS (20 Hz)

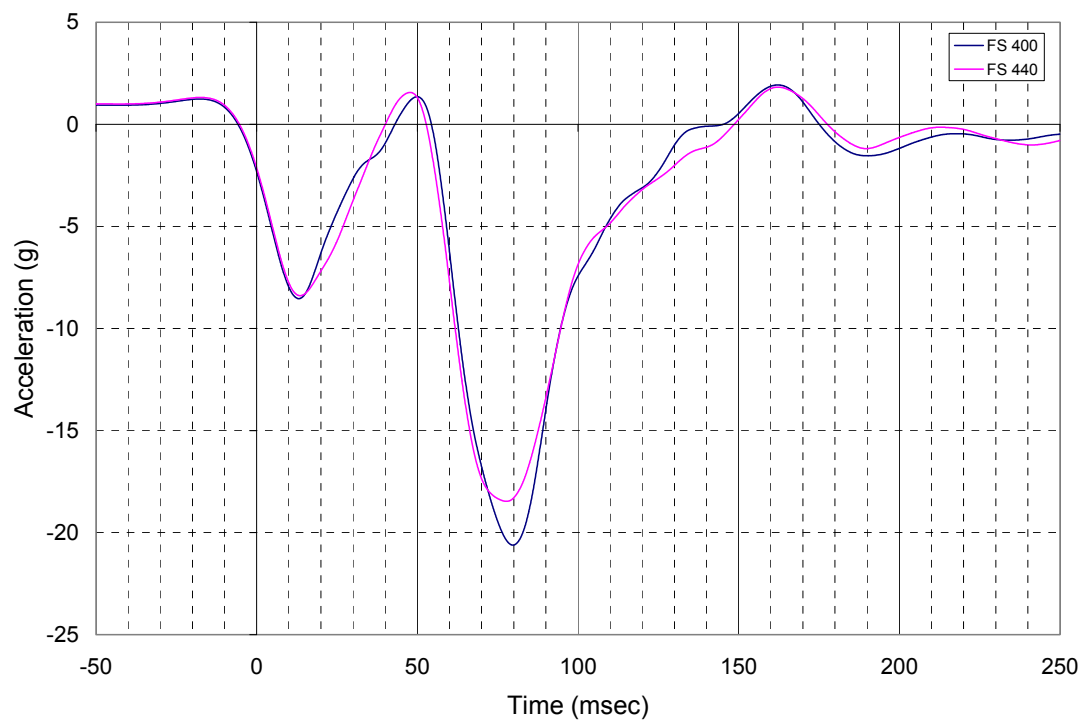


FIGURE 31. RIGHT UPPER SIDEWALL VERTICAL ACCELERATIONS (20 Hz)

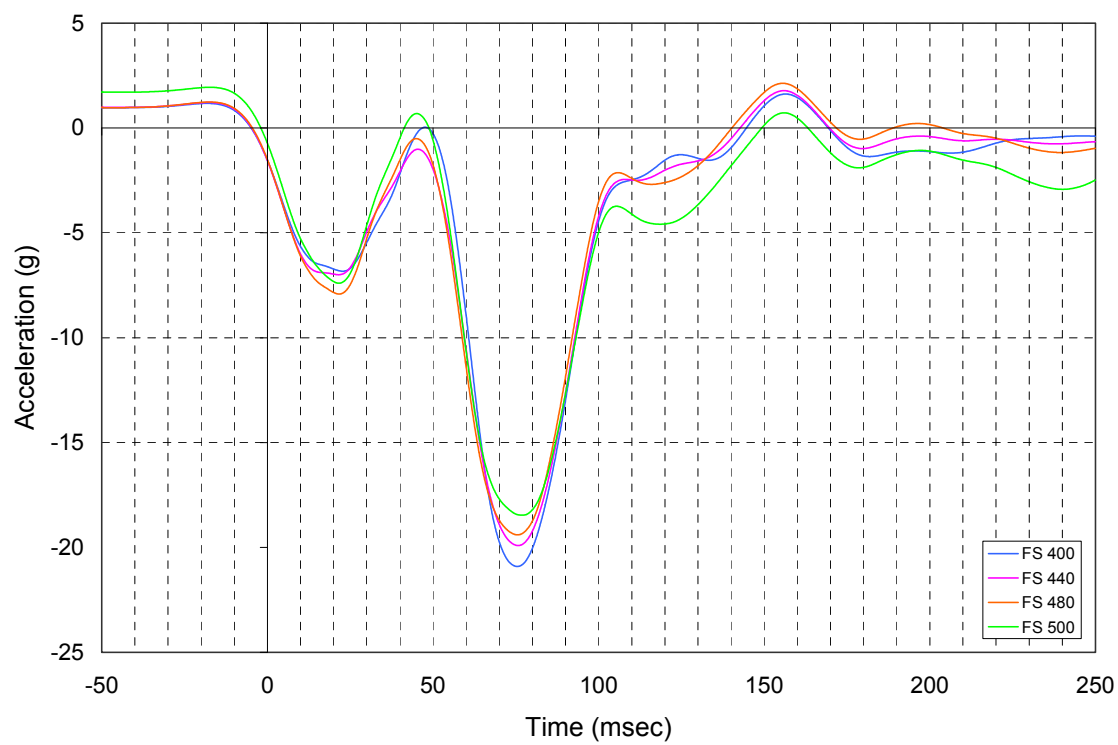


FIGURE 32. RIGHT LOWER SIDEWALL VERTICAL ACCELERATIONS (20 Hz)

The left sidewall fuselage acceleration data shows two small peaks preceding the major peak, which occurred at approximately 109 milliseconds after impact. The right sidewall fuselage acceleration data shows only a single small peak preceding the major peak, which occurred at approximately 77 milliseconds after impact. This could indicate that the cargo door located on the right-hand side affected the airframe accelerations. The sidewall acceleration results, fundamental impact pulse [8], and primary impact pulse are shown in table 11.

TABLE 11. SIDEWALL VERTICAL ACCELERATIONS (20 Hz)

		Fundamental Impact Pulse		Primary Impact Pulse		Peak Value	
		Pulse Duration (msec)	G_{max} (g)	Pulse Duration (msec)	G_{max} (g)	G_{peak} (g)	t_{peak} (msec)
Left Upper	FS 400	249	9	84	17	14	118
	FS 440	246	9	74	19	18	107
	FS 480	243	8	58	23	22	109
Left Lower	FS 400	189	11	83	21	18	110
	FS 440	-	-	-	-	-	-
	FS 480	178	11	70	23	20	108
	FS 500	177	11	67	24	22	107
Right Upper	FS 400	151	12	52	25	21	80
	FS 440	154	12	56	23	19	78
	FS 480	-	-	-	-	-	-
Right Lower	FS 400	150	13	56	24	21	75
	FS 440	147	13	63	22	20	76
	FS 480	145	13	61	22	19	75
	FS 500	151	13	57	23	19	77

The left upper portion of the fuselage section experienced longer pulse durations and lower G_{max} values due to the deflection of the fuselage ceiling caused by the combination of weights of the cameras, camera mounts, and the heavier Hitco bin.

SEAT TRACK VERTICAL ACCELERATIONS. The seat track accelerations are also presented in four groups: left inner seat track, left outer seat track, right inner seat track, and right outer seat track accelerations. The graphs of each group are shown in figures 33 to 36.

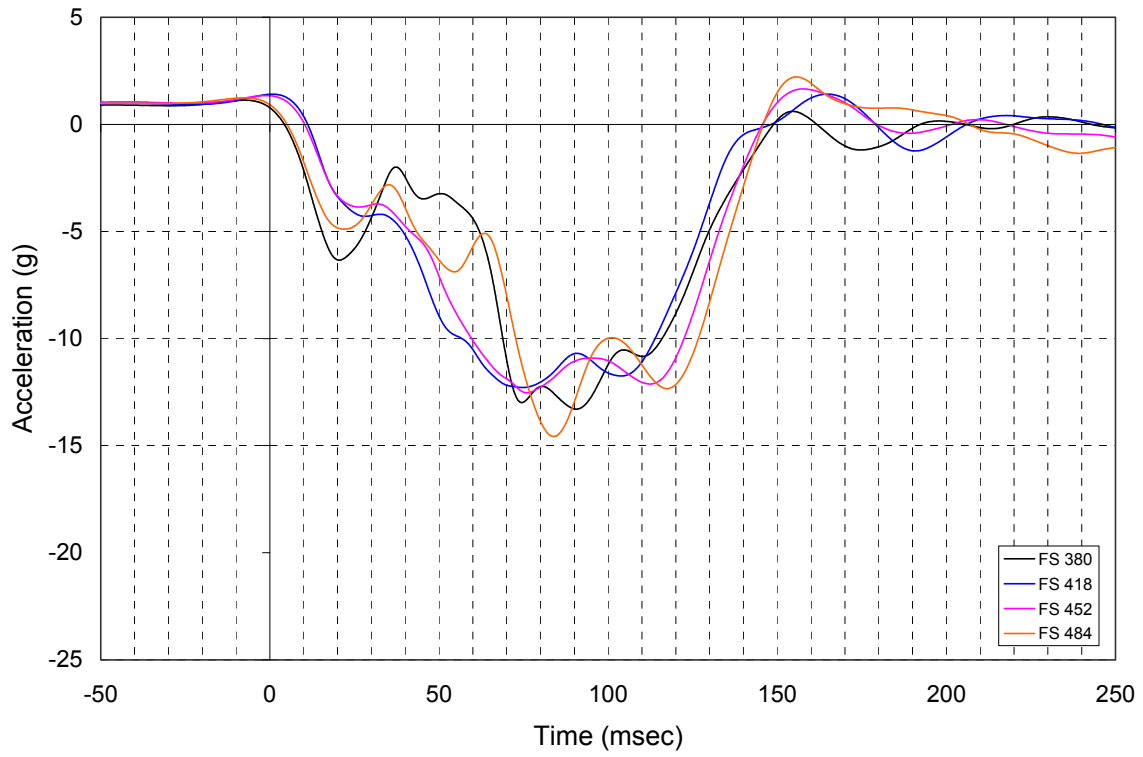


FIGURE 33. LEFT INNER SEAT TRACK VERTICAL ACCELERATIONS (20 Hz)

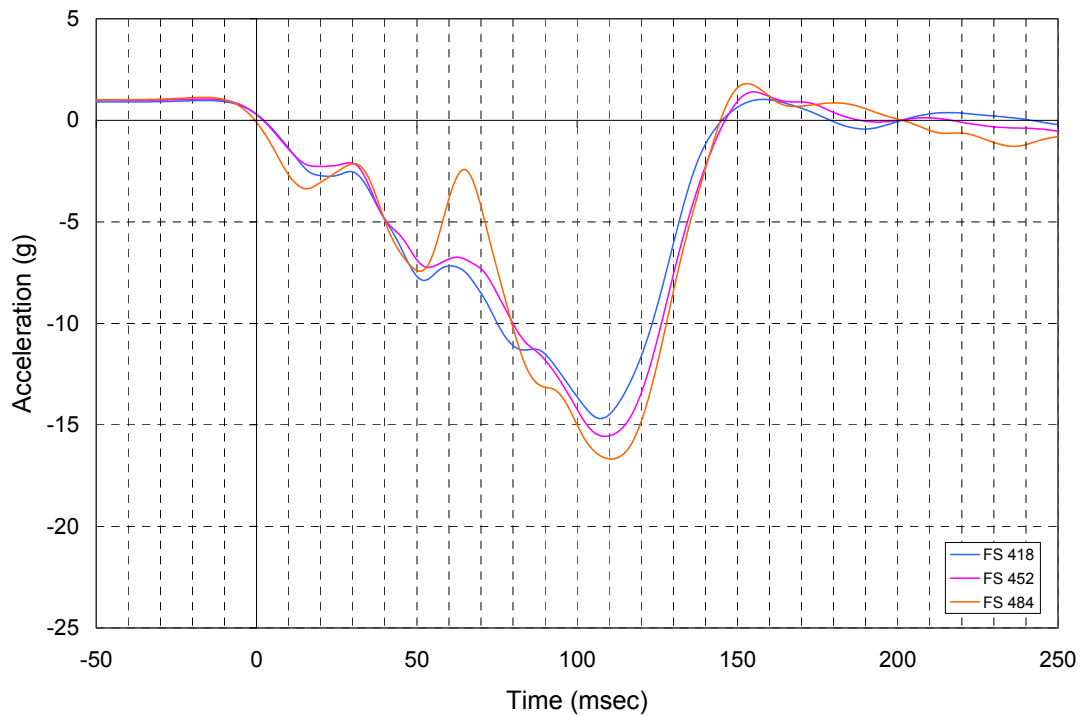


FIGURE 34. LEFT OUTER SEAT TRACK VERTICAL ACCELERATIONS (20 Hz)

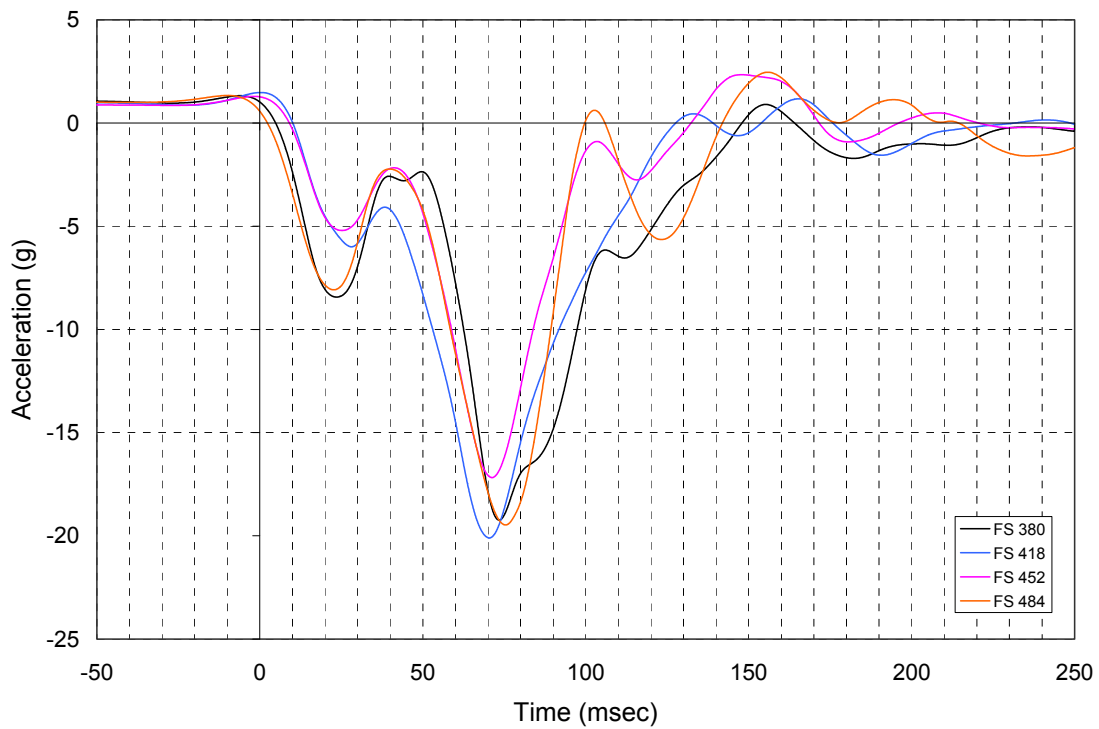


FIGURE 35. RIGHT INNER SEAT TRACK VERTICAL ACCELERATIONS (20 Hz)

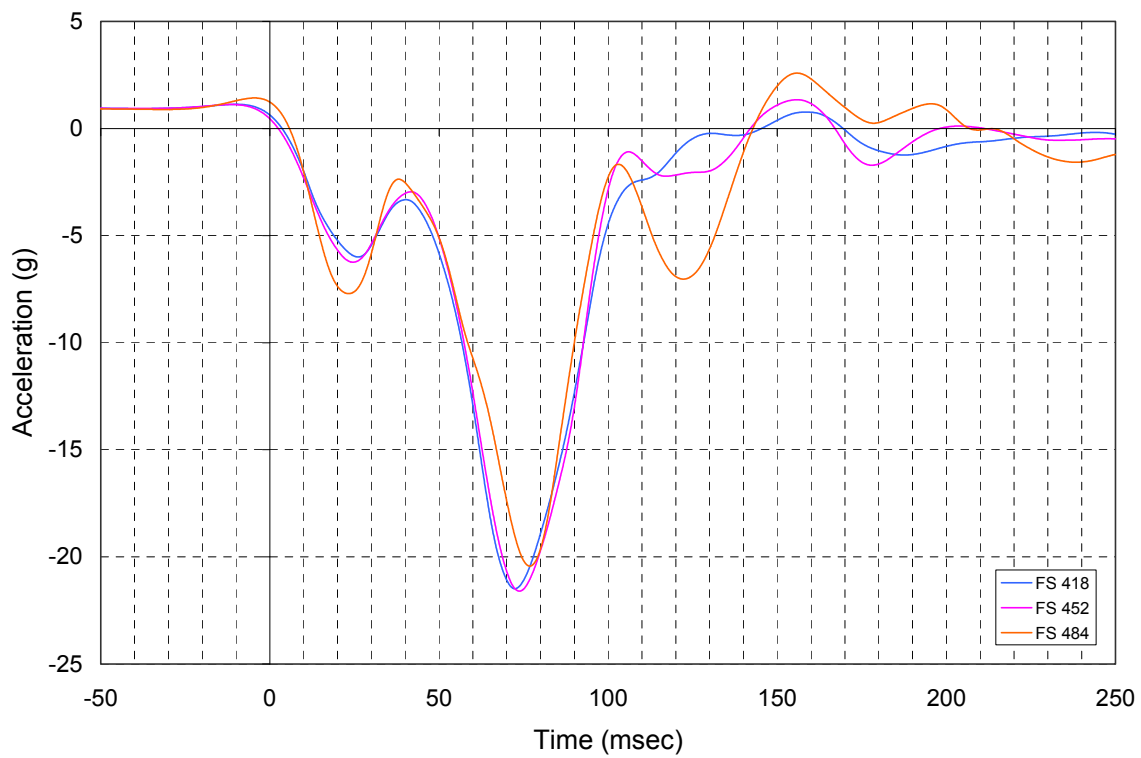


FIGURE 36. RIGHT OUTER SEAT TRACK VERTICAL ACCELERATIONS (20 Hz)

Similar to the sidewall accelerometers, the seat track accelerometers experienced multiple peaks preceding the major peak on the left seat track accelerations and a single peak preceding the major peak on the right seat track accelerations. However, the multiple peaks on the left seat track accelerations are not as obvious as shown in the sidewall data. The vertical seat track acceleration results are given in table 12.

TABLE 12. SEAT TRACK VERTICAL ACCELERATIONS (20 Hz)

		Fundamental Impact Pulse		Primary Impact Pulse		Peak Value	
		Pulse Duration (msec)	G_{max} (g)	Pulse Duration (msec)	G_{max} (g)	G_{peak} (g)	t_{peak} (msec)
Left Outer	FS 418	143	15	143	15	15	118
	FS 452	144	15	144	15	16	107
	FS 484	145	15	145	15	17	109
Left Inner	FS 380	145	13	145	13	13	110
	FS 418	137	15	137	15	12	-
	FS 452	135	16	135	16	13	108
	FS 484	141	15	141	15	15	107
Right Outer	FS 418	142	14	102	18	22	80
	FS 452	140	14	104	17	22	78
	FS 484	137	15	97	17	20	-
Right Inner	FS 380	143	15	143	15	19	75
	FS 418	118	17	118	17	20	76
	FS 452	123	11	94	14	17	75
	FS 484	140	13	97	16	20	77

The time of peak accelerations indicated that the cargo door caused the cabin floor loading to shift from the right side to the left. Also, the rigidity and stiffness of the frame surrounding the cargo door resulted in a higher G_{peak} for the seat track accelerations on the right side.

The seat track acceleration data indicated that they experienced an impact pulse of approximately 15 g's (G_{max}) of approximately 135 milliseconds duration.

BIN ANALYSIS.

The instrumented bin data consists of the measured load values, represented in pounds, and acceleration data, represented in g's. The data for both bins are found in appendix B. The data is sorted by bin and separated into three groups:

- Measured load data for each instrumented support
- Vertical load data for each instrumented support
- Bin acceleration data

Measured loads are strain gage bridge data that refer to the reacted loads of the bin supports and their corresponding vector components.

Calculated loads (Cal_m) for each support are based on strain gage bridge data and is defined by

$$Cal_m = (\sum F_z)(I_s) \quad (16)$$

where $\sum F_z$ is the sum of the vertical (z direction) vector component loads of the bin and I_s is the corresponding static influence coefficient for the designated support (see tables 6 and 9) determined from vertical static calibration load tests.

Inertial loads (In_{bin}) for the bin are based on accelerometer data and is defined by the kinematic equation

$$In_{bin} = \left(\frac{w}{g}\right)(a) \quad (17)$$

where w/g is the mass of the bin and its contents and a is the directional acceleration. When calculating the inertial load in the vertical direction, a is the average value of the three vertical-oriented bin accelerometers.

Calculated loads (Cal_g) for each support are based on measured accelerometer data and is defined by

$$Cal_g = (In_{bin})(I_s) \quad (18)$$

During the test, the dynamic influence coefficient (I_d), at any given time for any support in the vertical direction, was calculated by dividing the vertical vector load (F_z) of each link by the total vertical vector load ($\sum F_z$) of the bin, using the equation

$$I_d = \frac{F_z}{\sum F_z} \quad (19)$$

HITCO BIN. The bin was attached to the fuselage by 11 links. The bin and all mounting links remained intact during and after the test. A posttest inspection of the bin and the links showed no damage. The measured peak load during the test for each of the 11 links is shown in table 13.

A failure analysis on the links was conducted prior to the test. Links H1 and H2, are identical and carry the primary loads in the vertical direction. These links were identified as having the greatest probability of failure during the test. The failure load of these links was determined by testing to be 4500 lbs. However, as shown in table 13, the maximum load experienced by any link was 1237 lbs. This was well below the failure limit.

TABLE 13. HITCO BIN—MEASURED PEAK LOAD FOR EACH LINK (100 Hz)

Support	Peak Load (lbs)	Time after T ₀ (msec)
H1	1216	135
H2	1237	117
H3	217	61
H4	30	111
H5	559	110
H6	13	149
H7	592	112
H8	7	44
H9	322	61
H10	43	114
H11	73	117

The measured link loads were reduced into their vector component loads along the vertical, lateral, and longitudinal axes of the test fuselage section. Table 14 shows the vector component link loads at maximum bin loading during the test.

TABLE 14. HITCO BIN—VECTOR COMPONENT LINK LOADS AT MAXIMUM BIN LOADING (100 Hz)

Link	Vertical (z) Load (lbs) at 113 msec	Lateral (y) Load (lbs) at 113 msec	Longitudinal (x) Load (lbs) at 113 msec
H1	800	41	-
H2	1051	-18	-
H3	157	-22	-
H4	29	337	-
H5	437	-45	-
H6	-10	194	-
H7	583	40	-
H8	-12	240	-
H9	277	-14	-
H10	34	279	-
H11	4	20	70
Total Load	3350	1052	70

A comparison between the measured vertical load and the Cal_m load is shown in table 15. The first set of data was taken at the equivalent static loading of 5 g's (1057 lbs) and the second set of data at maximum total vertical loading. Although the total load remains the same, the distribution of load among the links is different.

TABLE 15. HITCO BIN—COMPARISON OF Cal_m VS MEASURED VERTICAL LOADS (100 Hz)

Link	Cal_m Vertical (z) Load (lbs) at 14 msec	Measured Vertical (z) Load (lbs) at 14 msec	Cal_m Vertical (z) Load (lbs) at 113 msec	Measured Vertical (z) Load (lbs) at 113 msec	Vertical Influence Coefficient		
					Static	Dynamic at 14 msec	Dynamic at 113 msec
H1	379	179	1200	800	0.358	0.170	0.239
H2	325	187	1029	1051	0.307	0.178	0.314
H3	62	83	198	157	0.059	0.079	0.047
H4	0	4	0	29	0.000	0.004	0.009
H5	111	203	352	437	0.106	0.193	0.130
H6	-2	-3	-7	-10	-0.002	-0.003	-0.003
H7	120	265	379	583	0.113	0.252	0.174
H8	1	-1	3	-12	0.001	0.000	-0.004
H9	68	133	215	277	0.064	0.126	0.083
H10	0	5	0	34	0.000	0.005	0.010
H11	-5	2	-17	4	-0.005	0.002	0.001
Total Load	1059	1057	3352	3350			

Figures 37 and 38 show the vertical acceleration data filtered at 20 and 100 Hz. Two different filters were used to define the pulse shape after impact.

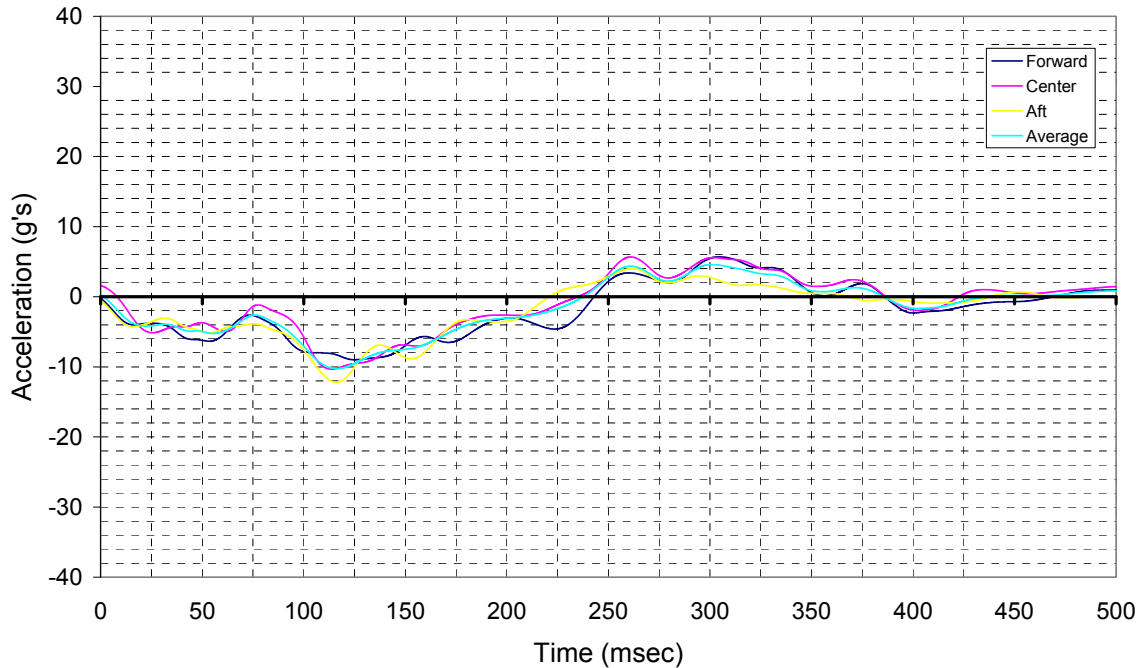


FIGURE 37. HITCO BIN—VERTICAL ACCELERATION (20 Hz)

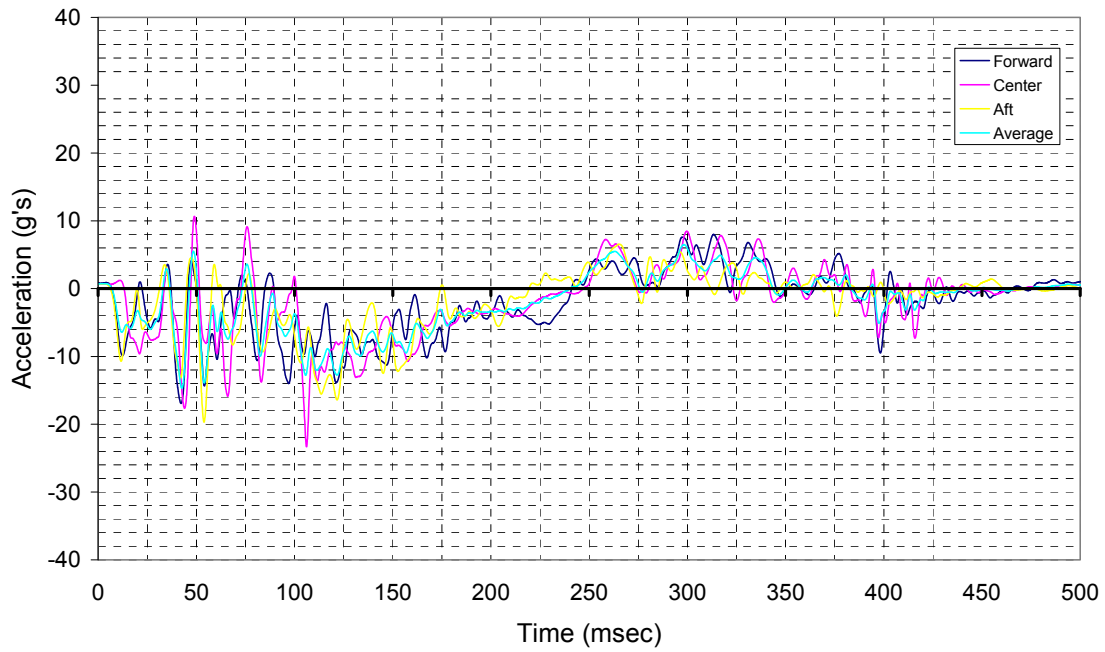


FIGURE 38. HITCO BIN—VERTICAL ACCELERATION (100 Hz)

Figure 39 shows the velocity of the bin, which was calculated by integrating the average acceleration. The impact velocity was calculated to be 30 ft/sec.

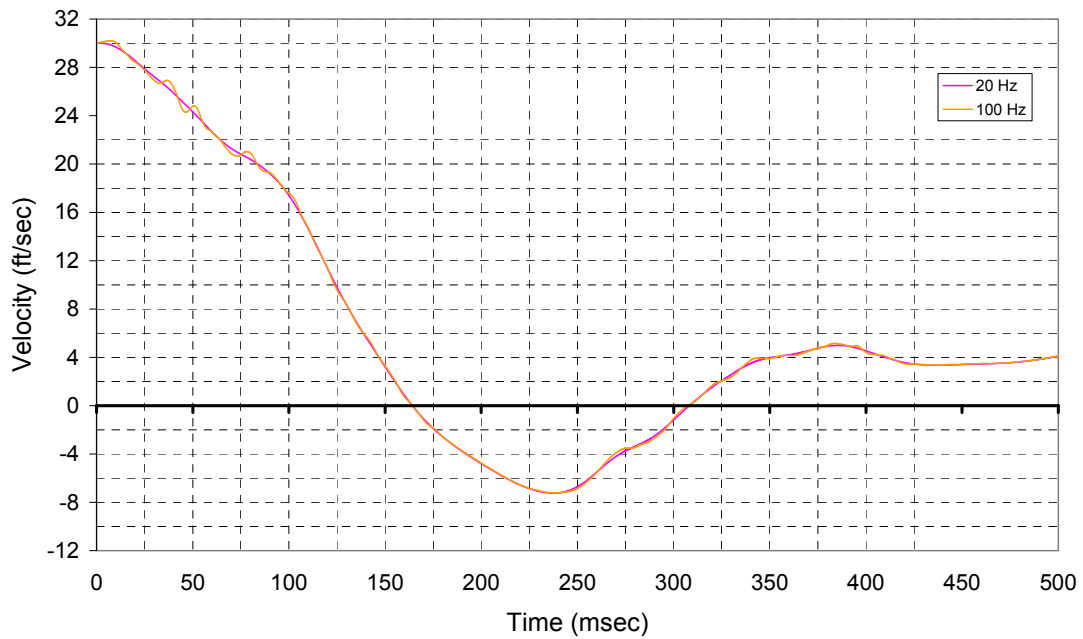


FIGURE 39. HITCO BIN—CALCULATED VERTICAL VELOCITY

A comparison between measured total bin loads and inertial bin loads in the vertical, lateral, and longitudinal directions are shown in figures 40 to 42. There was generally good agreement between the two. The three peaks seen in figure 40 are attributed to the unique crushing on the left side of the fuselage.

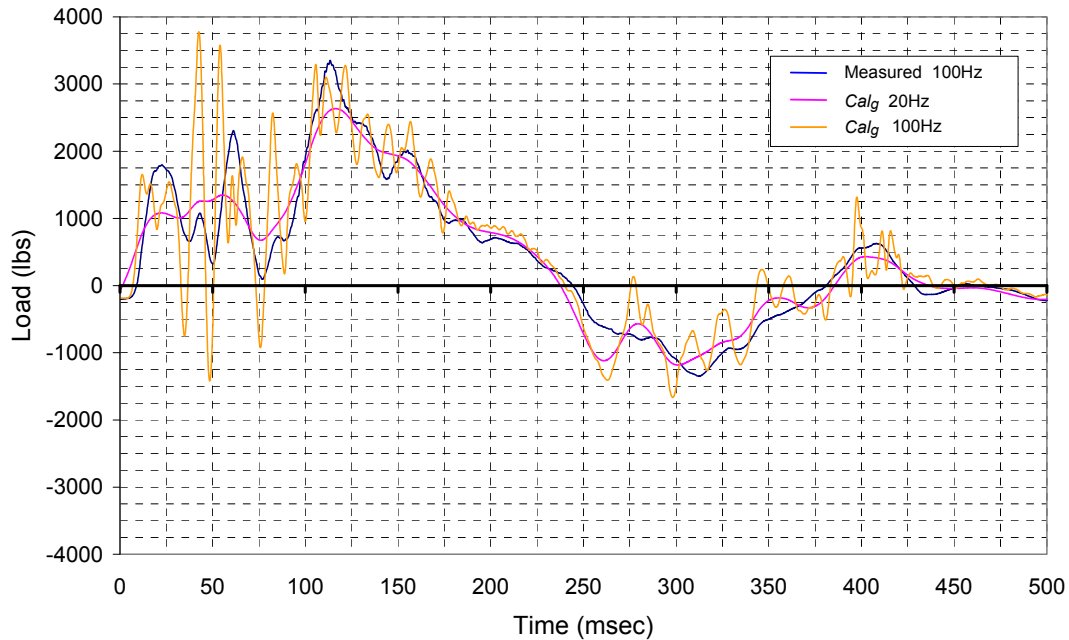


FIGURE 40. HITCO BIN—TOTAL VERTICAL LOAD

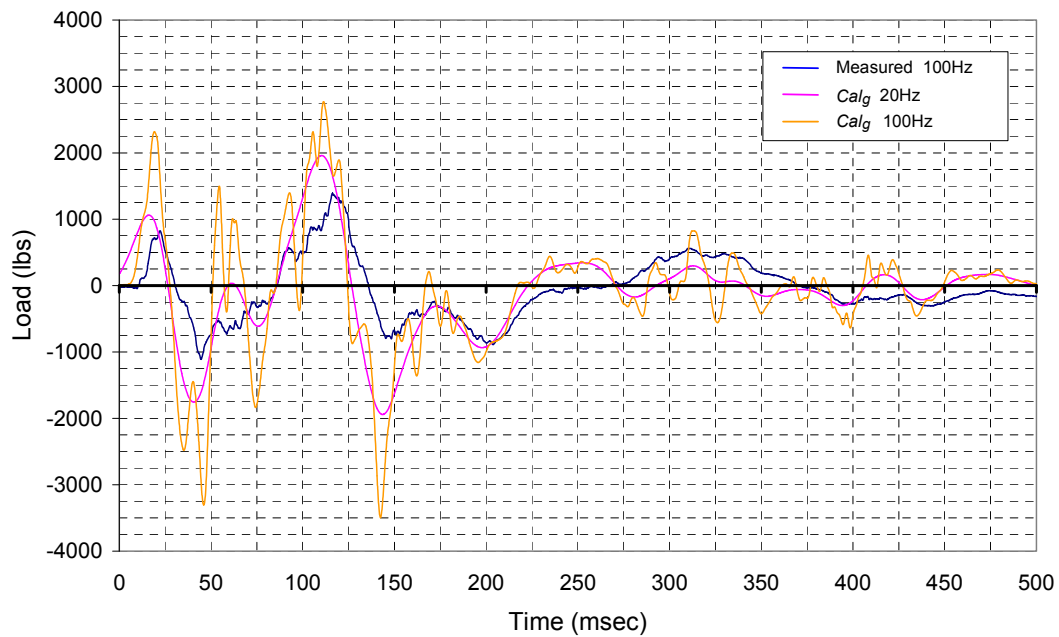


FIGURE 41. HITCO BIN—TOTAL LATERAL LOAD

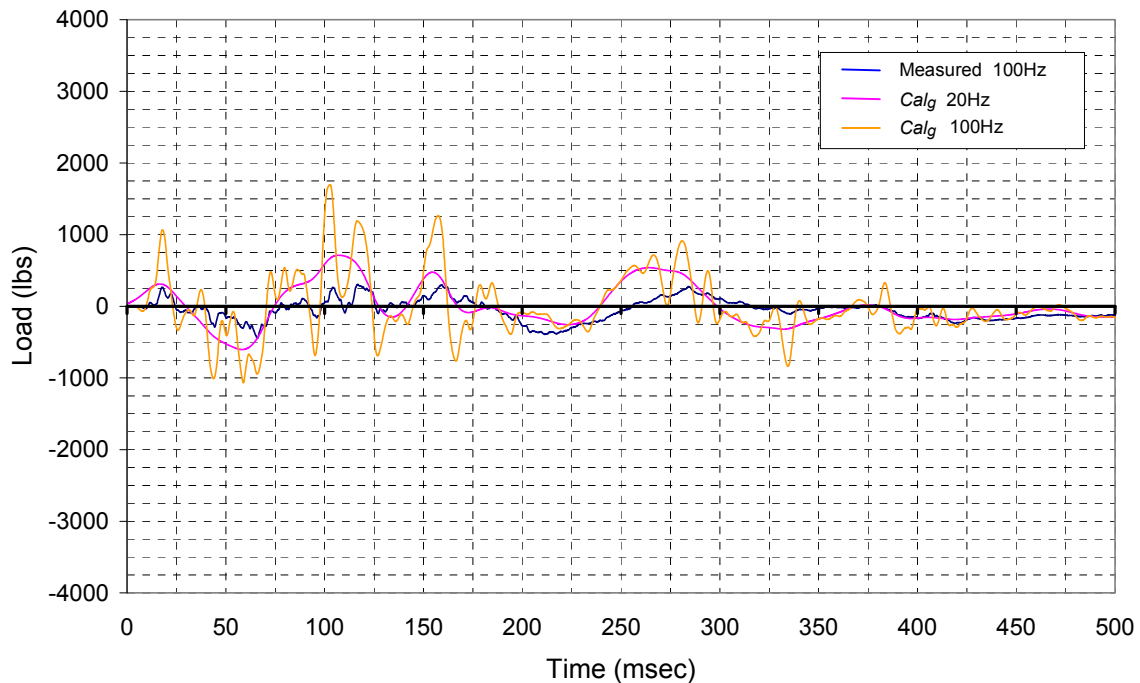


FIGURE 42. HITCO BIN—TOTAL LONGITUDINAL LOAD

HEATH TECNNA BIN. The bin was attached to the fuselage by 11 instrumented supports. The bin and the mounting supports remained intact during and after the test. A posttest inspection of the bins and the links showed no damage. The measured peak load during the test for each of the 11 instrumented supports is shown in table 16.

A failure analysis on the supports was conducted prior to the test. Supports HT2 and HT4 are identical and carry the primary loads in the vertical direction. These supports were identified as having the greatest probability of failure during the test. The failure load of these supports was determined by testing to be 1650 lbs. However, as shown in table 9, the maximum load by either support was 1063 lbs. This was well below the failure limit.

The measured support loads were reduced into their vector component loads along the vertical, lateral, and longitudinal axes of the test fuselage section. Table 17 shows the vector component support loads at maximum bin loading during the test.

A comparison between the measured vertical load and the Cal_m load is shown in table 18. The first set of data was taken at the equivalent static loading of 5 g's (656 lbs) and the second set of data at maximum total vertical loading. Although the load remains the same, the distribution of the load among the supports is different.

TABLE 16. HEATH TECNA BIN—MEASURED PEAK LOAD FOR EACH SUPPORT (100 Hz)

Support	Load (lbs)	Time after T_0 (msec)
HT1	1100	102
HT2	908	102
HT3	1241	103
HT4	1063	103
HT5A	168	85
HT5B	345	53
HT6A	456	84
HT6B	-268	120
HT7A	209	84
HT7B	-255	39
HT8A	430	78
HT8B	-407	164
HT9A	634	79
HT9B	-564	81
HT10A	170	55
HT10B	114	118
HT10C	305	258
HT11A	-136	121
HT11B	37	121
HT11C	-200	73

TABLE 17. HEATH TECNA BIN—VECTOR COMPONENT SUPPORT LOADS AT MAXIMUM BIN LOADING (100 Hz)

Support	Vertical (z) Load at 102 ms	Lateral (y) Load at 102 ms	Longitudinal (x) Load at 102 ms
HT1	1093	96	----
HT2	1221	107	----
HT3	906	0	----
HT4	1045	0	----
HT5A	23	22	----
HT5B	-3	-21	----
HT6A	46	44	----
HT6B	-3	-28	----
HT7A	50	48	----
HT7B	-6	-53	----
HT8A	90	87	----
HT8B	-8	-69	----
HT9A	88	85	----
HT9B	-27	-222	----
HT10A	-12	-16	----
HT10B	----	----	----
HT10C	----	----	161
HT11A	-37	-50	----
HT11B	----	----	----
HT11C	----	----	-74
Total load	2512	30	87

TABLE 18. HEATH TECNA BIN—COMPARISON OF Cal_m VS MEASURED VERTICAL LOADS (100 Hz)

Support	Cal_m Vertical (z) Load at 13 msec	Measured Vertical (z) Load at 13 msec	Cal_m Vertical (z) Load at 102 msec	Measured Vertical (z) Load at 102 msec	Influence Coefficient		
					Static	Dynamic at 13 msec	Dynamic at 102 msec
HT1	216	114	827	1093	0.332	0.175	0.435
HT2	194	97	751	906	0.299	0.150	0.361
HT3	214	107	834	1221	0.329	0.165	0.486
HT4	191	108	739	1045	0.294	0.166	0.416
HT5A	42	20	161	23	0.064	0.030	0.009
HT5B	-3	18	-13	-3	-0.005	0.027	-0.001
HT6A	77	162	299	46	0.119	0.250	0.018
HT6B	-5	-5	-20	-3	-0.008	-0.007	-0.001
HT7A	19	19	73	50	0.029	0.030	0.020
HT7B	-1	-6	-5	-6	-0.002	-0.009	-0.002
HT8A	48	112	186	90	0.074	0.172	0.036
HT8B	-4	-10	-15	-8	-0.006	-0.015	-0.003
HT9A	75	160	289	88	0.115	0.246	0.035
HT9B	-7	-29	-25	-27	-0.010	-0.045	-0.011
HT10A	-8	12	-30	-12	-0.012	0.018	-0.005
HT10B	----	----	----	----	----	----	----
HT10C	----	----	-	----	----	----	----
HT11A	-14	-23	-53	-37	-0.021	-0.036	-0.015
HT11B	----	----	----	----	----	----	----
HT11C	----	----	----	----	----	----	----
Total Load*	650	651	2508	2512			

*Note: HT2 and HT4 are not included in the total as they are mating support to HT1 and HT4, respectively.

Figures 43 and 44 show the vertical acceleration data for the three z oriented accelerometers and the corresponding average acceleration (filtered at 20 Hz and 100 Hz, respectively).

Figure 45 shows the velocity of the bin, which was calculated by integrating the average acceleration. The impact velocity was calculated to be 30 ft/sec.

A comparison between measured total loads and inertial loads in the vertical, lateral, and longitudinal directions are shown in figures 46 to 48. There was generally good agreement between the two.

Figure 46 shows two significant pulses occurring at 27 and 102 msec after T_0 . These are attributable to the unique crushing of the fuselage on the right side.

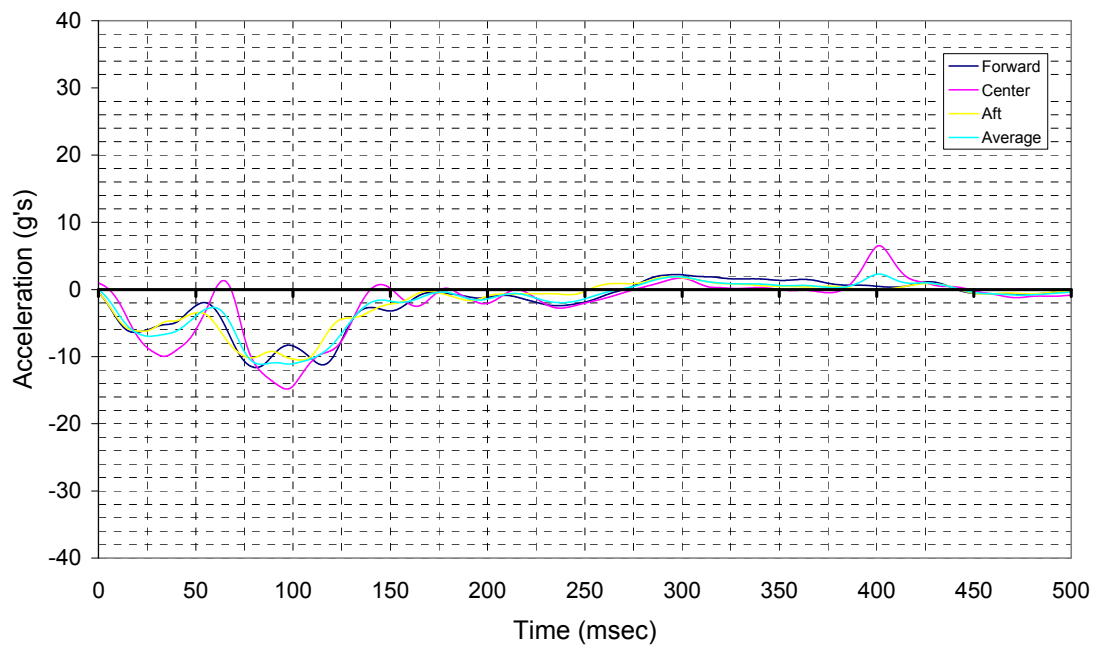


FIGURE 43. HEATH TECNA BIN—VERTICAL ACCELERATION (20 Hz)

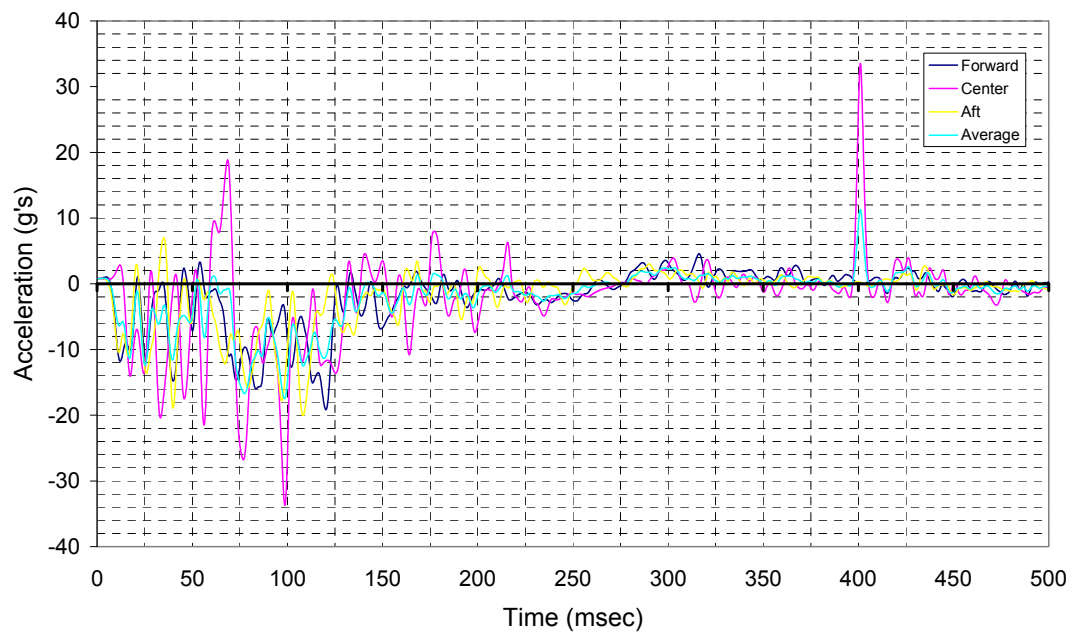


FIGURE 44. HEATH TECNA BIN—VERTICAL ACCELERATION (100 Hz)

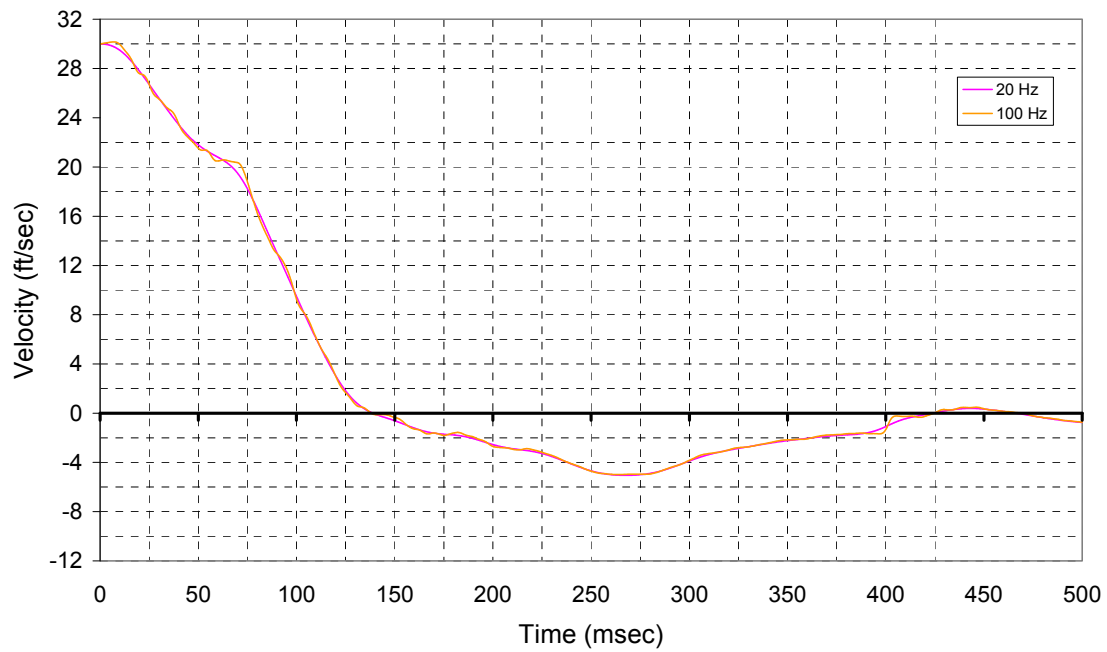


FIGURE 45. HEATH TECNA BIN—CALCULATED VERTICAL VELOCITY

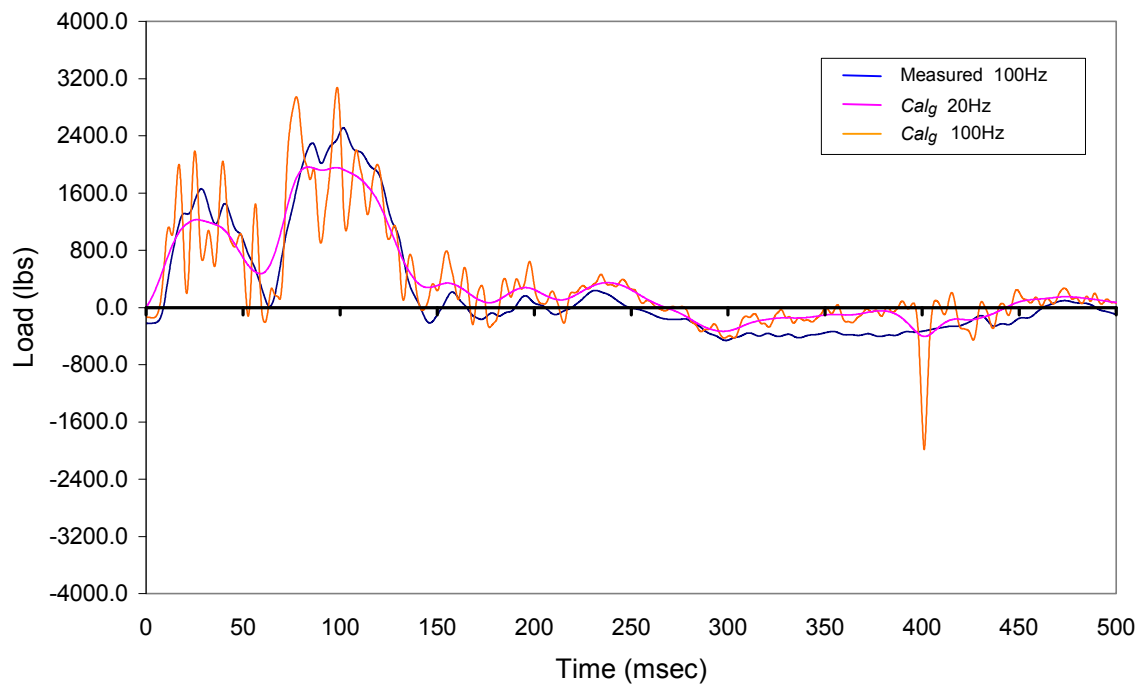


FIGURE 46. HEATH TECNA BIN—TOTAL VERTICAL LOAD

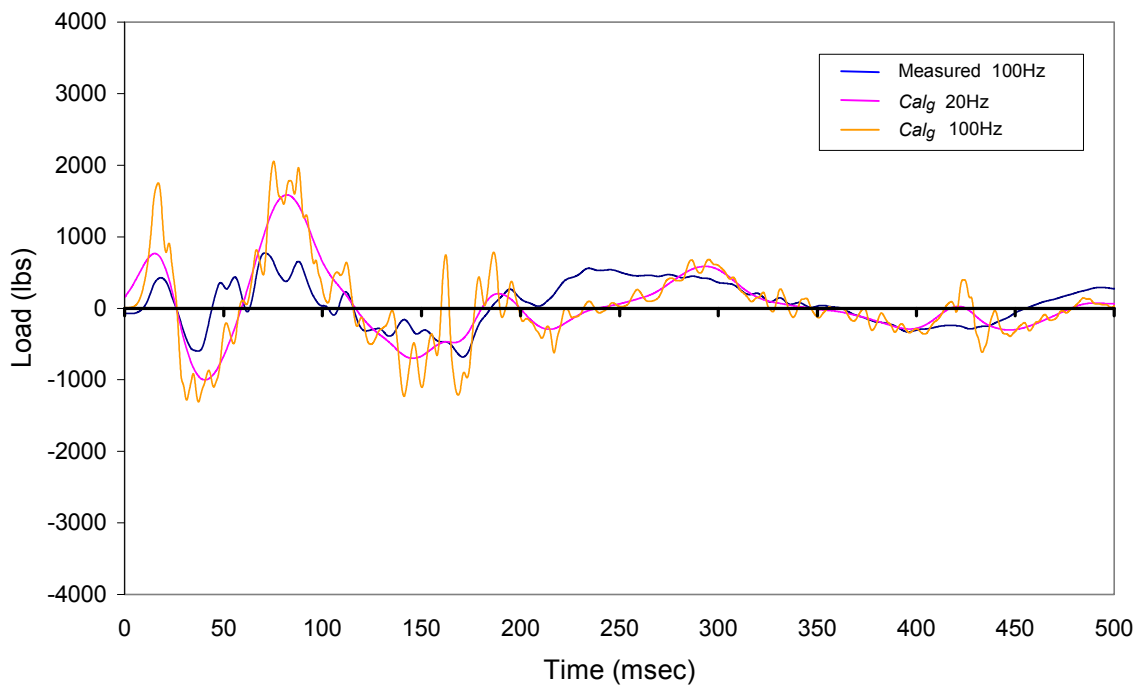


FIGURE 47. HEATH TECNA BIN—TOTAL LATERAL LOAD

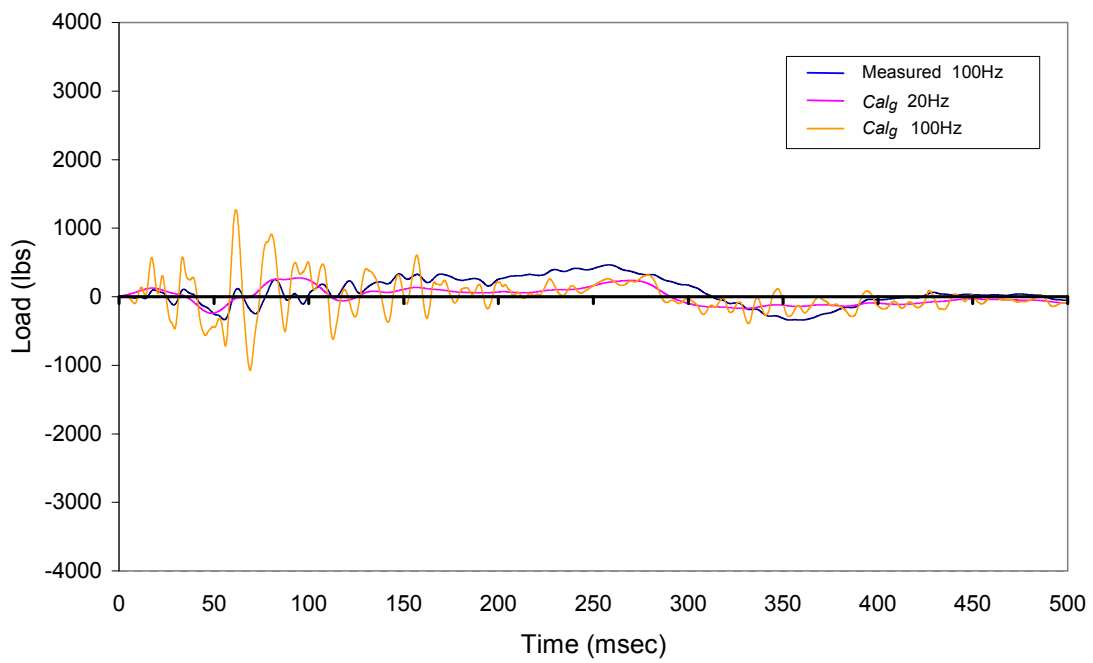


FIGURE 48. HEATH TECNA BIN—TOTAL LONGITUDINAL LOAD

DROP TEST PLATFORM.

PLATFORM LOAD CELLS. Load cell data were verified by the comparing the energy stored in the falling fuselage section to the energy transferred to the platform. This was accomplished by applying the principle of linear impulse and momentum for a rigid body, using

$$\int_{t_1}^{t_2} F dt = mv_1 - mv_2 \quad (20)$$

where

F is the sum of the weight measured by the 12 load cells minus the weight of the test fuselage section

m is the mass of the test fuselage section

v_1 and v_2 are the velocities of the test fuselage section prior to and after impact (30 ft/sec and 0 ft/sec respectively)

t_1 and t_2 are defined as the time of impact (t_0) and 800 ms after impact (t_{800}).

The time when the platform stabilizes is approximately t_{800} , as shown in figure 49. The integrated value from the measured loads was 8093 slug-ft/sec. This compares favorably to the value of 8366 slug-ft/sec, which was calculated using the mass and velocity of the fuselage section.

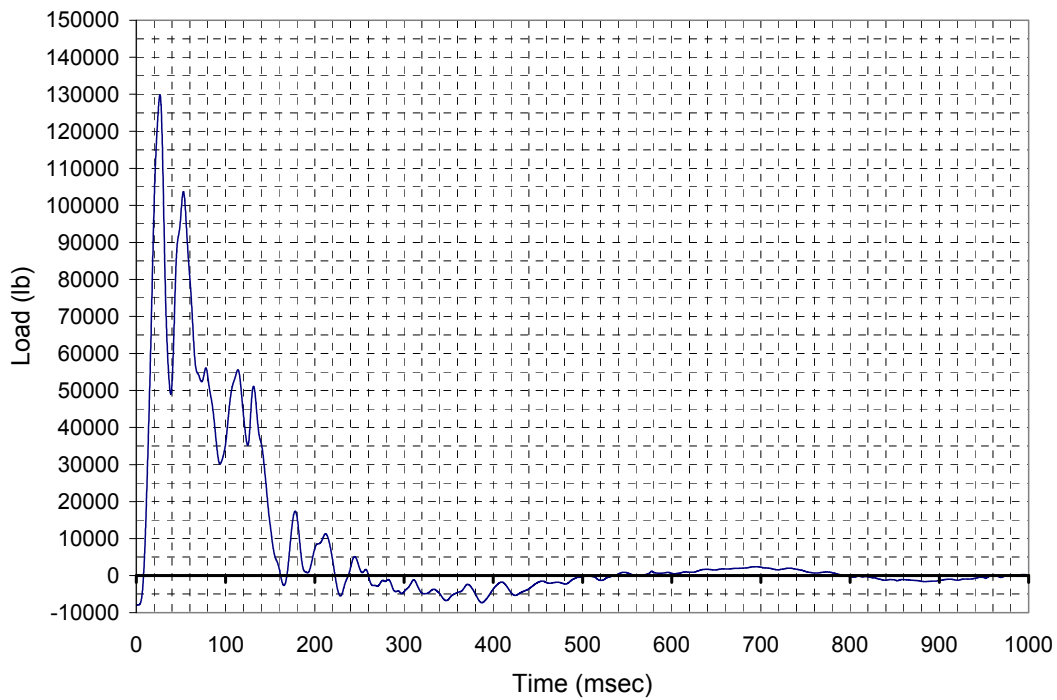


FIGURE 49. DROP TEST PLATFORM—TOTAL REACTED LOAD

The platform load cell data are presented in appendix B.

PLATFORM ACCELERATIONS. It was observed that the platform accelerometer data exhibits symmetry between the forward and aft locations along the platform centerline. These data are presented in the appendix B. Analysis indicated that there was no significant platform response superimposed on the airframe data.

PLATFORM STRING POTENTIOMETER DISPLACEMENTS. The string potentiometer data indicate that the drop test platform displaced a maximum of 0.22 inch upwards. The maximum displacement at the center of the platform was 0.127 inch downward. Platform string potentiometer data are shown in appendix B and in table 19.

TABLE 19. DROP TEST PLATFORM—STRING POTENTIOMETER
MAXIMUM DISPLACEMENTS

String Potentiometer Location No.					Displacement (in)				
3	6	---	9	12	0.220↑	0.043↓	---	0.055↓	0.088↑
2	5	13	8	11	0.214↑	0.034↓	0.127↓	0.036↓	0.113↑
1	4	---	7	10	0.219↑	0.008↓	---	0.010↓	0.161↑

ANTHROPOMORPHIC TEST DUMMIES.

Six ATDs were used to measure loads and accelerations in their respective lumbar and pelvic areas. ATD data are presented appendix B and table 9. During maximum loading, the high-speed film shows that the ATD'S appear to remain upright and the seats intact.

TABLE 20. ANTHROPOMORPHIC TEST DUMMY DATA

ATD No.	Location	Lumbar Load (lbs)	Accelerometer Data	
			G_{peak} (g)	Pulse Duration (msec)
1	FS 406 LS	765	15.1	118
2	FS 406 RS	628	11.0	57
3	FS 442 LS	-	13.1	110
4	FS 442 RS	692	16.3	43
5	FS 478 LS	922	15.0	122
6	FS 478 RS	880	13.6	62

RESULTS AND DISCUSSION

FUSELAGE STRUCTURE.

The cabin floor beams and seat tracks showed no damage after impact. However, the fuselage experienced damage in cabin sidewall, crown, and cargo areas.

Due to the weights of the bins, cameras, and camera mounts, all the frames from FS 380 through FS 500 were fractured at locations $(y,z) = (-59",54")$ and $(y,z) = (59",54")$ (figures C-55 to C-70 in appendix C). The frame at FS 380 also showed two additional fractures at locations $(y,z) = (-28",86")$ and $(y,z) = (-45",75")$. Two other fractures occurred on the FS 400 frame at the locations where the camera mount legs were attached. High-speed photography showed that, during the event, the fuselage area located just under the left camera mount deflected approximately 6 inches into the cabin area.

The cargo area experienced severe permanent deformation due to impact with the platform (figure 50). The left side experienced 23 inches of static crush in the front and 27.5 inches aft. The right side experienced 15.8 inches of static crush in the front and 18.4 inches aft. This difference was due to the support provided by the rigid and stiff reinforced cargo door frame on the right side. This is further reinforced by a review of the high-speed film which showed that the test fuselage section impacted the platform at a level attitude. After which, the crush on the right side eventually stopped while the crush on the left continued for some time. This resulted in the buckling of the fuselage on the left side as figure 51 shows. The static and dynamic deformation of the cargo area is shown in table 21. The luggage in the cargo area provided a load path, which influenced the g forces experienced by the fuselage section and the manner in which the fuselage crushed. This resulted in multiple fractures of the cargo frames as figure 52 shows.

TABLE 21. CARGO AREA—FUSELAGE CRUSH MEASUREMENTS

Measurement	Left Side		Right Side	
	Forward	Aft	Forward	Aft
Pretest (in)	59.5	59.5	59.5	59.5
Posttest (in)	36.5	32	43.8	41.1
Static Crush (in)	23	27.5	15.8	18.4
Dynamic Crush (in)*	28	30.3	21	24

*Note: Dynamic Crush obtained from film analysis.



FIGURE 50. CARGO AREA DEFORMATION



FIGURE 51. LEFT VIEW—BUCKLE OF THE FUSELAGE SKIN



FIGURE 52. FRONT VIEW—FRACTURED CARGO FRAMES

OVERHEAD STOWAGE BINS.

The bins, their supports, and fuselage attachment points showed no signs of damage.

A review of the recorded data showed no signs of any abnormalities.

Using the integrated bin accelerometer data, the calculated impact velocity was 30 ft/sec for both bins. This is equal to the fuselage impact velocity.

Using load data, the Hitco bin and the Heath Tecna bin sustained 13 and 14 g's in the vertical direction respectively (maximum measured total vertical vector load divided by the loaded bin weight (equation 17)). Using accelerometer data filtered at 20 Hz, the Hitco and Heath Tecna bins sustained approximately 10 and 11 g's, respectively, in the vertical direction. Using accelerometer data filtered at 100 Hz, they sustained 12 and 17 g's, respectively, in the vertical direction.

A comparison between the total measured vertical load and the vertical inertial load for both bins (figures 40 and 46) shows generally good agreement. Therefore, the measured vertical vector loads were deemed valid and used for static versus dynamic comparisons of bin loading.

The Hitco bin accelerometers and the sidewall-mounted links mimicked the fuselage accelerometer response on the left side with three major pulses. However, the two primary links, H1 and H2, only experienced two major pulses not three. The localized deformation of the upper left side fuselage may have influenced the loading.

On the right side, the response of the Heath Tecna bin accelerometers and supports showed the same two major pulses as seen by the fuselage accelerometers.

During the static load calibration of the overhead bins, the fuselage and bins behaved as a rigid body, resulting in minimum structural deformation. However, during the crash test, the test fuselage section may be considered a nonrigid body as evidenced by the severe structural deformation of the fuselage. This deformation (flexing, bending, asymmetrical crushing of the fuselage, etc.), as well as the introduction of a lateral load component resulted in differences between static and dynamic loading of the bins and their supports as shown in tables 15 and 18 for the Hitco and Heath Tecna bin, respectively.

COMPARISON OF DYNAMIC AND STATIC LOADING—HITCO BIN. A comparison of dynamic and static vertical loading for each link using measured loads, Cal_m and Cal_g are shown in figures B-40 to B-50 in appendix B. These figures show good agreement among the data.

The Cal_m load for the two main vertical links, H1 and H2, was greater than the measured load for the first 27 msec. Thereafter the measured values were generally larger than the Cal_m values. This was especially true during the time of maximum vertical loading during the two major pulses. Conversely, the Cal_m vertical load for the other links was less than the measured load.

A comparison of bin loading at 5-g static equivalent load condition (14 msec) and at maximum total vertical loading (113 msec) with corresponding static and dynamic vertical influence coefficients was shown in table 15. The dynamic vertical influence coefficients just prior to impact (preimpact, -1 g), 5-g static equivalent loading and maximum vertical loading are shown in table 22.

TABLE 22. HITCO BIN—DYNAMIC/STATIC INFLUENCE COEFFICIENTS (100 Hz)

Condition	H1 Dynamic Influence Coefficient	H2 Dynamic Influence Coefficient	H1 Static Influence Coefficient	H2 Static Influence Coefficient
Preimpact (-1g)	0.37	0.42	0.31	0.36
5-g Static Equivalent Load (1057 lbs)	0.17	0.18	0.31	0.36
13-g Loading (3350 lbs)	0.24	0.31	0.31	0.36

Load Capability. The data show that this bin was able to support, without failure, dynamic loads in excess of twice the static load certification requirement. Maximum dynamic loading of critical supports H1 and H2 was at approximately 30% of failure load.

COMPARISON OF DYNAMIC AND STATIC LOADING—HEATH TECNA BIN. A comparison of dynamic and static vertical loading for each support using measured loads, Cal_m and Cal_g , are shown in figures B-76 to B-91. These figures show good agreement among the data.

The Cal_m load for the two main vertical supports, HT1 and HT3, was greater than the measured load for the first 27 msec. Thereafter the measured values were generally larger than the Cal_m values. This was especially true during the time of maximum vertical loading during the two major pulses. Conversely, the Cal_m vertical load for the other supports was less than the measured load.

A comparison of bin loading at 5-g static equivalent load condition (13 msec) and at maximum total vertical loading (102 msec), with corresponding static and dynamic vertical influence coefficients are shown in table 18. The dynamic vertical influence coefficients just prior to impact (preimpact, -1 g), 5-g static equivalent loading, and the maximum vertical loading are shown in table 23.

TABLE 23. HEATH TECNA BIN—DYNAMIC/STATIC INFLUENCE COEFFICIENTS (100 HZ)

Condition	HT1 Dynamic Influence Coefficient	HT3 Dynamic Influence Coefficient	HT1 Static Influence Coefficient	HT3 Static Influence Coefficient
Preimpact (-1g)	0.23	0.28	0.33	0.33
5-g Static Equivalent Load (656 lbs)	0.18	0.17	0.33	0.33
13-g Loading (2512 lbs)	0.44	0.49	0.33	0.33

Load Capability. The data show that this bin was able to support, without failure, dynamic loads in excess of twice the static load certification requirement. Maximum dynamic loading of critical supports HT2 and HT4 was at approximately 70% of failure load.

SEATS.

The seats experienced approximately 15-g vertical loading, this was in excess of the seats' TSO static load rating.

A postcrash inspection determined that all seat pans remained intact; all seat legs remained attached to the seat tracks, and there was no seat back damage (i.e., excessive reclining). The Weber seats remained upright, damage was confined to the bending of the cross tubes and spreader tubes (figures C-80 to C-88). The rear legs of the UOP seats fractured and caused the seats to collapse (figures C-89 to C-97). A description of the seat damage is found in table 24. An actual crash impact imparts a longitudinal drag load on the aircraft that may significantly change the load distribution in a seat. Thus, the seat fracture modes observed in this test are not necessarily reflective of what may occur in service. Therefore, special consideration must be given when considering the results of seat test data obtained from this vertical drop test.

TABLE 24. SEAT DAMAGE

Left Side—Weber Seats					
Row	Seat Legs	Seat Frames	Aisle Seat Back	Center Seat Back	Window Seat Back
1	Intact	Fractured	Upright	Upright	Upright
2	Intact	Fractured	Upright	Upright	Upright
3	Intact	Fractured	Upright	Upright	Upright
Right Side—UOP Seats					
Row	Seat Legs	Seat Frames	Aisle Seat Back	Center Seat Back	Window Seat Back
1	Fractured	Intact	Upright	Upright	Upright
2	Fractured	Intact	Upright	Upright	Upright
3	Fractured	Intact	Upright	Upright	Upright

CONCLUSIONS

On November 29, 2000 the Federal Aviation Administration (FAA) conducted a vertical impact test of a narrow-body transport airplane fuselage section, which included two different types of in-service overhead stowage bins. The test was conducted at the FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey. The objective of the test was to evaluate the response behavior of the overhead stowage bin installations when subjected to a severe, but survivable, impact condition. Of particular interest was a comparison of the pretest static, steady-state forces that the bins were subjected to during their calibration versus the dynamic forces generated during the impact test. The conclusions are as follows

1. Fuselage
 - a. A narrow-body transport fuselage section with overhead stowage bins was dropped from a height of 14 feet resulting in a vertical impact velocity of 30 feet

per second. This resulted in what was considered a severe, but survivable, impact condition.

- b. The 10-foot-long fuselage section sustained severe nonsymmetrical damage. The left side crushed approximately 2 feet; the right side, which included a cargo door and its associated reinforced doorframe, crushed 1.5 feet.
- c. Luggage, which was located in the cargo compartment, influenced the manner in which the fuselage crushed, affecting the g forces experienced by the fuselage section and the pulse duration. The cargo compartment also sustained a series of frame fractures, two in the middle of the fuselage, one on the bottom right side, and two on the left.
- d. All the frames in the upper cabin area were fractured due to the deflection of the upper fuselage caused by the weight of the bins, cameras and camera mounts. However, a habitable environment was maintained for the occupants.
- e. The seat tracks experienced a vertical impact pulse of approximately 15 g's and a pulse duration of approximately 135 msec.

2. Hitco Overhead Stowage Bin

- a. The Hitco bin and its support links maintained their structural integrity and remained attached to the fuselage.
- b. The Hitco bin sustained a 13-g vertical load factor during the test.
- c. A comparison between the total measured vertical load and the vertical inertial bin load showed, generally, good agreement.
- d. The load distribution among the Hitco bin links was different in the dynamic case versus the static case. The results are influenced by the difference in static and dynamic deformation as well as a lateral load component experienced by the bins and fuselage during the test.
- e. The Hitco bin was able to support dynamic loads in excess of twice the static load certification requirement. Maximum dynamic loading of critical supports H1 and H2 was at approximately 30% of failure load.

3. Heath Tecna Overhead Stowage Bin

- a. The Heath Tecna bin and its supports maintained their structural integrity and remained attached to the fuselage.
- b. The Heath Tecna bin sustained a 14-g vertical load factor during the test.

- c. A comparison between the total measured vertical load and the vertical inertial bin load showed, generally, good agreement.
 - d. The load distribution among the Heath Tecna bin supports was different in the dynamic case versus the static case. The results are influenced by the difference in static and dynamic deformation as well as a lateral load component experienced by the bins and fuselage during the test.
 - e. The Heath Tecna bin was able to support dynamic loads in excess of twice the static load certification requirement. Maximum dynamic loading of critical supports HT2 and HT4 was at approximately 70% of failure load.
4. Seats
- a. The seats experienced approximately 15-g vertical loading, this was in excess of the seats' TSO static load rating.
 - b. The seats experienced damage ranging from limited damage of the cross tubes and spreader tubes to fracture of the rear seat legs, causing the seats to collapse.

REFERENCES

1. Improved Seat Safety Standards, 14 CFR Part 25, Amendment No. 25-64, Effective date June 16, 1988.
2. Crash Dynamics and Engineering Development Program, *Federal Register*, Volume 49, No. 185, September 21, 1984.
3. Ault, D., "Longitudinal Acceleration Test of Overhead Luggage Bins in a Transport Airframe Section," FAA Technical Center, Atlantic City International Airport, NJ, DOT/FAA/CT-92/9, November 1992.
4. Logue, T., McGuire, R., Reinhardt, J., Vu, T., Vertical Drop Test of a Narrow-Body Fuselage Section with Overhead Stowage Bins and Auxiliary Fuel Tank on Board, FAA Technical Center, Atlantic City International Airport, NJ, DOT/FAA/CT-94/116, April 1995.
5. McGuire, R. and Macy, T., "Longitudinal Acceleration Tests of Overhead Luggage Bins and Auxiliary Fuel Tank in a Transport Airplane Airframe Section," FAA William J. Hughes Technical Center, Atlantic City International Airport, NJ, DOT/FAA/AR-99/4, June 1999.
6. McGuire, R., "Longitudinal Acceleration Tests of Overhead Luggage Bins and Auxiliary Fuel Tank in a Transport Airplane Airframe Section, Part II," FAA William J. Hughes Technical Center, Atlantic City International Airport, NJ, DOT/FAA/AR-99/4,II, October 2000.

7. SAE International, "Surface Vehicle Recommended Practice," SAE J211/1, Revised March 1995.
8. Jackson, Karen E. and Fasanella, Edwin L., "Crash Simulation of Vertical Drop Tests of Two Boeing 737 Fuselage Sections," FAA William J. Hughes Technical Center, Atlantic City International Airport, NJ, DOT/FAA/AR-02/62.

APPENDIX A—CALIBRATION DATA

A.1 HITCO BIN—CALIBRATION SUPPORT BRACKETS AND FIXTURES

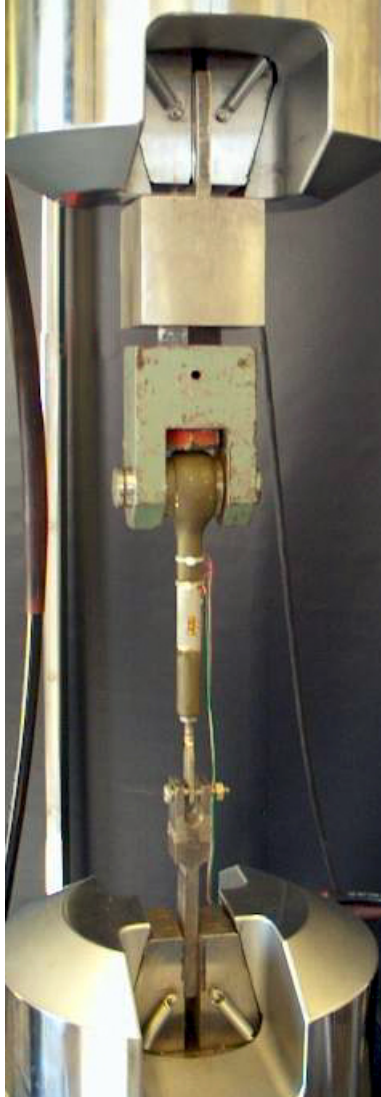
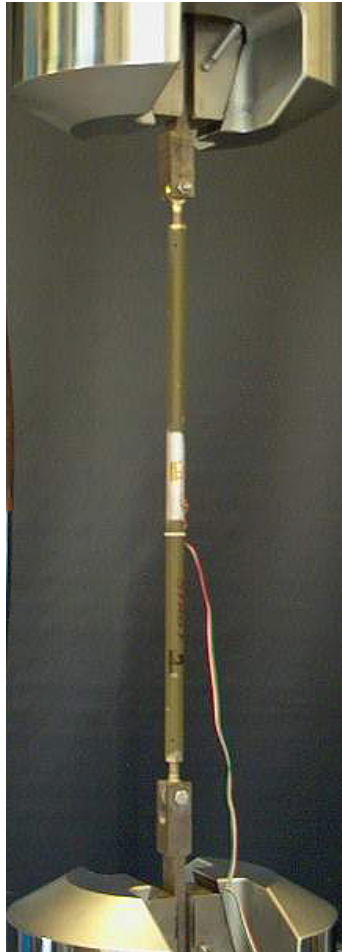


FIGURE A-1. FIXTURE FOR TIE
ROD LINK



FIGURE A-2. FIXTURE
FOR SUPPORT LINK



FIRGURE A-3. FIXTURE FOR STRUT LINK

A.2 HITCO BIN—TYPICAL LOAD CALIBRATION CURVES FOR LINKS H1 TO H11

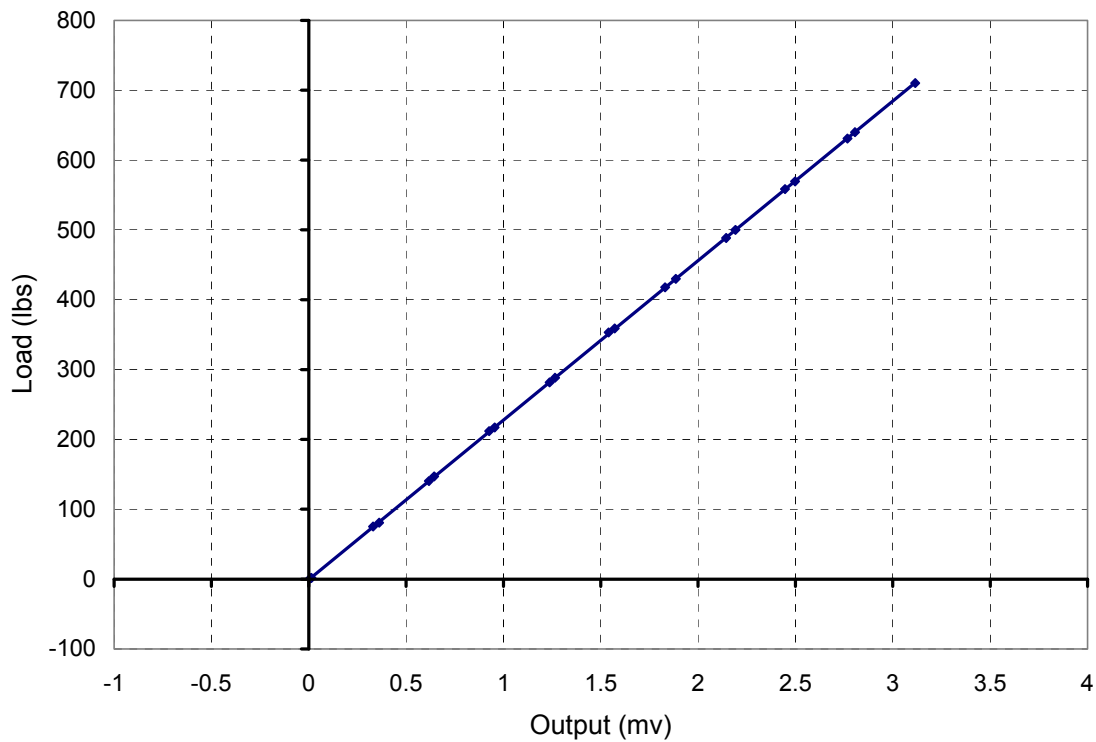


FIGURE A-4. LINK H1

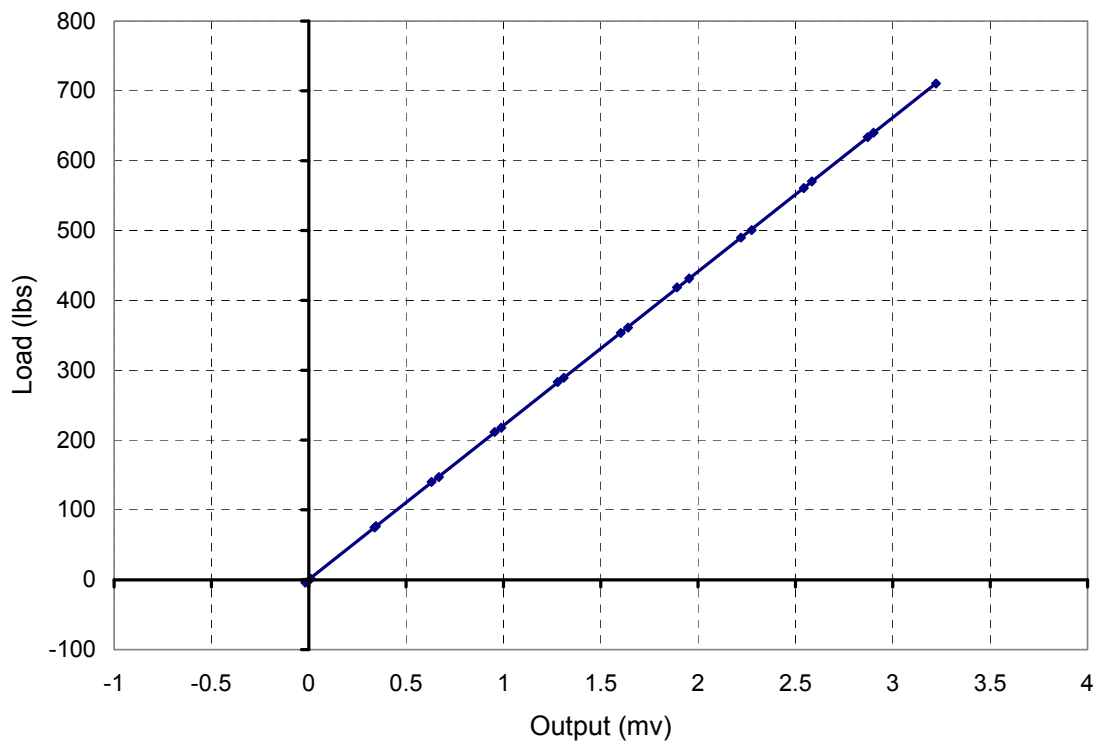


FIGURE A-5. LINK H2

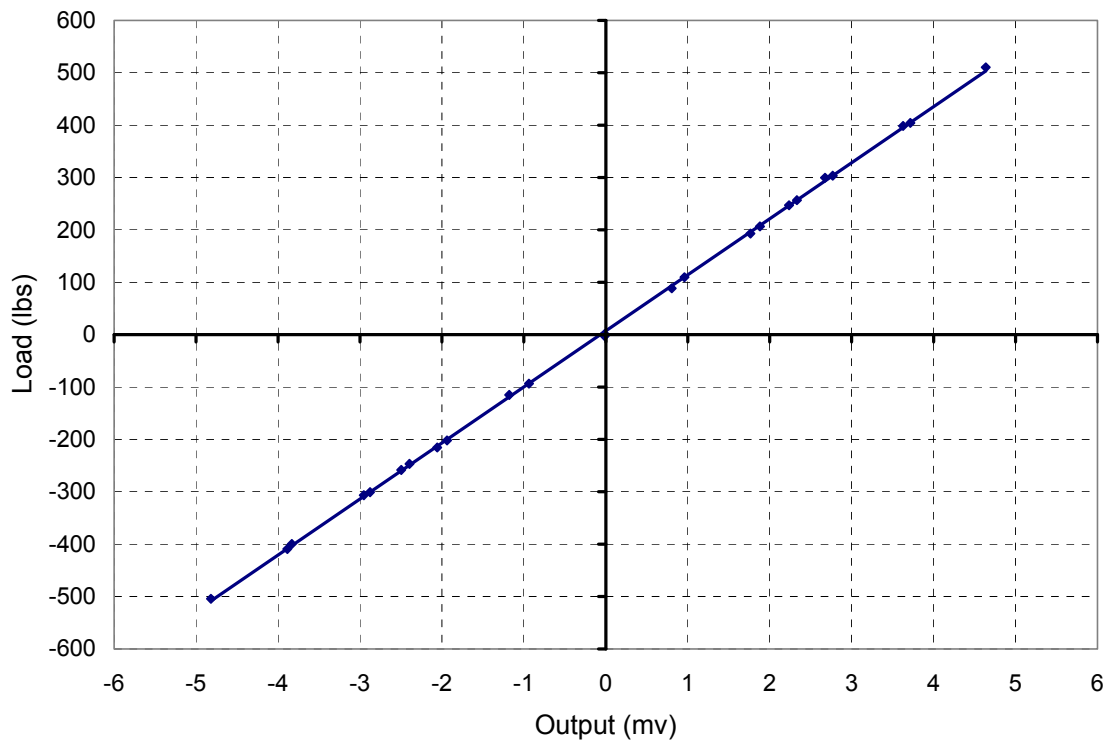


FIGURE A-6. LINK H3

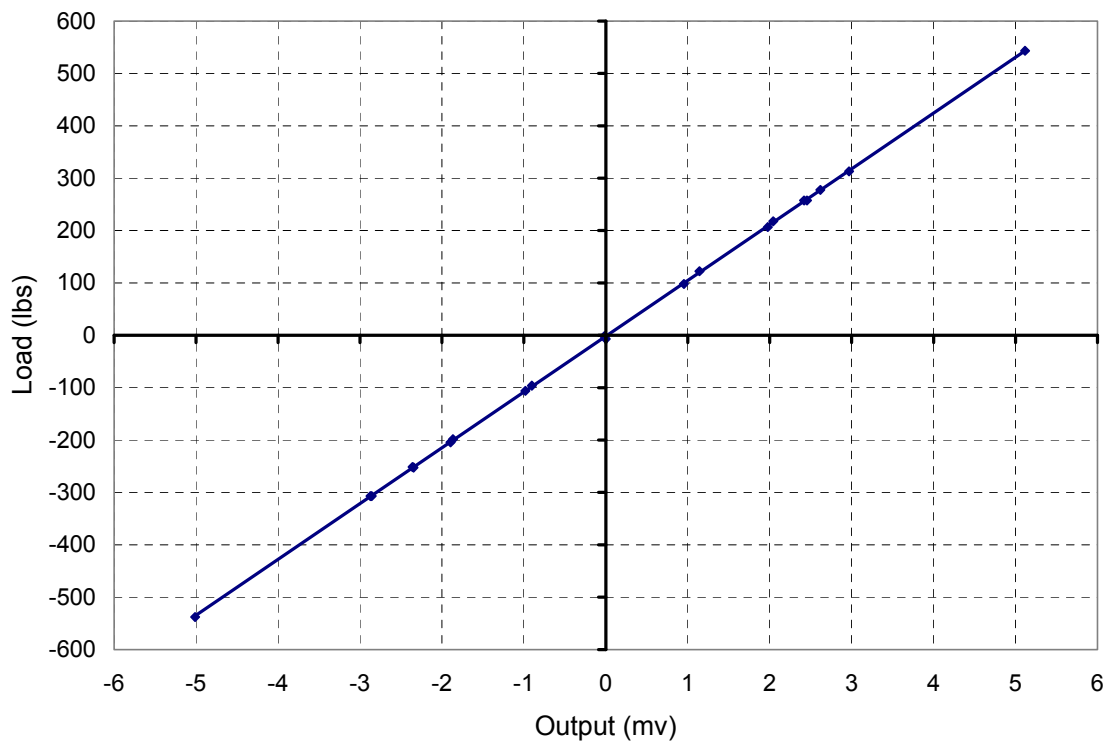


FIGURE A-7. LINK H4

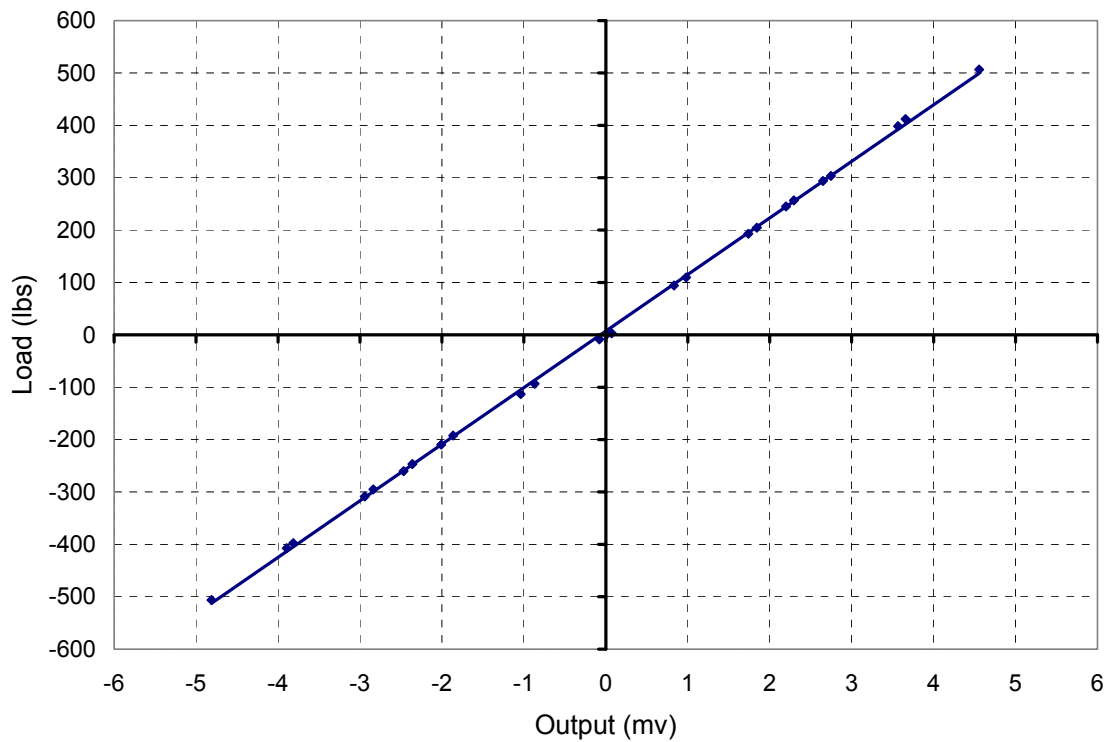


FIGURE A-8. LINK H5

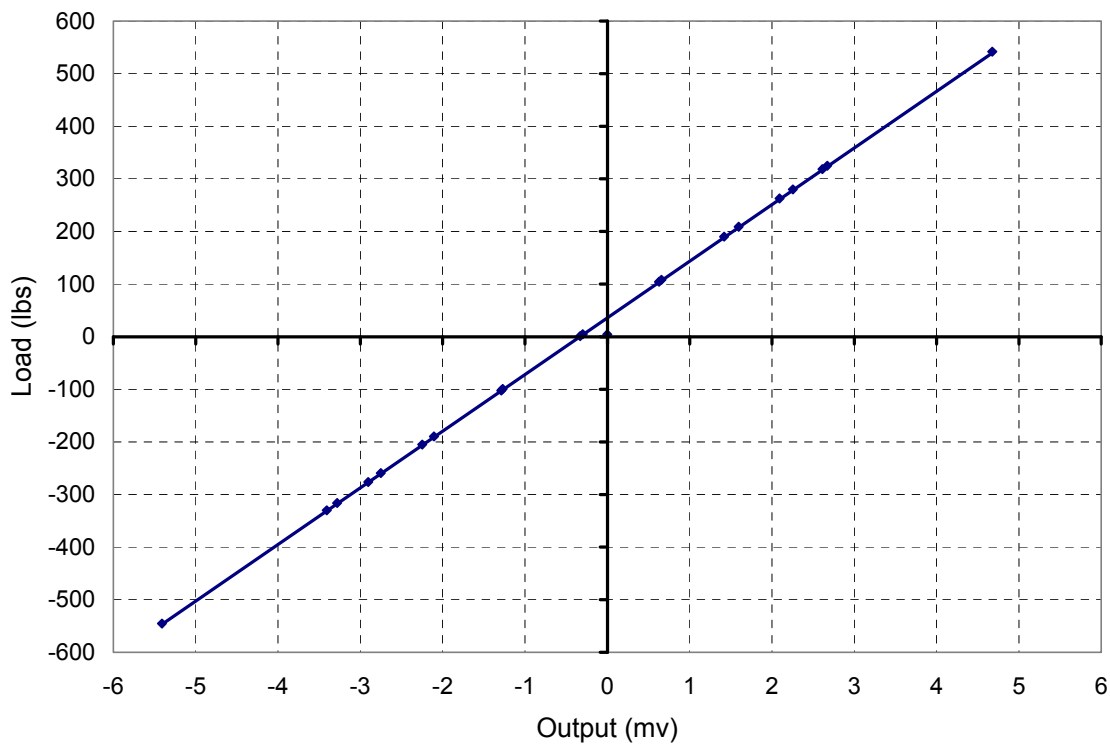


FIGURE A-9. LINK H6

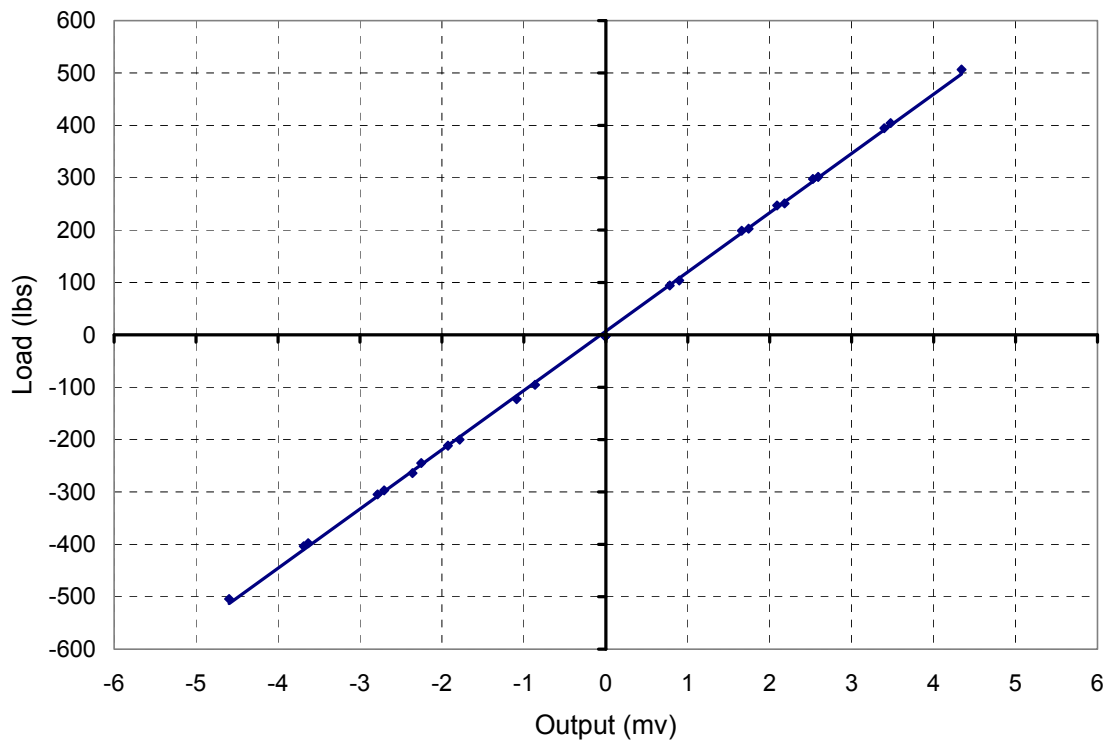


FIGURE A-10. LINK H7

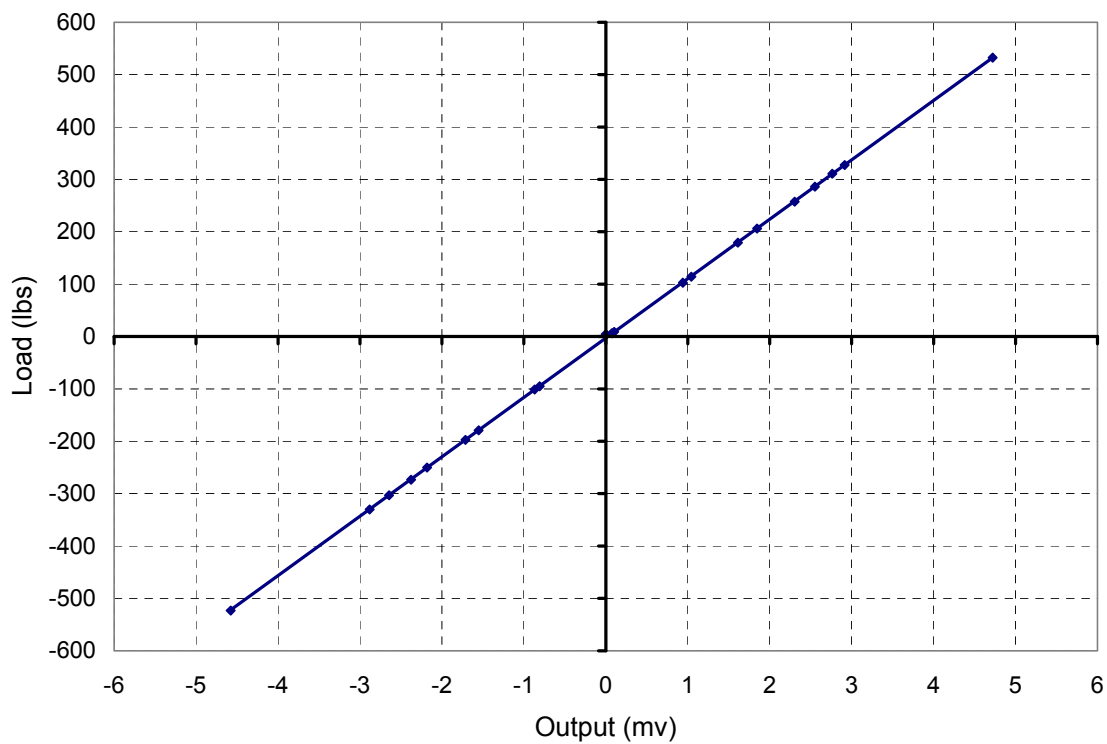


FIGURE A-11. LINK H8

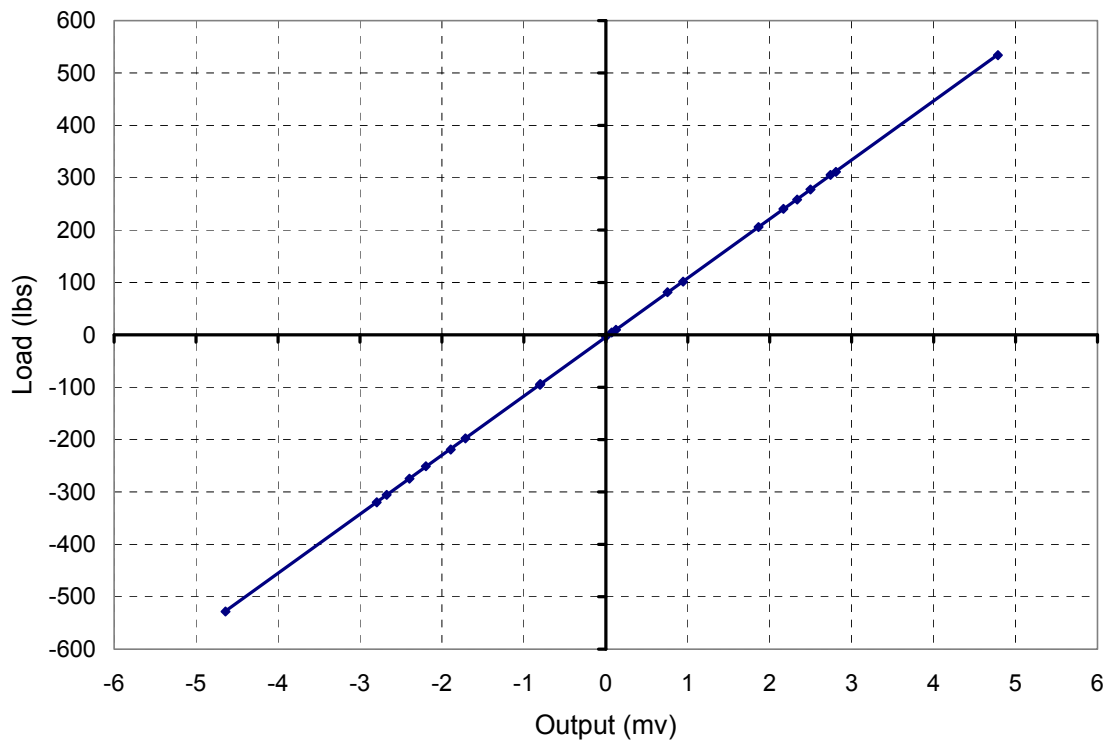


FIGURE A-12. LINK H9

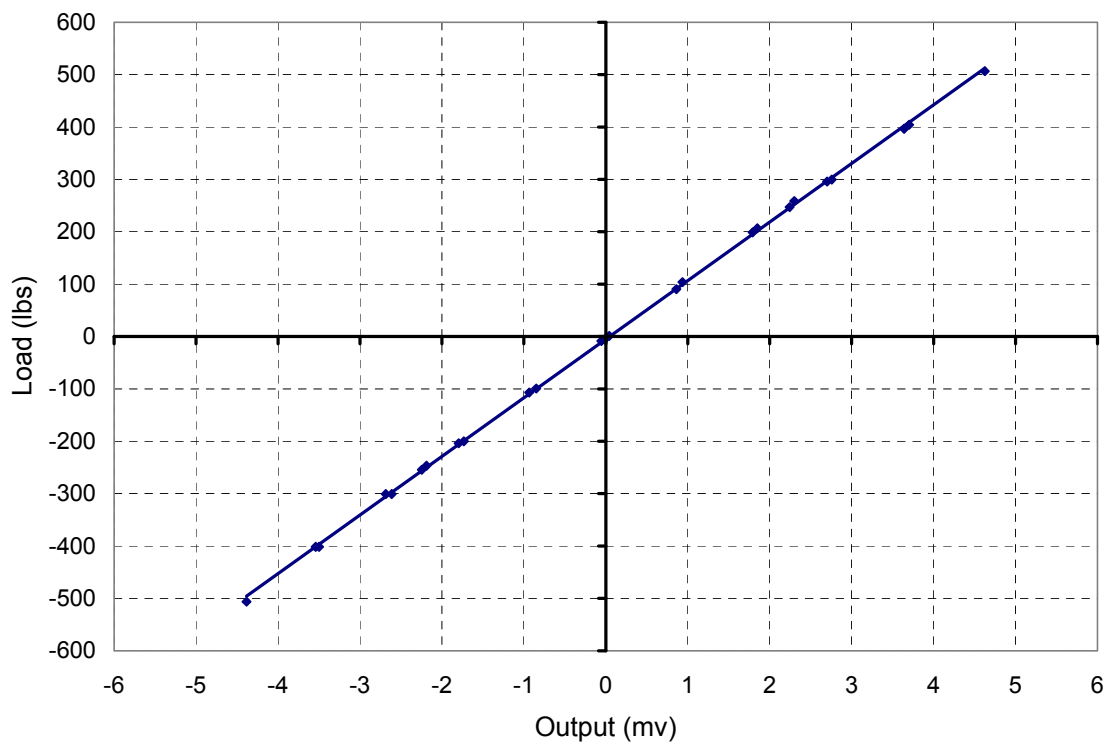


FIGURE A-13. LINK H10

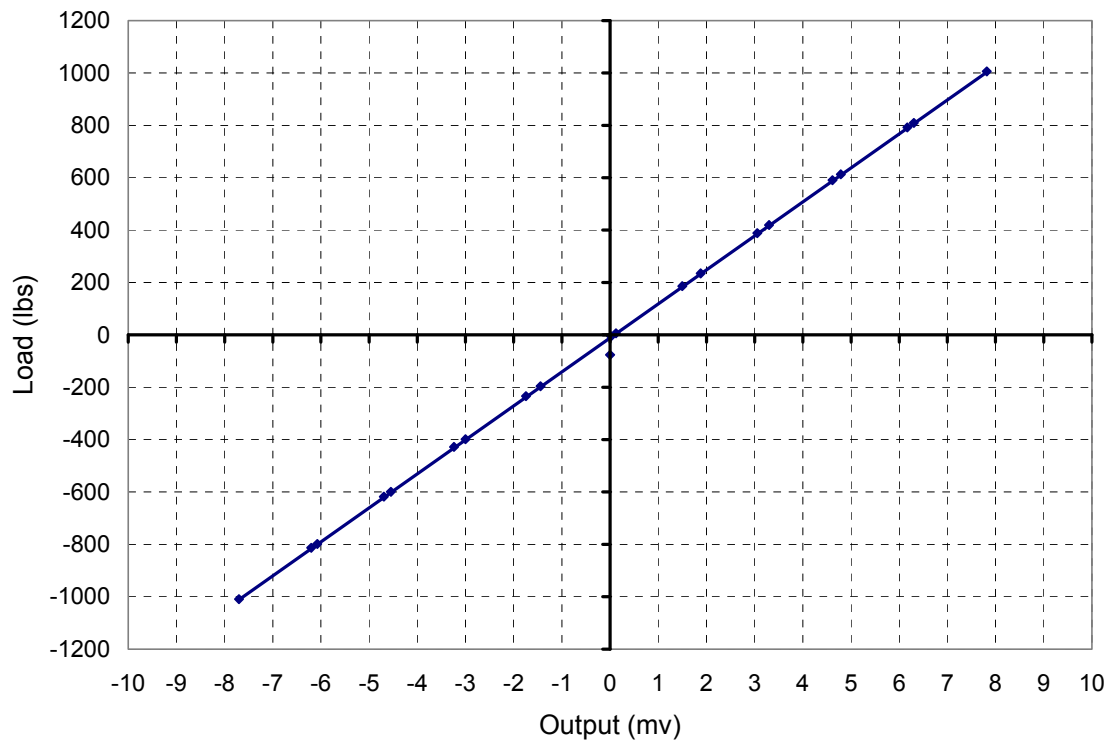


FIGURE A-14. LINK H11

A-3 HITCO BIN—POSTTEST TIE ROD LINKS, LINEARITY CHECK

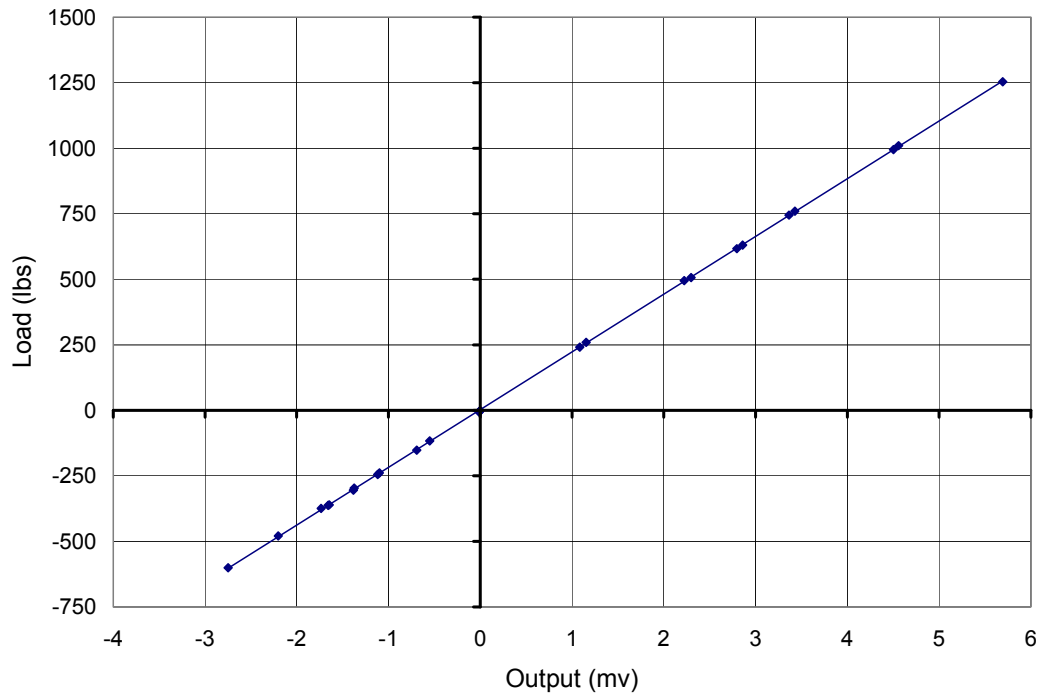


FIGURE A-15. H1 LINEARITY CHECK

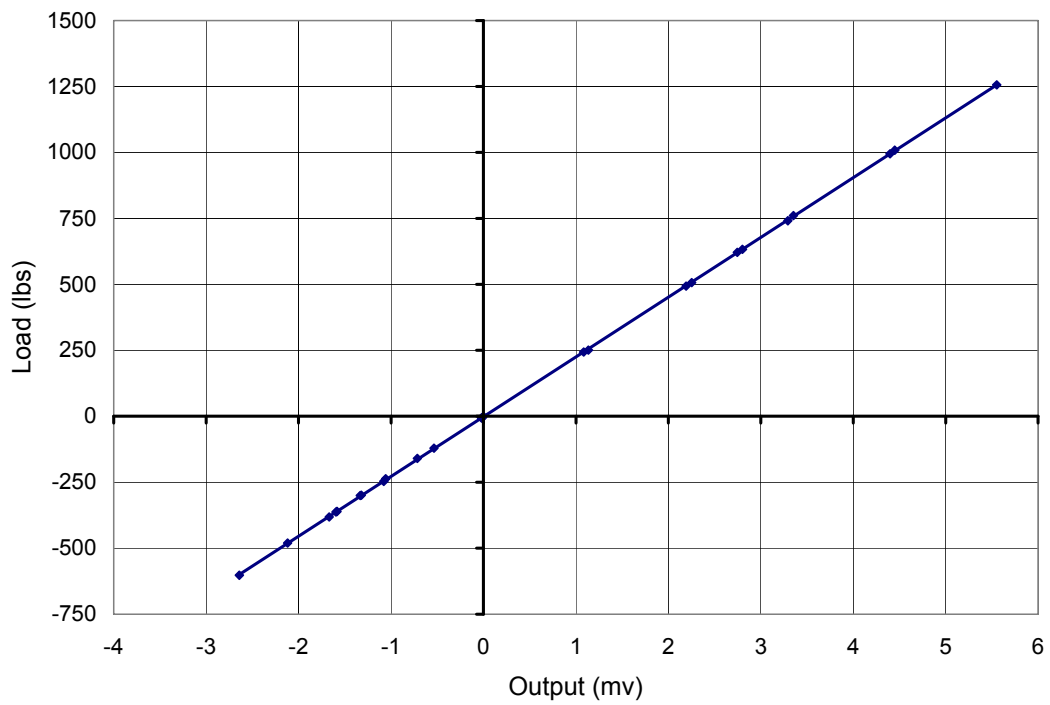


FIGURE A-16. H2 LINEARITY CHECK

TABLE A-1. HITCO BIN SENSITIVITY COEFFICIENTS

Support Link	Sensitivity Coefficient z direction $y = mx + b$		Nonlinearity Typical	Hysteresis Typical
	Slope (LB/MV)	Offset (LB)	% FS	% FS
H1	220.7	0.0	<2	<2
H2	227.5	-1.0	<2	<2
H3	107.1	6.0	<1	<1
H4	106.7	-3.1	<1	<1
H5	108.0	8.0	<1	<1
H6	107.7	35.6	<1	<1
H7	113.1	7.0	<1	<1
H8	113.5	-4.3	<1	<1
H9	112.9	-6.1	<1	<1
H10	108.9	-6.9	<1	<1
H11	129.9	-13.0	<1	<1

TABLE A-2. HITCO BIN—STATIC SYSTEM CALIBRATION NO. 1

Link No.	Applied Vertical Load (lbs)											Angle	Angle
	0	200	400	600	800	1000	800	600	400	200	0	α	β
H1	0	75	147	218	291	358	291	218	147	69	-2	93	
H2	-1	55	122	186	246	313	259	197	137	68	-3	89	
H3	6	14	25	35	46	58	47	37	26	18	6	82	
H4	-3	-2	-2	-1	1	6	3	0	-2	0	0	175	
H5	8	26	46	64	85	106	85	66	47	31	10	84	
H6	35	35	35	34	35	36	35	34	34	34	35	183	
H7	7	26	46	67	88	110	90	69	47	31	9	94	
H8	-4	-4	-7	-8	-10	-12	-10	-9	-8	-6	-3	183	
H9	-6	8	20	35	49	63	51	37	22	10	-1	87	
H10	-7	-5	-4	-1	-1	0	0	-2	-3	-5	-4	173	
H11	-13	-13	-17	-17	-17	-21	-19	-16	-13	-10	-10	167	17
	Vertical Vector Load Component (lbs)											Influence Coefficient I_s @ 1001 lbs	
H1	0	75	147	218	291	358	291	218	147	69	-2	0.357	
H2	-1	55	122	186	246	313	259	197	137	68	-3	0.313	
H3	6	14	25	35	46	57	47	37	26	18	6	0.057	
H4	0	0	0	0	0	1	0	0	0	0	0	0.001	
H5	8	26	46	64	85	105	85	66	47	31	10	0.105	
H6	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-0.002	
H7	7	26	46	67	88	110	90	69	47	31	9	0.110	
H8	0	0	0	0	1	1	1	0	0	0	0	0.001	
H9	-6	8	20	35	49	63	51	37	22	10	-1	0.063	
H10	-1	-1	0	0	0	0	0	0	0	-1	0	0.000	
H11	-3	-3	-4	-4	-4	-5	-4	-4	-3	-2	-2	-0.005	
Sum	8	198	399	598	798	1001	816	618	420	222	14		
	Lateral Vector Load Component (lbs)												
H1	0	4	8	11	15	19	15	11	8	4	0		
H2	0	-1	-2	-3	-4	-5	-5	-3	-2	-1	0		
H3	-1	-2	-3	-5	-6	-8	-7	-5	-4	-3	-1		
H4	-3	-2	-2	-1	1	6	3	0	-2	0	0		
H5	-1	-3	-5	-7	-9	-11	-9	-7	-5	-3	-1		
H6	35	35	35	34	35	36	35	34	34	34	35		
H7	0	2	3	5	6	8	6	5	3	2	1		
H8	-4	-4	-7	-8	-10	-12	-10	-9	-8	-6	-3		
H9	0	0	-1	-2	-3	-3	-3	-2	-1	-1	0		
H10	-7	-5	-4	-1	-1	0	0	-2	-3	-5	-4		
H11	-13	-13	-17	-17	-17	-20	-19	-16	-13	-10	-10		
Sum	8	11	5	7	8	8	8	6	7	12	17		
	Longitudinal Vector Load Component (lbs)												
H11	-12	-12	-16	-16	-16	-20	-18	-15	-12	-9	-9		
Sum	-12	-12	-16	-16	-16	-20	-18	-15	-12	-9	-9		

TABLE A-3. HITCO BIN—STATIC SYSTEM CALIBRATION NO. 2

Link No.	Applied Vertical Load (lbs)											Angle α	Angle β
	0	200	400	600	800	1000	800	600	400	200	0		
H1	0	71	140	207	278	345	278	207	144	75	4	93	17
H2	-1	53	117	173	239	304	241	184	128	66	-10	89	
H3	6	16	29	40	50	60	49	38	26	14	5	82	
H4	-3	-3	-3	-1	0	1	-2	-4	-5	-5	-3	175	
H5	8	26	49	70	89	106	87	66	44	22	5	84	
H6	35	33	33	35	36	28	28	26	27	27	31	183	
H7	7	28	49	73	92	111	90	68	43	24	6	94	
H8	-4	-7	-10	-13	-14	-18	-17	-16	-13	-11	-7	183	
H9	-6	7	21	38	51	63	48	33	18	4	-5	87	
H10	-7	-6	-5	-2	-2	-3	-5	-6	-7	-8	-7	173	
H11	-13	-15	-16	-18	-21	-22	-22	-20	-18	-13	-14	167	
Influence Coefficient I _s @ 981 lbs													
Vertical Vector Load Component (lbs)													
H1	0	71	140	207	278	345	278	207	144	75	4	0.351	
H2	-1	53	117	173	239	304	241	184	128	66	-10	0.310	
H3	6	16	29	40	50	59	49	38	26	14	5	0.061	
H4	0	0	0	0	0	0	0	0	0	0	0	0.000	
H5	8	26	49	70	89	105	87	66	44	22	5	0.107	
H6	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	-2	-0.001	
H7	7	28	49	73	92	111	90	68	43	24	6	0.113	
H8	0	0	1	1	1	1	1	1	1	1	0	0.001	
H9	-6	7	21	38	51	63	48	33	18	4	-5	0.064	
H10	-1	-1	-1	0	0	0	-1	-1	-1	-1	-1	0.000	
H11	-3	-3	-4	-4	-5	-5	-5	-4	-4	-3	-3	-0.005	
Sum	8	195	398	594	791	981	785	589	396	199	-1		
Lateral Vector Load Component (lbs)													
H1	0	4	7	11	15	18	15	11	8	4	0		
H2	0	-1	-2	-3	-4	-5	-4	-3	-2	-1	0		
H3	-1	-2	-4	-6	-7	-8	-7	-5	-4	-2	-1		
H4	-3	-3	-3	-1	0	1	-2	-4	-5	-5	-3		
H5	-1	-3	-5	-7	-9	-11	-9	-7	-5	-2	-1		
H6	35	33	33	35	36	28	28	26	27	27	31		
H7	0	2	3	5	6	8	6	5	3	2	0		
H8	-4	-7	-10	-13	-14	-18	-17	-16	-13	-11	-7		
H9	0	0	-1	-2	-3	-3	-3	-2	-1	0	0		
H10	-7	-6	-5	-2	-2	-3	-5	-6	-7	-8	-7		
H11	-13	-15	-16	-18	-20	-21	-21	-19	-18	-13	-14		
Sum	8	2	-2	-1	-3	-16	-19	-21	-16	-10	0		
Longitudinal Vector Load Component (lbs)													
H11	-12	-14	-15	-17	-20	-20	-20	-19	-17	-12	-13		
Sum	-12	-14	-15	-17	-20	-20	-20	-19	-17	-12	-13		

TABLE A-4. HITCO BIN—STATIC SYSTEM CALIBRATION NO. 3

Applied Vertical Load (lbs)												Angle	Angle
Link No.	0	200	400	600	800	1000	800	600	400	200	0	α	β
H1	0	73	140	207	289	364	291	213	147	75	4	93	
H2	-1	57	111	164	242	297	246	184	126	62	-5	89	
H3	6	16	28	39	49	59	48	39	26	14	6	82	
H4	-3	-6	-5	-4	-3	-2	-4	-5	-6	-8	-6	175	
H5	8	28	51	72	88	104	88	70	46	27	11	84	
H6	35	35	35	34	34	33	32	32	31	32	34	183	
H7	7	27	50	72	91	116	90	71	47	25	14	94	
H8	-4	-7	-9	-13	-15	-16	-15	-14	-11	-9	-7	183	
H9	-6	8	22	38	51	65	49	34	19	4	-4	87	
H10	-7	-7	-7	-6	-6	-2	-6	-7	-9	-10	-10	173	
H11	-13	-16	-19	-24	-25	-19	-24	-23	-21	-20	-18	167	17
Vertical Vector Load Component (lbs)												Influence Coefficient $I_s @ 997 \text{ lbs}$	
H1	0	73	140	207	289	364	291	213	147	75	4	0.365	
H2	-1	57	111	164	242	297	246	184	126	62	-5	0.298	
H3	6	16	28	39	49	58	48	39	26	14	6	0.059	
H4	0	-1	0	0	0	0	0	0	-1	-1	-1	0.000	
H5	8	28	51	72	88	103	88	70	46	27	11	0.104	
H6	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-0.002	
H7	7	27	50	72	91	116	90	71	47	25	14	0.116	
H8	0	0	0	1	1	1	1	1	1	0	0	0.001	
H9	-6	8	22	38	51	65	49	34	19	4	-4	0.065	
H10	-1	-1	-1	-1	-1	0	-1	-1	-1	-1	-1	0.000	
H11	-3	-4	-4	-5	-6	-4	-5	-5	-5	-4	-4	-0.004	
Sum	8	202	394	583	801	997	803	602	403	199	19		
Lateral Vector Load Component (lbs)													
H1	0	4	7	11	15	19	15	11	8	4	0		
H2	0	-1	-2	-3	-4	-5	-4	-3	-2	-1	0		
H3	-1	-2	-4	-5	-7	-8	-7	-5	-4	-2	-1		
H4	-3	-6	-5	-4	-3	-2	-4	-5	-6	-8	-6		
H5	-1	-3	-5	-8	-9	-11	-9	-7	-5	-3	-1		
H6	35	35	35	34	34	33	32	32	31	32	34		
H7	0	2	3	5	6	8	6	5	3	2	1		
H8	-4	-7	-9	-13	-15	-16	-15	-14	-11	-9	-7		
H9	0	0	-1	-2	-3	-3	-3	-2	-1	0	0		
H10	-7	-7	-7	-6	-6	-2	-6	-7	-9	-10	-10		
H11	-13	-16	-19	-23	-24	-19	-23	-22	-20	-19	-18		
Sum	8	-1	-6	-14	-16	-6	-18	-18	-16	-15	-7		
Longitudinal Vector Load Component (lbs)													
H11	-12	-15	-18	-22	-23	-18	-22	-21	-20	-19	-17		
Sum	-12	-15	-18	-22	-23	-18	-22	-21	-20	-19	-17		

A.4 HEATH TECNA BIN—CALIBRATION SUPPORT BRACKETS AND FIXTURES

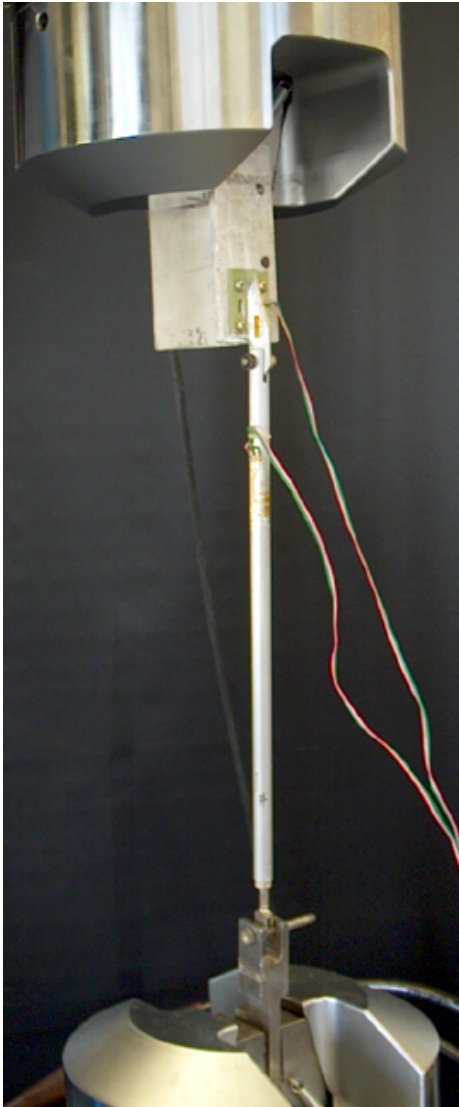


FIGURE A-17. FIXTURE FOR
HT1 THROUGH HT4

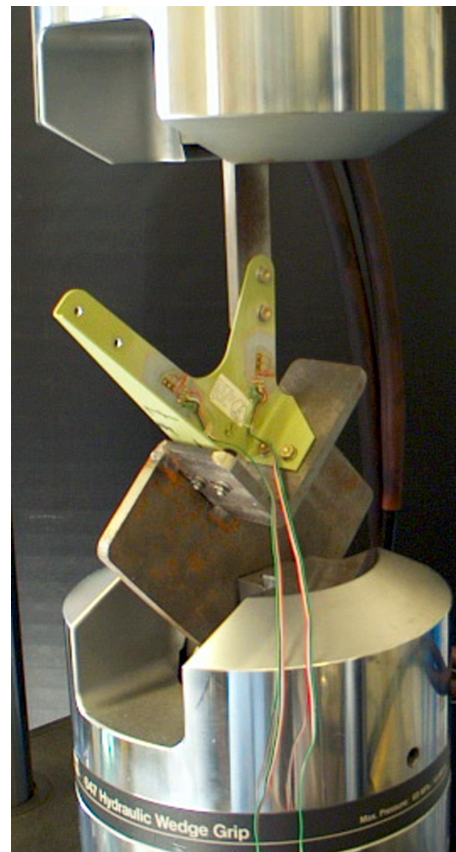


FIGURE A-18. FIXTURE FOR
HT5 THROUGH HT9

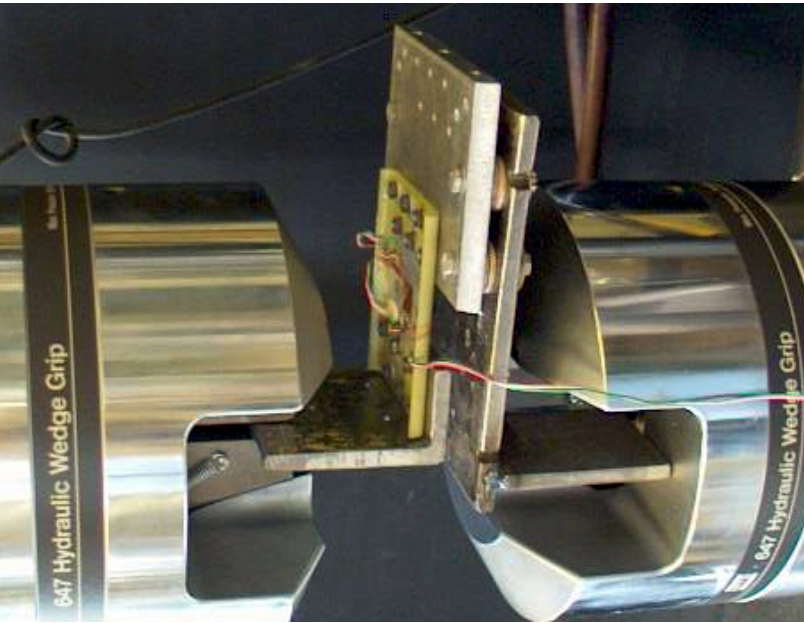


FIGURE A-19. FIXTURE FOR HT10 AND
HT11 - BENDING

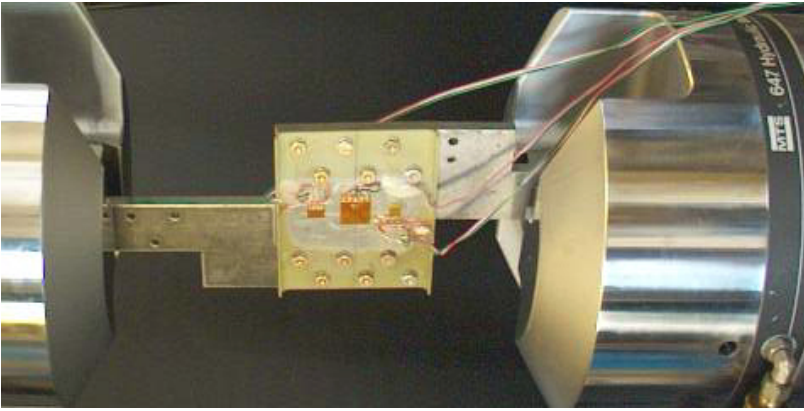


FIGURE A-20. FIXTURE FOR
HT10 AND HT11 - SHEAR

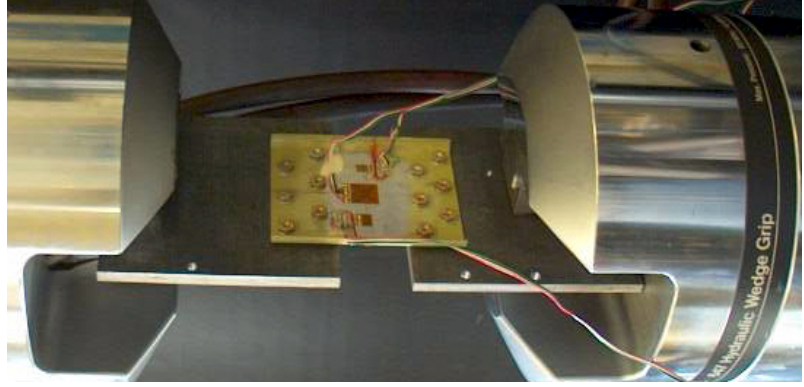


FIGURE A-21. FIXTURE FOR
HT10 AND HT11 - TENSION
AND COMPRESSION

A.5 HEATH TECNA BIN—TYPICAL LOAD CALIBRATION CURVES FOR HT1 TO HT11

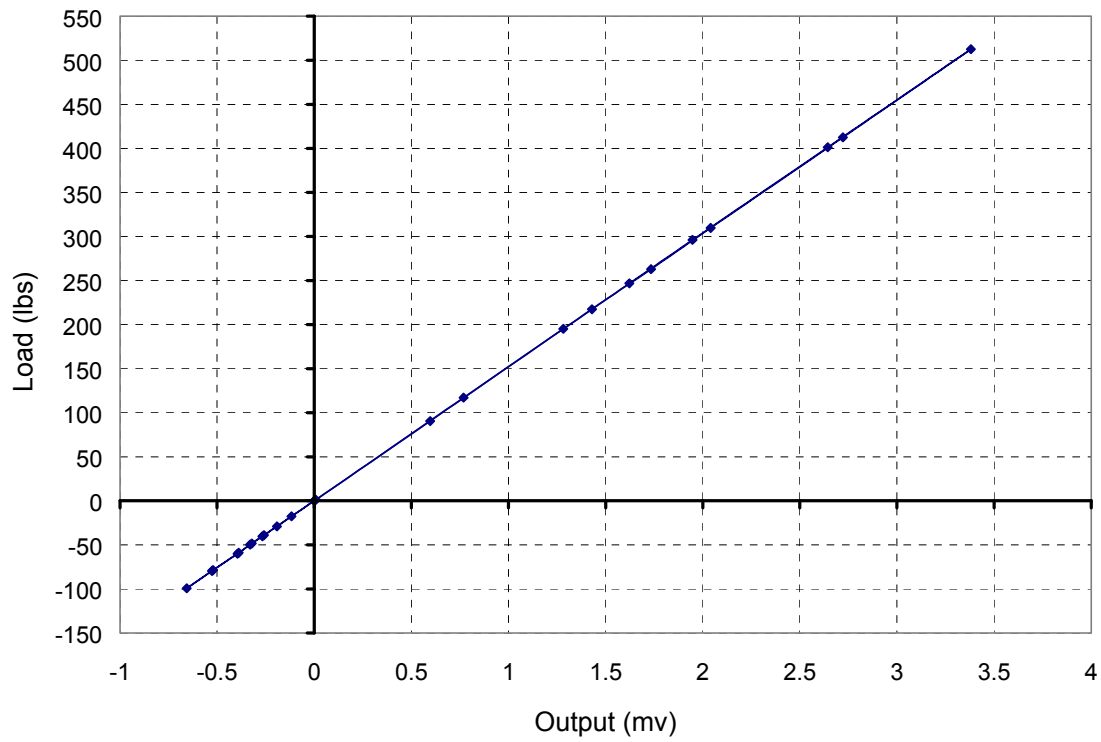


FIGURE A-22. HT1

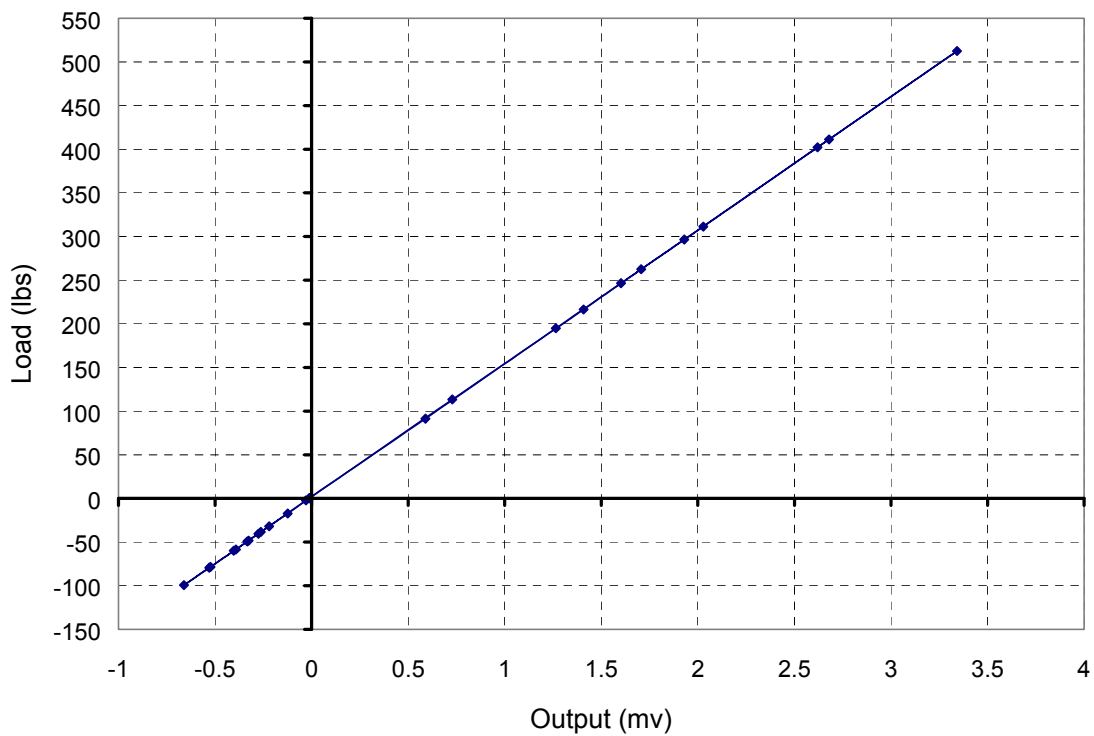


FIGURE A-23. HT2

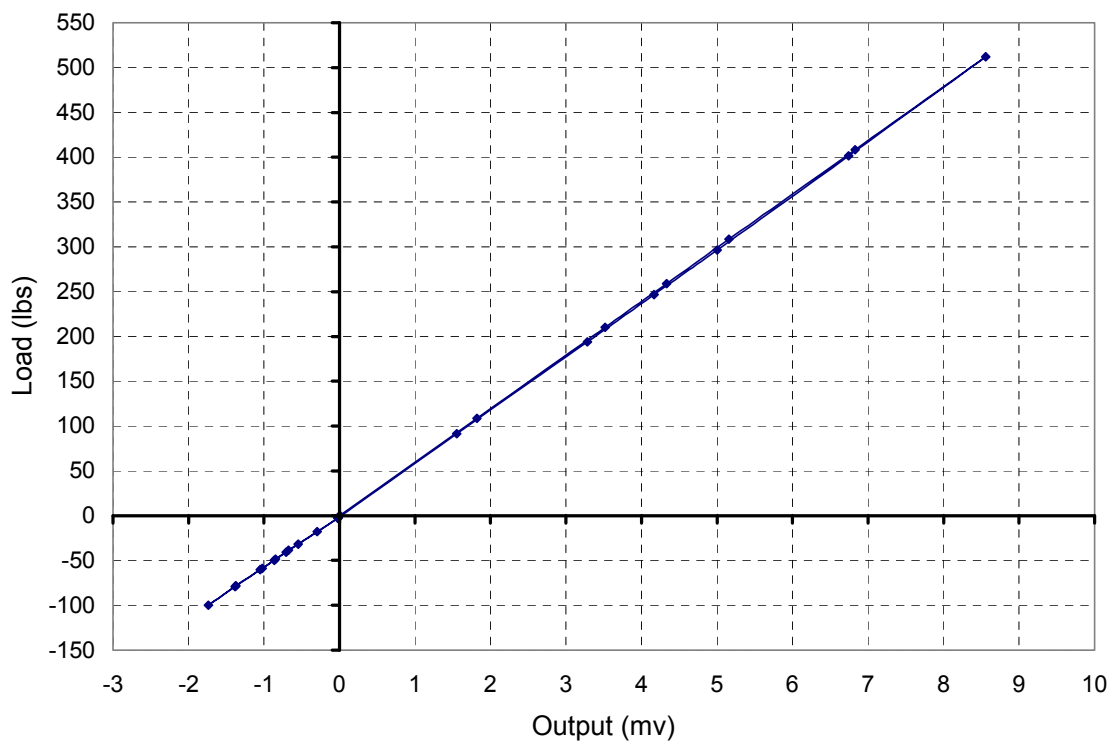


FIGURE A-24. HT3

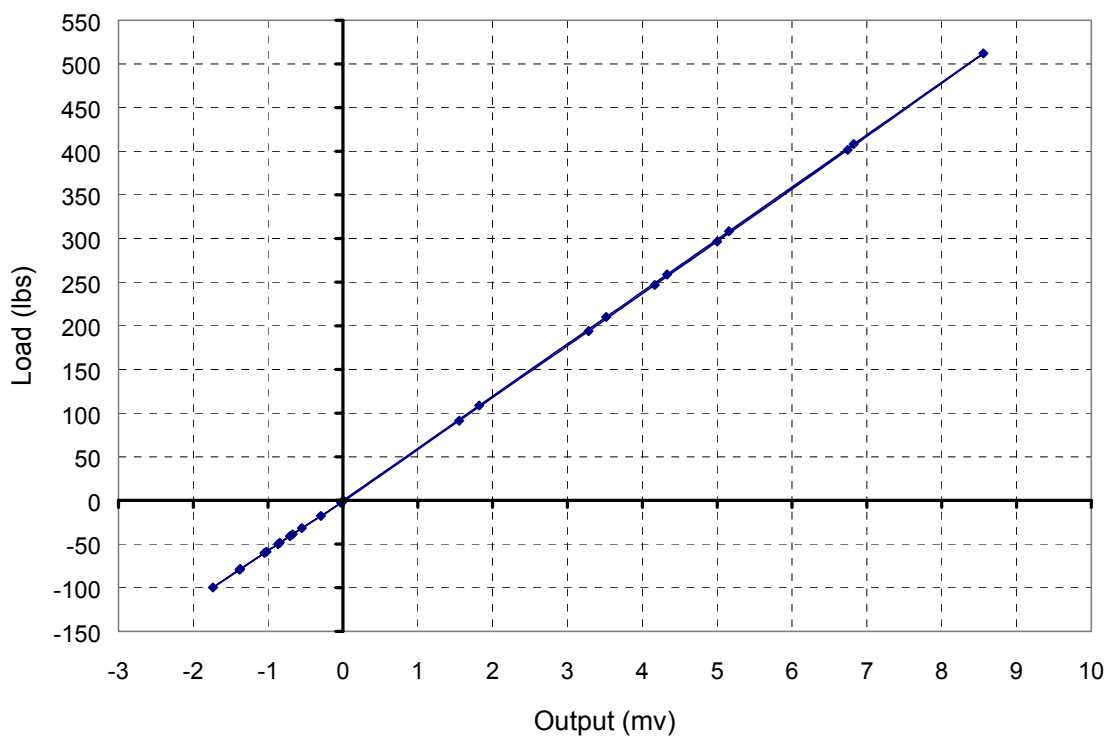


FIGURE A-25. HT4

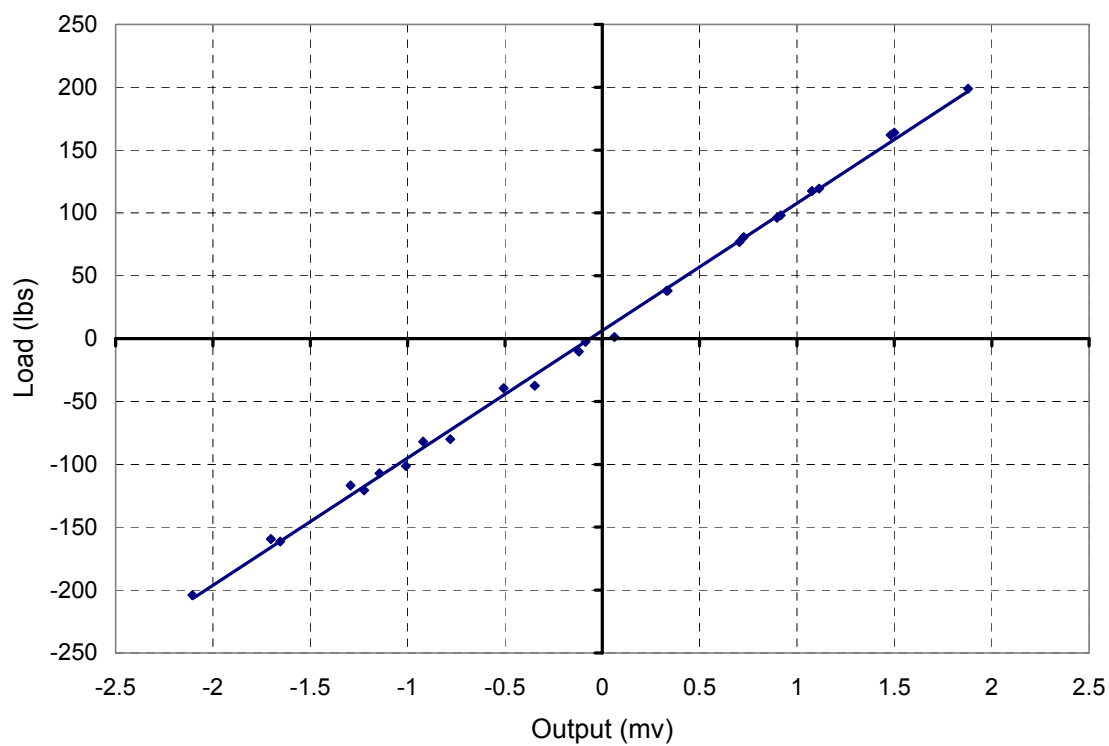


FIGURE A-26. HT5 CH A

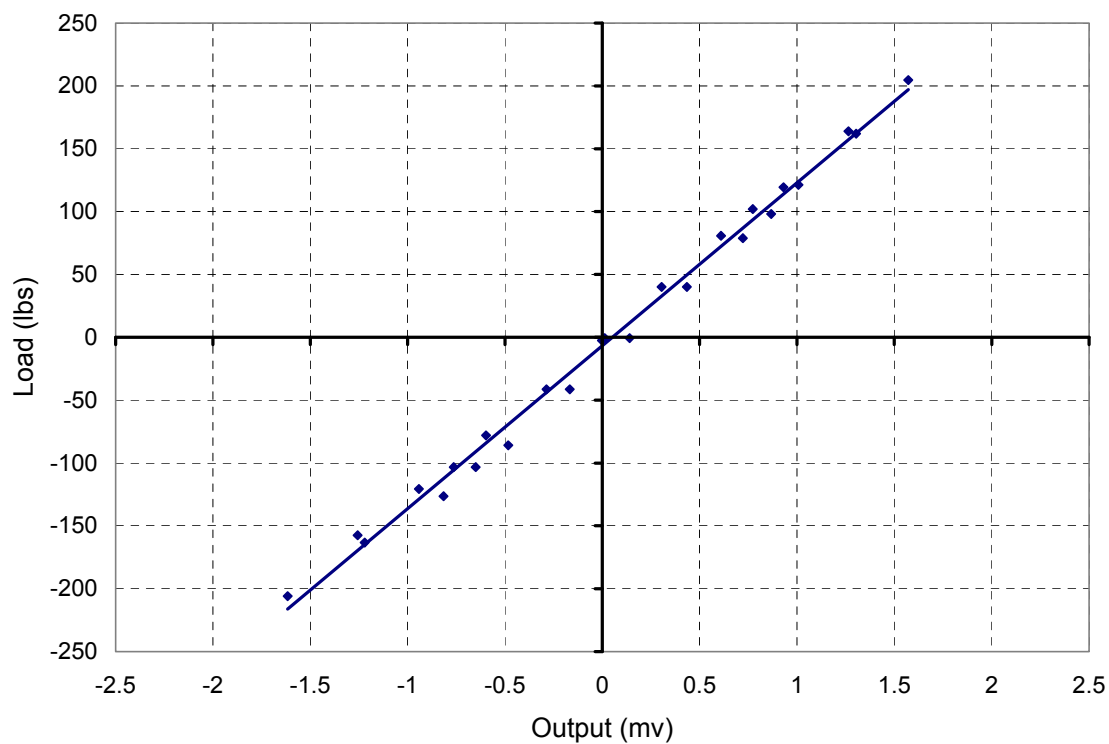


FIGURE A-27. HT5 CH B

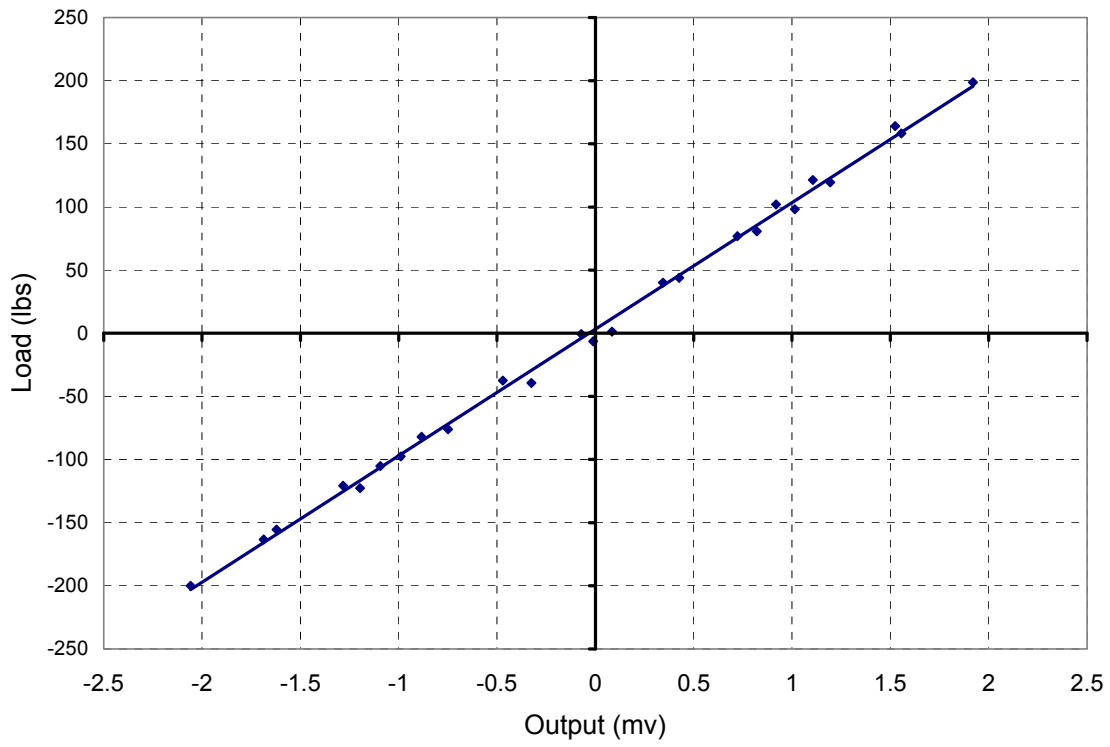


FIGURE A-28. HT6 CH A

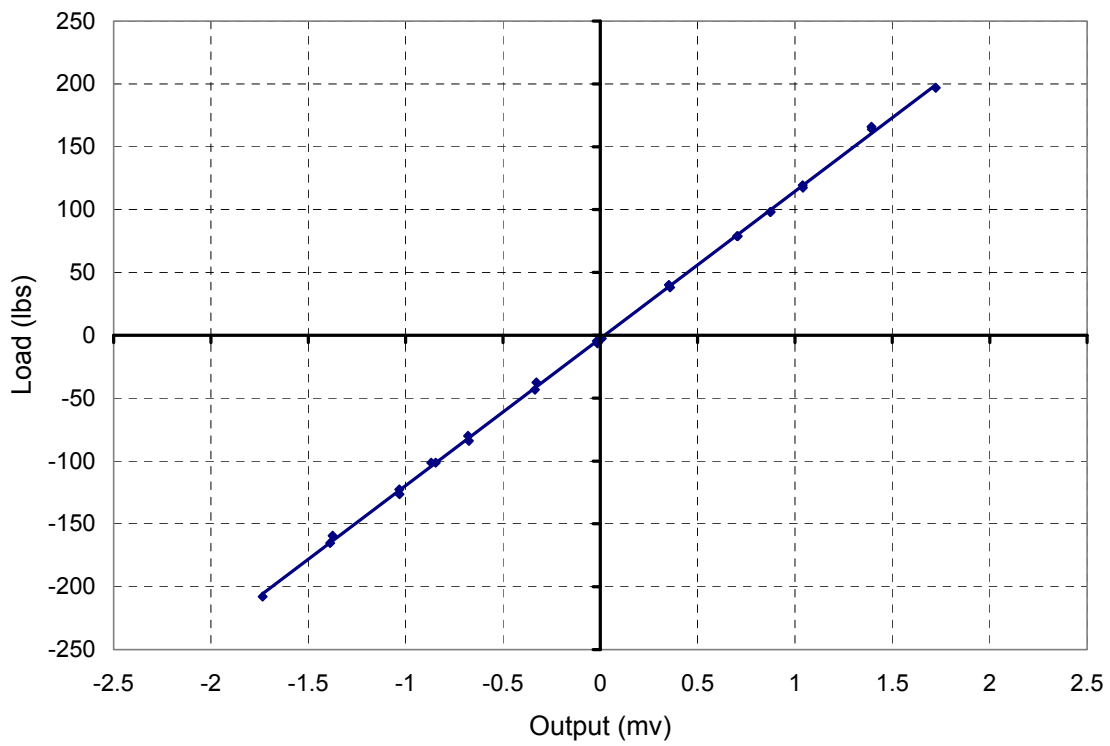


FIGURE A-29. HT6 CH B

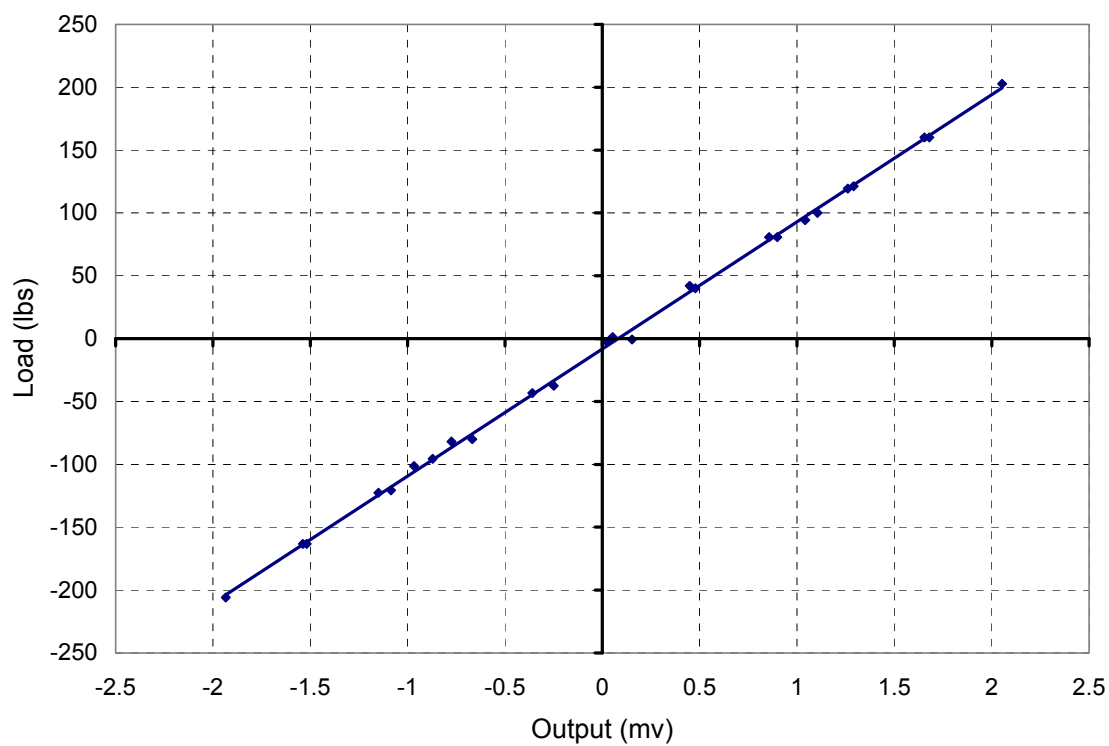


FIGURE A-30. HT7 CH A

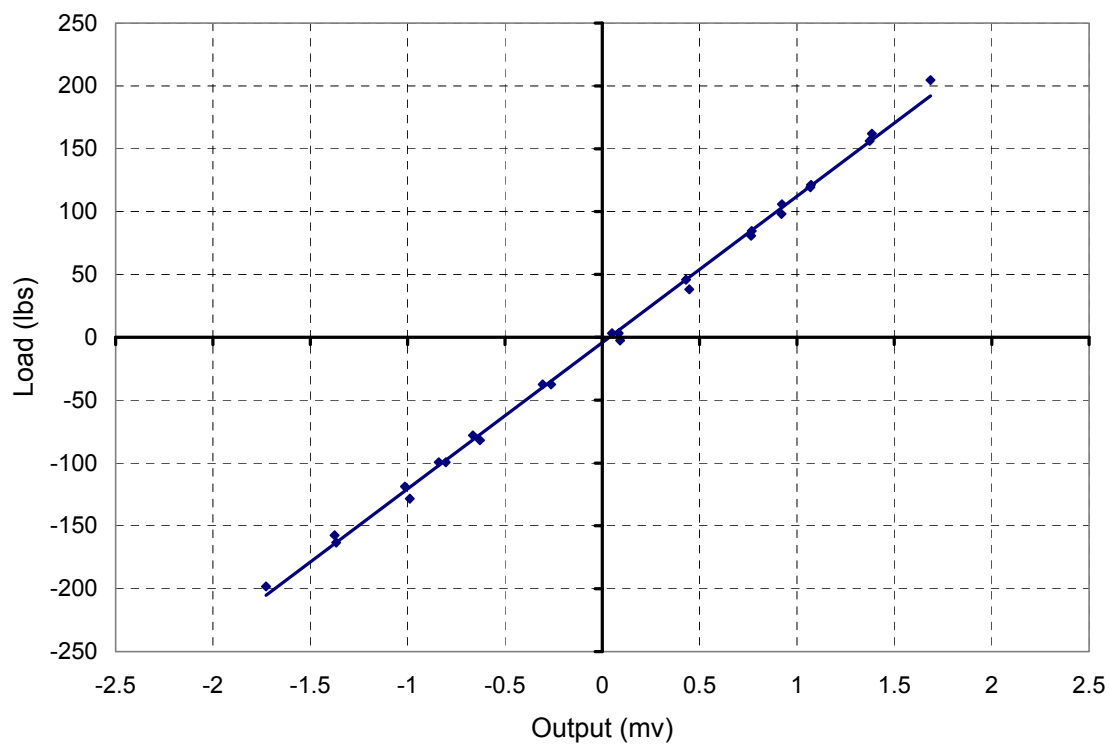


FIGURE A-31. HT7 CH B

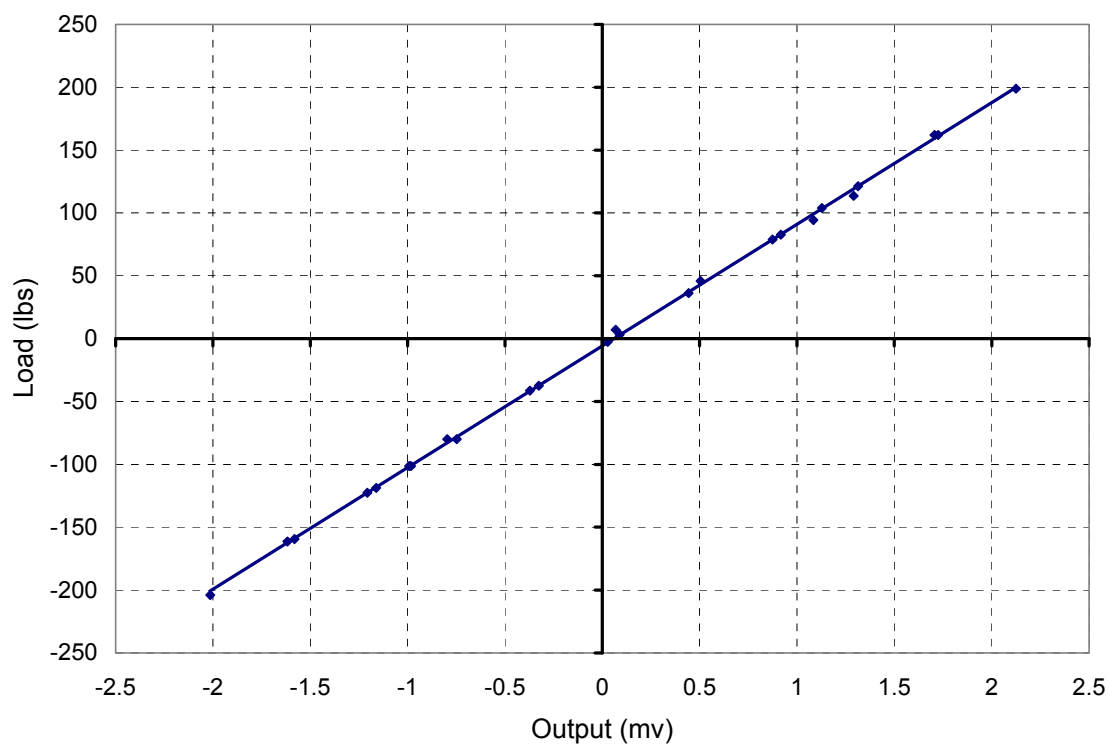


FIGURE A-32. HT8 CH A

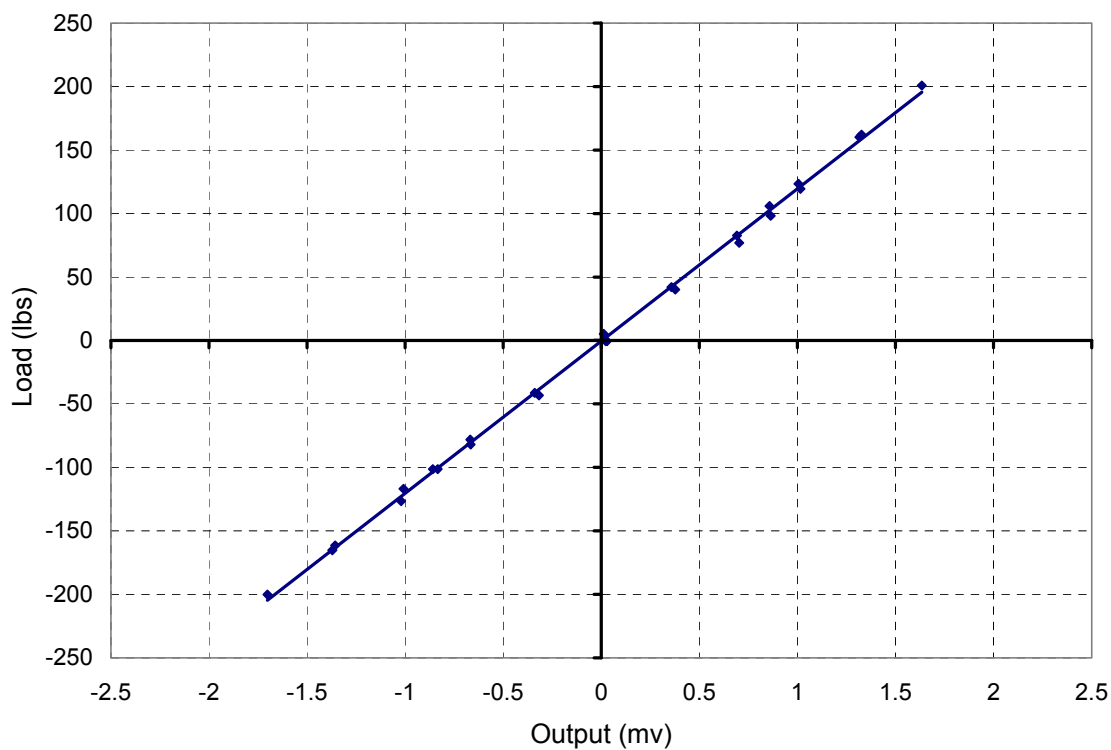


FIGURE A-33. HT8 CH B

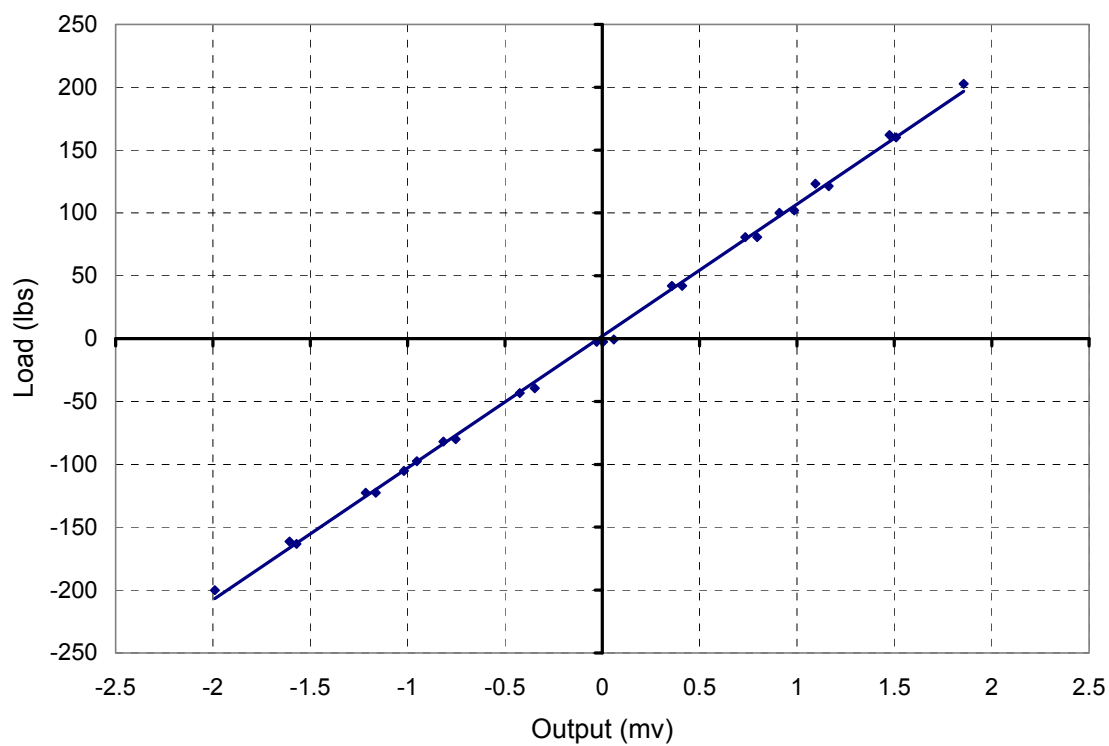


FIGURE A-34. HT9 CH A

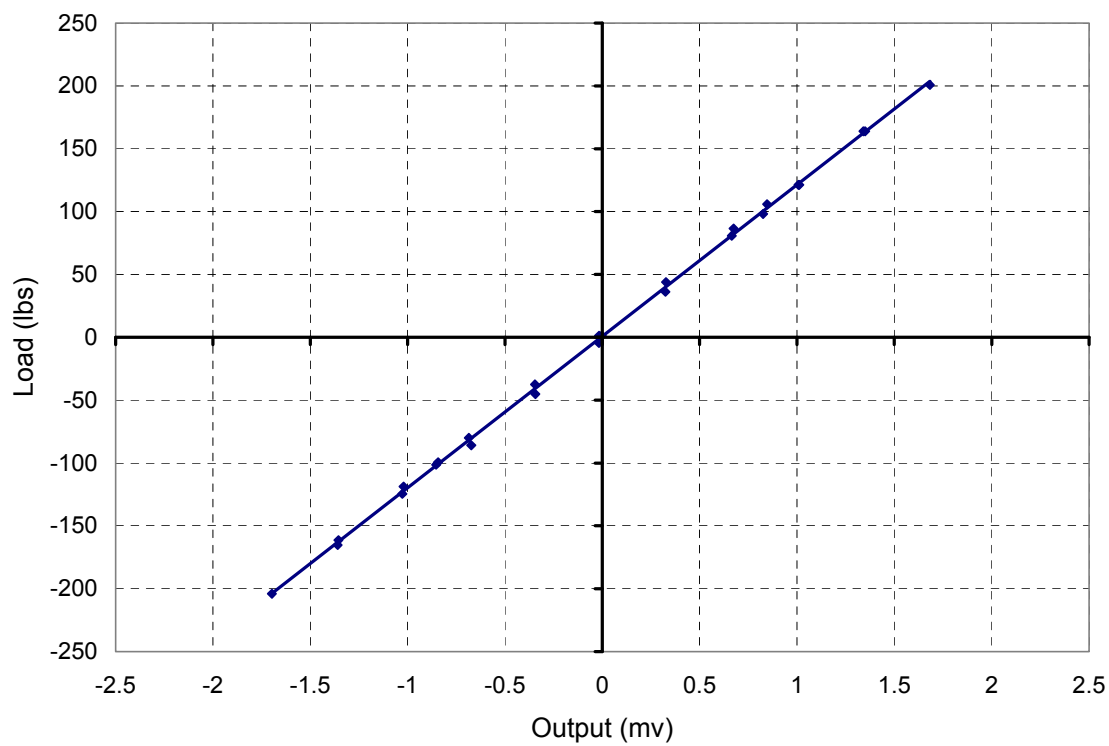


FIGURE A-35. HT9 CH B

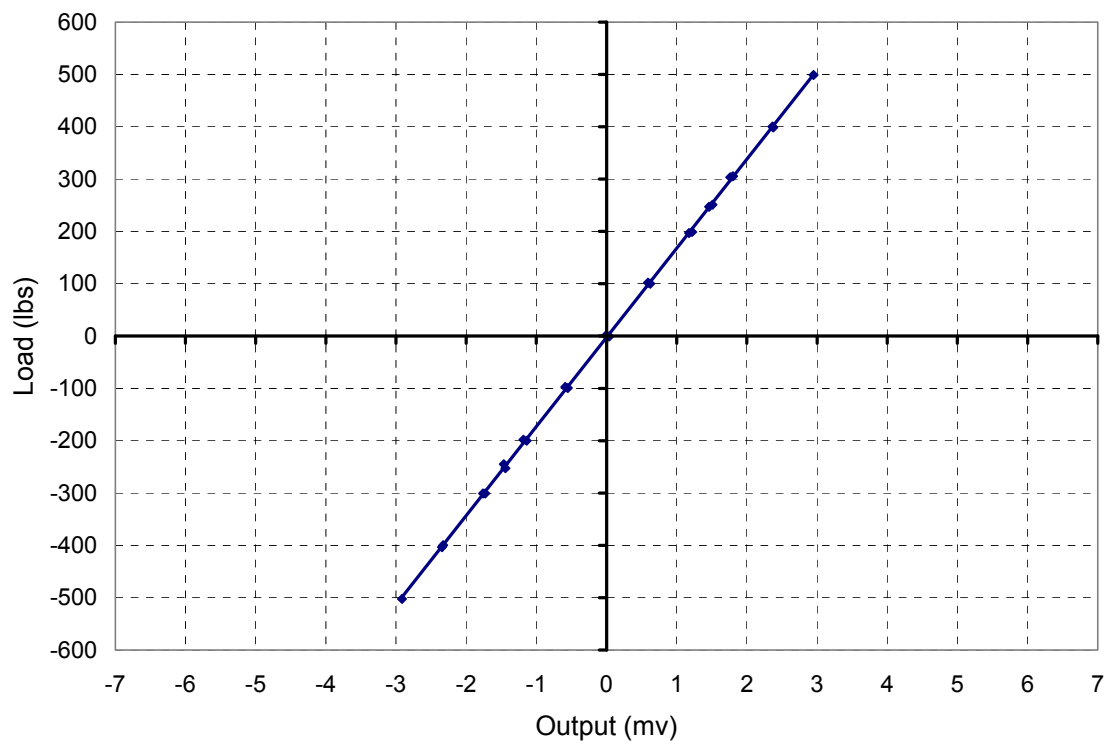


FIGURE A-36. HT10 CH A

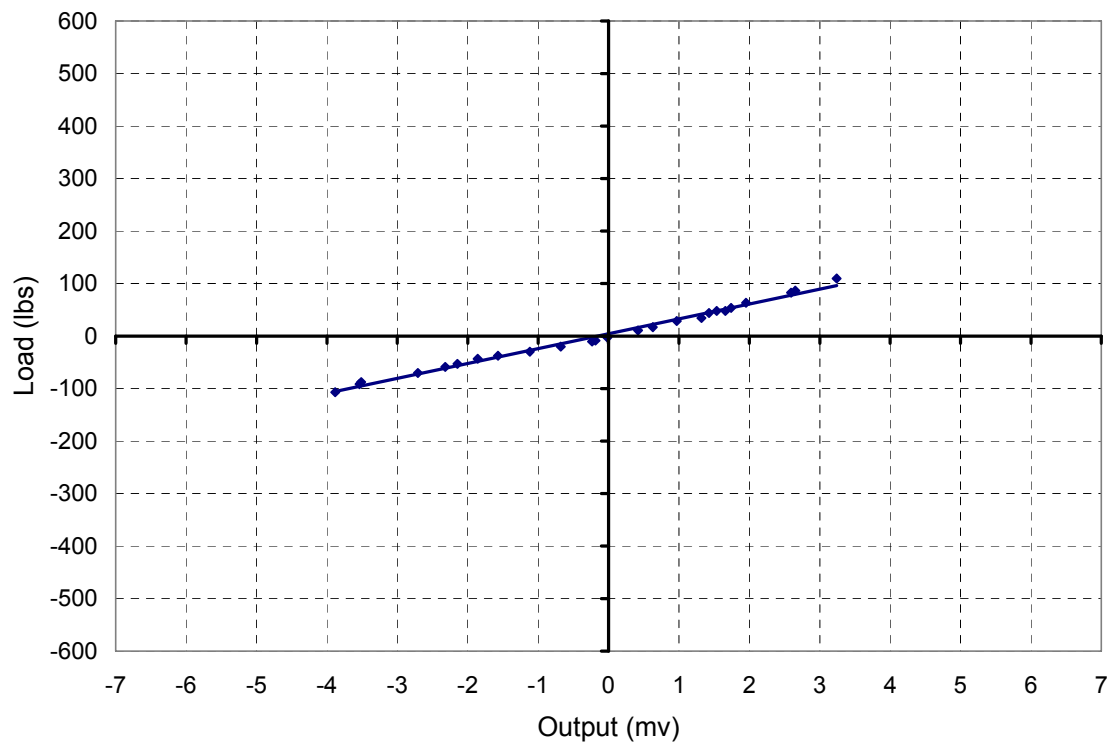


FIGURE A-37. HT10 CH B

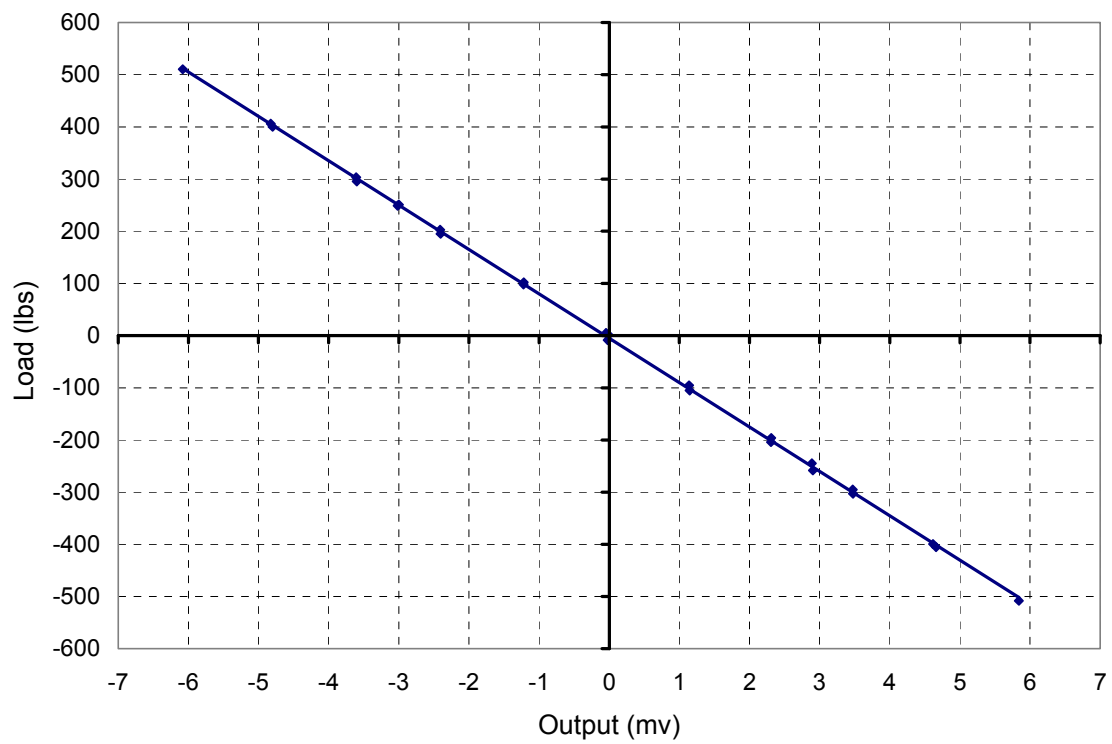


FIGURE A-38. HT10 CH C

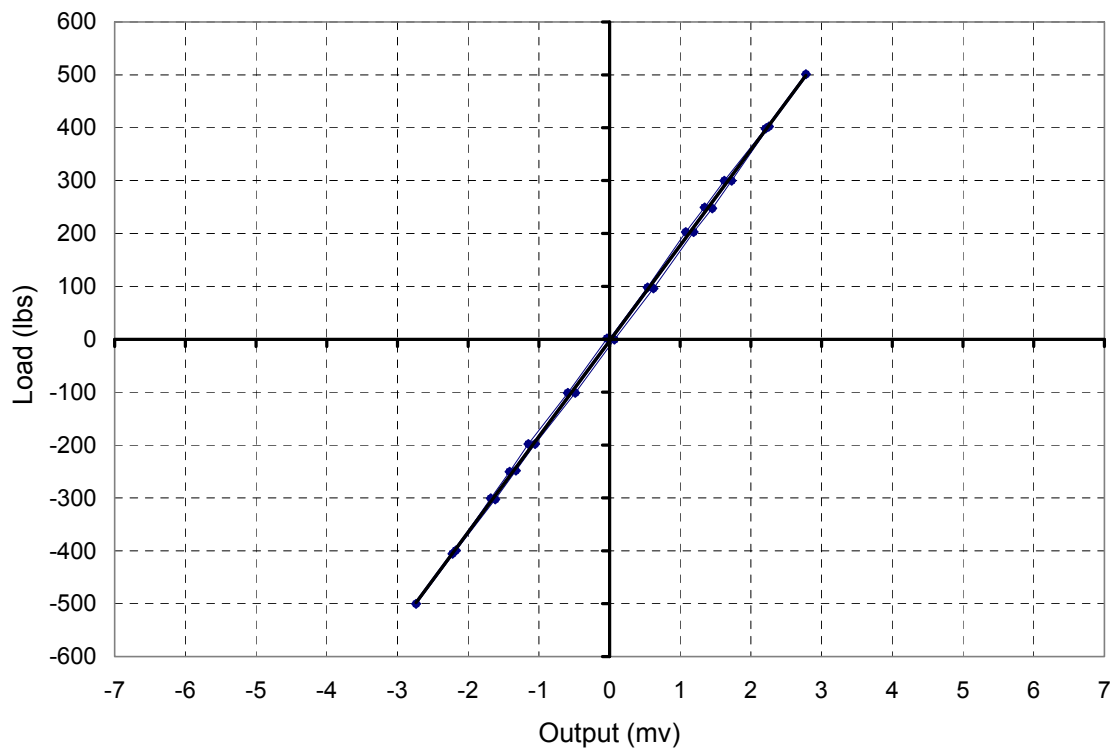


FIGURE A-39. HT11 CH A

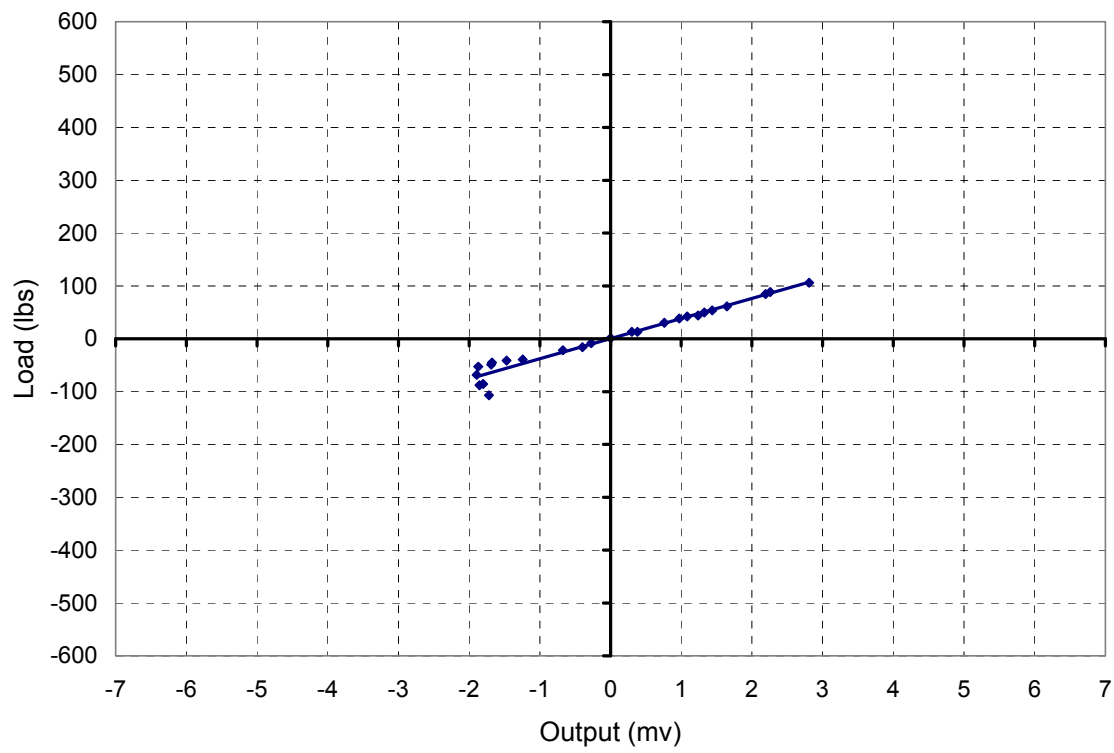


FIGURE A-40. HT11 CH B

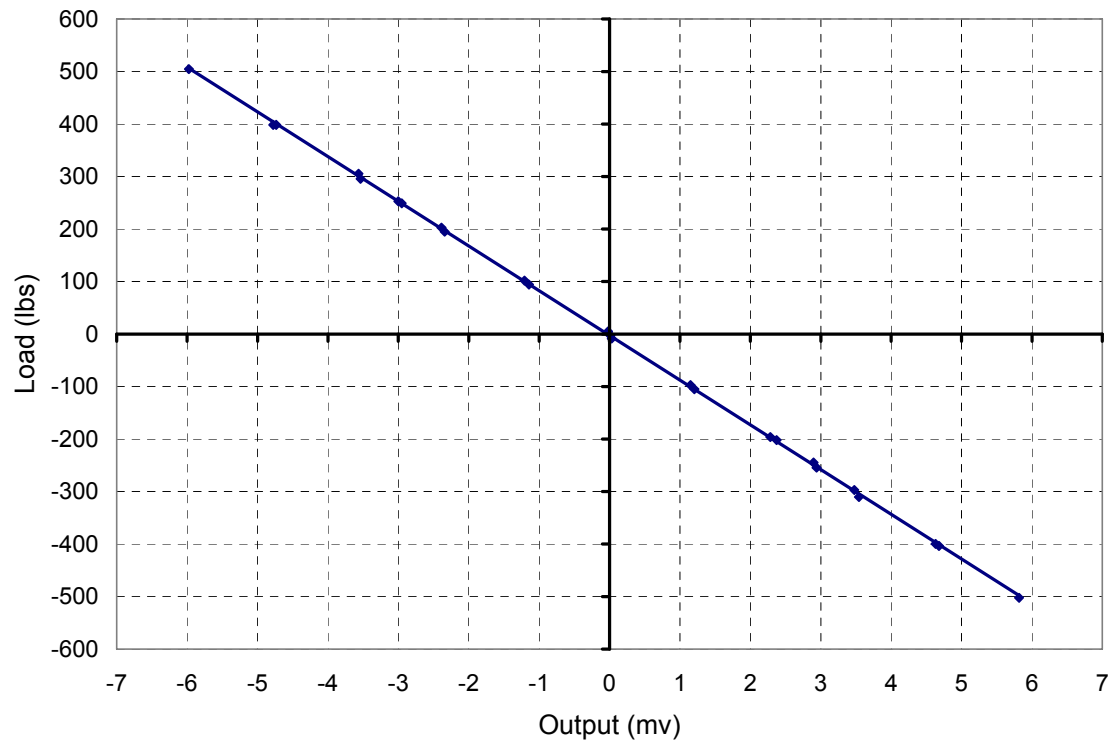


FIGURE A-41. HT11 CH C

A.6 HEATH TECNA BIN—POSTTEST STRUT/MATING SUPPORT LINEARITY CHECK

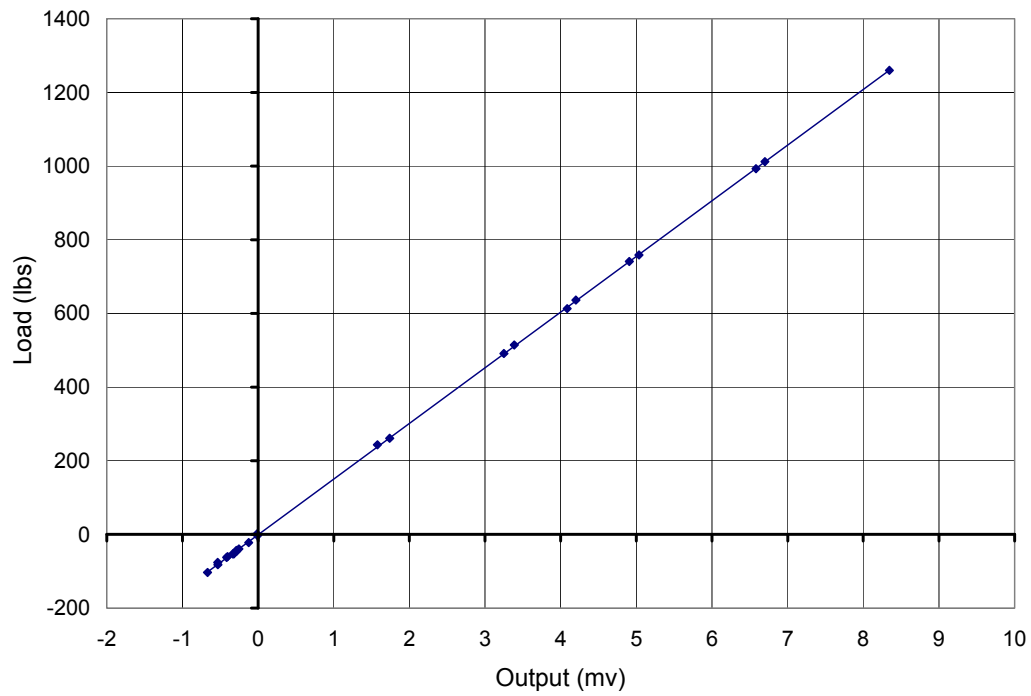


FIGURE A-42. HT 1 LINEARITY CHECK

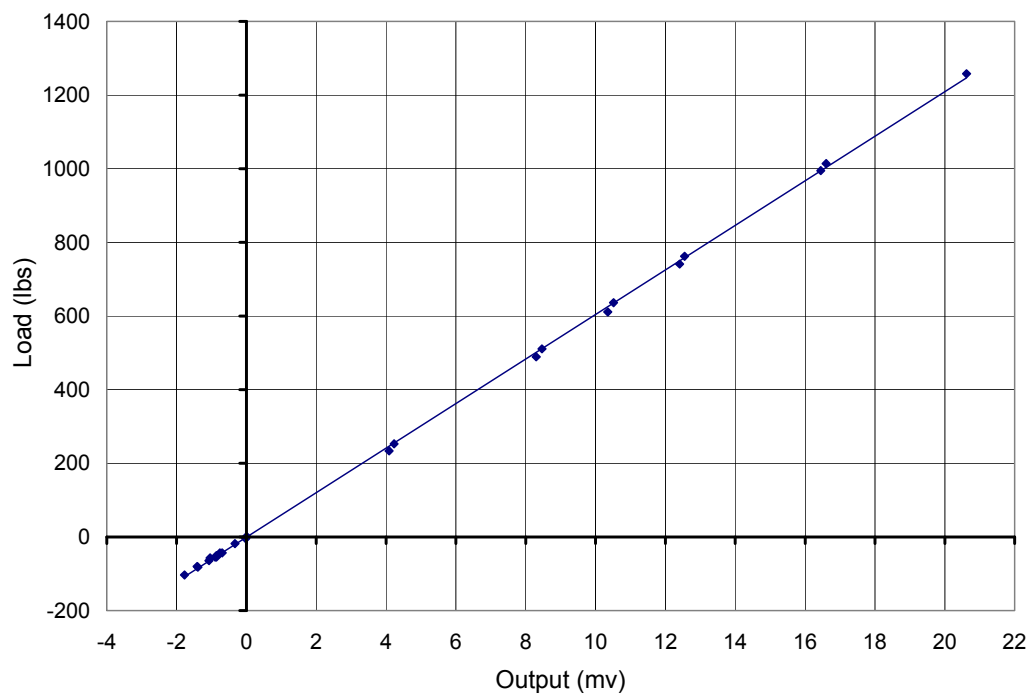


FIGURE A-43. HT 3 LINEARITY CHECK

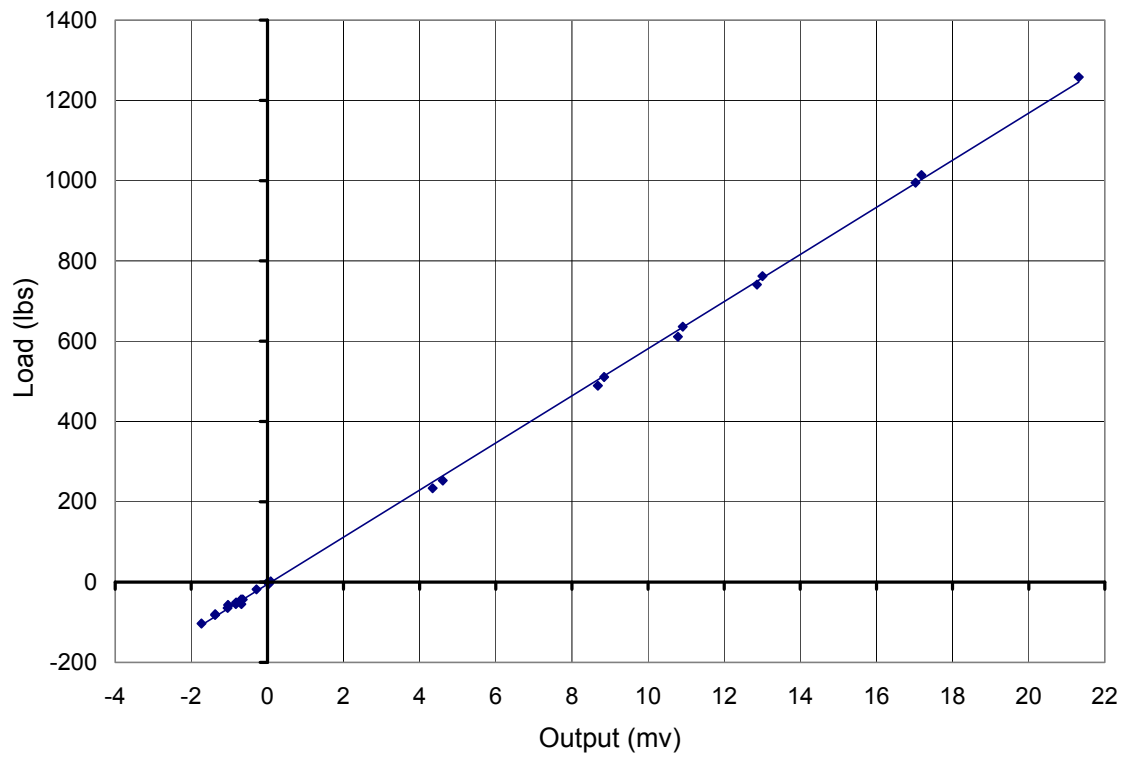


FIGURE A-44. HT 2 LINEARITY CHECK

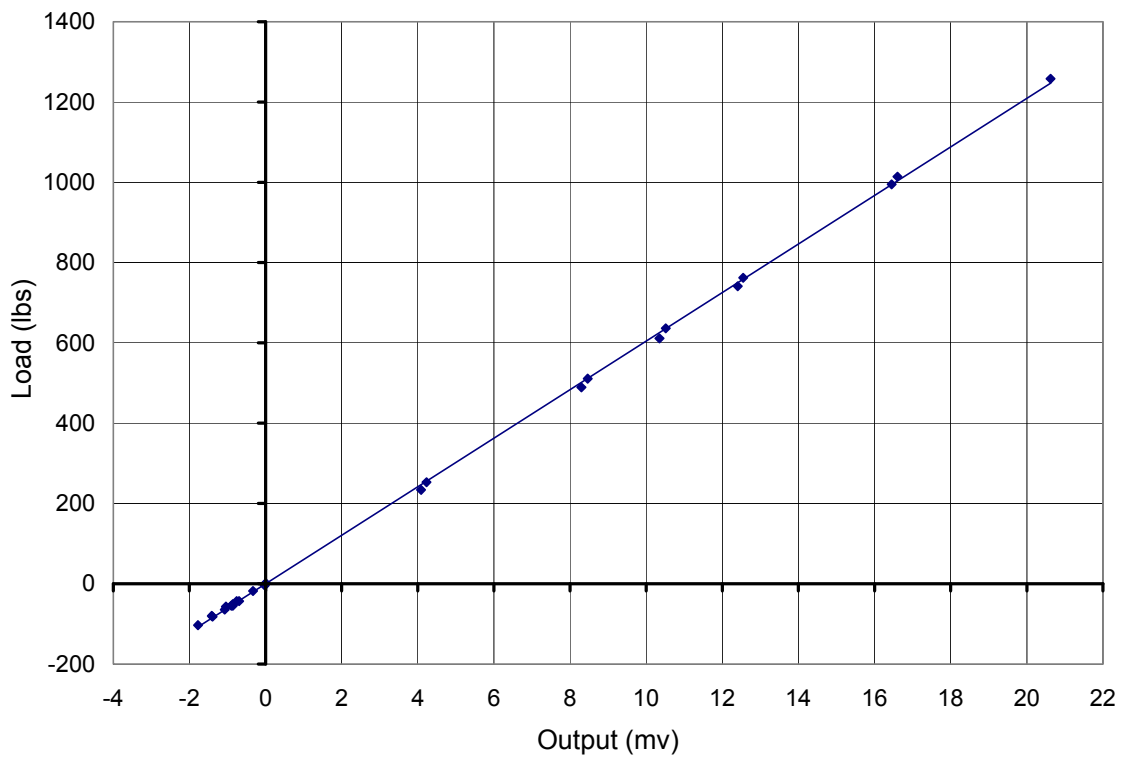


FIGURE A-45. HT 4 LINEARITY CHECK

TABLE A-5. HEATH TECNA BIN SENSITIVITY COEFFICIENTS

Support	Sensitivity Coefficient z direction $y = mx + b$		Nonlinearity Typical	Hysteresis Typical
	Slope (lb/mv)	Offset (lbs)	% FS	% FS
HT1	152	-1	<1	<1
HT2	153.2	0	<1	<1
HT3	59.5	0	<1	<1
HT4	59.3	-6	<1	<1
HT5A	101.2	5	<3	<3
HT5B	129.7	-7	<3	<3
HT6A	100.2	2	<3	<3
HT6B	117.1	-3	<3	<3
HT7A	101.2	-9	<3	<3
HT7B	116.5	-4	<3	<3
HT8A	96.8	-7	<3	<3
HT8B	119.9	0	<3	<3
HT9A	104.9	1	<3	<3
HT9B	120.5	1	<3	<3
HT10A	169.7	-6	<2	<2
HT10B	28.45	6	<2	<2
HT10C	-83.4	-13	<4	<2
HT11A	180.7	-16	<2	<2
HT11B	38.5	-2	<2	<2
HT11C	-83.5	-9	<4	<1.5

TABLE A-6. HEATH TECNA BIN—STATIC SYSTEM CALIBRATION NO. 1

Support No.	Applied Vertical Load (lbs)													Angle α
	0	100	200	300	400	500	600	500	400	300	200	100	0	
	Measured Support Load (lbs)													
HT1 (Strut)	-1	34	69	102	133	170	205	170	134	103	69	34	0	85
HT3 (Strut)	0	35	69	105	138	176	209	175	139	105	69	35	0	85
HT2 (T)	0	33	65	96	123	155	187	158	126	100	66	35	1	90
HT4 (T)	-6	27	60	91	120	154	185	155	125	93	61	29	-6	90
HT5 CH A	5	12	20	29	37	45	53	45	38	28	19	11	4	46
HT5 CH B	-7	-10	-12	-15	-14	-19	-22	-20	-19	-16	-13	-11	-8	7
HT6 CH A	2	16	34	49	67	82	93	78	64	45	28	11	-4	46
HT6 CH B	-3	-8	-14	-21	-24	-32	-38	-36	-29	-24	-17	-11	-5	7
HT7 CH A	-9	-4	1	6	13	18	24	18	13	7	2	-3	-9	46
HT7 CH B	-4	-5	-5	-7	-6	-8	-9	-10	-9	-7	-6	-6	-6	7
HT8 CH A	-7	3	15	26	38	50	61	51	39	28	17	6	-5	46
HT8 CH B	0	-5	-10	-16	-19	-26	-30	-26	-21	-17	-11	-7	-3	7
HT9 CH A	1	15	32	48	64	79	94	78	63	46	31	15	2	46
HT9 CH B	1	-6	-13	-22	-30	-39	-47	-39	-31	-23	-13	-6	1	7
HT10 CH A	-6	-6	-8	-9	-10	-11	-13	-11	-10	-8	-8	-7	-6	37
HT10 CH C	-13	-11	-10	-9	-7	-4	-4	-4	-6	-9	-10	-12	-13	---
HT11 CH A	-16	-17	-18	-19	-19	-20	-20	-21	-21	-21	-21	-21	-21	37
HT11 CH C	-9	-13	-16	-19	-23	-25	-30	-26	-23	-20	-16	-13	-10	---
	Vertical Vector Load Component (lbs)													Influence Coefficient I_s @ 609 lb
HT1 (Strut)	-1	34	70	102	132	169	204	169	133	103	69	34	0	0.335
HT3 (Strut)	0	35	69	105	137	175	208	174	138	105	69	35	0	0.342
HT2 (T)	0	33	65	96	123	155	187	158	126	100	66	35	1	0.307
HT4 (T)	-6	27	66	91	120	154	185	155	125	93	61	29	-6	0.304
HT5 CH A	4	9	11	21	27	32	38	32	27	20	14	8	3	0.063
HT5 CH B	-1	-1	-1	-2	-2	-2	-3	-2	-2	-2	-2	-1	-1	-0.004
HT6 CH A	1	12	23	35	48	59	67	56	46	32	20	8	-3	0.110
HT6 CH B	0	-1	-1	-3	-3	-4	-5	-4	-4	-3	-2	-1	-1	-0.008
HT7 CH A	-6	-3	7	4	9	13	17	13	9	5	1	-2	-6	0.028
HT7 CH B	0	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-0.002
HT8 CH A	-5	2	16	19	27	36	44	37	28	20	12	4	-4	0.072
HT8 CH B	0	-1	-1	-2	-2	-3	-4	-3	-3	-2	-1	-1	0	-0.006
HT9 CH A	1	11	22	35	46	57	68	56	45	33	22	11	1	0.111
HT9 CH B	0	-1	-2	-3	-4	-5	-6	-5	-4	-3	-2	-1	0	-0.009
HT10 CH A	-4	-4	-1	-5	-6	-7	-8	-7	-6	-5	-5	-4	-4	-0.013
HT11 CH A	-10	-10	-1	-2	-2	-12	-12	-13	-13	-13	-13	-13	-13	-0.020
Sum Minus Mating Support	-22	81	210	303	408	508	609	503	396	290	182	76	-27	
Sum Minus Struts	-27	72	203	284	381	472	568	472	375	276	172	71	-32	

Note: "T" = Mating Support

TABLE A-6. HEATH TECNA BIN—STATIC SYSTEM CALIBRATION NO. 1 (Continued)

Support No.	Applied Vertical Load (lbs)													Angle α
	0	100	200	300	400	500	600	500	400	300	200	100	0	
	Lateral Vector Load Component (lbs)													
HT1 (Strut)	0	3	6	9	12	15	18	15	12	9	6	3	0	
HT3 (Strut)	0	3	6	9	12	15	18	15	12	9	6	3	0	
HT2 (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	
HT4 (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	
HT5 CH A	3	8	14	20	26	31	37	31	26	19	13	8	3	
HT5 CH B	-7	-10	-12	-15	-14	-19	-22	-20	-19	-16	-13	-11	-8	
HT6 CH A	1	11	24	34	47	57	65	54	44	31	19	8	-3	
HT6 CH B	-3	-8	-14	-21	-24	-32	-38	-36	-29	-24	-17	-11	-5	
HT7 CH A	-6	-3	1	4	9	13	17	13	9	5	1	-2	-6	
HT7 CH B	-4	-5	-5	-7	-6	-8	-9	-10	-9	-7	-6	-6	-6	
HT8 CH A	-5	2	10	18	26	35	42	35	27	19	12	4	-3	
HT8 CH B	0	-5	-10	-16	-19	-26	-30	-26	-21	-17	-11	-7	-3	
HT9 CH A	1	10	22	33	44	55	65	54	44	32	22	10	1	
HT9 CH B	1	-6	-13	-22	-30	-39	-47	-39	-31	-23	-13	-6	1	
HT10 CH A	-5	-5	-6	-7	-8	-9	-10	-9	-8	-6	-6	-6	-5	
HT11 CH A	-13	-14	-14	-15	-15	-16	-16	-17	-17	-17	-17	-17	-17	
Sum Minus Mating Support	-36	-17	9	25	60	73	91	62	42	16	-3	-29	-51	
Sum Minus Struts	-36	-23	-4	7	37	43	54	32	18	-3	-15	-35	-51	
	Longitudinal Vector Load Component (lbs)													
HT10C	-13	-11	-10	-9	-7	-4	-4	-4	-6	-9	-10	-12	-13	
HT11C	-9	-13	-16	-19	-23	-25	-30	-26	-23	-20	-16	-13	-10	
Sum	-22	-24	-26	-28	-30	-29	-34	-30	-29	-29	-26	-25	-23	

Note: "T" = Mating Support

TABLE A-7. HEATH TECNA BIN—STATIC SYSTEM CALIBRATION NO. 2

Support No.	Applied Vertical Load (lbs)													Angle α
	0	100	200	300	400	500	600	500	400	300	200	100	0	
	Measured Support Load (lbs)													
HT1 (Strut)	-1	33	66	102	133	166	199	166	133	100	67	33	0	85
HT3 (Strut)	0	34	69	106	139	170	201	172	137	106	69	34	-2	85
HT2 (T)	0	32	63	95	123	151	181	154	125	96	65	32	1	90
HT4 (T)	-6	26	59	91	121	148	178	150	122	92	60	27	-6	90
HT5 CH A	5	13	22	30	38	47	56	47	39	30	21	13	5	46
HT5 CH B	-7	-9	-13	-14	-17	-20	-24	-20	-17	-15	-13	-11	-8	7
HT6 CH A	2	20	38	53	72	90	107	89	71	53	37	20	3	46
HT6 CH B	-3	-5	-15	-20	-26	-32	-39	-32	-26	-20	-15	-9	-5	7
HT7 CH A	-9	-4	1	6	12	18	25	18	13	7	2	-4	-9	46
HT7 CH B	-4	2	-7	-6	-8	-8	-10	-9	-9	-7	-7	-6	-6	7
HT8 CH A	-7	4	17	27	40	53	67	53	40	27	17	4	8	46
HT8 CH B	0	-5	-11	-14	-20	-24	-31	-25	-21	-16	-10	-6	-1	7
HT9 CH A	1	17	33	48	65	84	103	83	64	46	31	15	0	46
HT9 CH B	1	-7	-15	-23	-31	-41	-53	-43	-33	-24	-16	-7	1	7
HT10 CH A	-6	-7	-8	-9	-10	-11	-13	-11	-10	-9	-8	-6	-5	37
HT10 CH C	-13	-11	-9	-7	-6	-4	-2	-4	-6	-8	-9	-11	-12	---
HT11 CH A	-16	-17	-19	-19	-20	-20	-21	-20	-19	-19	-17	-17	-16	37
HT11 CH C	-9	-12	-16	-19	-23	-26	-30	-27	-23	-19	-16	-12	-9	---
	Vertical Vector Load Component (lbs)													Influence Coefficient I_s @ 616 lb
HT1 (Strut)	-1	33	67	102	132	165	198	165	132	100	67	33	0	0.322
HT3 (Strut)	0	34	69	106	138	169	200	171	136	106	69	34	-2	0.325
HT2 (T)	0	32	63	95	123	151	181	154	125	96	65	32	1	0.294
HT4 (T)	-6	26	65	91	121	148	178	150	122	92	60	27	-6	0.289
HT5 CH A	4	9	12	22	27	34	40	34	28	22	15	9	4	0.065
HT5 CH B	-1	-1	-1	-2	-2	-2	-3	-2	-2	-2	-2	-1	-1	-0.005
HT6 CH A	1	14	26	38	52	65	77	64	51	38	27	14	2	0.125
HT6 CH B	0	-1	-1	-2	-3	-4	-5	-4	-3	-2	-2	-1	-1	-0.008
HT7 CH A	-6	-3	7	4	9	13	18	13	9	5	1	-3	-6	0.029
HT7 CH B	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-0.002
HT8 CH A	-5	3	17	19	29	38	48	38	29	19	12	3	6	0.078
HT8 CH B	0	-1	-1	-2	-2	-3	-4	-3	-3	-2	-1	-1	0	-0.006
HT9 CH A	1	12	23	35	47	60	74	60	46	33	22	11	0	0.120
HT9 CH B	0	-1	-2	-3	-4	-5	-6	-5	-4	-3	-2	-1	0	-0.010
HT10 CH A	-4	-4	-1	-5	-6	-7	-8	-7	-6	-5	-5	-4	-3	-0.013
HT11 CH A	-10	-10	-2	-2	-2	-12	-13	-12	-11	-11	-10	-10	-10	-0.021
Sum Minus Mating Support	-22	85	212	309	413	511	616	511	402	296	191	83	-12	
Sum Minus Struts	-27	77	205	287	386	475	577	478	380	278	180	75	-15	

Note: "T" = Mating Support

TABLE A-7. HEATH TECNA BIN—STATIC SYSTEM CALIBRATION NO. 2 (Continued)

Support No.	Applied Vertical Load (lbs)												Angle α
	0	100	200	300	400	500	600	500	400	300	200	100	0
	Lateral Vector Load (lbs)												
HT1 (Strut)	0	3	6	9	12	14	17	14	12	9	6	3	0
HT3 (Strut)	0	3	6	9	12	15	18	15	12	9	6	3	0
HT2 (T)	0	0	0	0	0	0	0	0	0	0	0	0	0
HT4 (T)	0	0	0	0	0	0	0	0	0	0	0	0	0
HT5 CH A	3	9	15	21	26	33	39	33	27	21	15	9	3
HT5 CH B	-7	-9	-13	-14	-17	-20	-24	-20	-17	-15	-13	-11	-8
HT6 CH A	1	14	26	37	50	63	74	62	49	37	26	14	2
HT6 CH B	-3	-5	-15	-20	-26	-32	-39	-32	-26	-20	-15	-9	-5
HT7 CH A	-6	-3	1	4	8	13	17	13	9	5	1	-3	-6
HT7 CH B	-4	2	-7	-6	-8	-8	-10	-9	-9	-7	-7	-6	-6
HT8 CH A	-5	3	12	19	28	37	47	37	28	19	12	3	6
HT8 CH B	0	-5	-11	-14	-20	-24	-31	-25	-21	-16	-10	-6	-1
HT9 CH A	1	12	23	33	45	58	72	58	44	32	22	10	0
HT9 CH B	1	-7	-15	-23	-31	-41	-53	-43	-33	-24	-16	-7	1
HT10 CH A	-5	-6	-6	-7	-8	-9	-10	-9	-8	-7	-6	-5	-4
HT11 CH A	-13	-14	-15	-15	-16	-16	-17	-16	-15	-15	-14	-14	-13
Sum Minus													
Mating Support	-36	-2	7	33	56	83	101	78	53	27	6	-18	-31
Sum Minus Struts	-36	-8	-5	15	32	54	66	49	29	9	-5	-24	-31
	Longitudinal Vector Load Component (lbs)												
HT10C	-13	-11	-9	-7	-6	-4	-2	-4	-6	-8	-9	-11	-12
HT11C	-9	-12	-16	-19	-23	-26	-30	-27	-23	-19	-16	-12	-9
SUM	-22	-23	-25	-26	-29	-30	-32	-31	-29	-27	-25	-23	-21

Note: "T" = Mating Support

TABLE A-8. HEATH TECNA BIN—STATIC SYSTEM CALIBRATION NO. 3

Support No.	Applied Vertical Load (Lbs)													Angle α
	0	100	200	300	400	500	600	500	400	300	200	100	0	
	Measured Support Load (Lbs)													
HT1 (Strut)	-1	35	71	102	137	169	204	170	138	104	69	35	-1	85
HT3 (Strut)	0	36	70	101	136	166	202	166	137	101	68	34	0	85
HT2 (T)	0	33	66	95	125	154	183	154	128	96	66	35	1	90
HT4 (T)	-6	27	59	89	119	147	178	147	120	89	61	27	-6	90
HT5 CH A	5	13	21	30	39	48	56	47	38	30	21	13	5	46
HT5 CH B	-7	-9	-12	-14	-17	-21	-24	-20	-19	-15	-12	-11	-9	7
HT6 CH A	2	19	35	55	72	91	107	91	71	54	35	19	3	46
HT6 CH B	-3	-8	-14	-21	-27	-33	-39	-33	-28	-21	-14	-9	-4	7
HT7 CH A	-9	-4	1	7	12	19	24	19	13	7	1	-4	-8	46
HT7 CH B	-4	-4	-5	-7	-7	-8	-9	-8	-8	-6	-6	-5	-5	7
HT8 CH A	-7	3	14	27	38	52	63	51	38	27	15	4	-7	46
HT8 CH B	0	-3	-9	-15	-19	-24	-28	-23	-19	-13	-9	-4	1	7
HT9 CH A	1	15	32	49	64	82	98	82	62	48	30	14	0	46
HT9 CH B	1	-5	-14	-23	-31	-40	-48	-40	-30	-22	-13	-6	1	7
HT10 CH A	-6	-7	-8	-9	-10	-12	-13	-12	-10	-10	-8	-7	-6	37
HT10 CH C	-13	-12	-10	-9	-7	-5	-3	-4	-6	-8	-10	-12	-13	---
HT11 CH A	-16	-16	-17	-18	-19	-20	-21	-20	-19	-18	-17	-16	-16	37
HT11 CH C	-9	-13	-16	-20	-23	-27	-30	-26	-23	-19	-16	-13	-10	---
	Vertical Vector Load Component (lbs)													Influence Coefficient I_s @ 616 lb
HT1 (Strut)	-1	35	72	102	136	168	203	169	137	104	69	35	-1	0.330
HT3 (Strut)	0	36	70	101	135	165	201	165	136	101	68	34	0	0.327
HT2 (T)	0	33	66	95	125	154	183	154	128	96	66	35	1	0.297
HT4 (T)	-6	27	65	89	119	147	178	147	120	89	61	27	-6	0.289
HT5 CH A	4	9	12	22	28	35	40	34	27	22	15	9	4	0.065
HT5 CH B	-1	-1	-1	-2	-2	-3	-3	-2	-2	-2	-1	-1	-1	-0.005
HT6 CH A	1	14	24	40	52	65	77	65	51	39	25	14	2	0.125
HT6 CH B	0	-1	-1	-3	-3	-4	-5	-4	-3	-3	-2	-1	0	-0.008
HT7 CH A	-6	-3	7	5	9	14	17	14	9	5	1	-3	-6	0.028
HT7 CH B	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-0.002
HT8 CH A	-5	2	15	19	27	37	45	37	27	19	11	3	-5	0.074
HT8 CH B	0	0	-1	-2	-2	-3	-3	-3	-2	-2	-1	0	0	-0.006
HT9 CH A	1	11	22	35	46	59	70	59	45	35	22	10	0	0.114
HT9 CH B	0	-1	-2	-3	-4	-5	-6	-5	-4	-3	-2	-1	0	-0.009
HT10 CH A	-4	-4	-1	-5	-6	-7	-8	-7	-6	-6	-5	-4	-4	-0.013
HT11 CH A	-10	-10	-1	-1	-2	-12	-13	-12	-11	-11	-10	-10	-10	-0.021
Sum Minus														
Mating Support	-22	86	215	307	414	509	616	509	404	297	188	84	-21	
Sum Minus Struts	-27	76	204	288	386	476	573	475	378	278	179	77	-25	

Note: "T" = Mating Support

TABLE A-8. HEATH TECNA BIN—STATIC SYSTEM CALIBRATION NO. 3
(Continued)

Support No.	Applied Vertical Load (Lbs)												Angle α
	0	100	200	300	400	500	600	500	400	300	200	100	0
	Lateral Vector Load Components (Lbs)												
HT1 (Strut)	0	3	6	9	12	15	18	15	12	9	6	3	0
HT3 (Strut)	0	3	6	9	12	14	18	14	12	9	6	3	0
HT2 (T)	0	0	0	0	0	0	0	0	0	0	0	0	0
HT4 (T)	0	0	0	0	0	0	0	0	0	0	0	0	0
HT5 CH A	3	9	15	21	27	33	39	33	26	21	15	9	3
HT5 CH B	-7	-9	-12	-14	-17	-21	-24	-20	-19	-15	-12	-11	-9
HT6 CH A	1	13	24	38	50	63	74	63	49	38	24	13	2
HT6 CH B	-3	-8	-14	-21	-27	-33	-39	-33	-28	-21	-14	-9	-4
HT7 CH A	-6	-3	1	5	8	13	17	13	9	5	1	-3	-6
HT7 CH B	-4	-4	-5	-7	-7	-8	-9	-8	-8	-6	-6	-5	-5
HT8 CH A	-5	2	10	19	26	36	44	35	26	19	10	3	-5
HT8 CH B	0	-3	-9	-15	-19	-24	-28	-23	-19	-13	-9	-4	1
HT9 CH A	1	10	22	34	44	57	68	57	43	33	21	10	0
HT9 CH B	1	-5	-14	-23	-31	-40	-48	-40	-30	-22	-13	-6	1
HT10 CH A	-5	-6	-6	-7	-8	-10	-10	-10	-8	-8	-6	-6	-5
HT11 CH A	-13	-13	-14	-14	-15	-16	-17	-16	-15	-14	-14	-13	-13
Sum Minus													
Mating Support	-36	-9	10	33	57	81	103	82	52	34	9	-15	-38
Sum Minus Struts	-36	-15	-2	16	33	52	68	53	28	17	-3	-21	-38
	Longitudinal Vector Load Component (lbs)												
HT10C	-13	-12	-10	-9	-7	-5	-3	-4	-6	-8	-10	-12	-13
HT11C	-9	-13	-16	-20	-23	-27	-30	-26	-23	-19	-16	-13	-10
Sum	-22	-25	-26	-29	-30	-32	-33	-30	-29	-27	-26	-25	-23

Note: "T" = Mating Support

APPENDIX B—TEST DATA

B.1 FUSELAGE DATA—SIDE WALL ACCELERATIONS

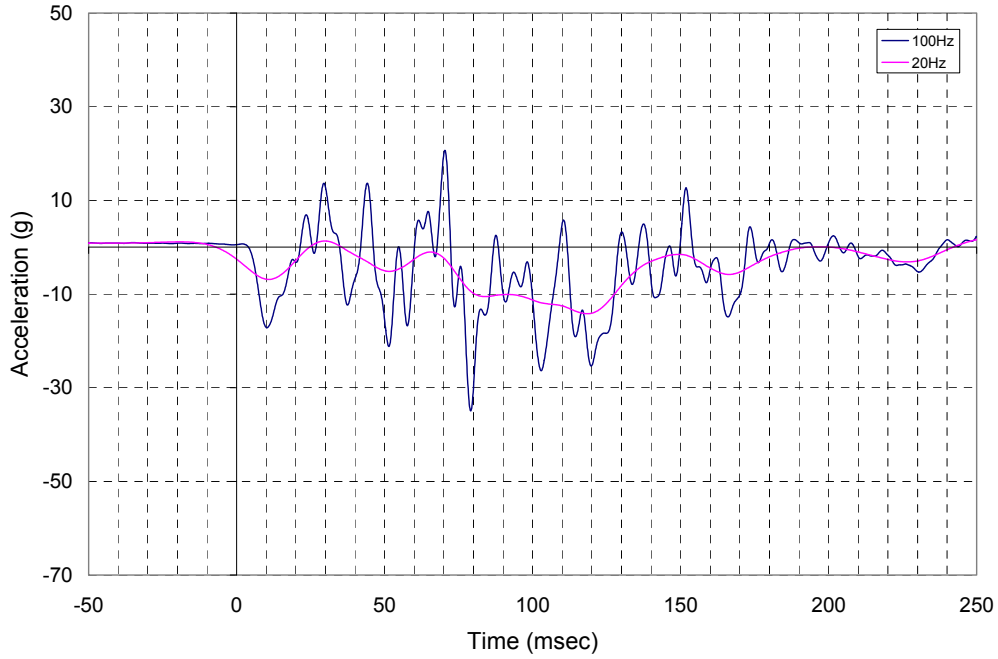


FIGURE B-1. FS 400 LEFT UPPER SIDE WALL ACCELERATION

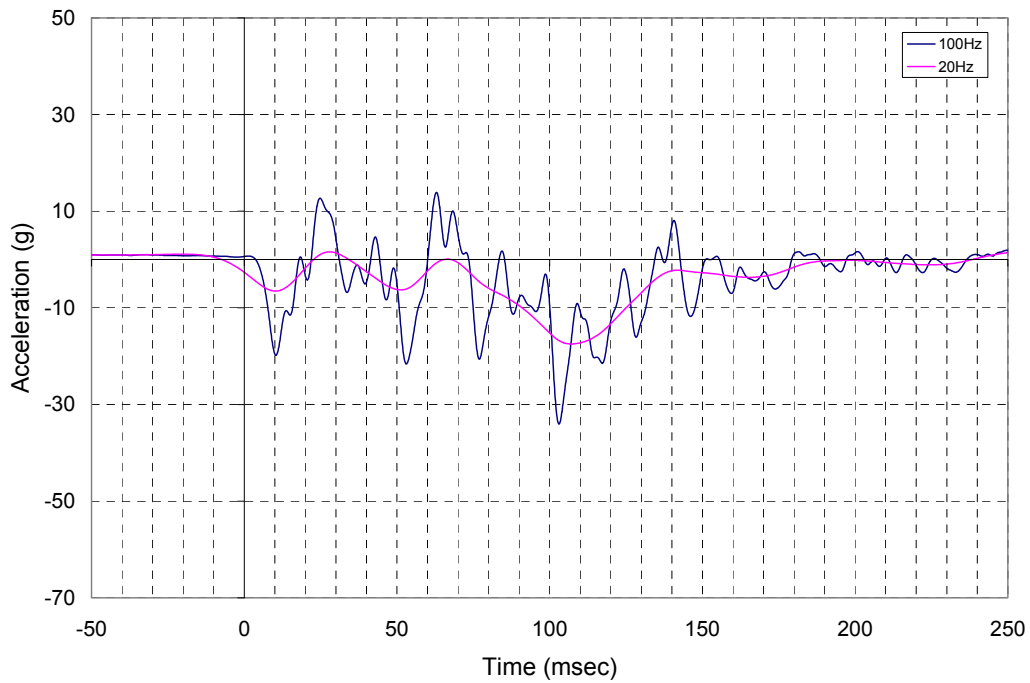


FIGURE B-2. FS 440 LEFT UPPER SIDE WALL ACCELERATION

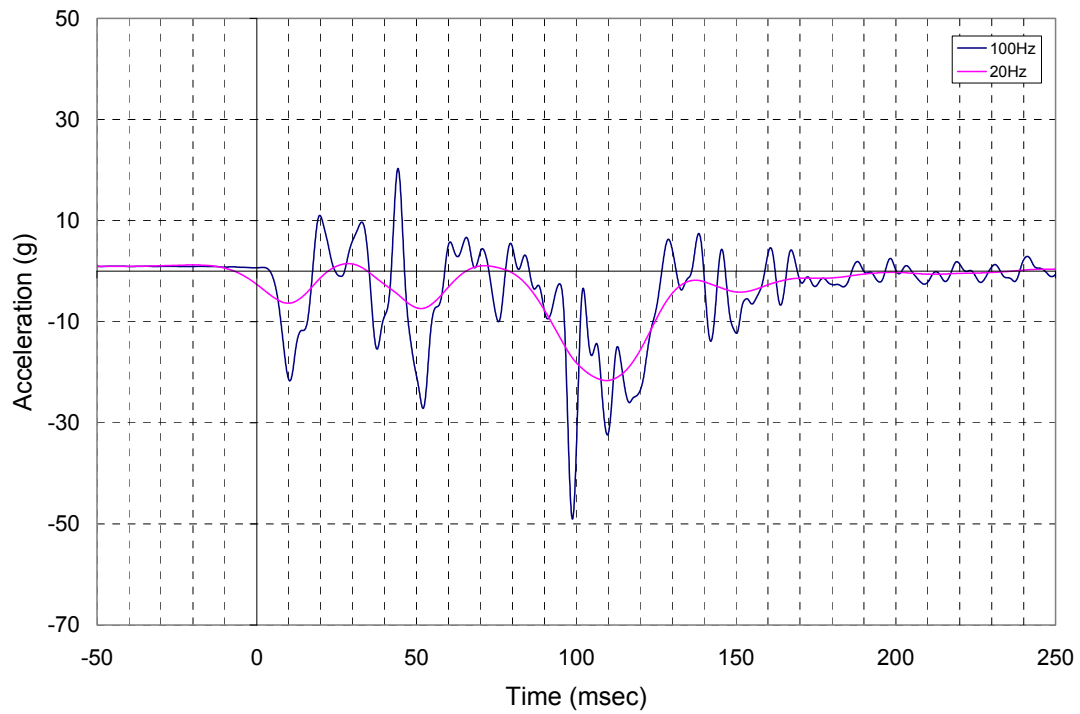


FIGURE B-3. FS 480 LEFT UPPER SIDE WALL ACCELERATION

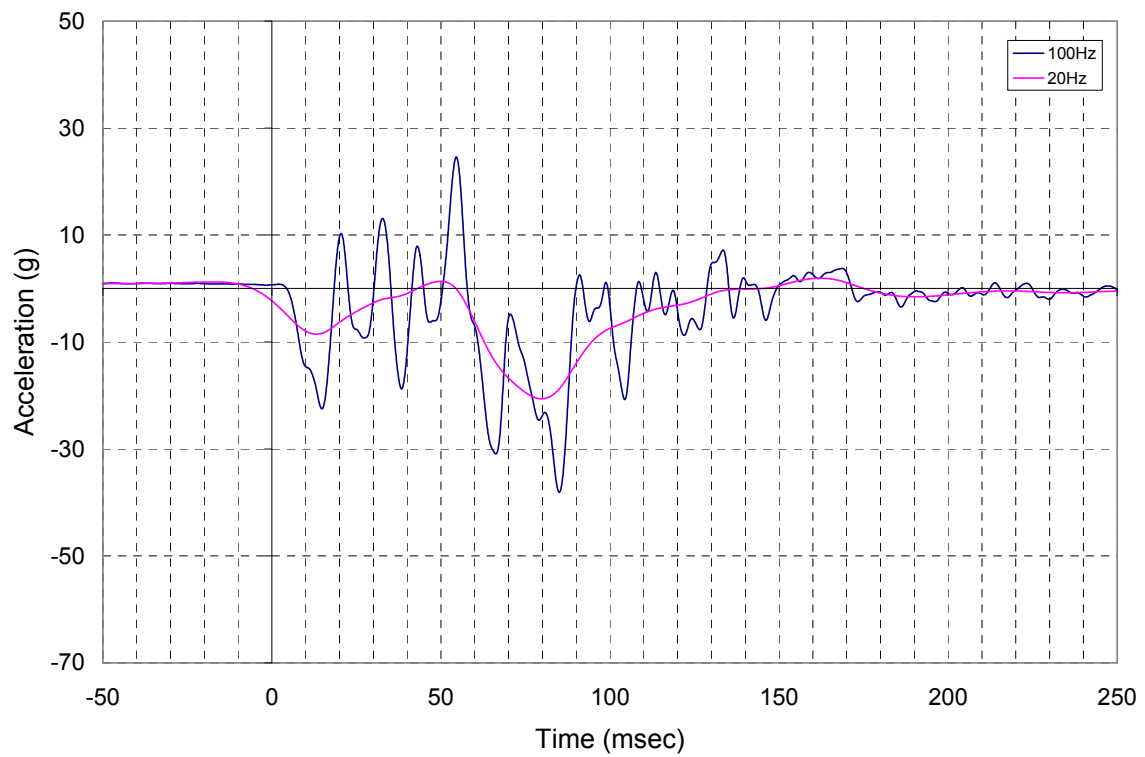


FIGURE B-4. FS 400 RIGHT UPPER SIDE WALL ACCELERATION

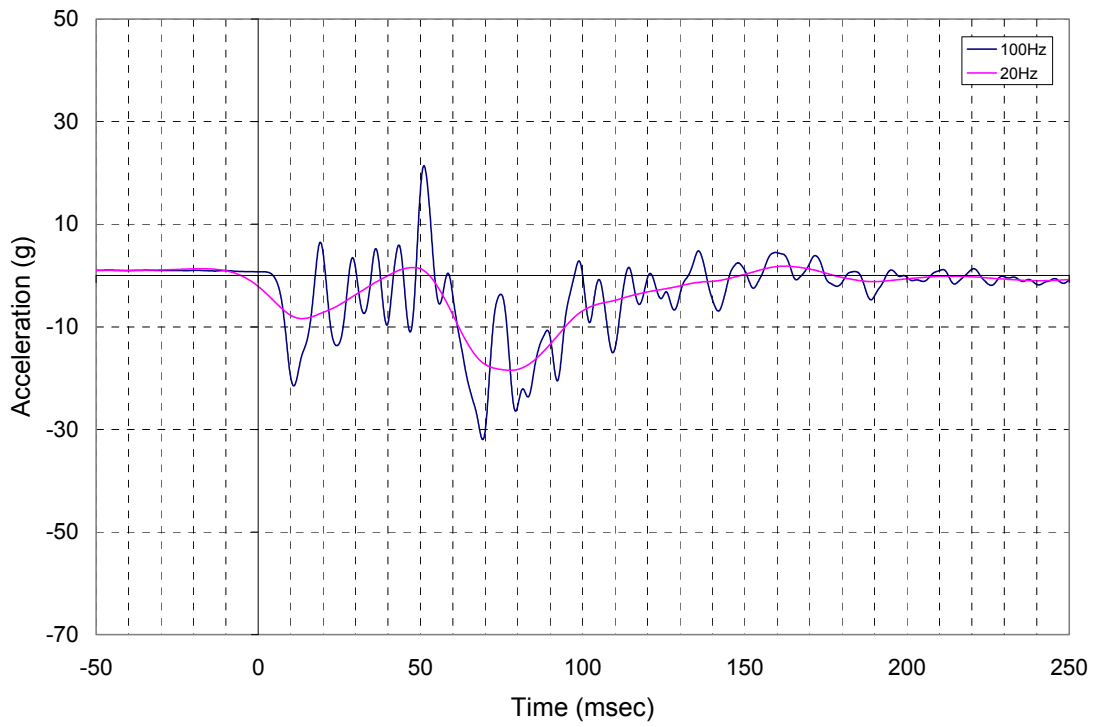


FIGURE B-5. FS 440 RIGHT UPPER SIDE WALL ACCELERATION

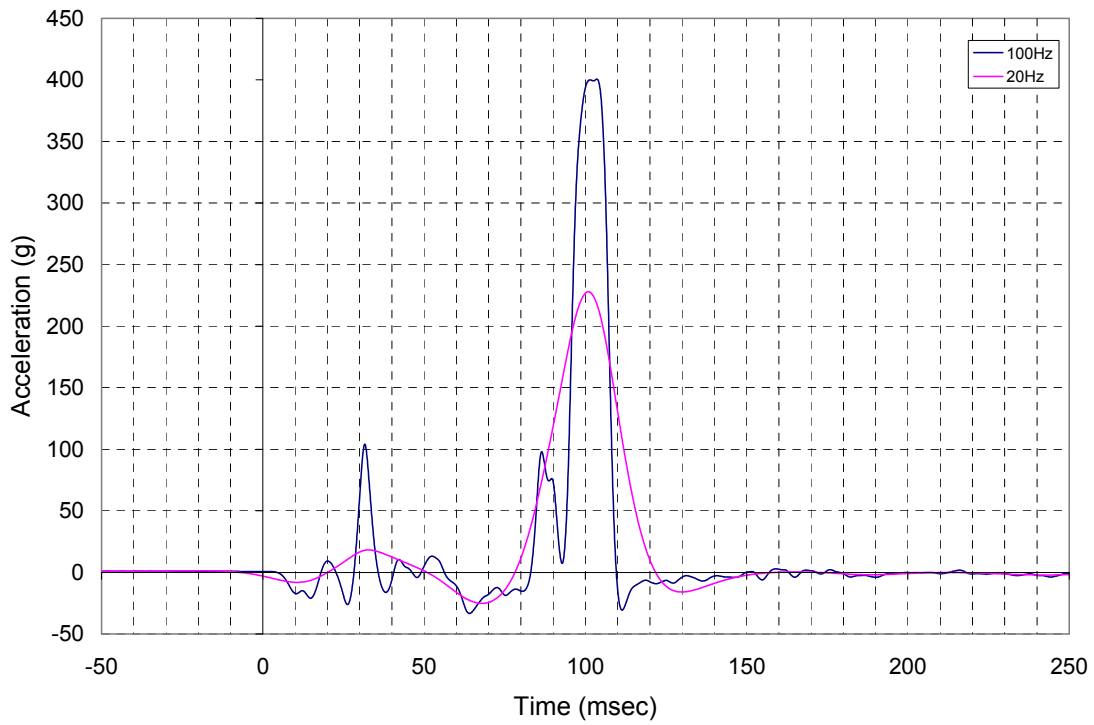


FIGURE B-6. FS 480 RIGHT UPPER SIDE WALL ACCELERATION

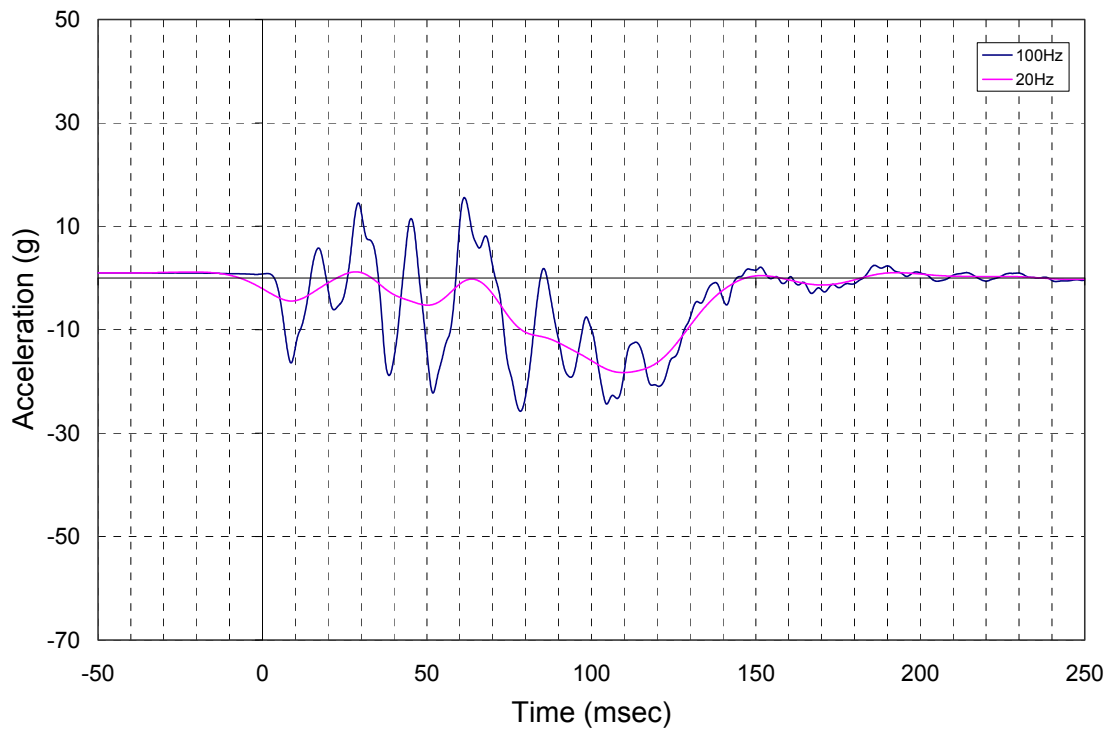


FIGURE B-7. FS 400 LEFT LOWER SIDE WALL ACCELERATION

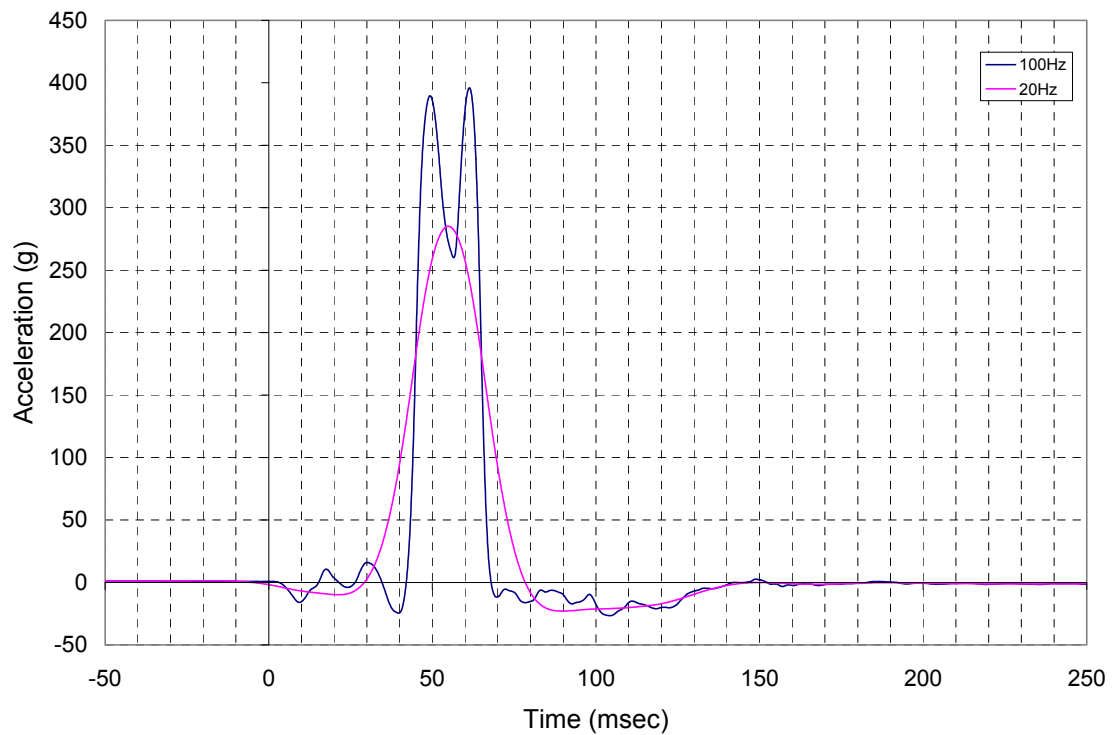


FIGURE B-8. FS 440 LEFT LOWER SIDE WALL ACCELERATION

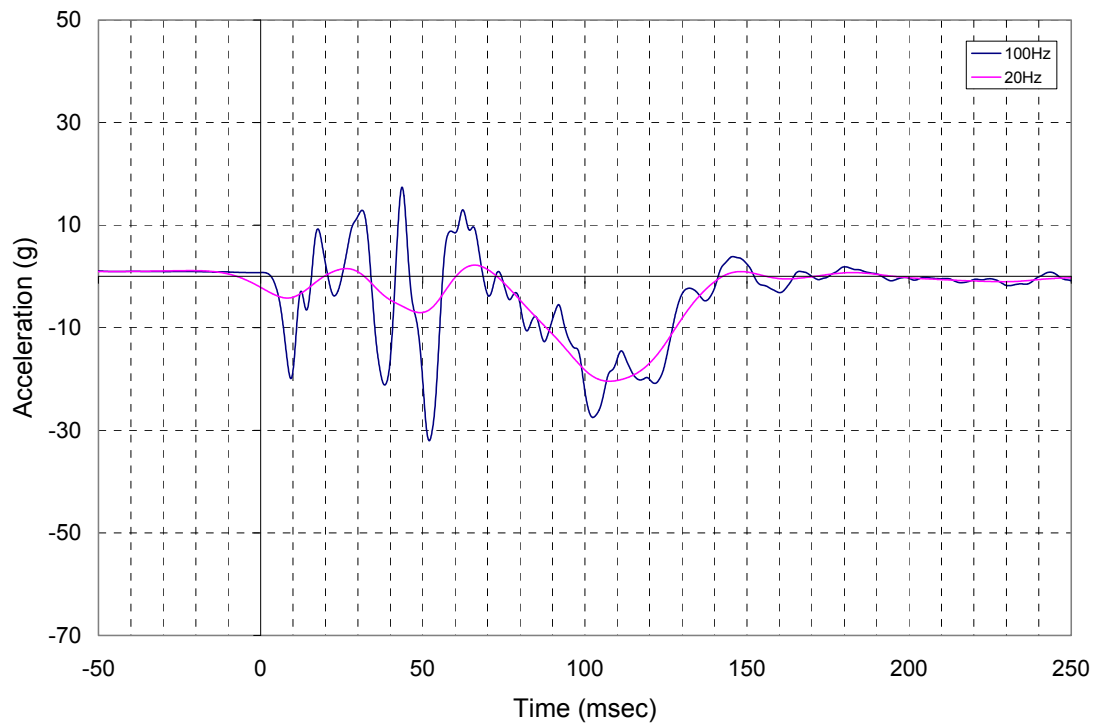


FIGURE B-9. FS 480 LEFT LOWER SIDE WALL ACCELERATION

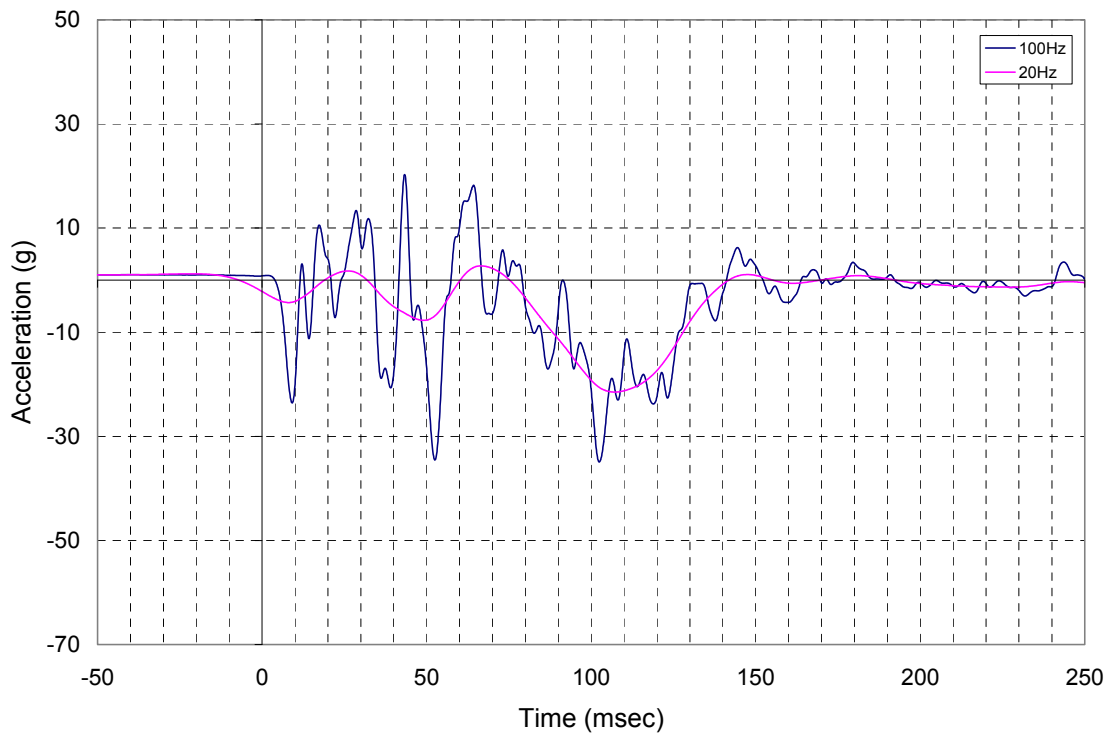


FIGURE B-10. FS 500 LEFT LOWER SIDE WALL ACCELERATION

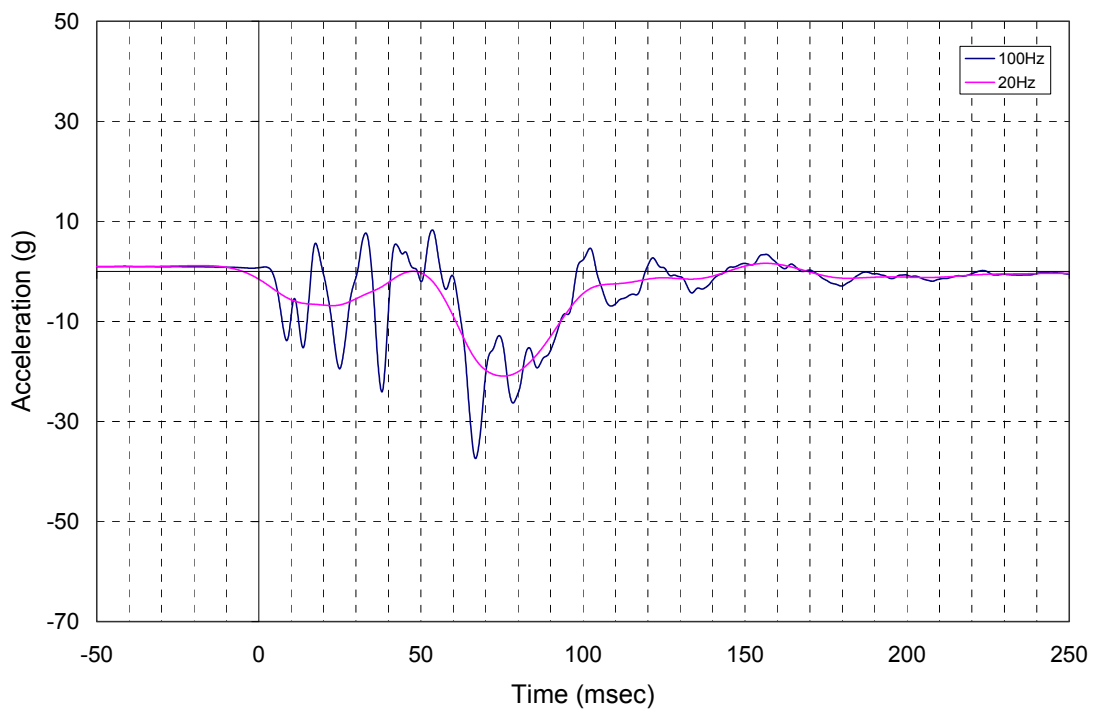


FIGURE B-11. FS 400 RIGHT LOWER SIDE WALL ACCELERATION

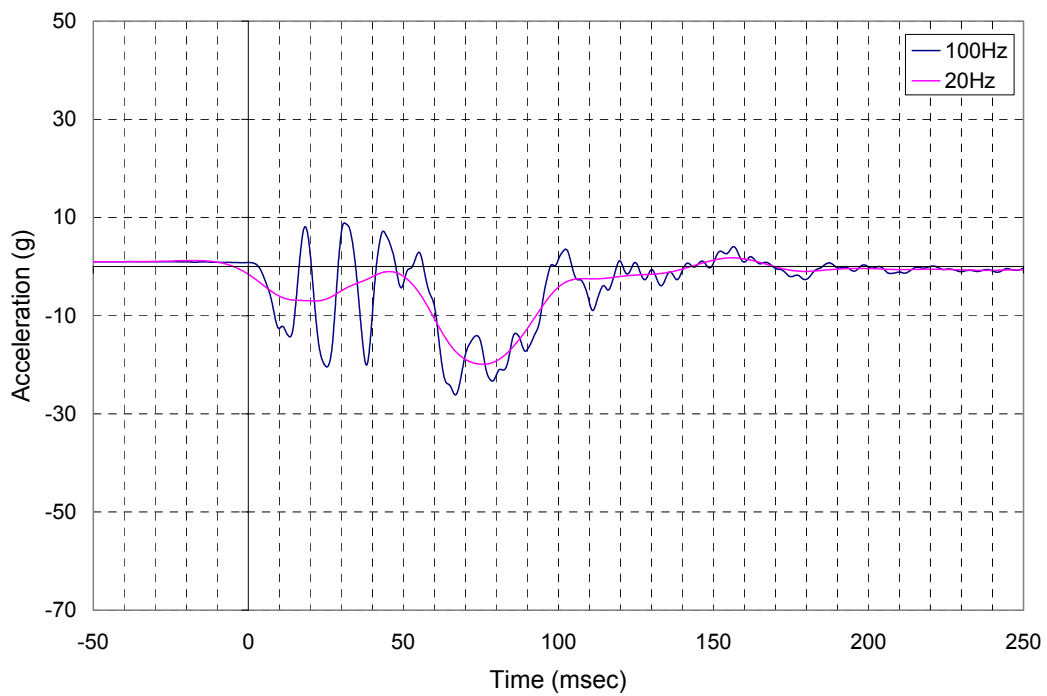


FIGURE B-12. FS 440 RIGHT LOWER SIDE WALL ACCELERATION

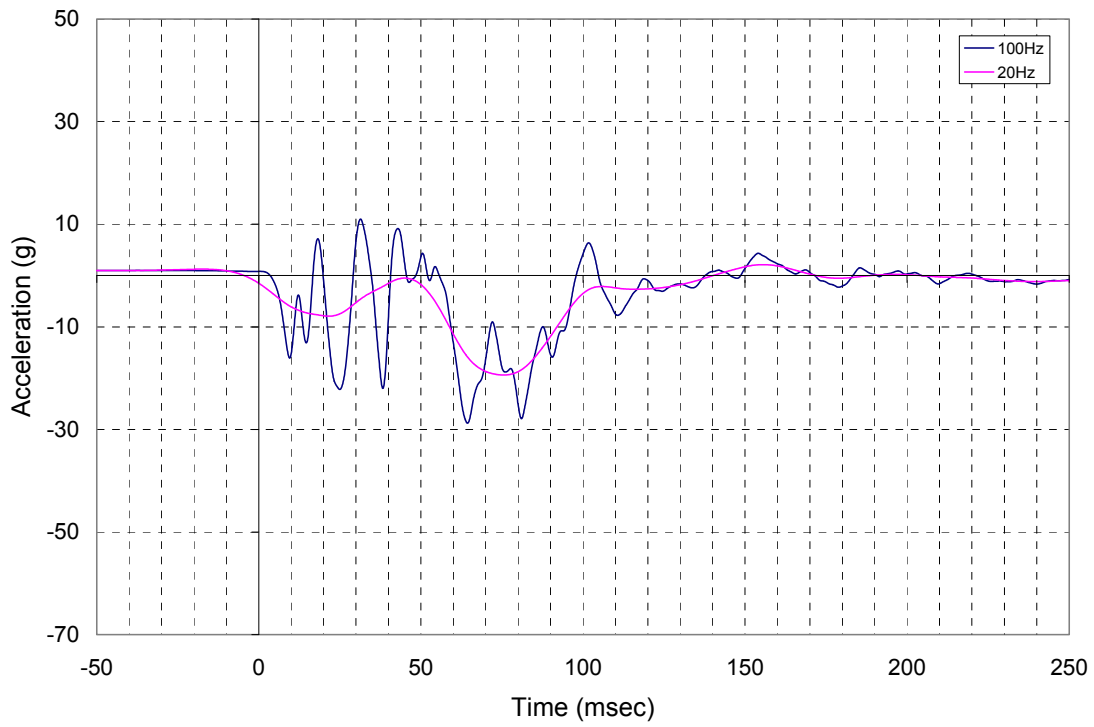


FIGURE B-13. FS 480 RIGHT LOWER SIDE WALL ACCELERATION

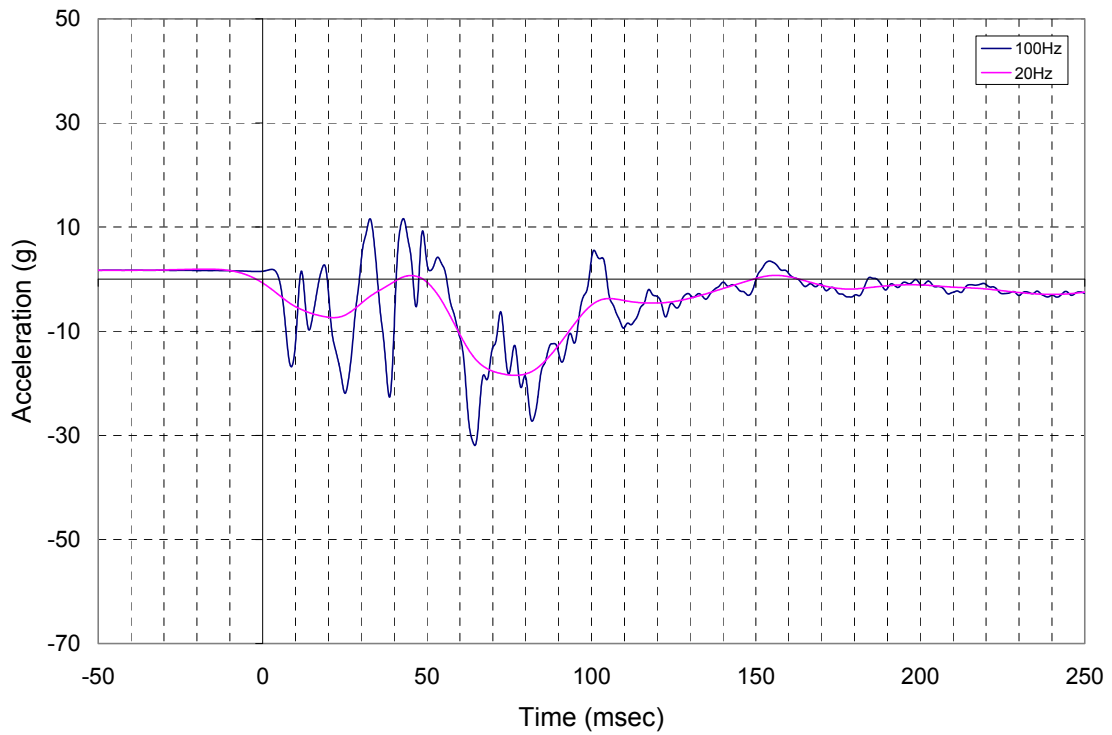


FIGURE B-14. FS 500 RIGHT LOWER SIDE WALL ACCELERATION

B.2 FUSELAGE DATA—SEAT TRACK ACCELERATIONS

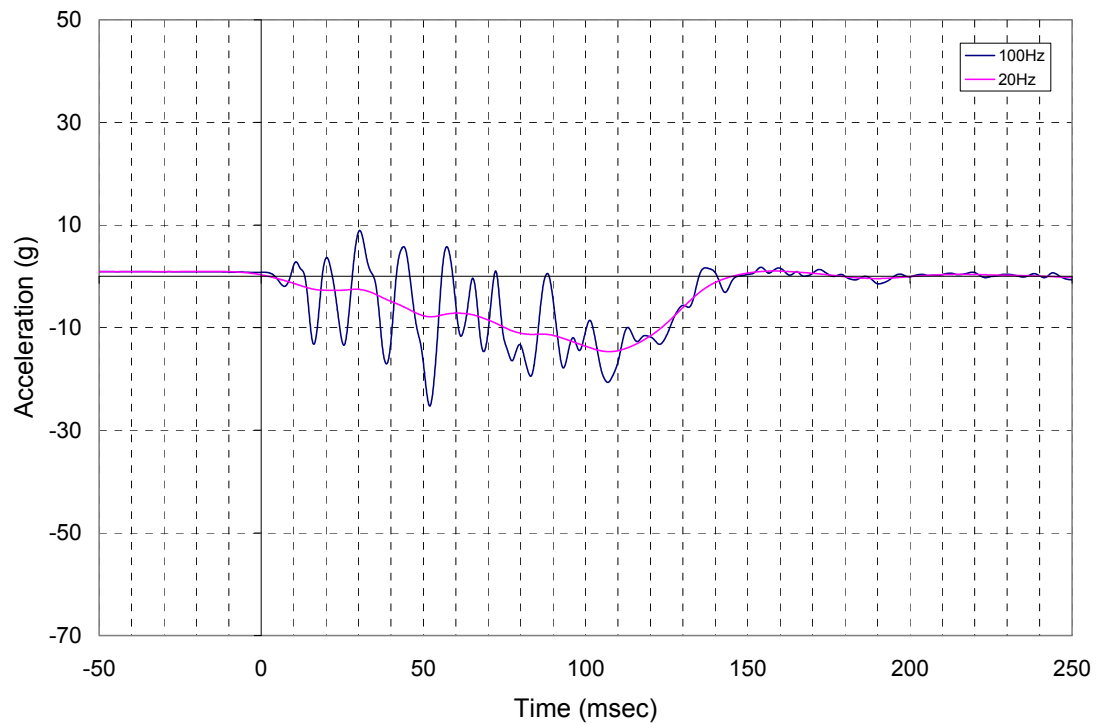


FIGURE B-15. FS 418 LEFT OUTER SEAT TRACK ACCELERATION

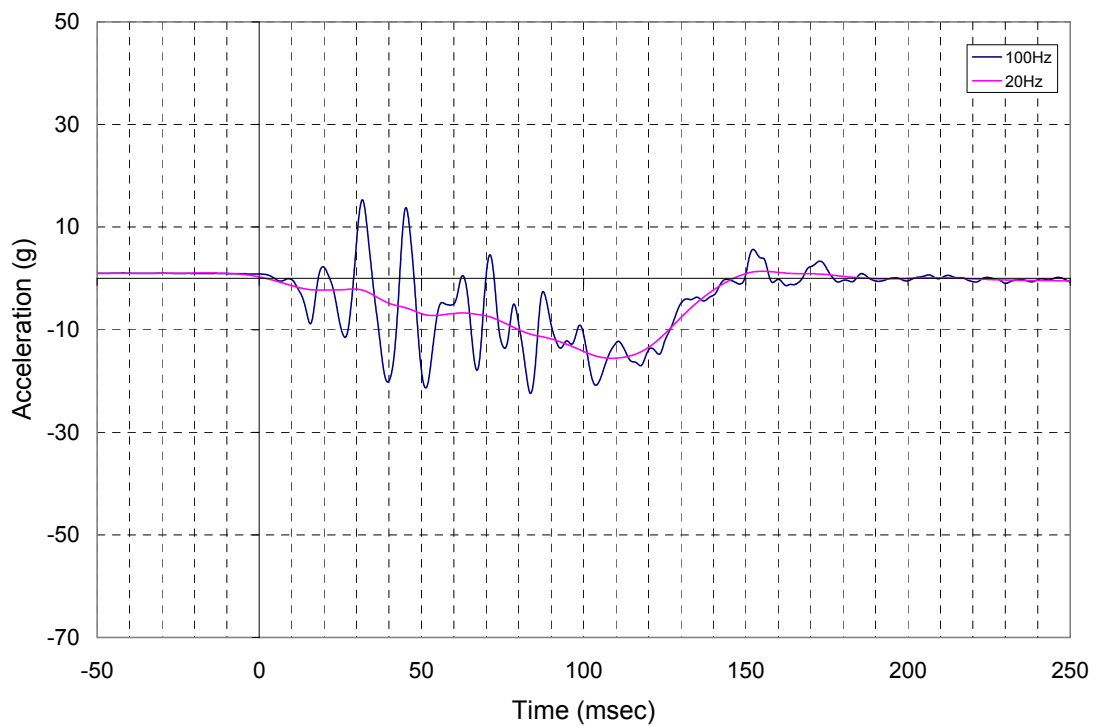


FIGURE B-16. FS 452 LEFT OUTER SEAT TRACK ACCELERATION

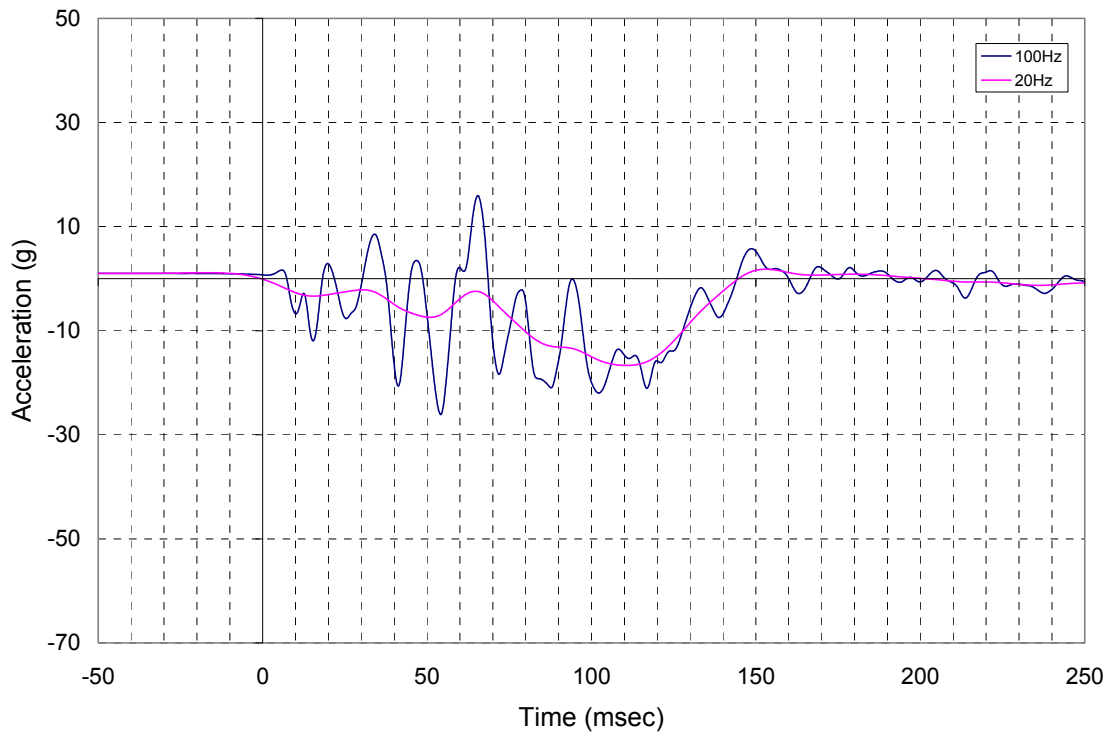


FIGURE B-17. FS 484 LEFT OUTER SEAT TRACK ACCELERATION

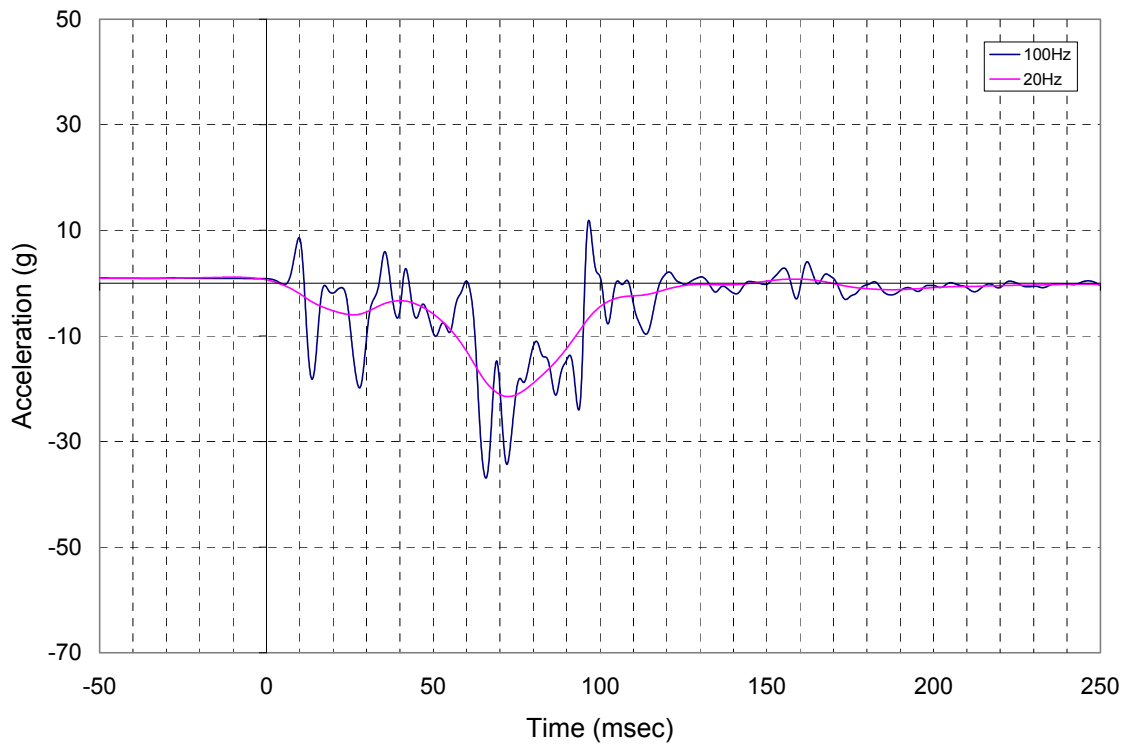


FIGURE B-18. FS 418 RIGHT OUTER SEAT TRACK ACCELERATION

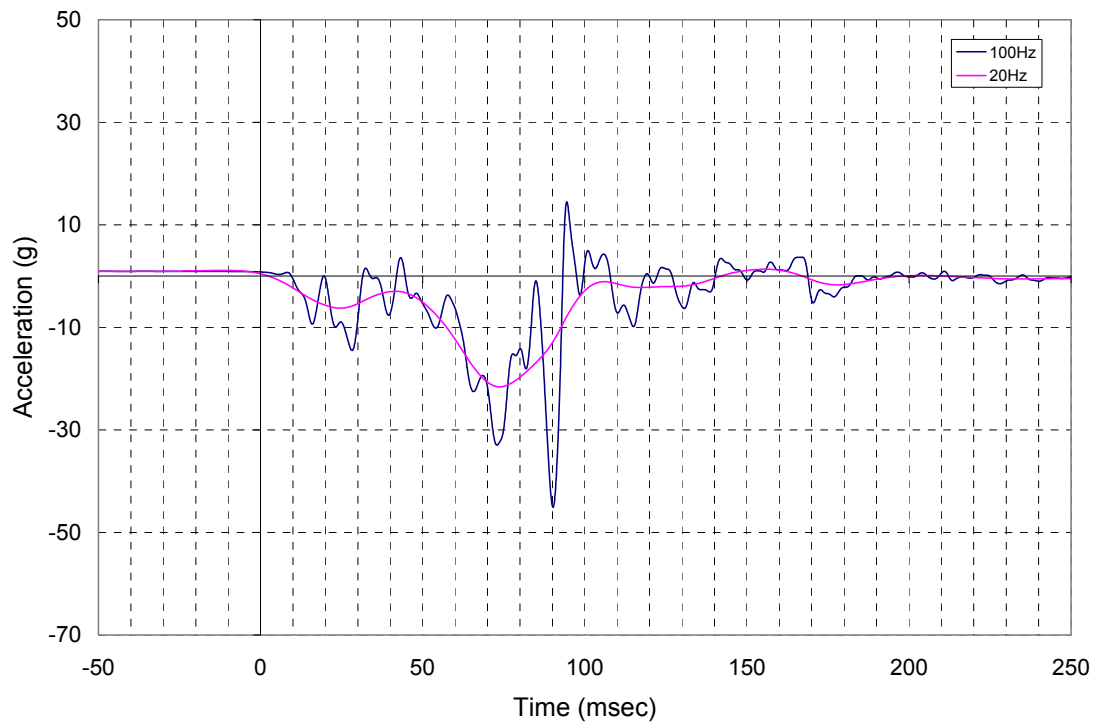


FIGURE B-19. FS 452 RIGHT OUTER SEAT TRACK ACCELERATION

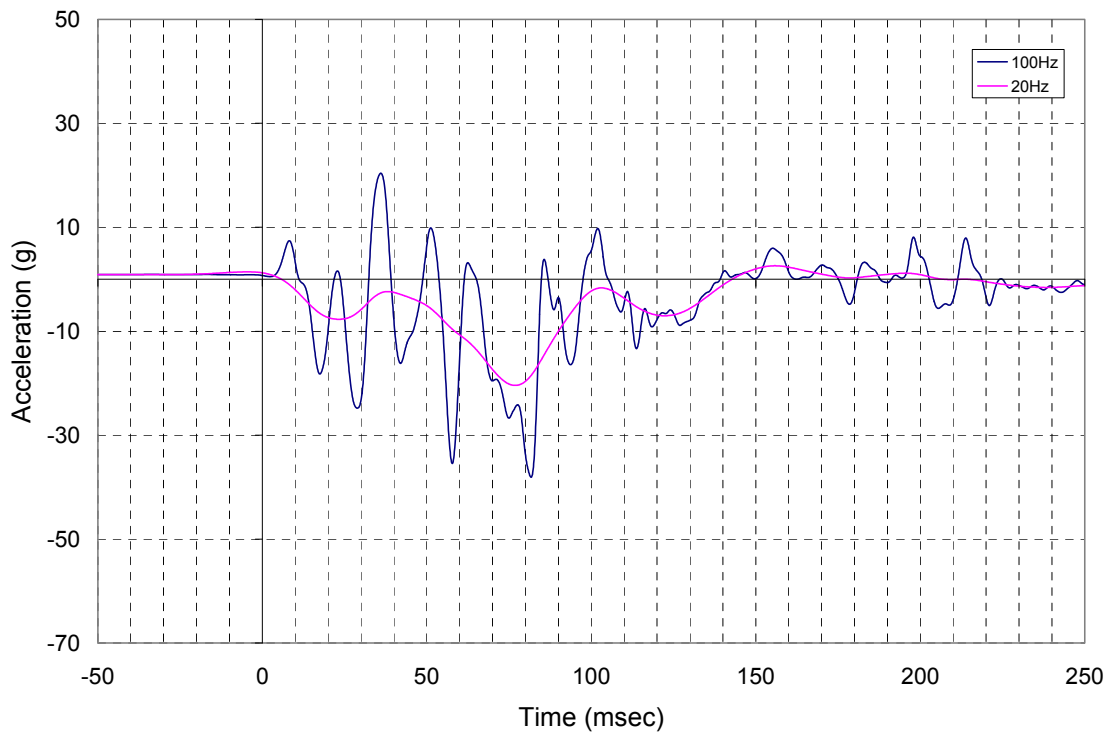


FIGURE B-20. FS 484 RIGHT OUTER SEAT TRACK ACCELERATION

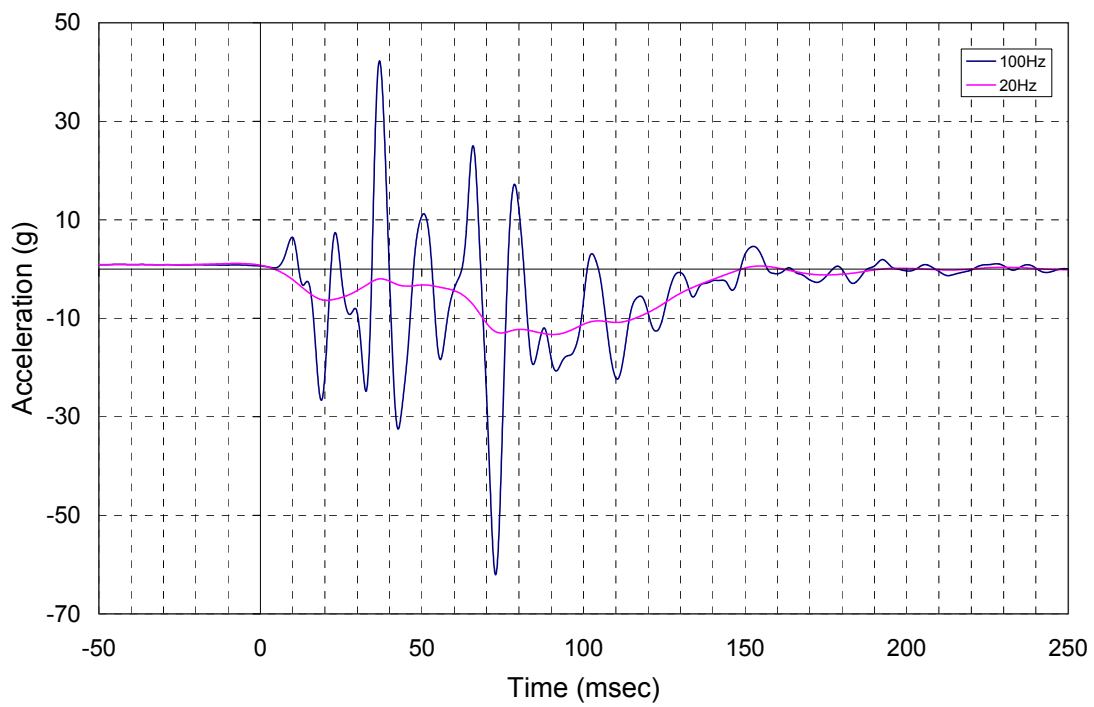


FIGURE B-21. FS 380 LEFT INNER SEAT TRACK ACCELERATION

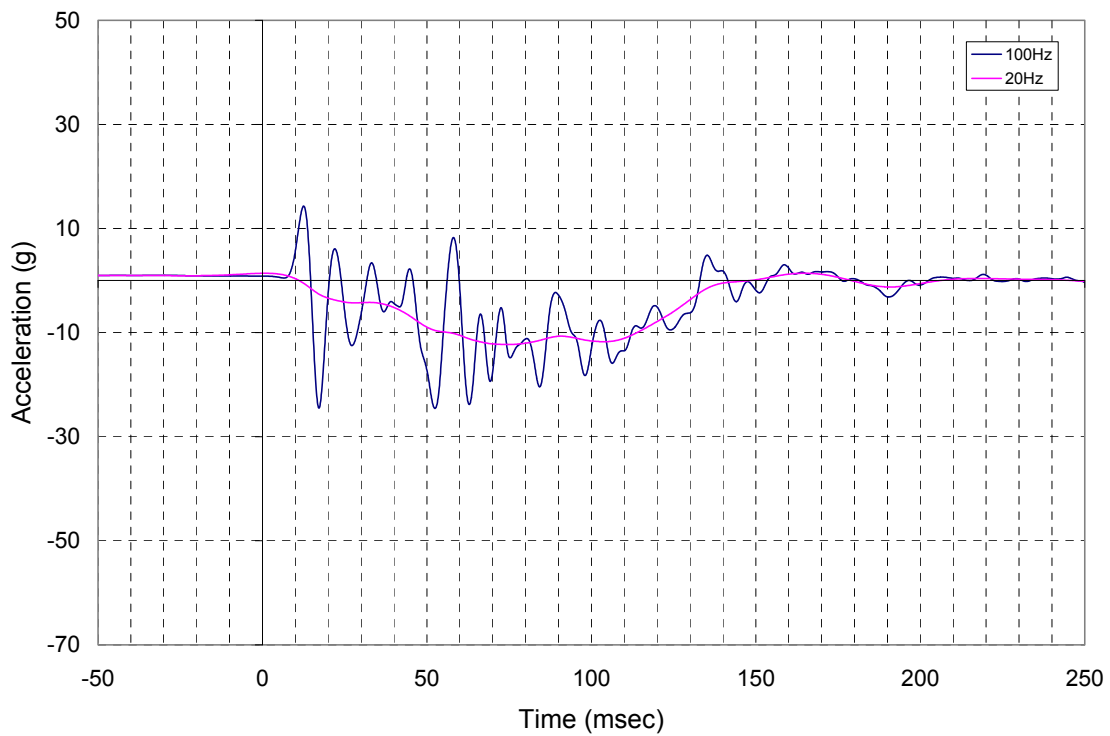


FIGURE B-22. FS 418 LEFT INNER SEAT TRACK ACCELERATION

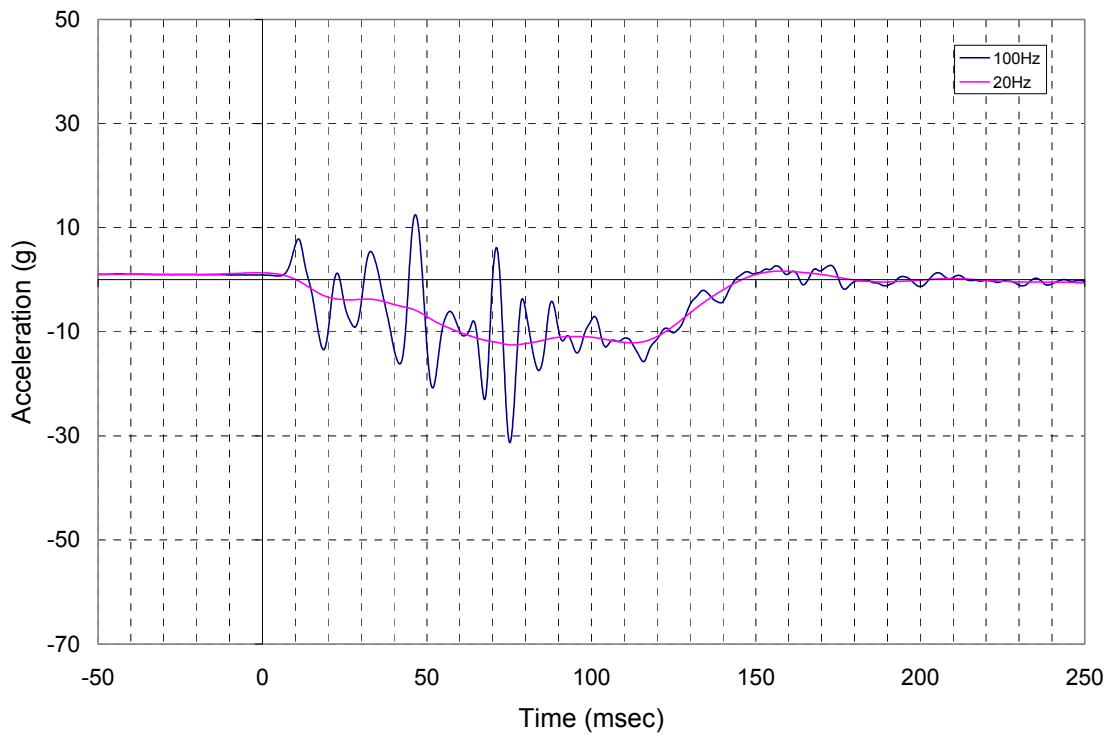


FIGURE B-23. FS 452 LEFT INNER SEAT TRACK ACCELERATION

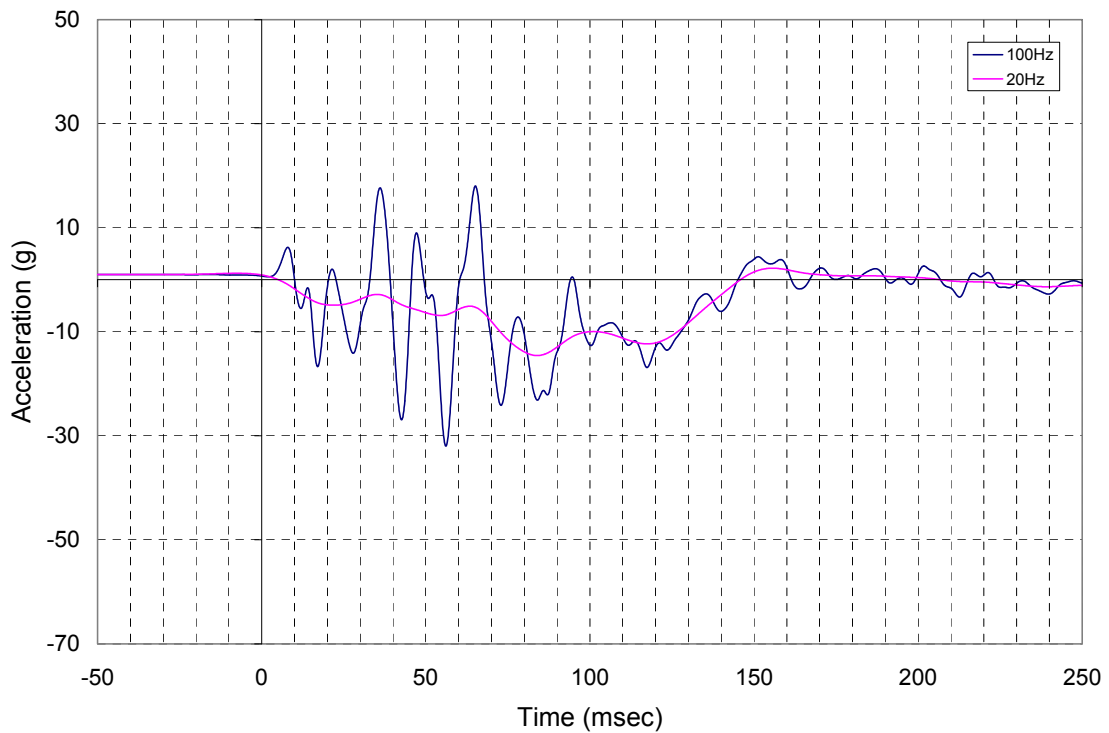


FIGURE B-24. FS 484 LEFT INNER SEAT TRACK ACCELERATION

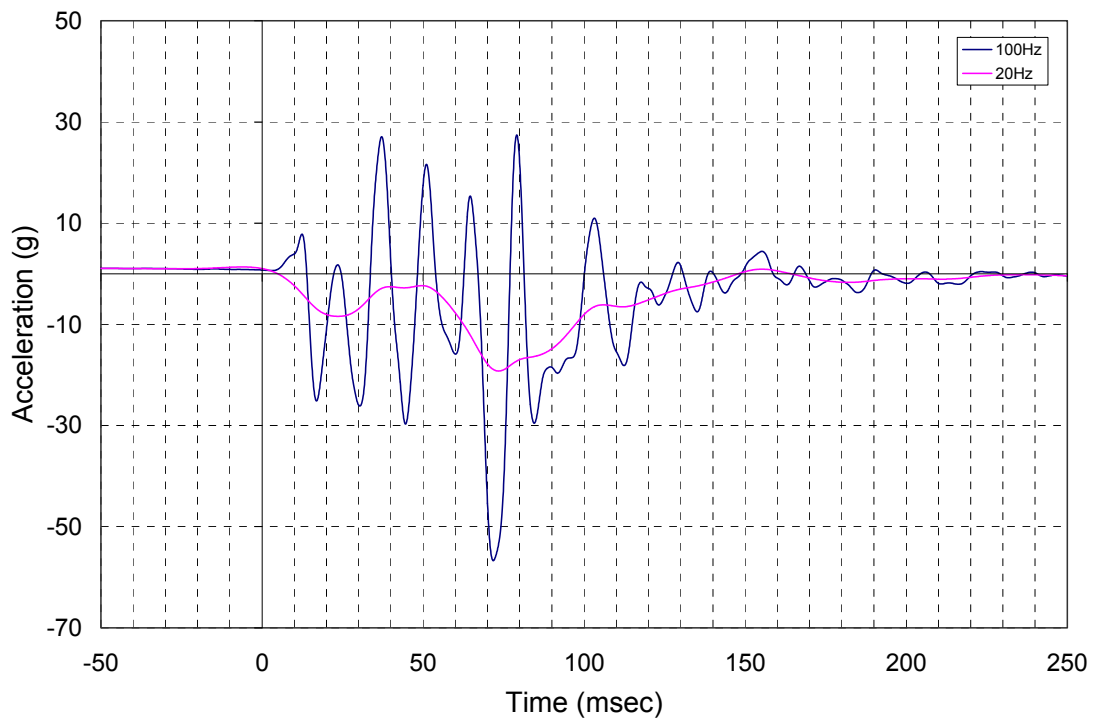


FIGURE B-25. FS 380 RIGHT INNER SEAT TRACK ACCELERATION

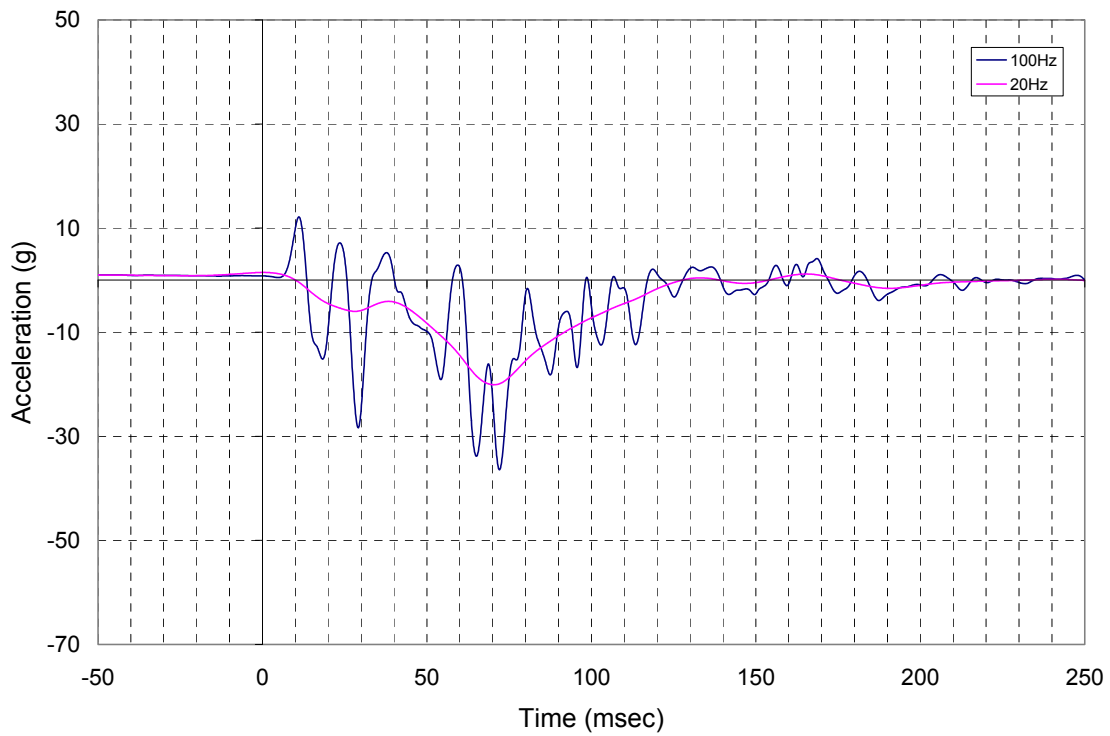


FIGURE B-26. FS 418 RIGHT INNER SEAT TRACK ACCELERATION

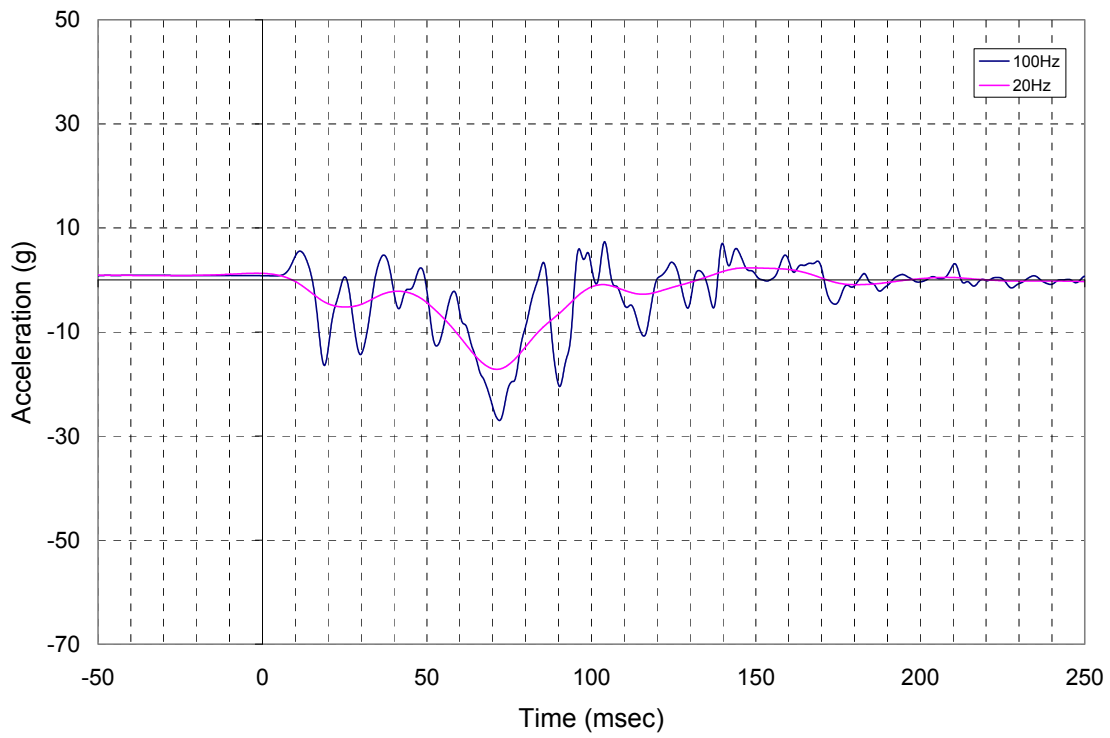


FIGURE B-27. FS 452 RIGHT INNER SEAT TRACK ACCELERATION

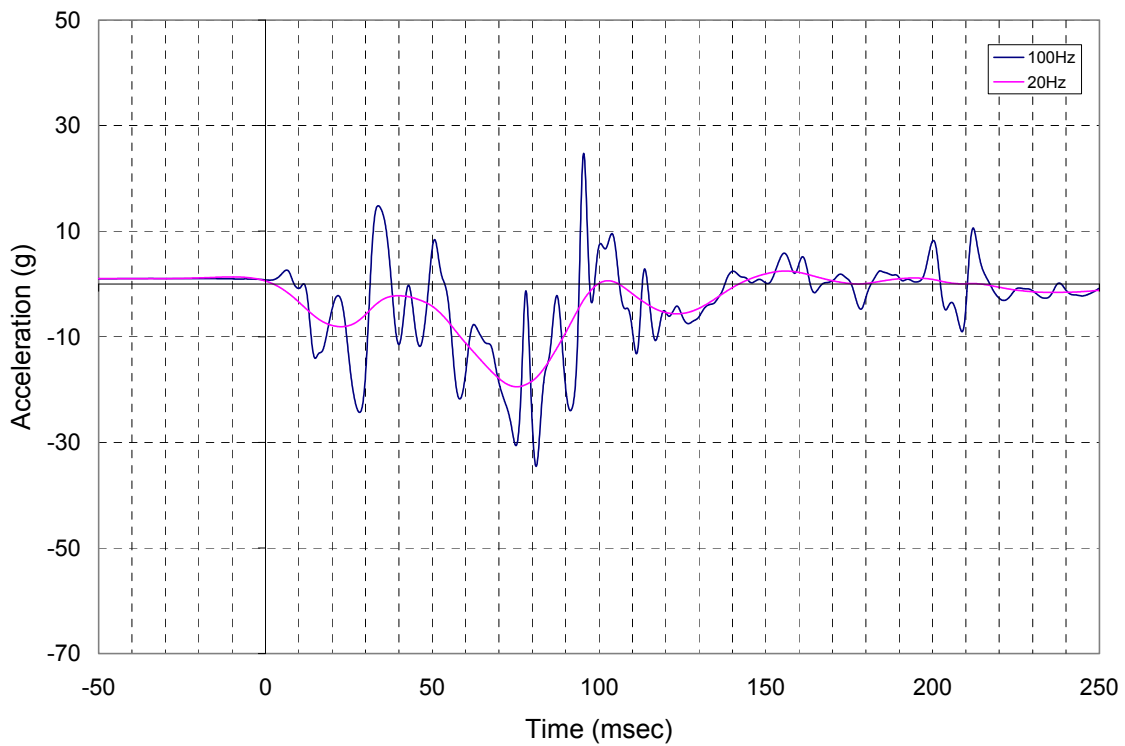


FIGURE B-28. FS 484 RIGHT INNER SEAT TRACK ACCELERATION

B.3 HITCO BIN—MEASURED LOADS

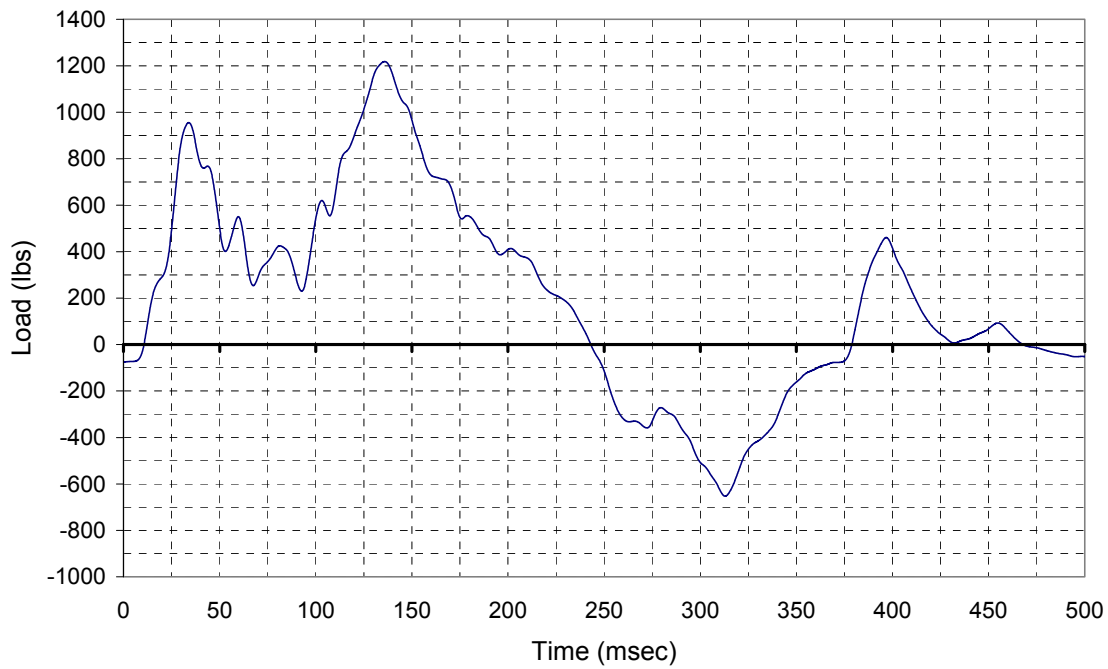


FIGURE B-29. H1—MEASURED LOAD (100 Hz)

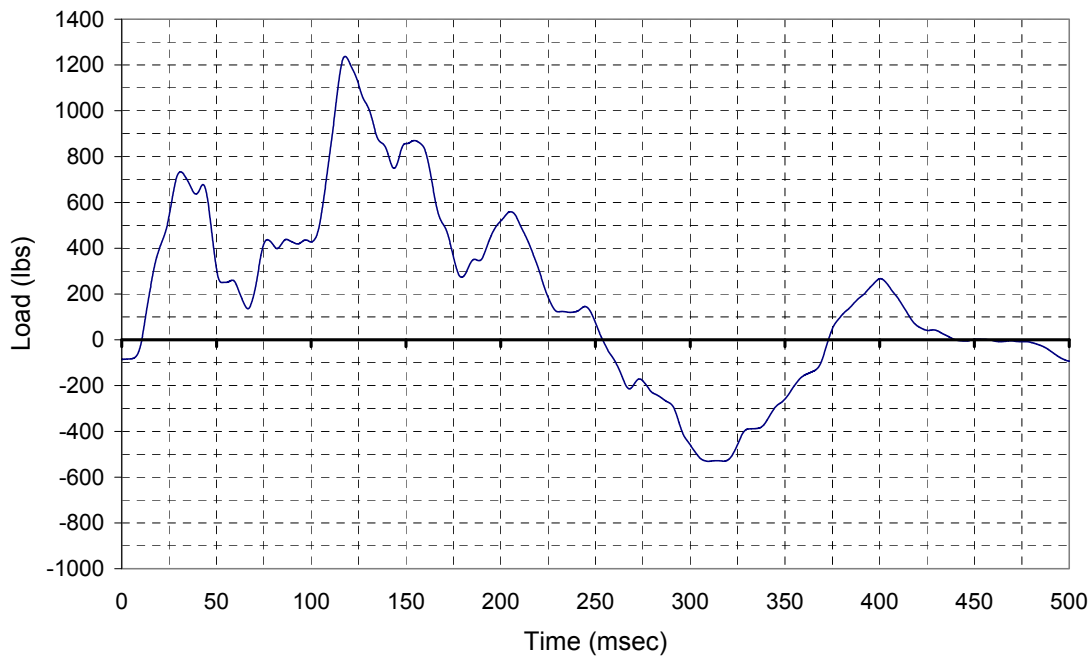


FIGURE B-30. H2—MEASURED LOAD (100 Hz)

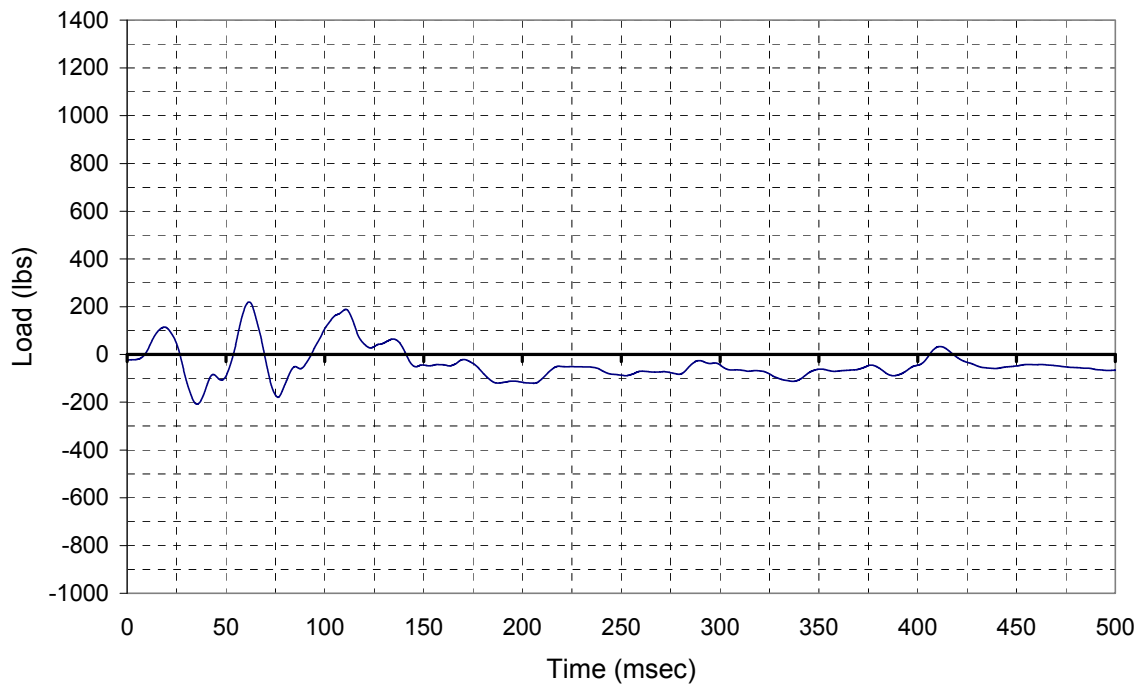


FIGURE B-31. H3—MEASURED LOAD (100 Hz)

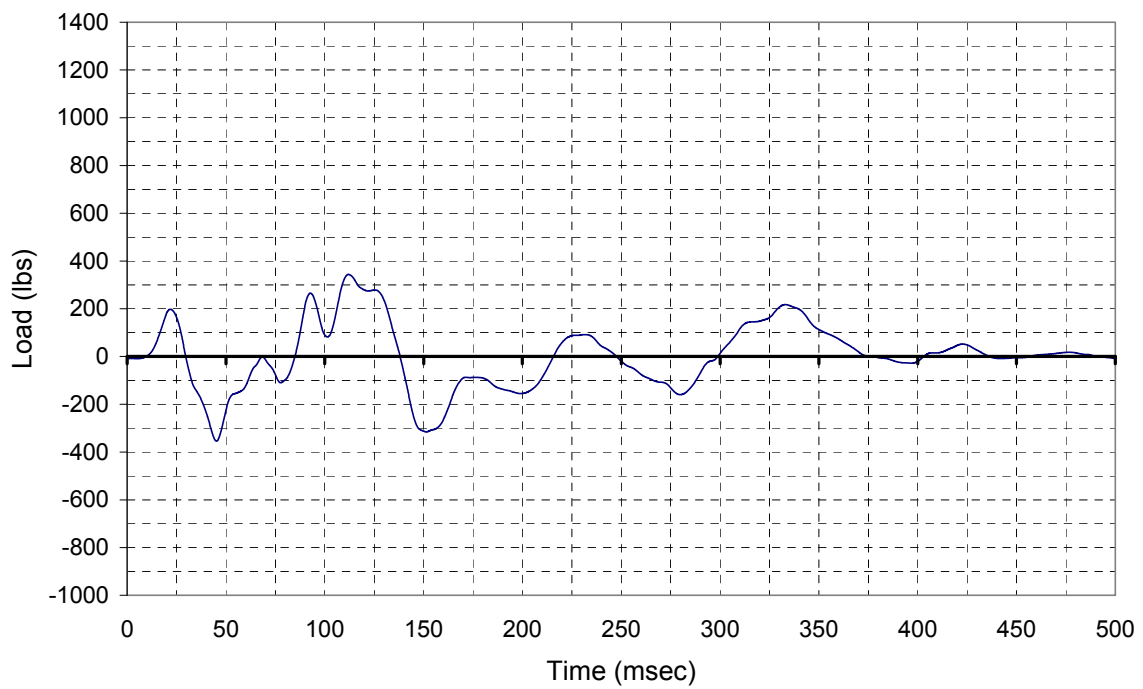


FIGURE B-32. H4—MEASURED LOAD (100 Hz)

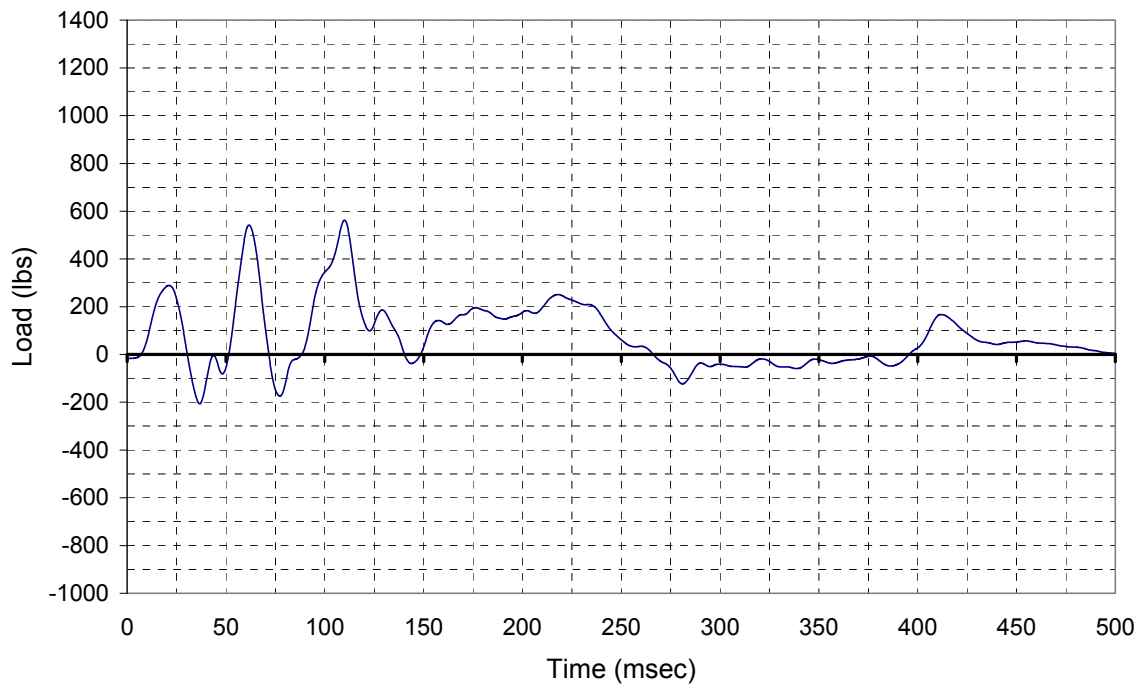


FIGURE B-33. H5—MEASURED LOAD (100 Hz)

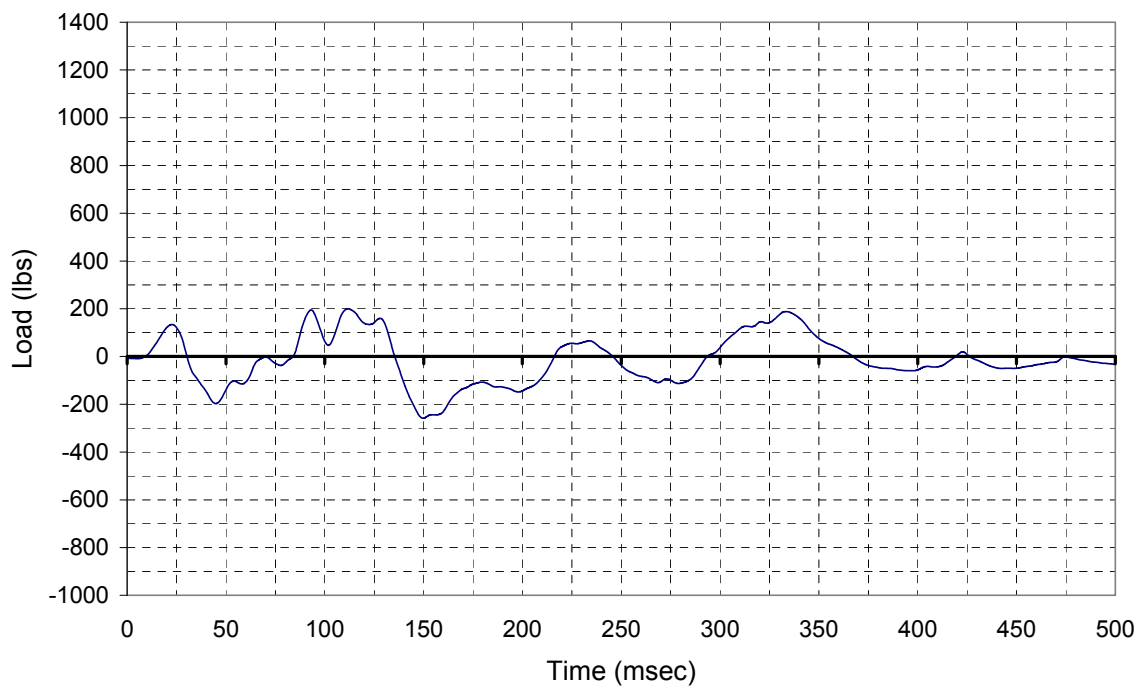


FIGURE B-34. H6—MEASURED LOAD (100 Hz)

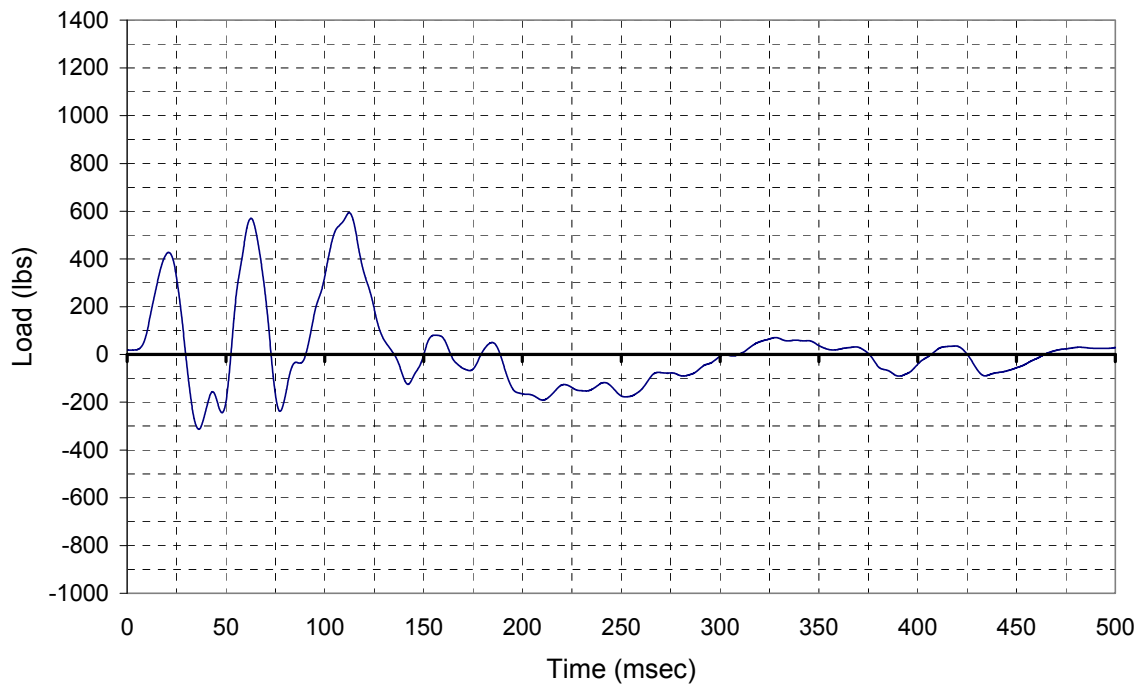


FIGURE B-35. H7—MEASURED LOAD (100 Hz)

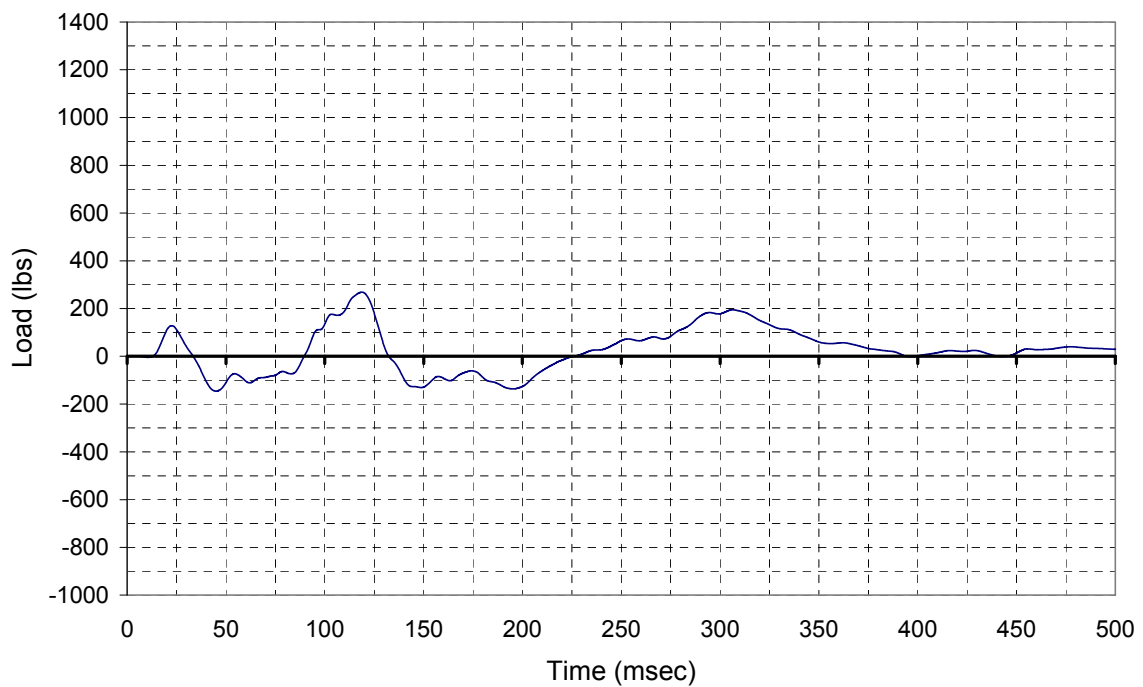


FIGURE B-36. H8—MEASURED LOAD (100 Hz)

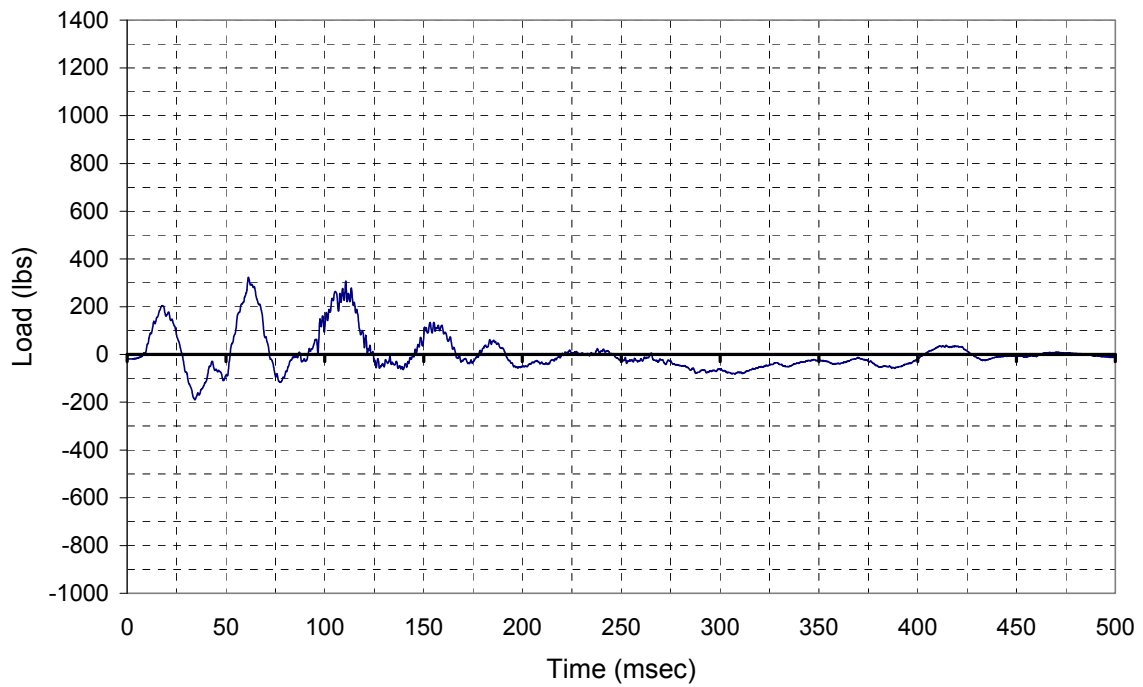


FIGURE B-37. H9—MEASURED LOAD (100 Hz)

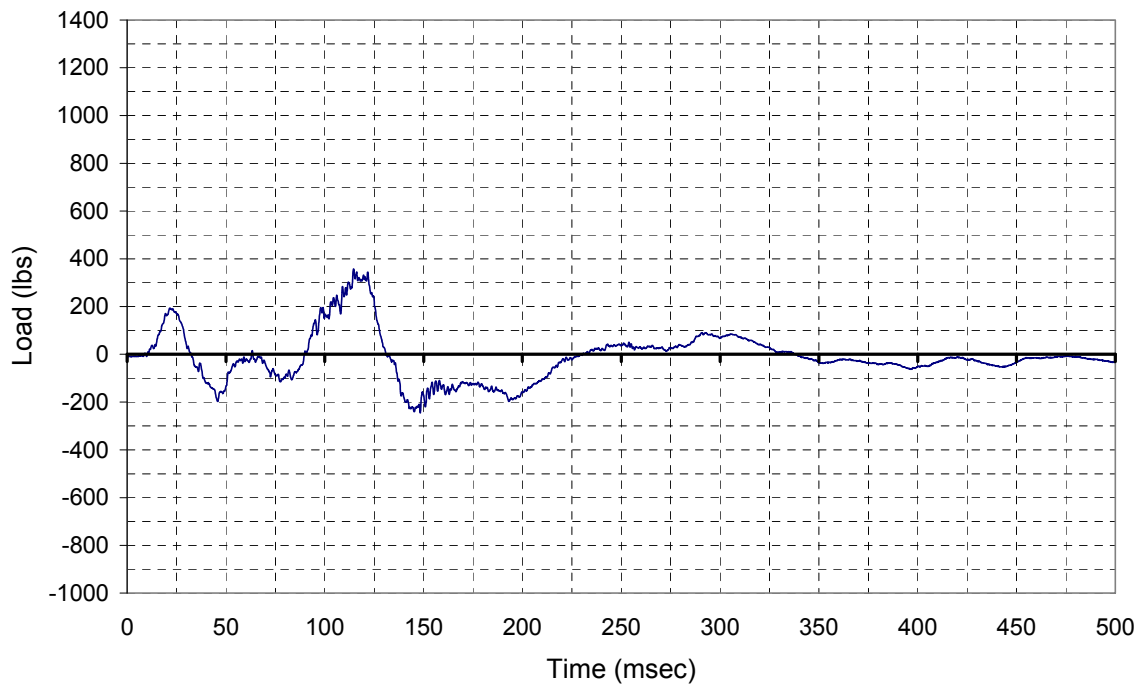


FIGURE B-38. H10—MEASURED LOAD (100 Hz)

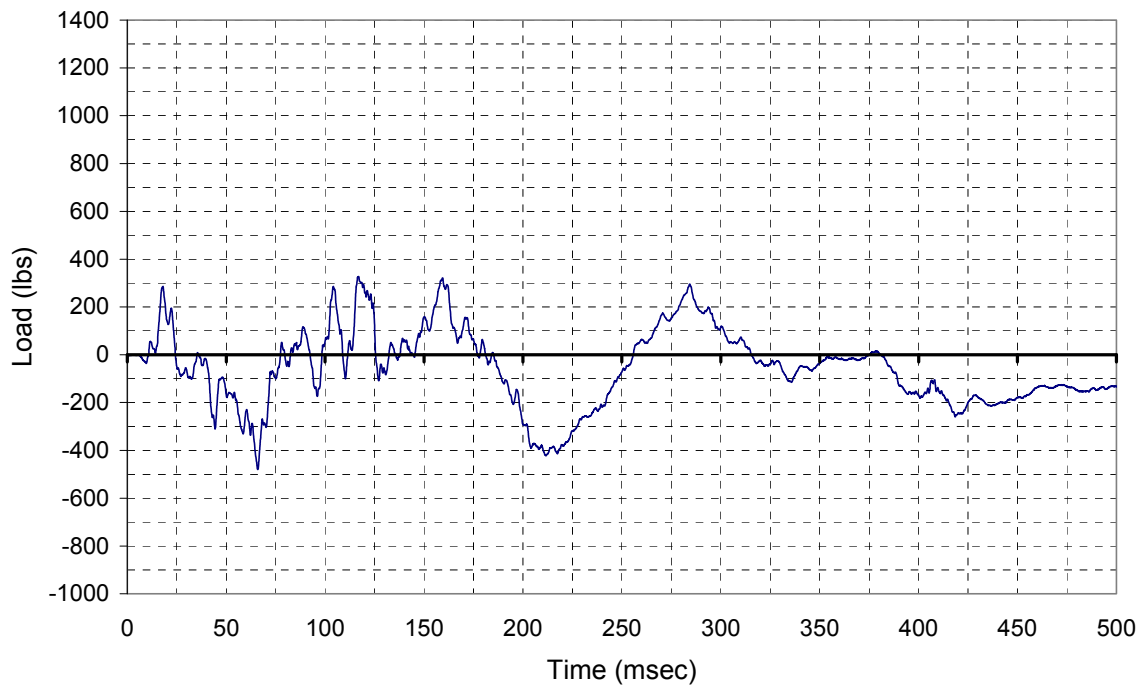


FIGURE B-39. H11—MEASURED LOAD (100 Hz)

B.4 HITCO BIN—VERTICAL VECTOR (Z) COMPONENT LOADS

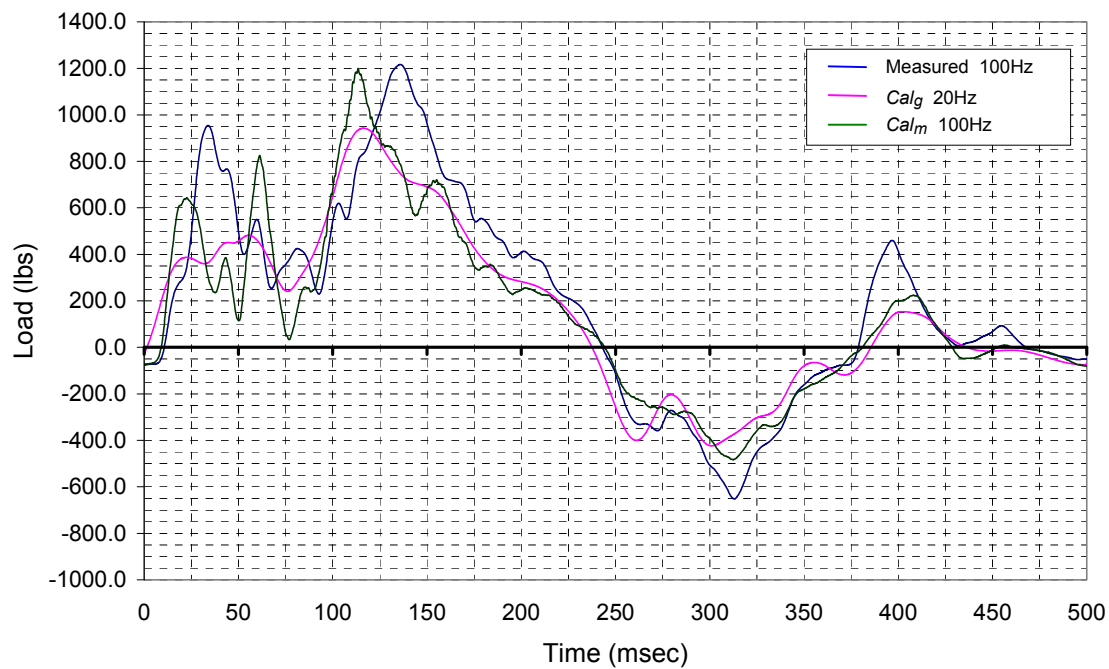


FIGURE B-40. HITCO BIN H1—VERTICAL VECTOR (Z) COMPONENT LOAD

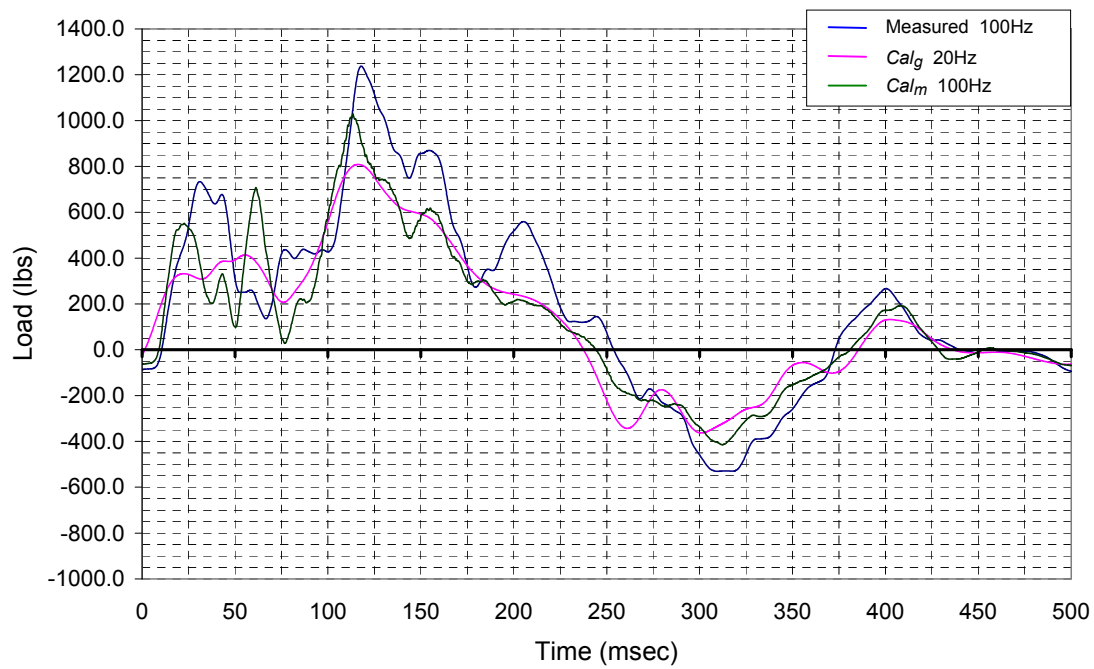


FIGURE B-41. HITCO BIN H2—VERTICAL VECTOR (Z) COMPONENT LOAD

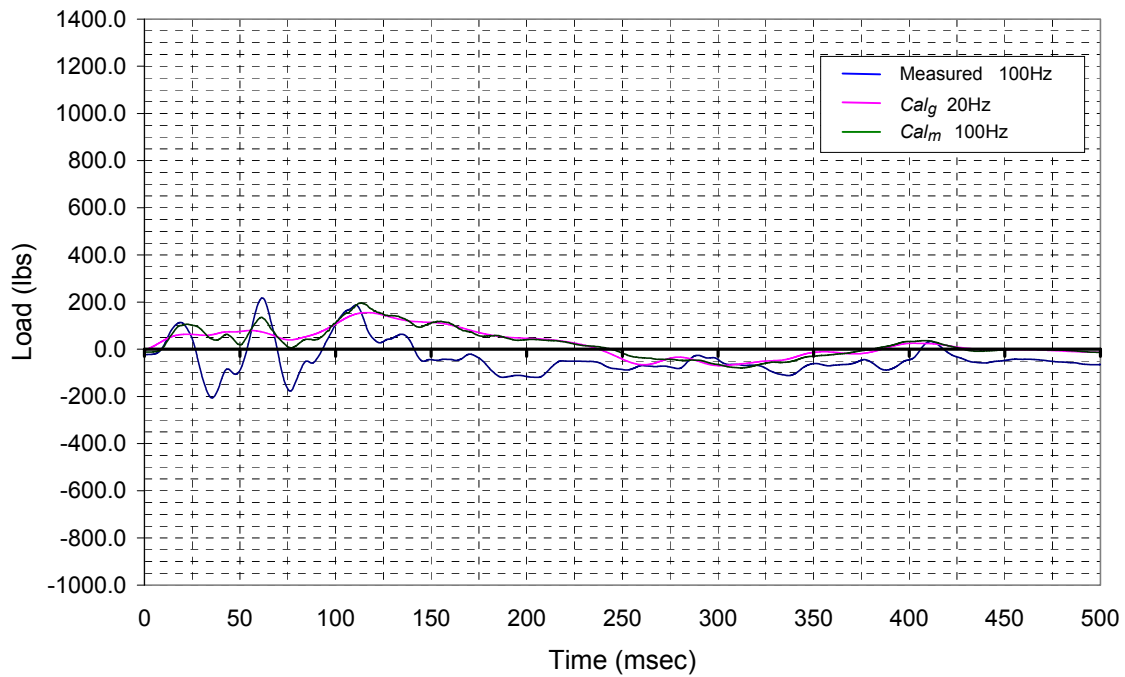


FIGURE B-42. HITCO BIN H3—VERTICAL VECTOR (Z) COMPONENT LOAD

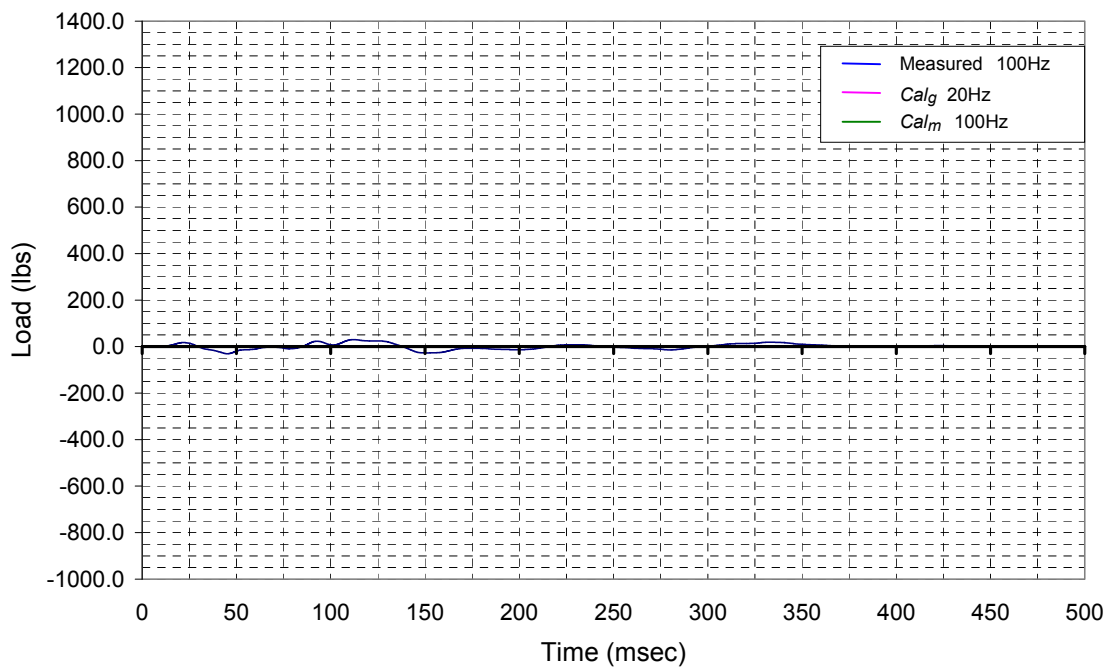


FIGURE B-43. HITCO BIN H4—VERTICAL VECTOR (Z) COMPONENT LOAD

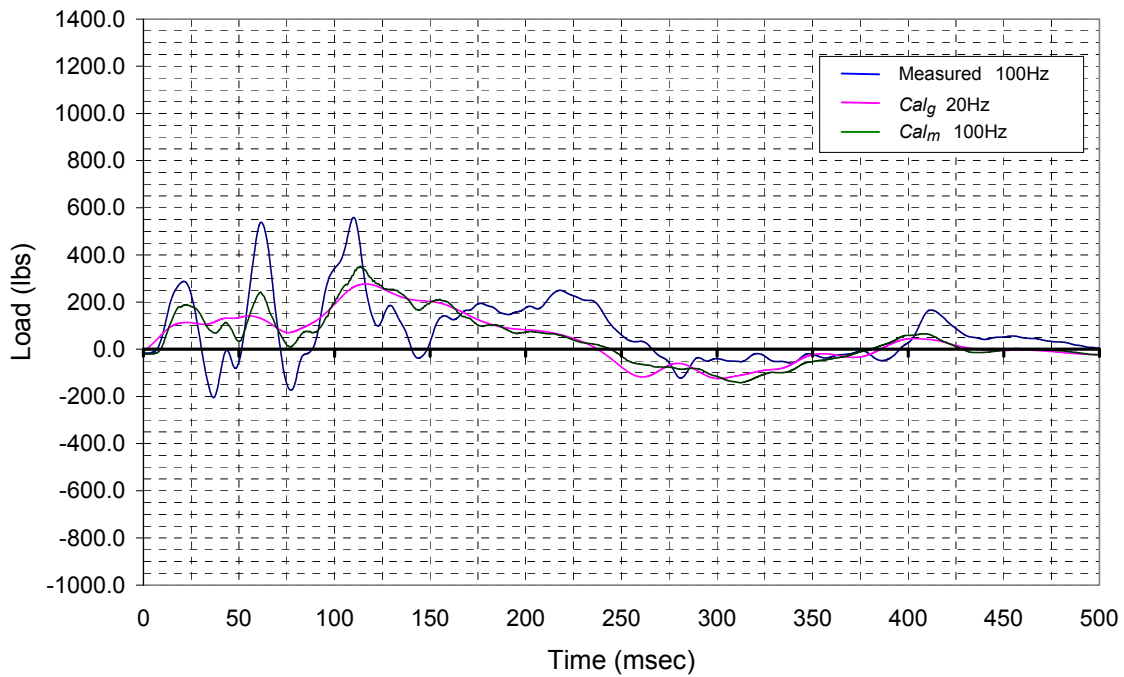


FIGURE B-44. HITCO BIN H5—VERTICAL VECTOR (Z) COMPONENT LOAD

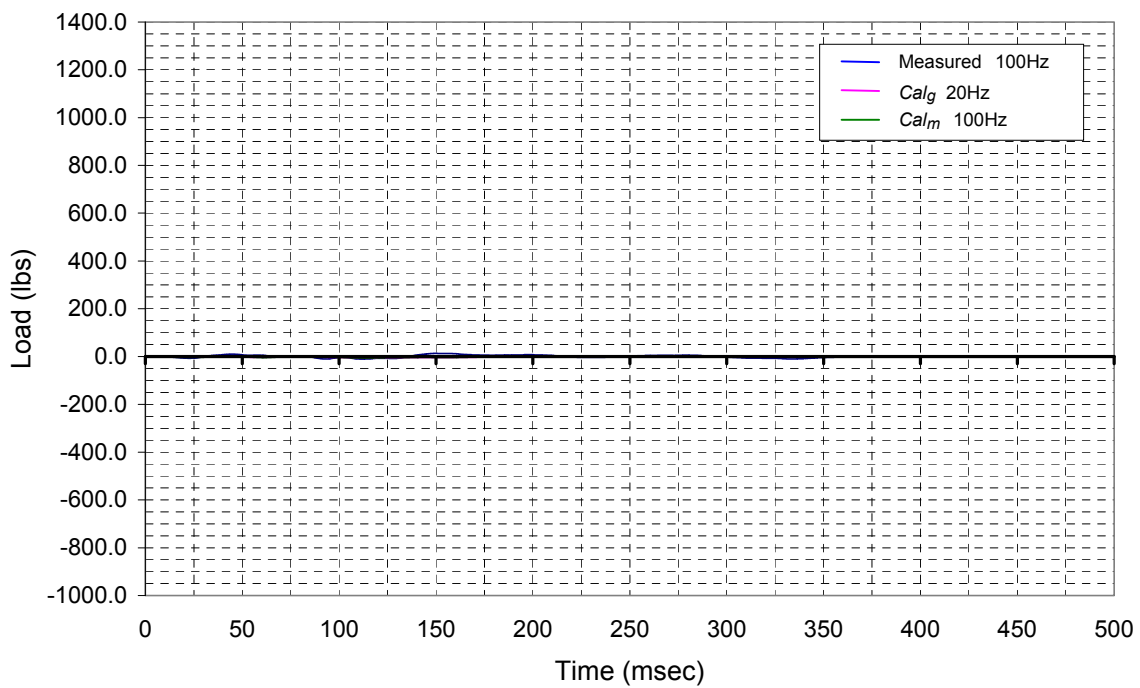


FIGURE B-45. HITCO BIN H6—VERTICAL VECTOR (Z) COMPONENT LOAD

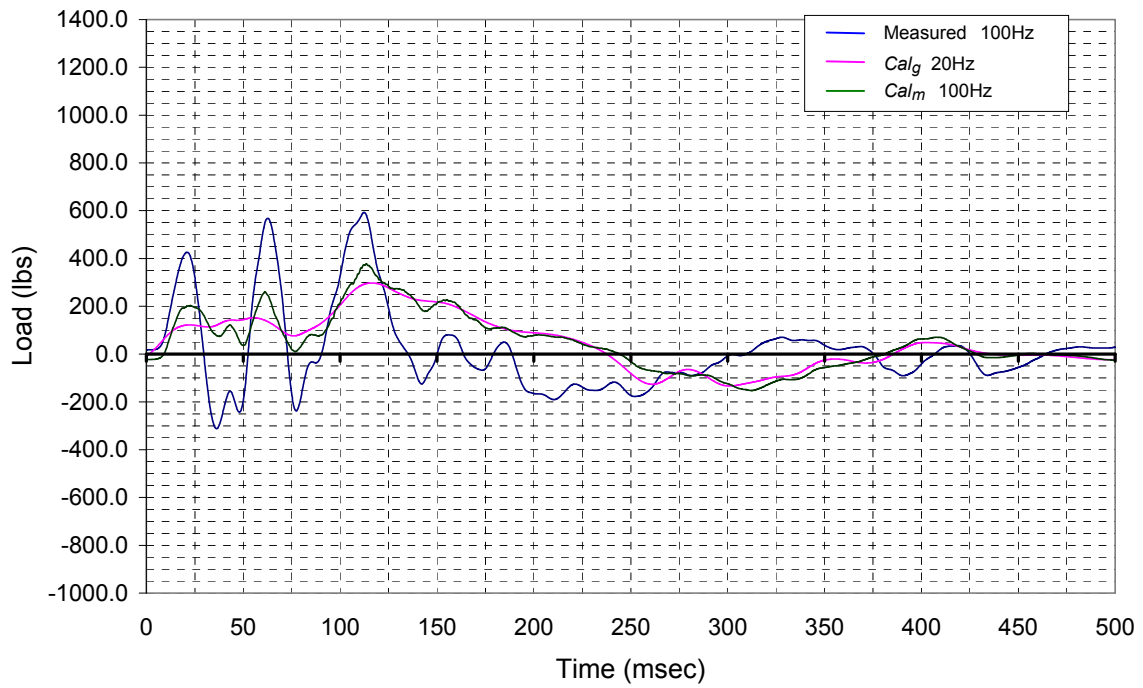


FIGURE B-46. HITCO BIN H7—VERTICAL VECTOR (Z) COMPONENT LOAD

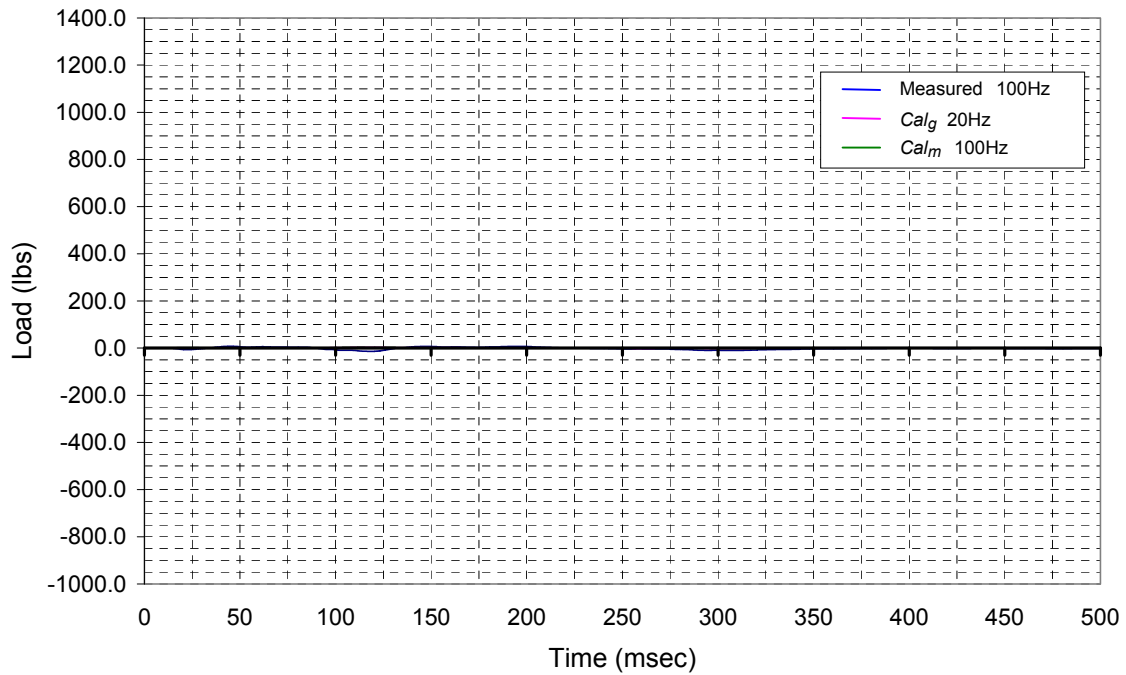


FIGURE B-47. HITCO BIN H8—VERTICAL VECTOR (Z) COMPONENT LOAD

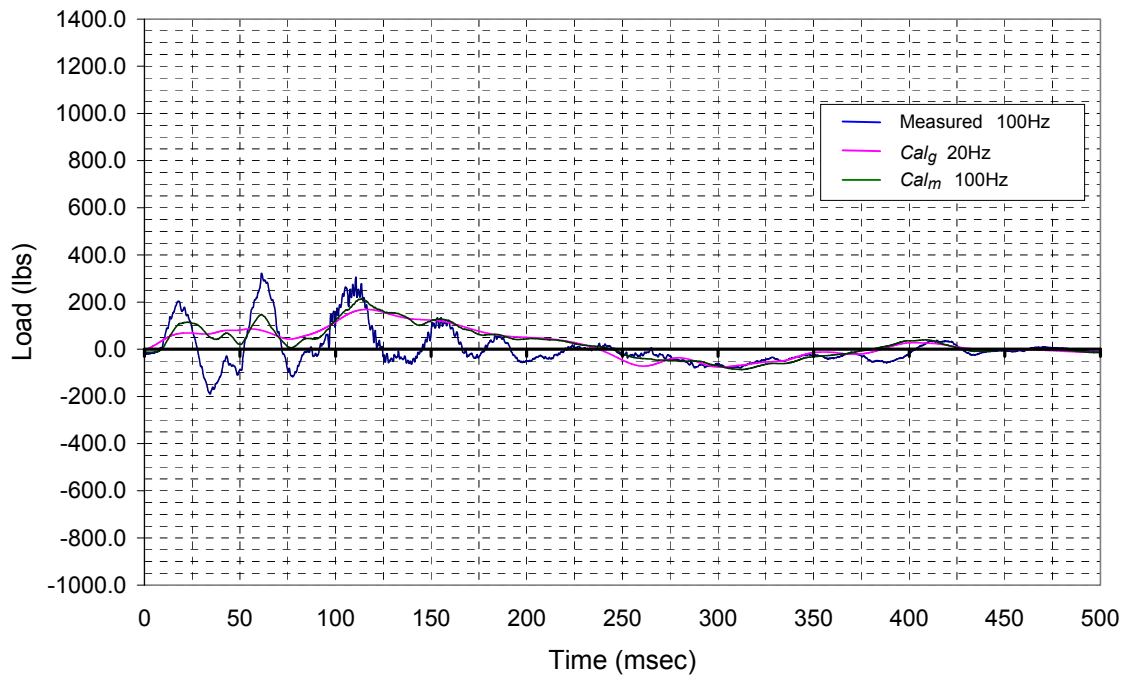


FIGURE B-48. HITCO BIN H9—VERTICAL VECTOR (Z) COMPONENT LOAD

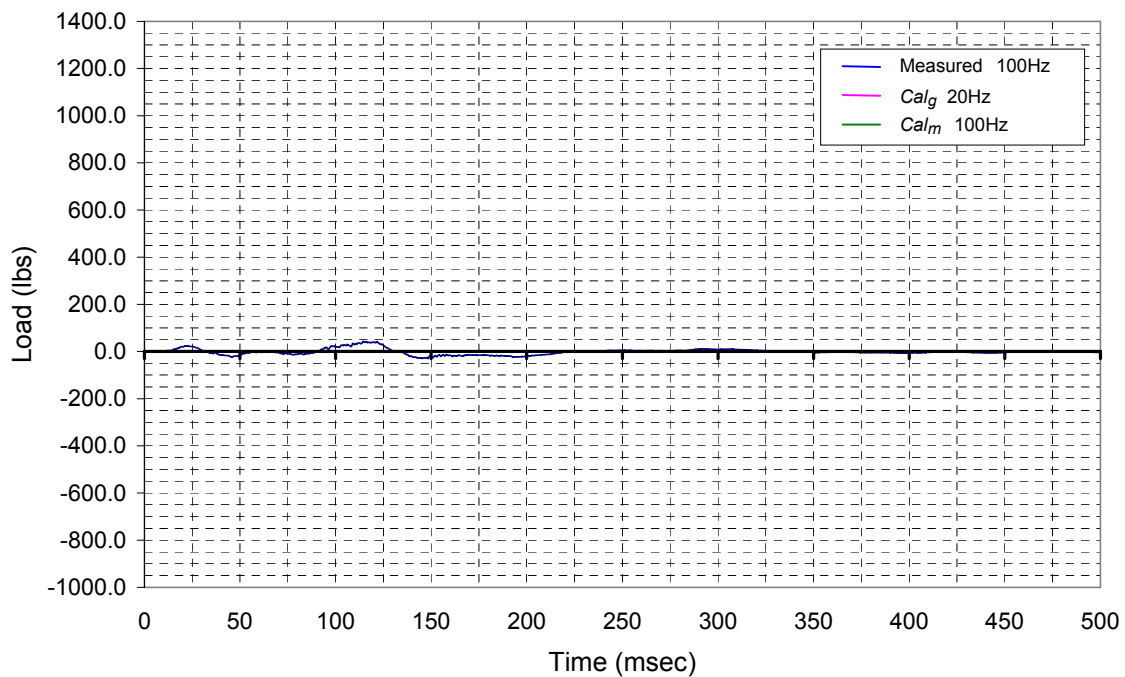


FIGURE B-49. HITCO BIN H10—VERTICAL VECTOR (Z) COMPONENT LOAD

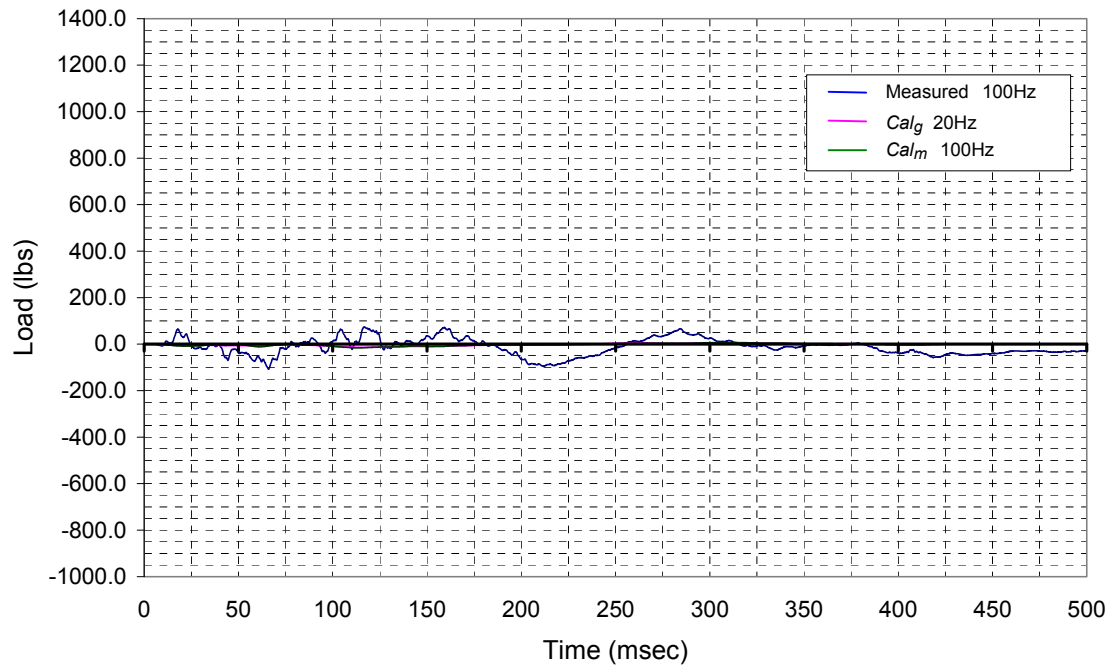


FIGURE B-50. HITCO BIN H11—VERTICAL VECTOR (Z) COMPONENT LOAD

B.5 HITCO BIN—ACCELEROMETER DATA

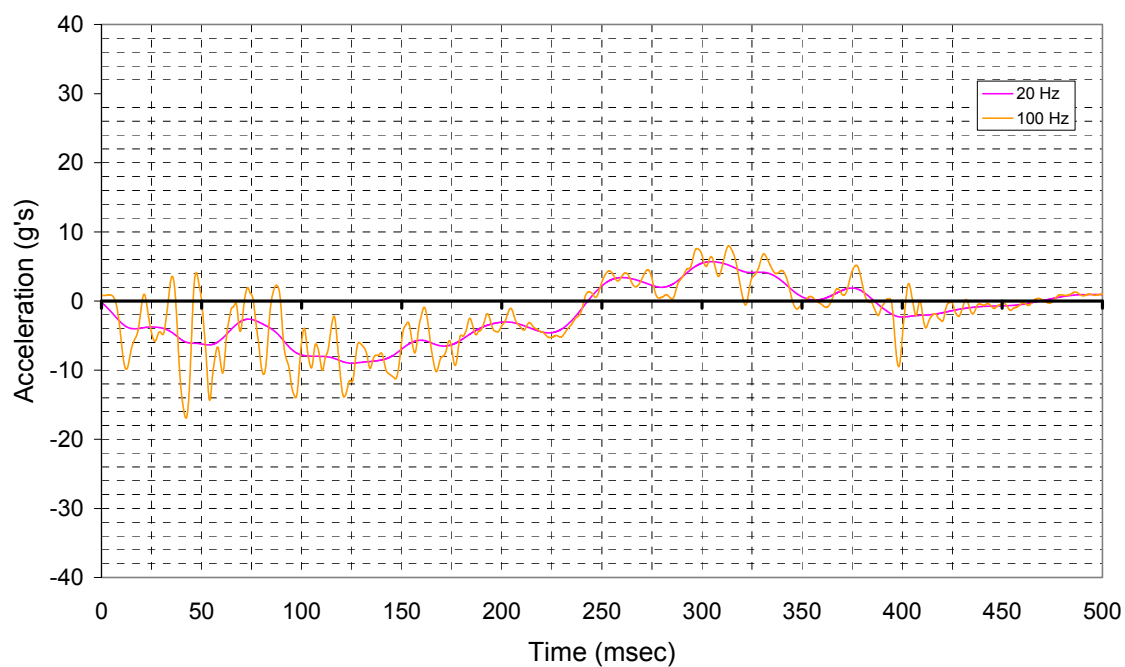


FIGURE B-51. HITCO BIN ACCEL (1)—FORWARD LOCATION, Z DIRECTION

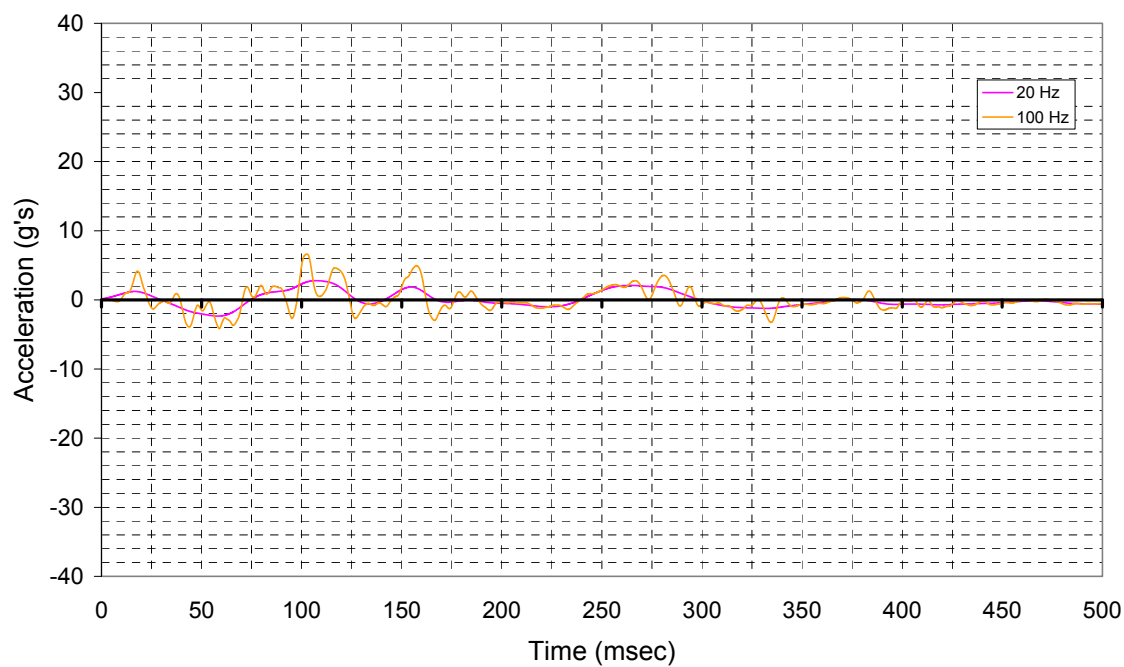


FIGURE B-52. HITCO BIN ACCEL (2)—CENTER LOCATION, X DIRECTION

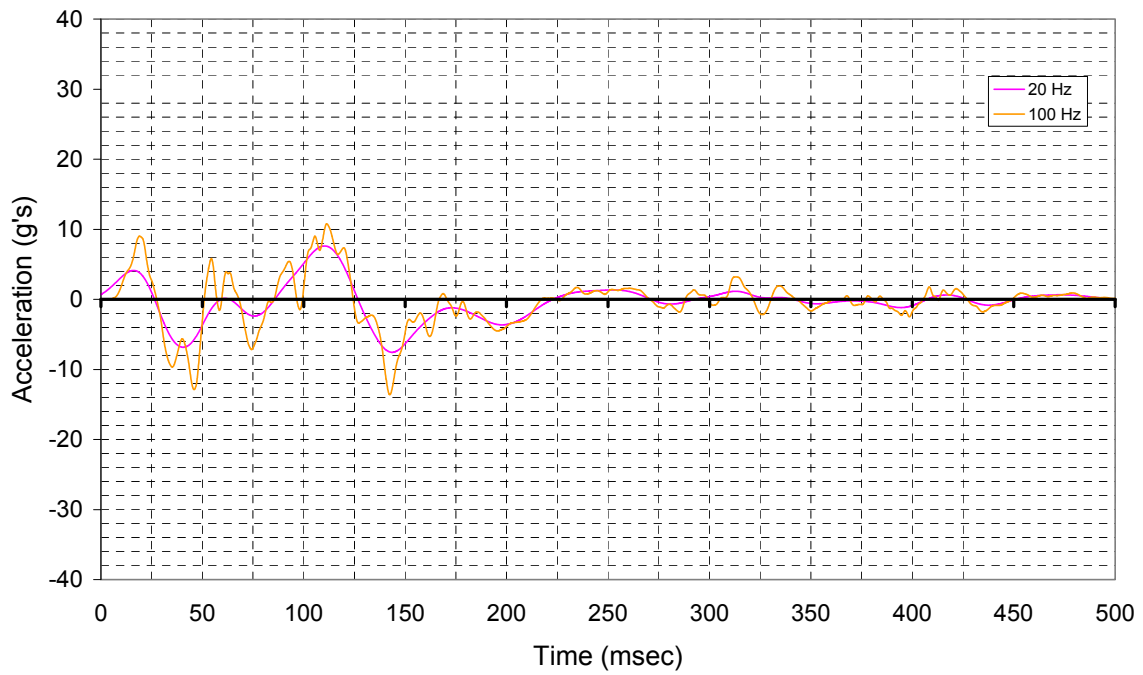


FIGURE B-53. HITCO BIN ACCEL (3)—CENTER LOCATION, Y DIRECTION

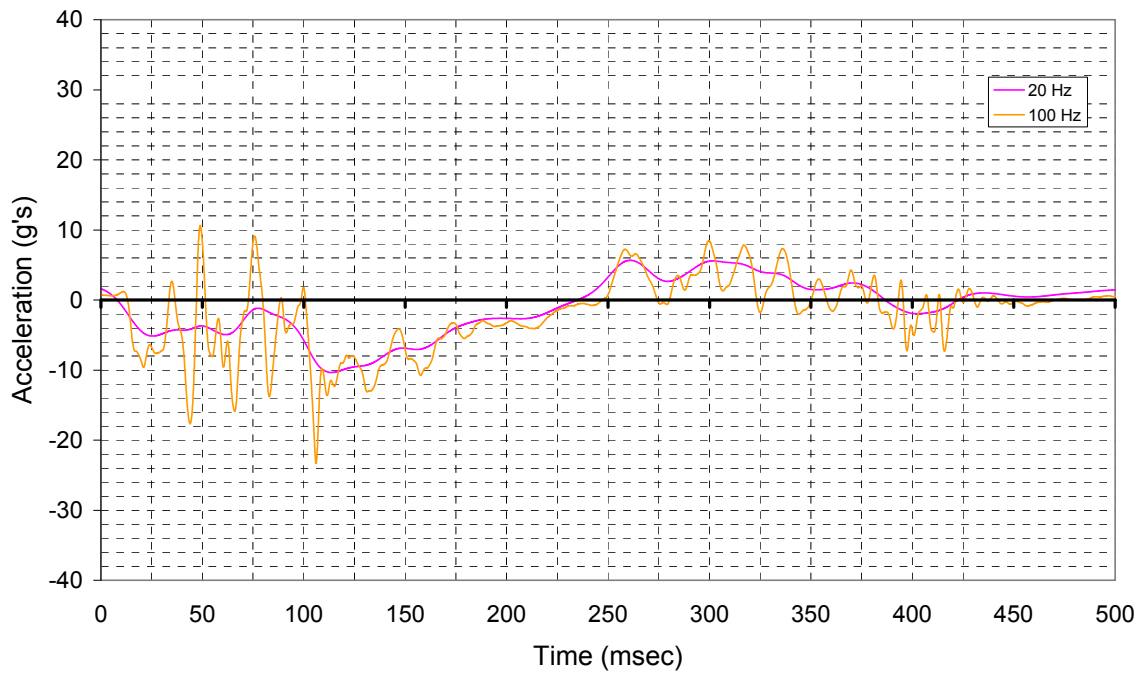


FIGURE B-54. HITCO BIN ACCEL (4)—CENTER LOCATION, Z DIRECTION

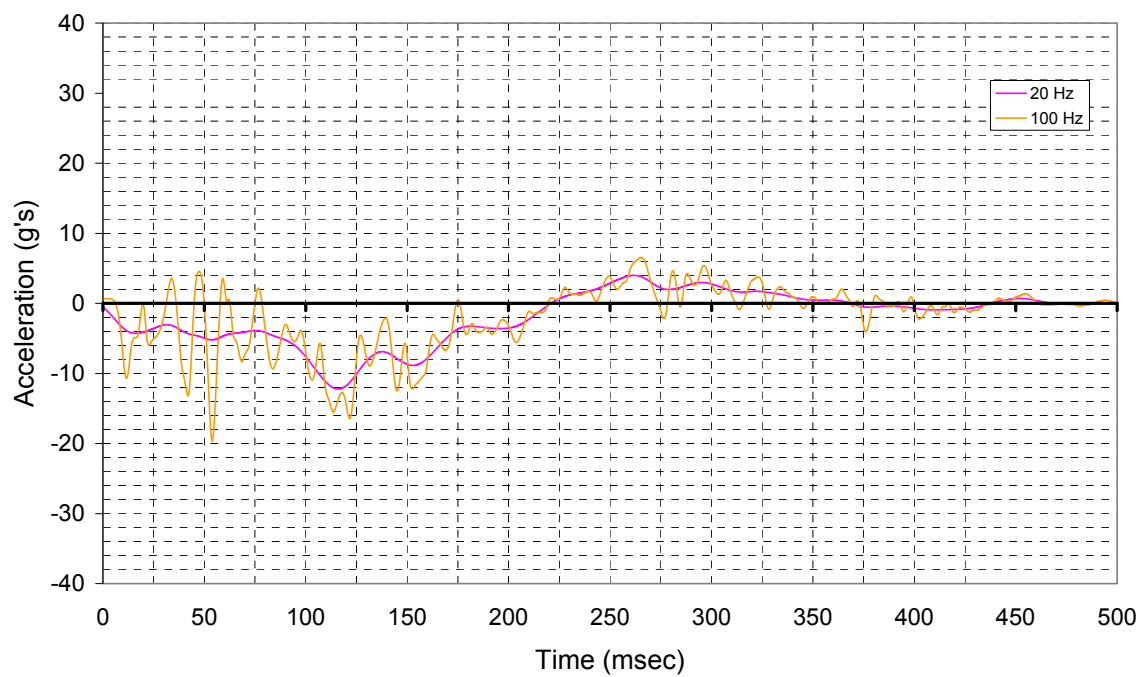


FIGURE B-55. HITCO BIN ACCEL (5)—AFT LOCATION, Z DIRECTION

B.6 HEATH TECNA BIN—MEASURED LOADS

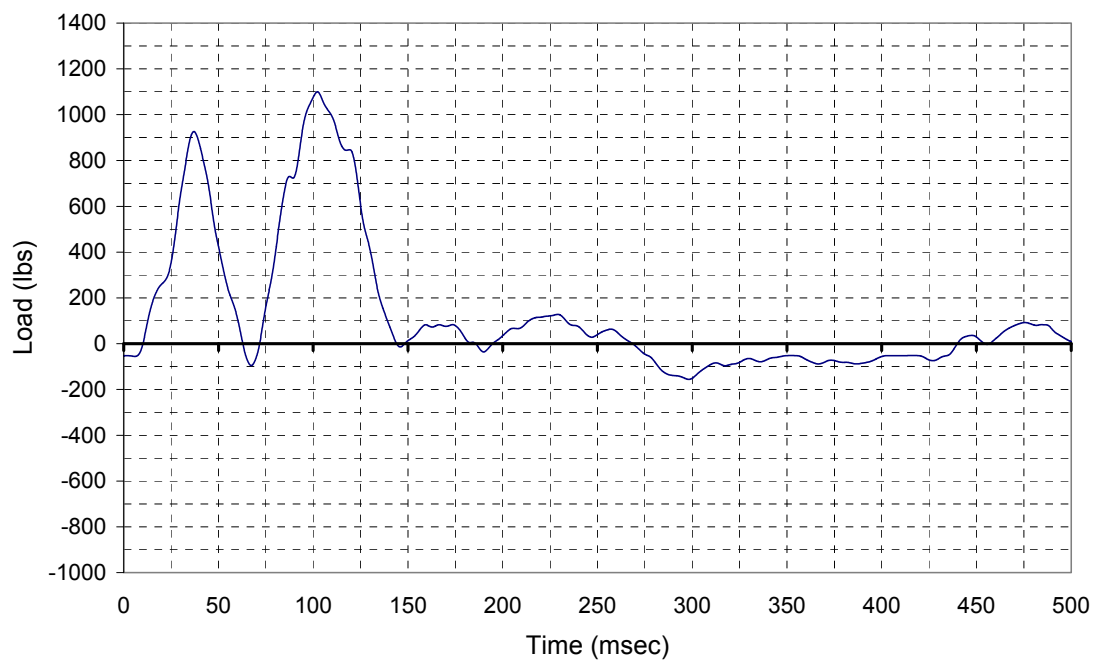


FIGURE B-56. HT1—MEASURED LOAD (100 Hz)

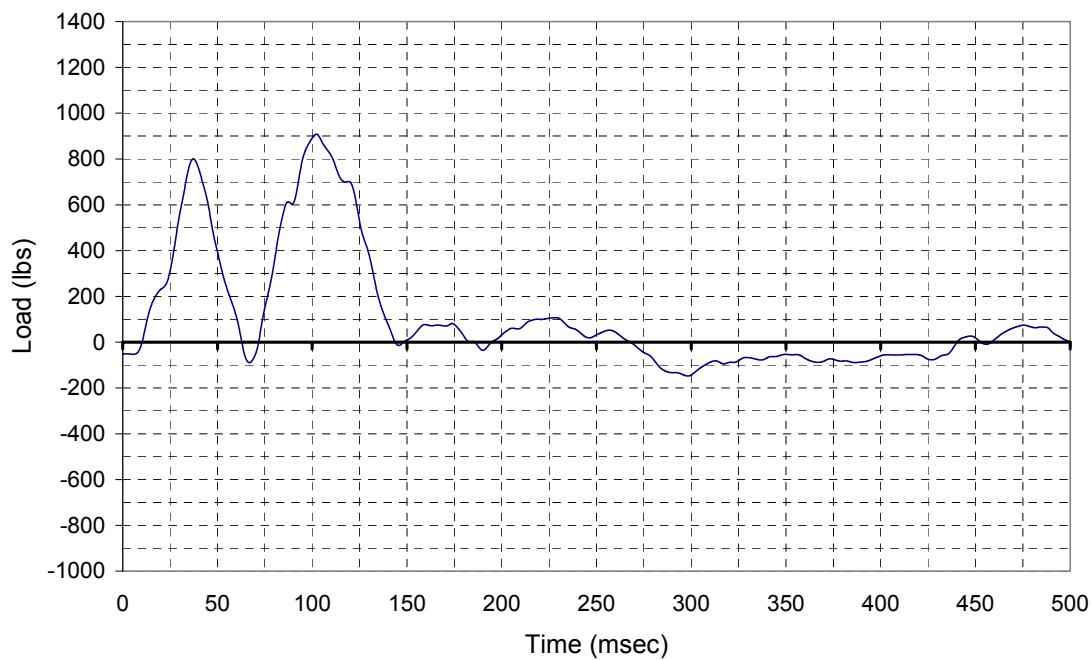


FIGURE B-57. HT2—MEASURED LOAD (100 Hz)

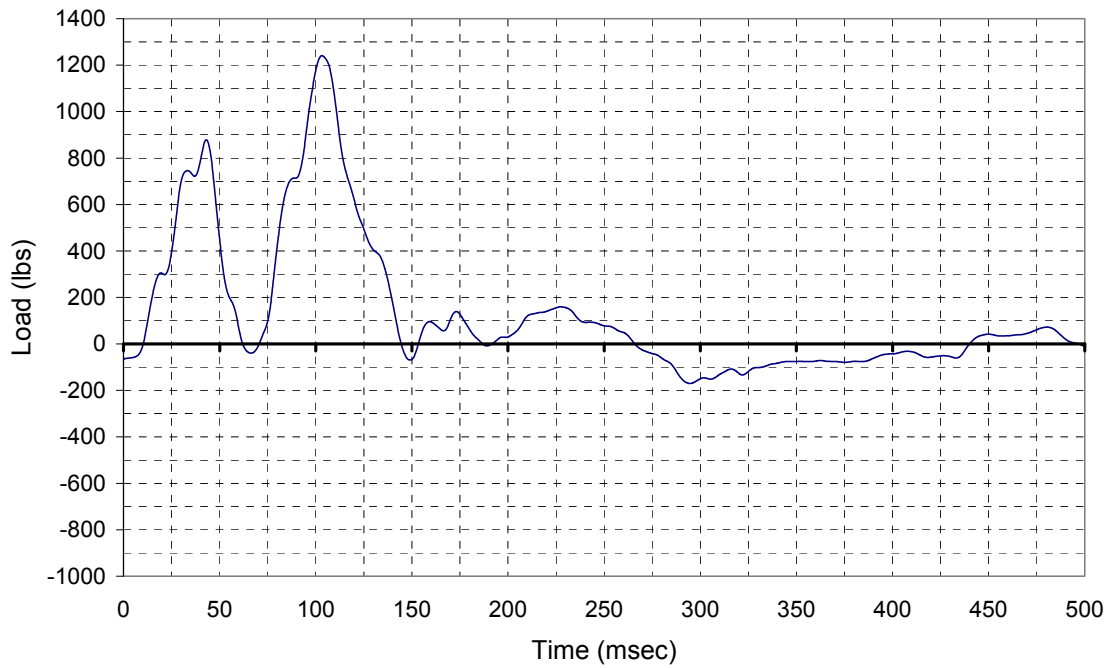


FIGURE B-58. HT3—MEASURED LOAD (100 Hz)

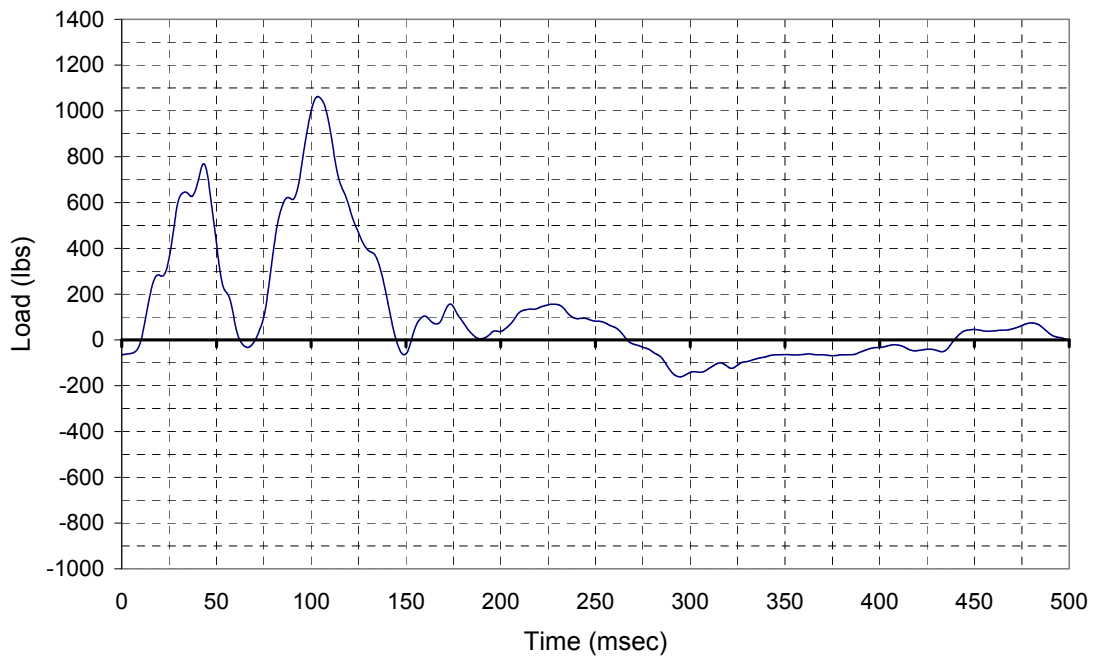


FIGURE B-59. HT4—MEASURED LOAD (100 Hz)

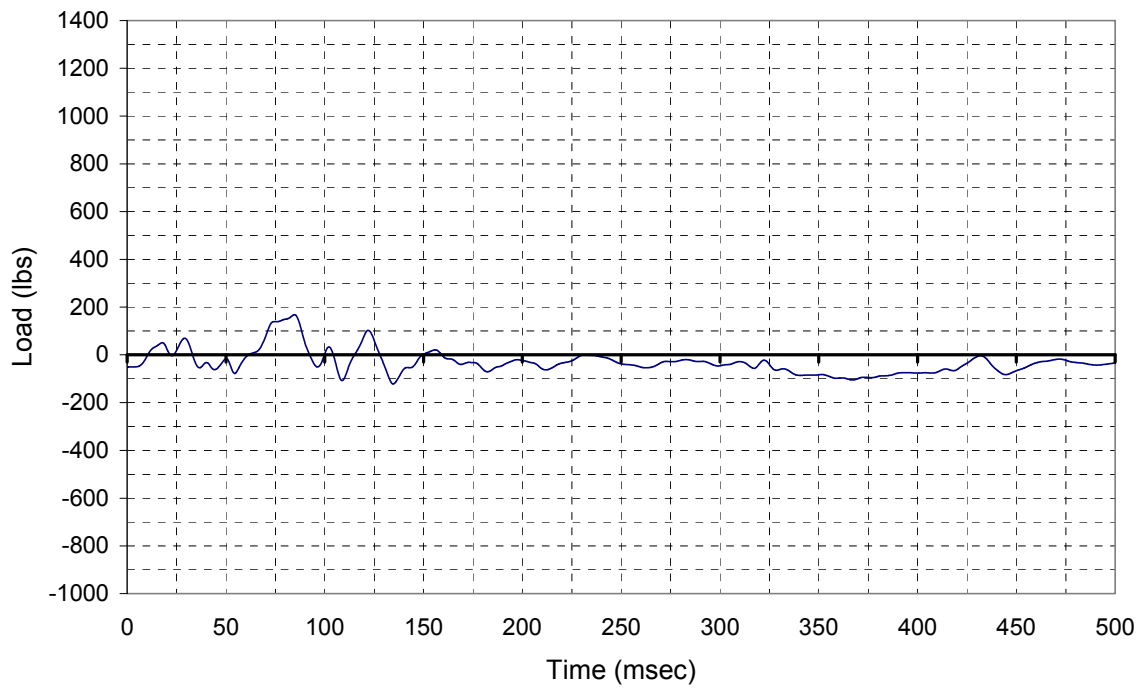


FIGURE B-60. HT5A—MEASURED LOAD (100 Hz)

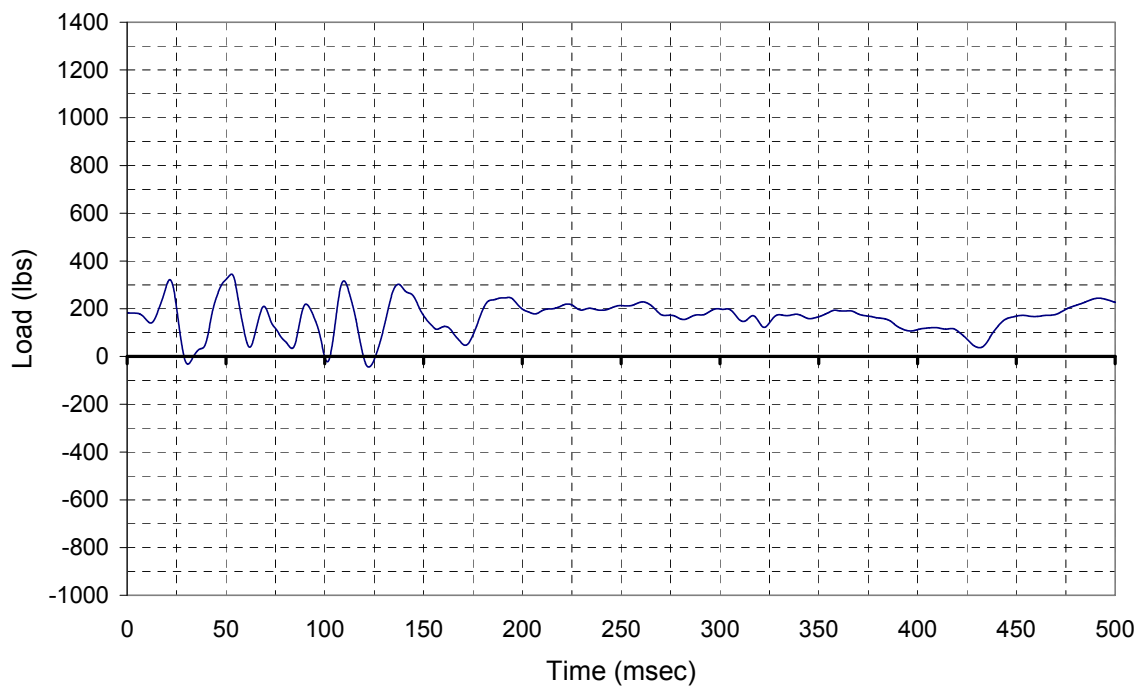


FIGURE B-61. HT5B—MEASURED LOAD (100 Hz)

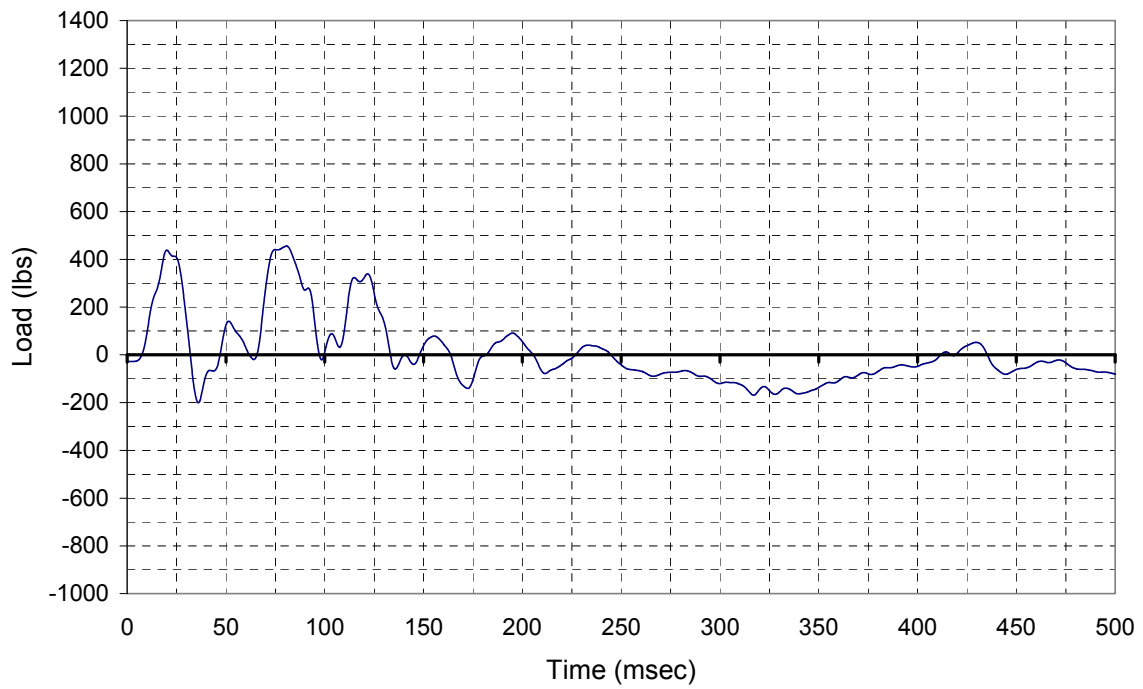


FIGURE B-62. HT6A—MEASURED LOAD (100 Hz)

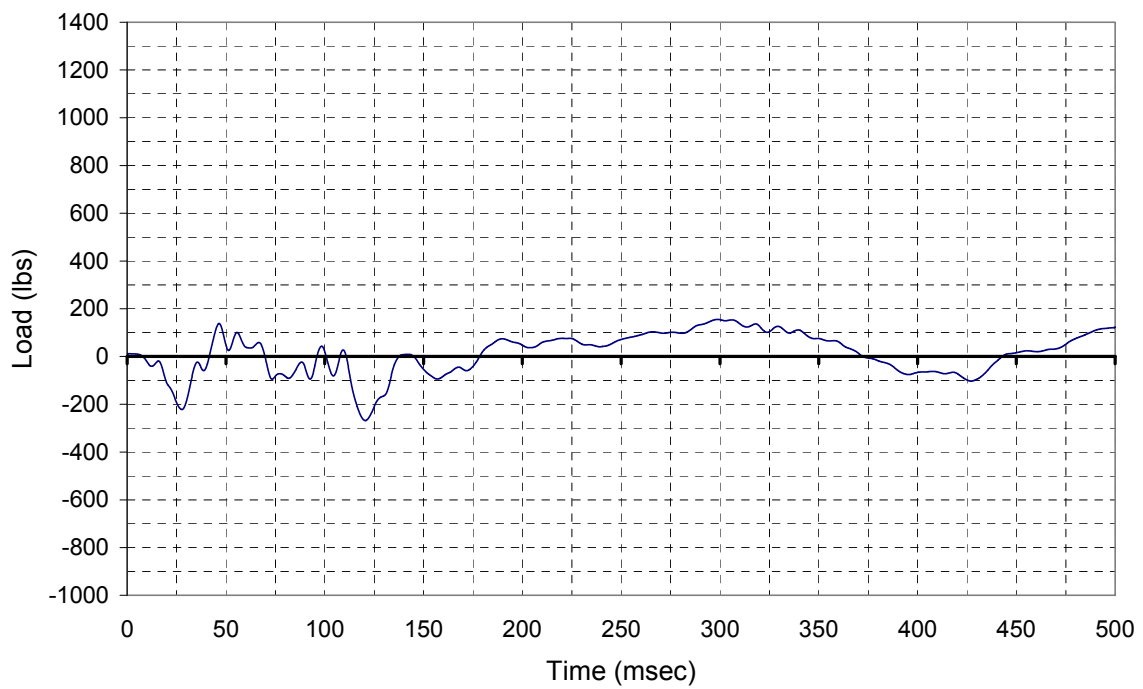


FIGURE B-63. HT6B—MEASURED LOAD (100 Hz)

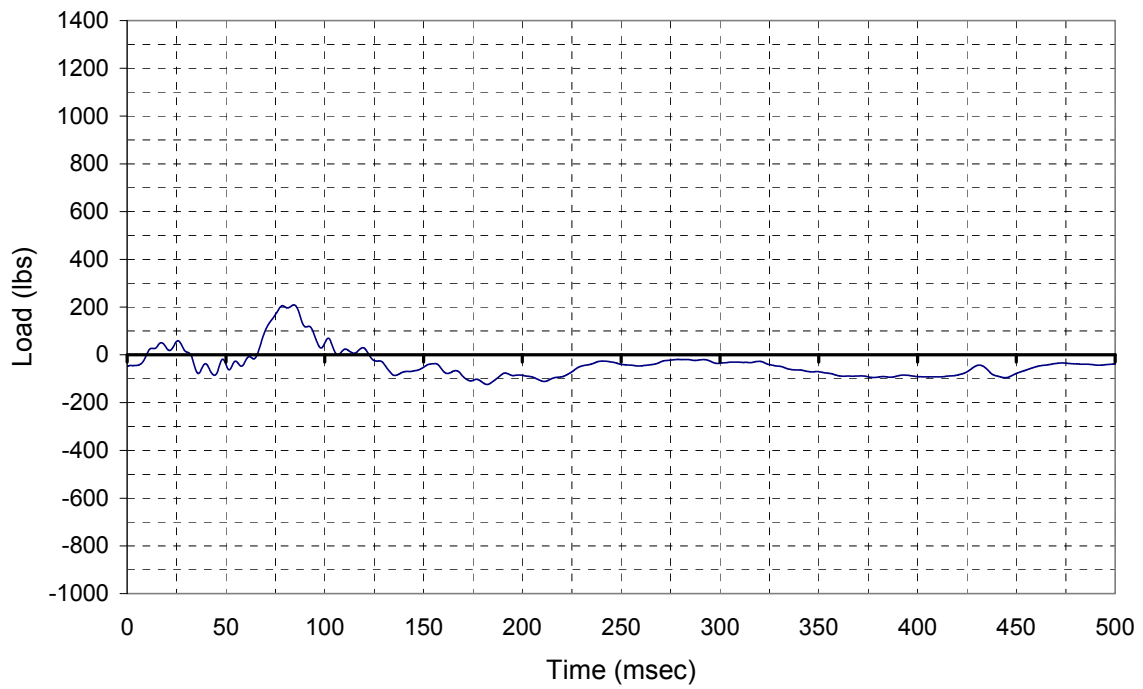


FIGURE B-64. HT7A—MEASURED LOAD (100 Hz)

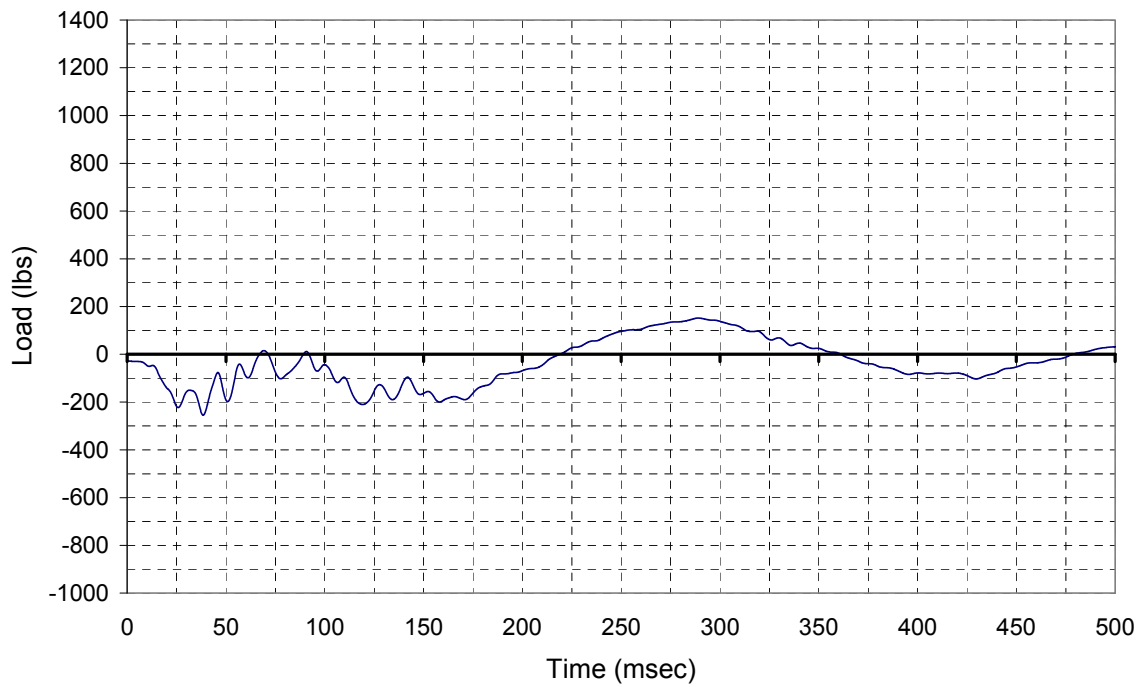


FIGURE B-65. HT7B—MEASURED LOAD (100 Hz)

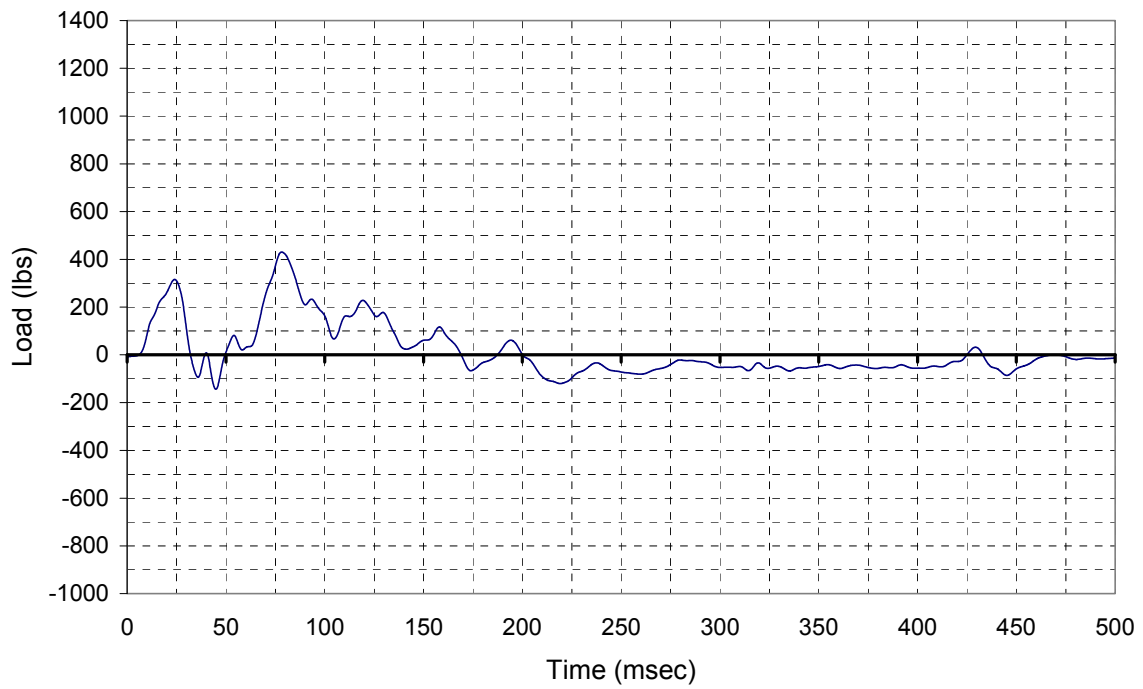


FIGURE B-66. HT8A—MEASURED LOAD (100 Hz)

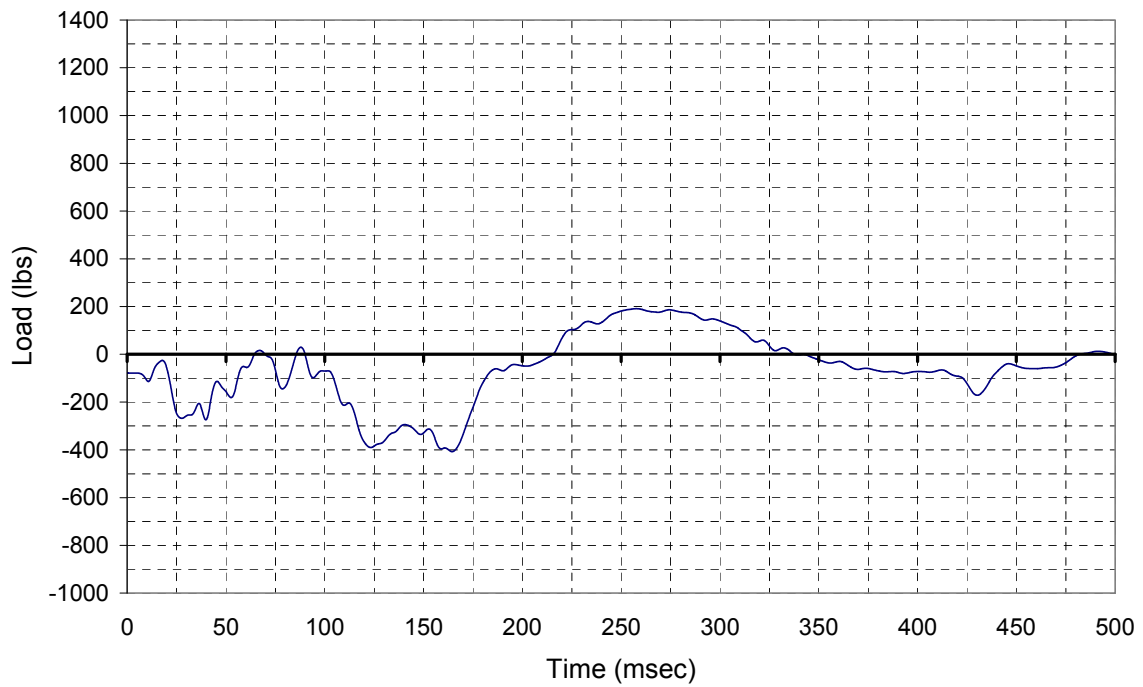


FIGURE B-67. HT8B—MEASURED LOAD (100 Hz)

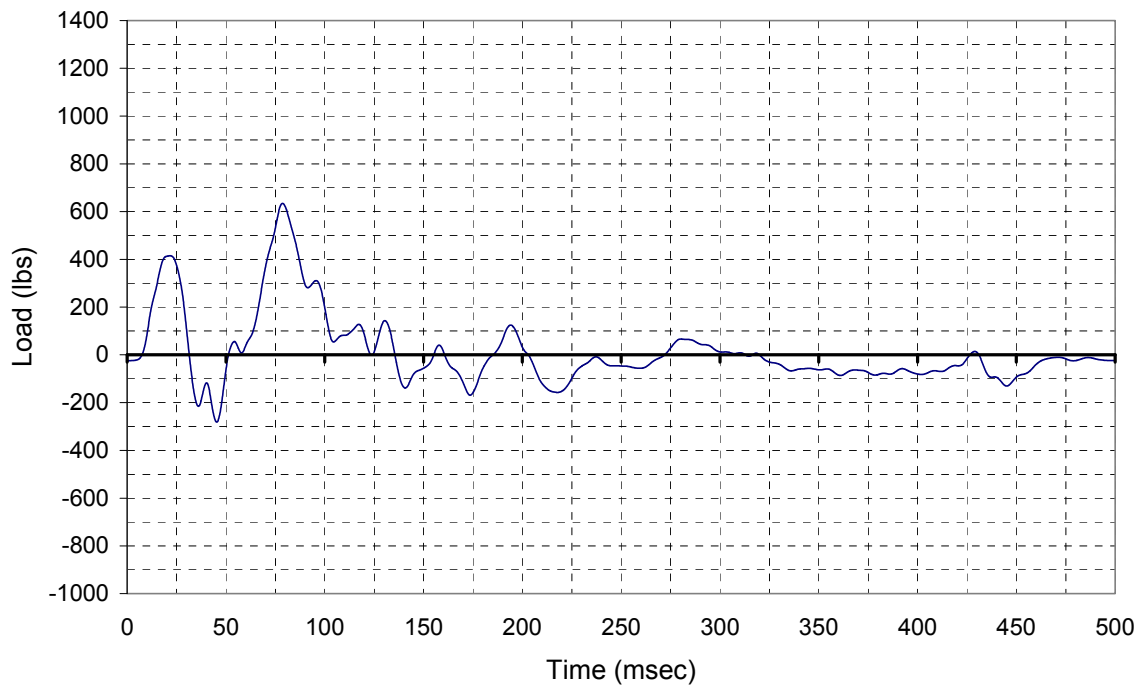


FIGURE B-68. HT9A—MEASURED LOAD (100 Hz)

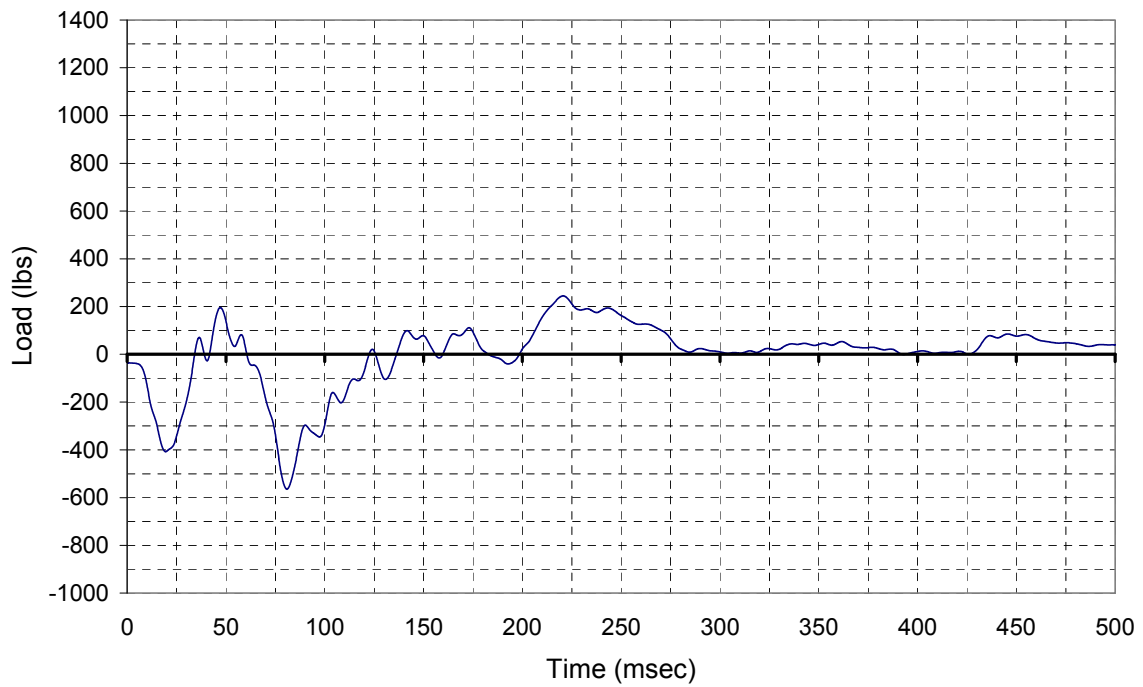


FIGURE B-69. HT9B—MEASURED LOAD (100 Hz)

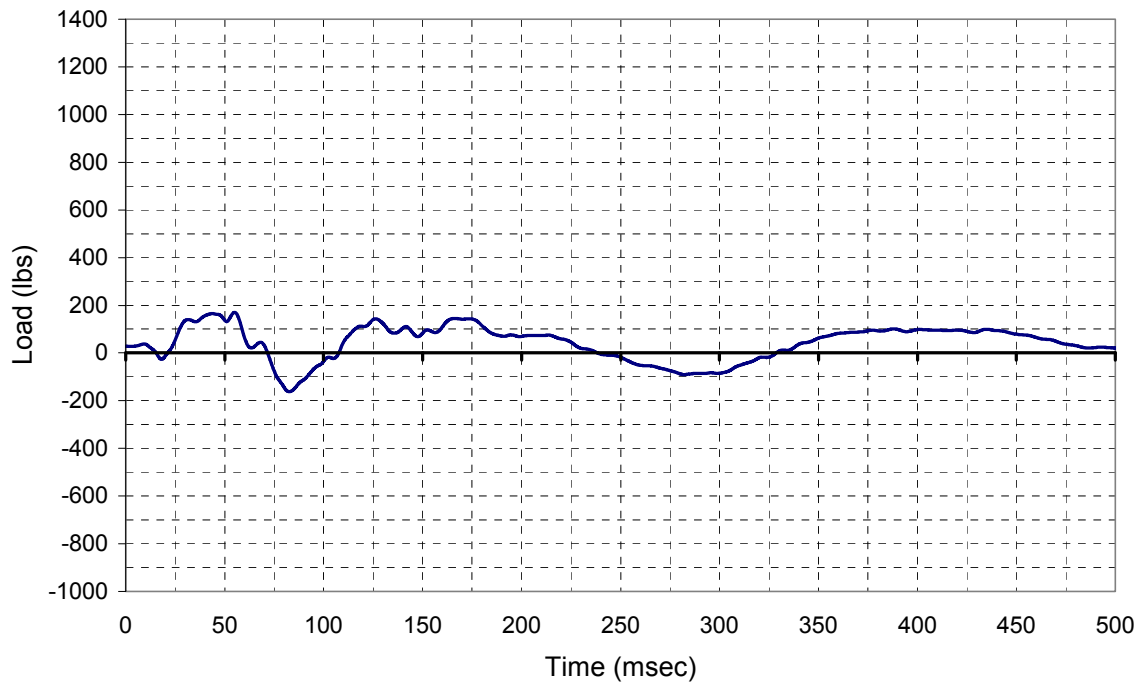


FIGURE B-70. HT10A—MEASURED LOAD (100 Hz)

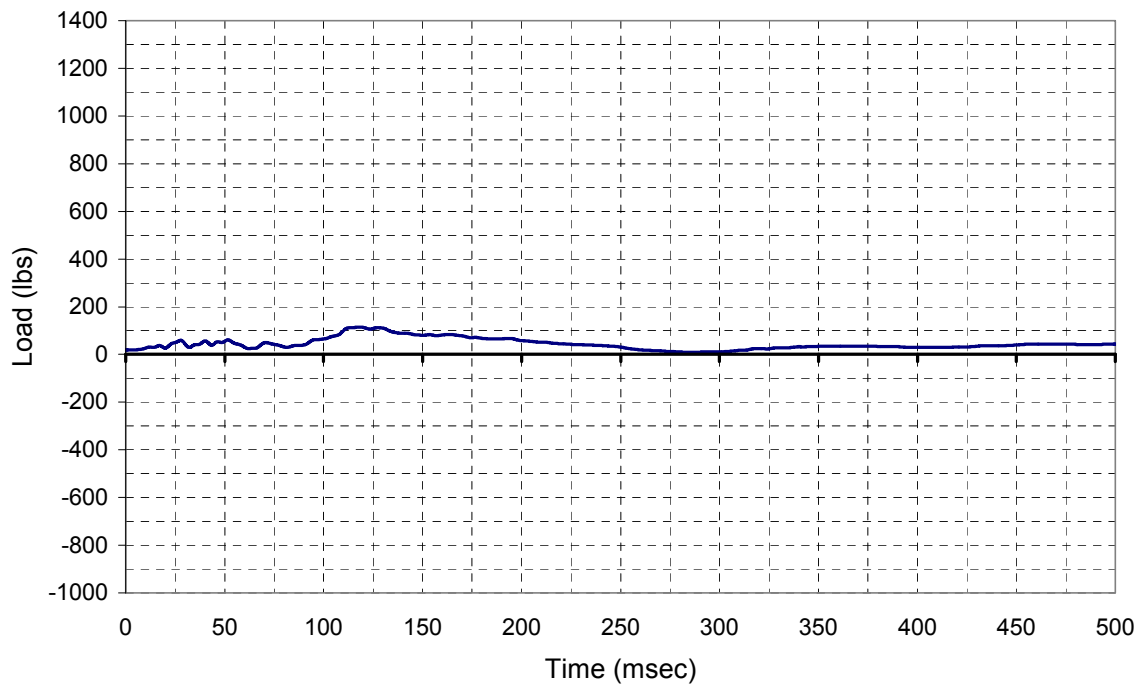


FIGURE B-71. HT10B—MEASURED LOAD (100 Hz)

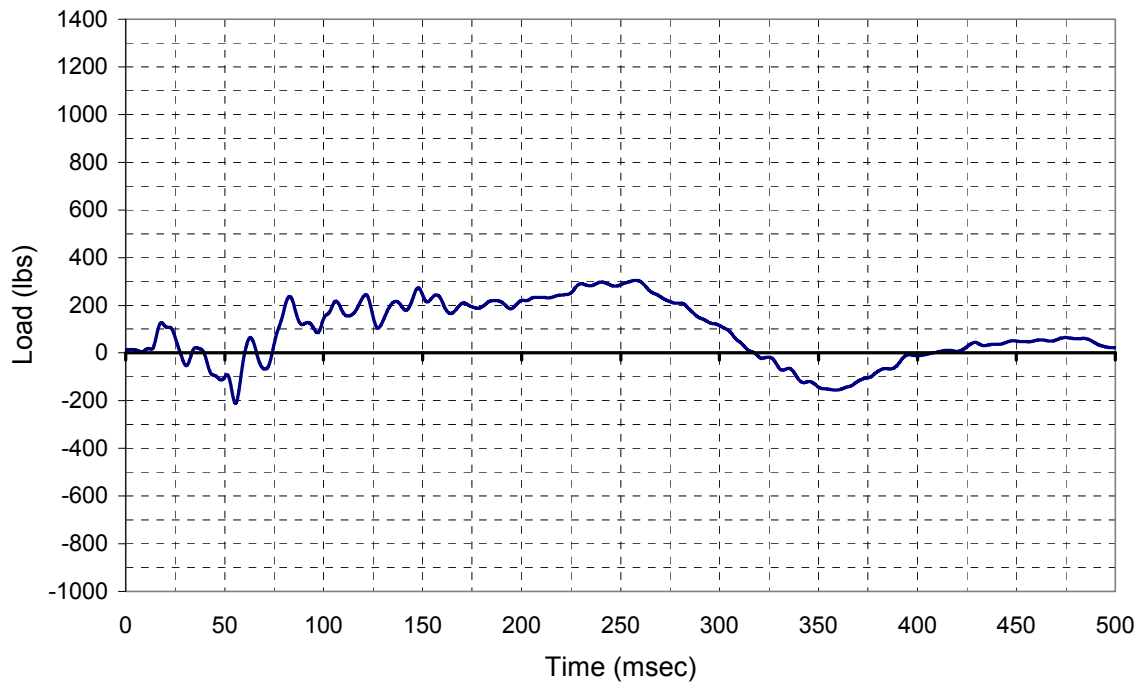


FIGURE B-72. HT10C—MEASURED LOAD (100 Hz)

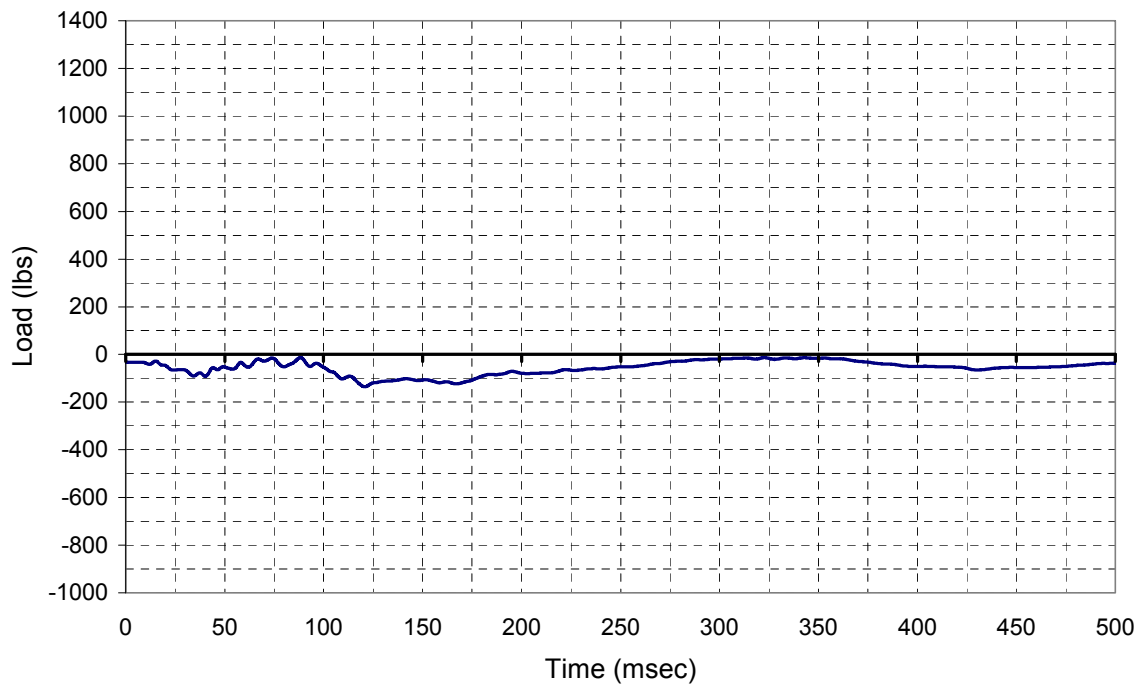


FIGURE B-73. HT11A—MEASURED LOAD (100 Hz)

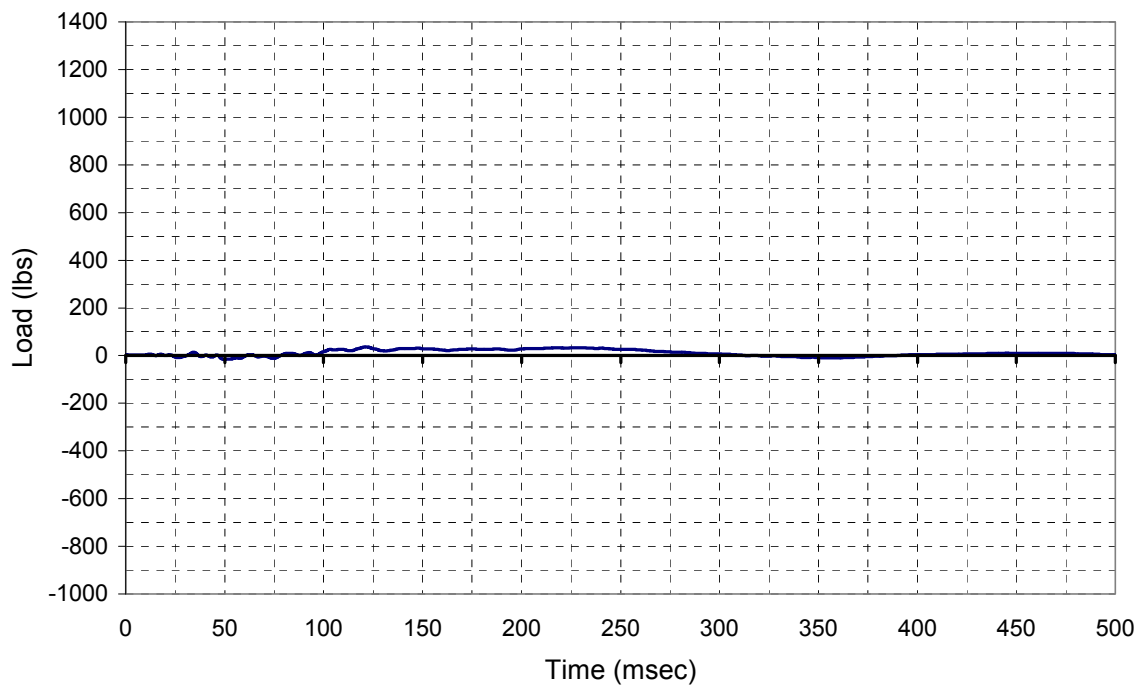


FIGURE B-74. HT11B—MEASURED LOAD (100 Hz)

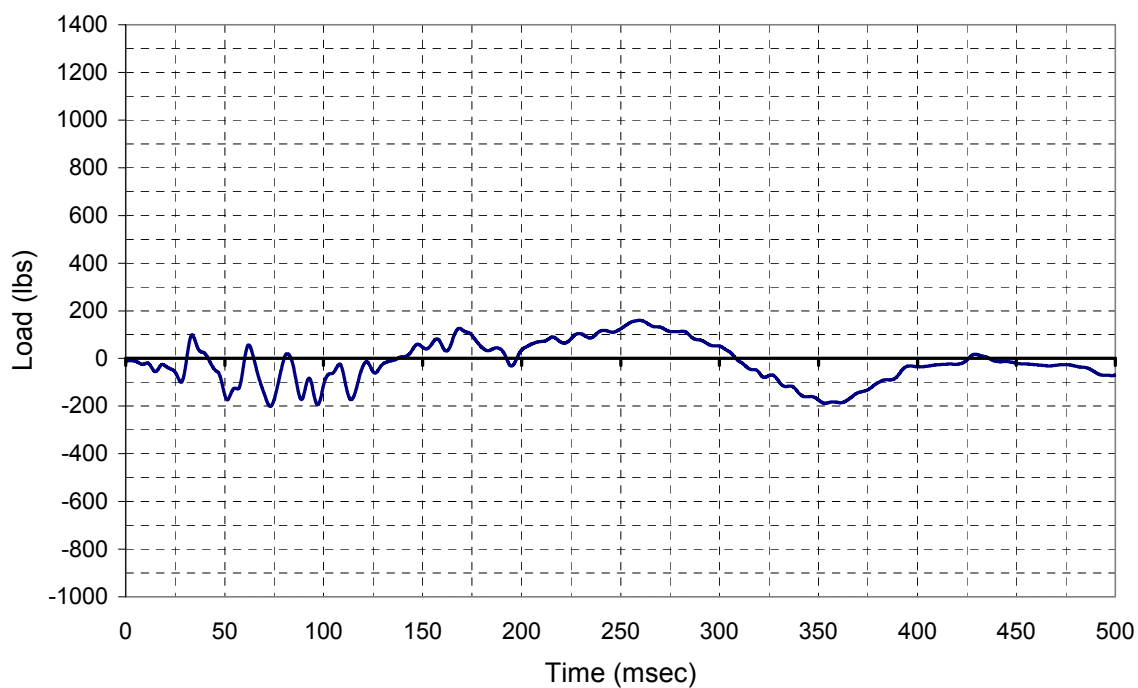


FIGURE B-75. HT11C—MEASURED LOAD (100 Hz)

B.7 HEATH TECNA BIN—VERTICAL VECTOR (Z) COMPONENT LOADS

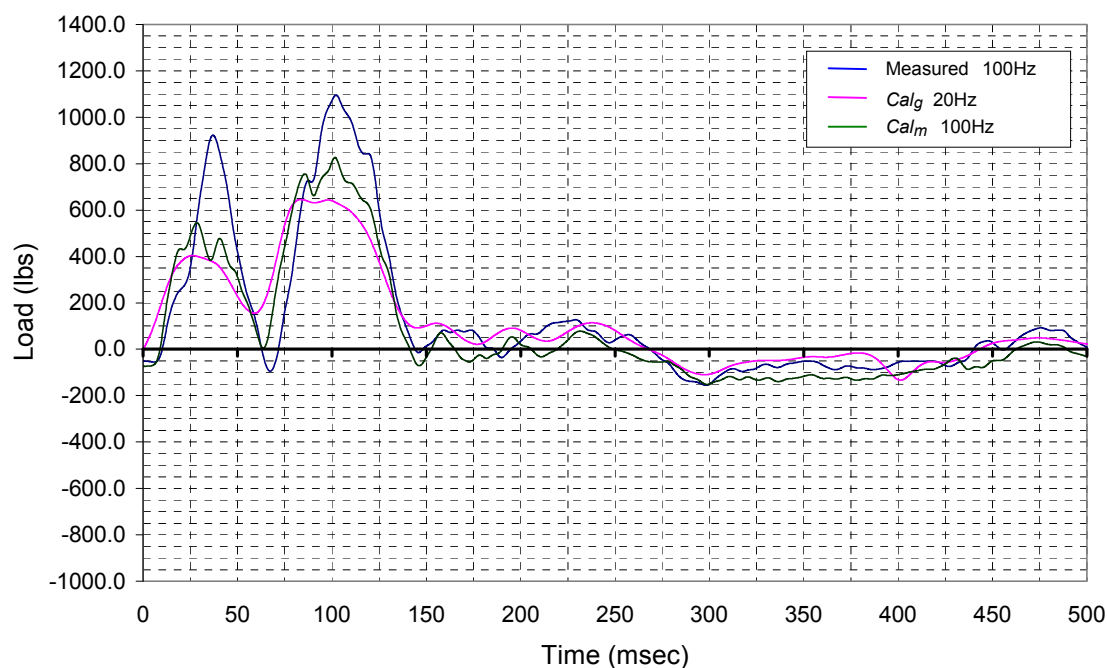


FIGURE B-76. HT1—VERTICAL VECTOR (Z) COMPONENT LOAD

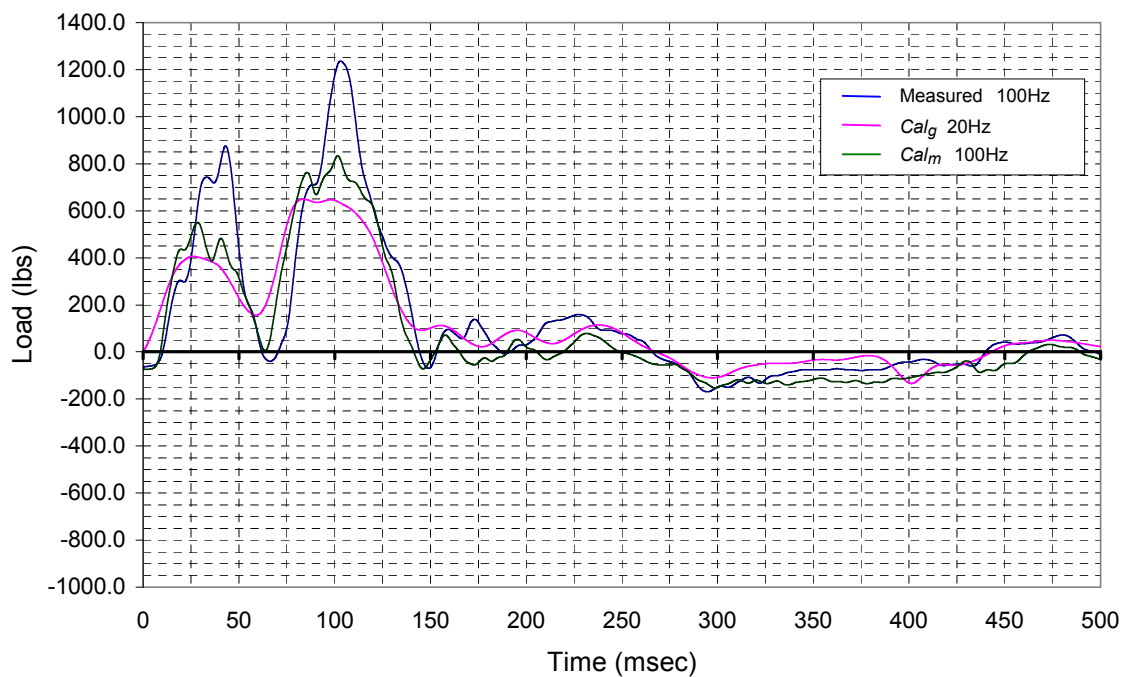


FIGURE B-77. HT3—VERTICAL VECTOR (Z) COMPONENT LOAD

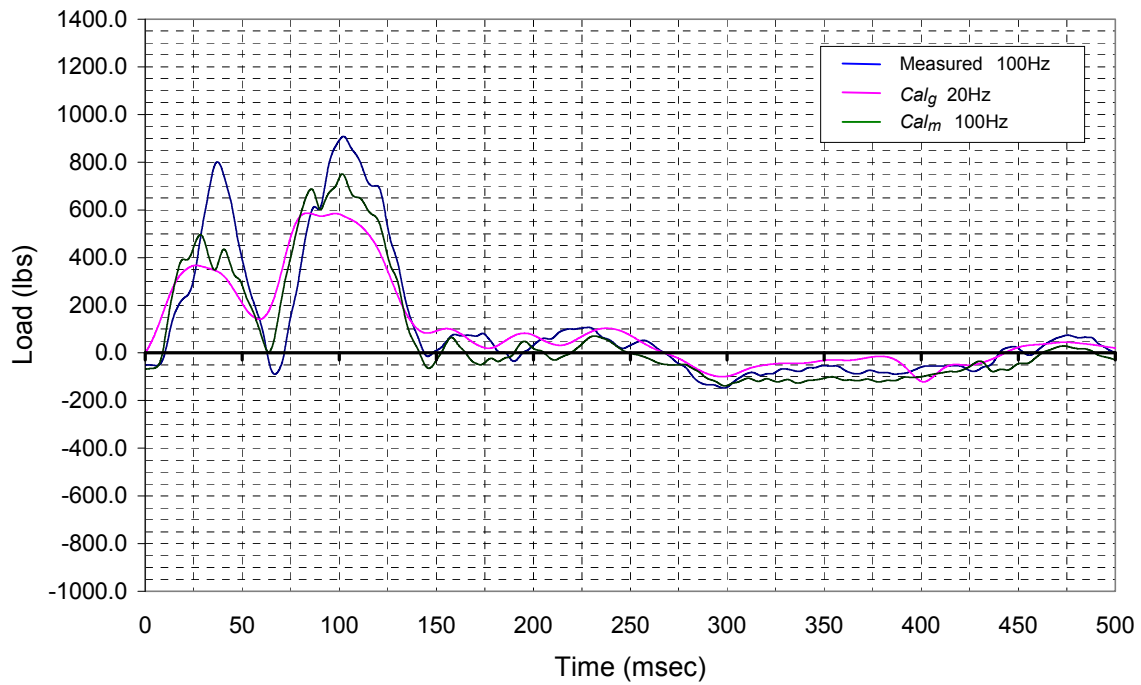


FIGURE B-78. HT2—VERTICAL VECTOR (Z) COMPONENT LOAD

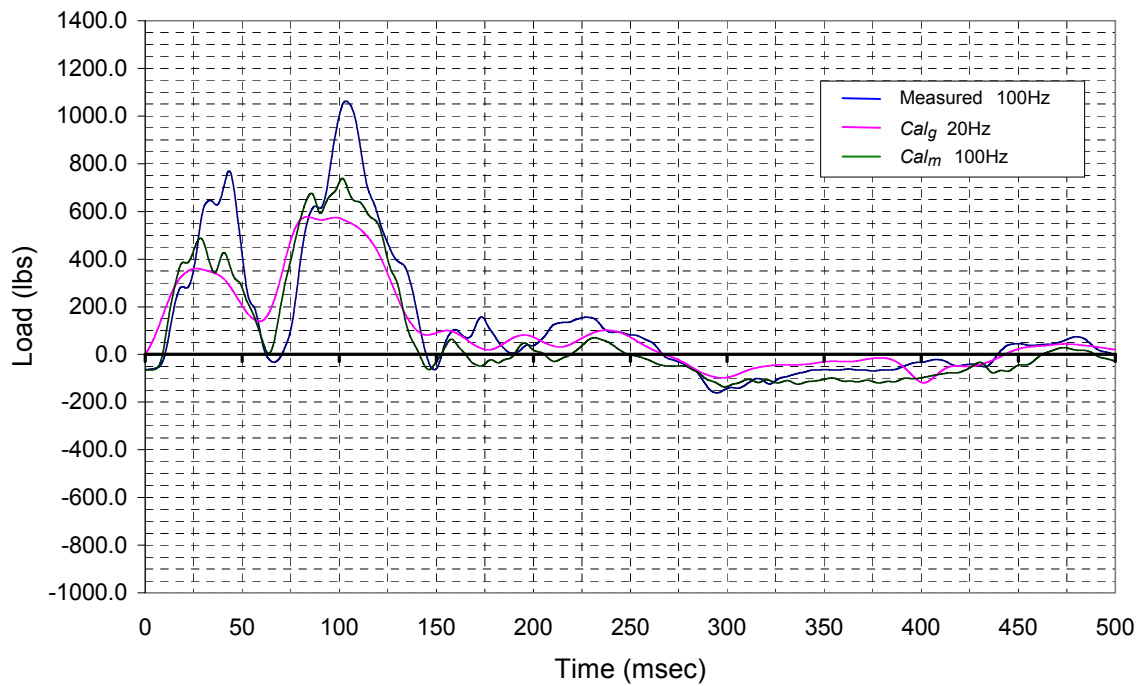


FIGURE B-79. HT4—VERTICAL VECTOR (Z) COMPONENT LOAD

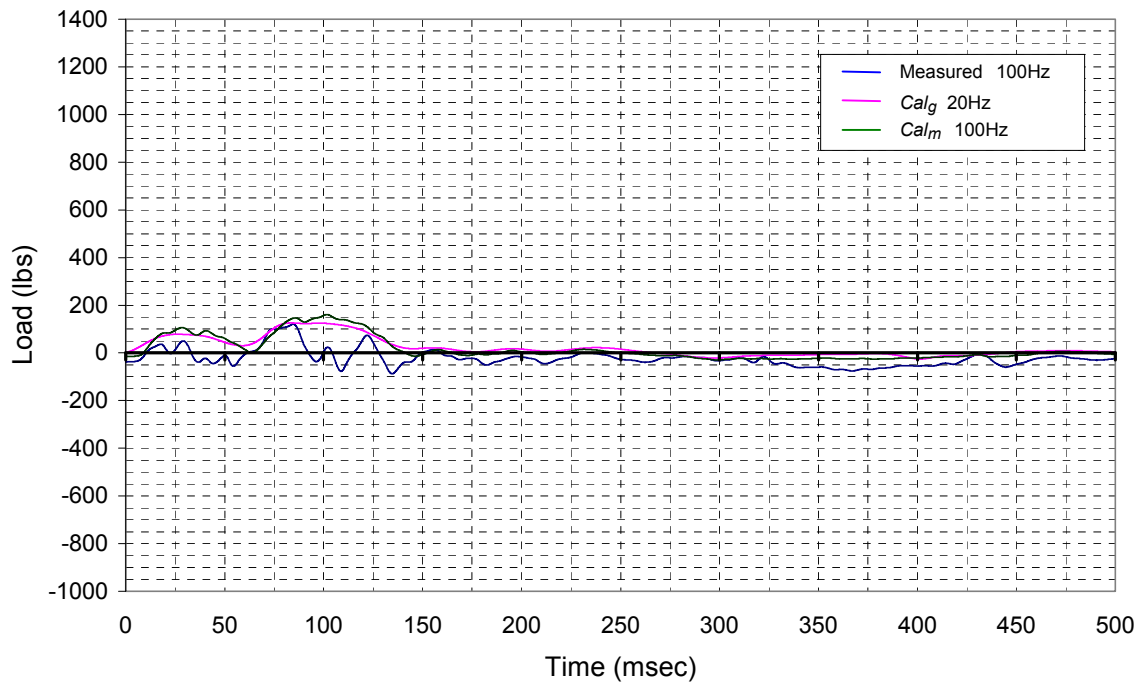


FIGURE B-80. HT5A—VERTICAL VECTOR (Z) COMPONENT LOAD

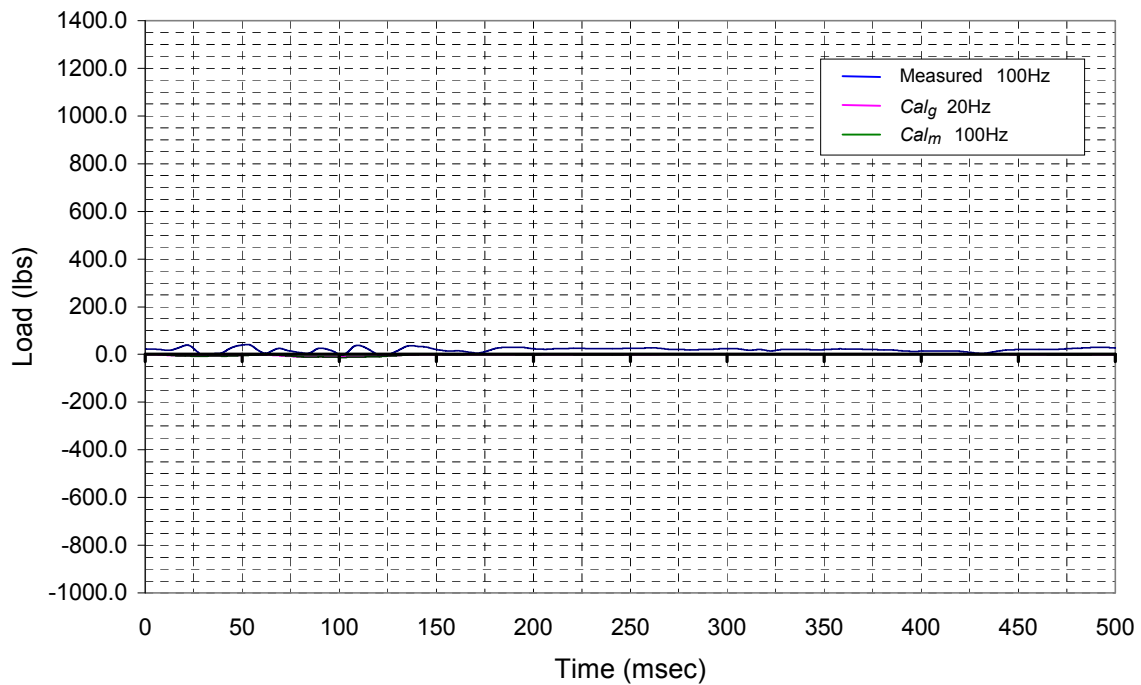


FIGURE B-81. HT5B—VERTICAL VECTOR (Z) COMPONENT LOAD

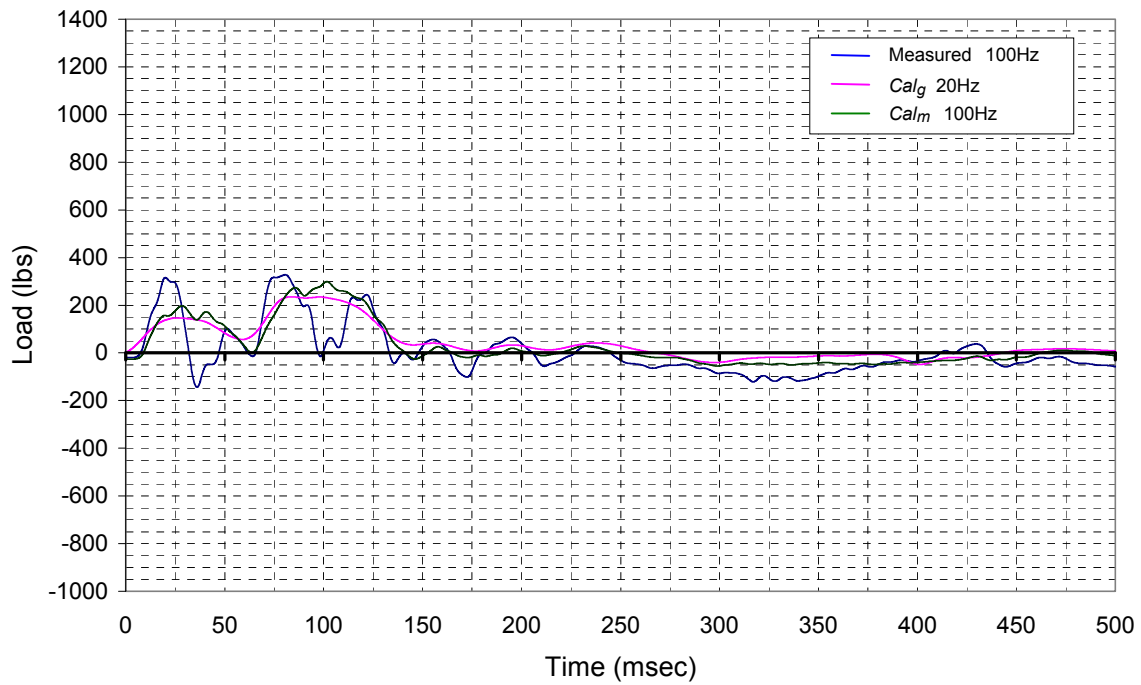


FIGURE B-82. HT6A—VERTICAL VECTOR (Z) COMPONENT LOAD

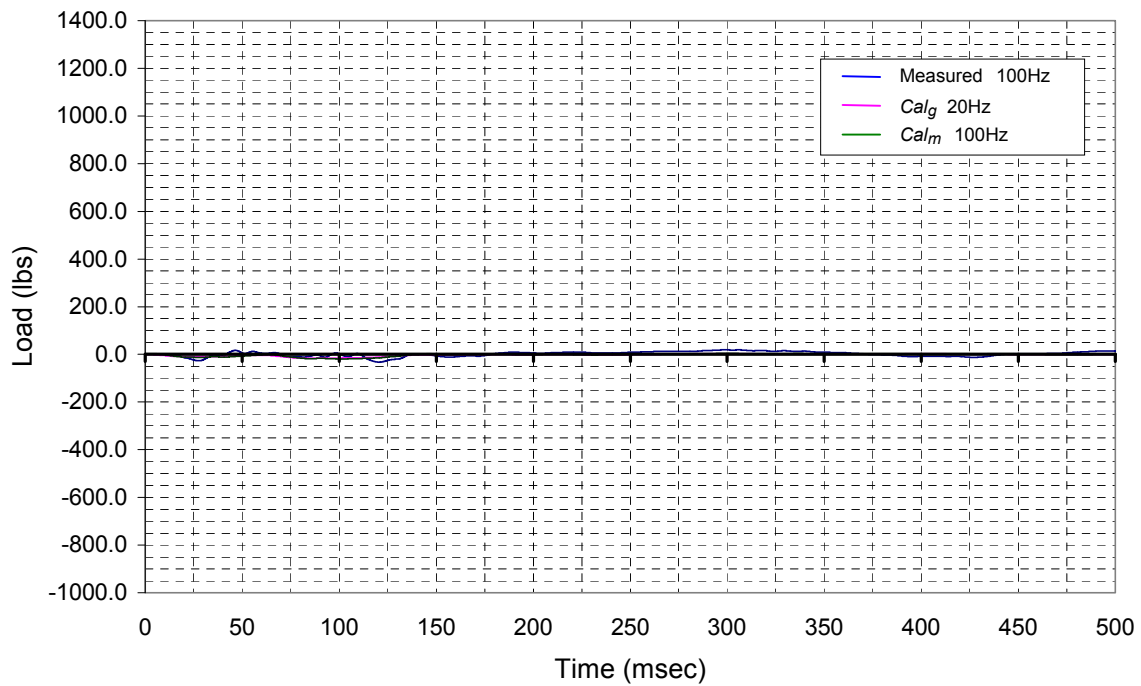


FIGURE B-83. HT6B—VERTICAL VECTOR (Z) COMPONENT LOAD

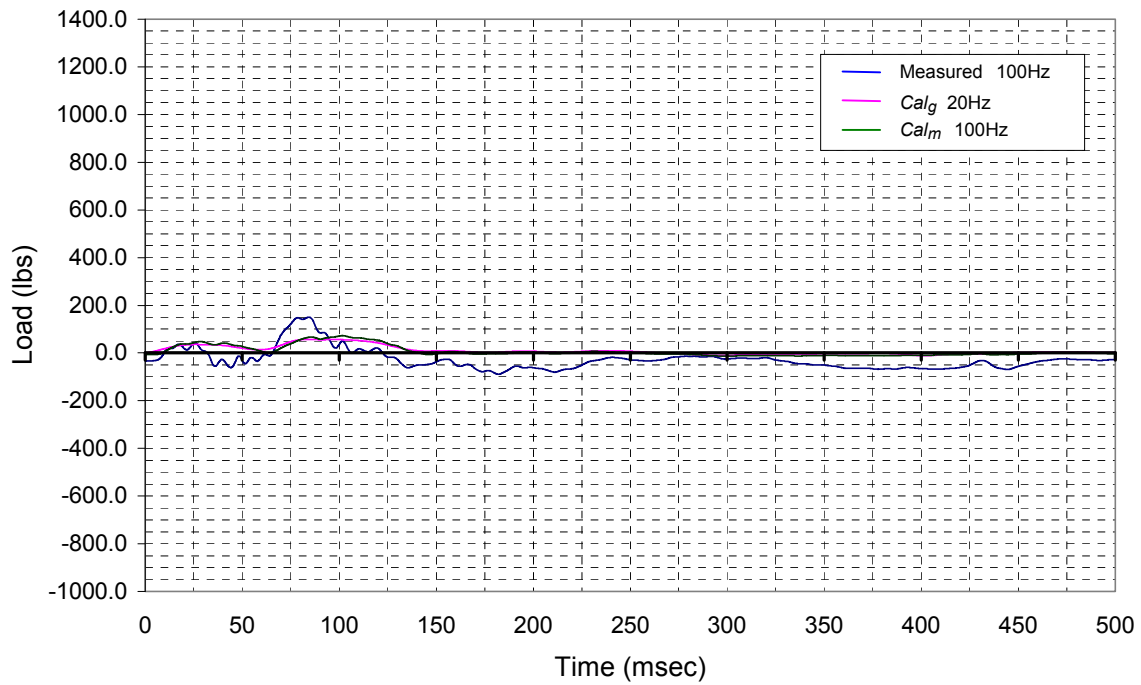


FIGURE B-84. HT7A—VERTICAL VECTOR (Z) COMPONENT LOAD

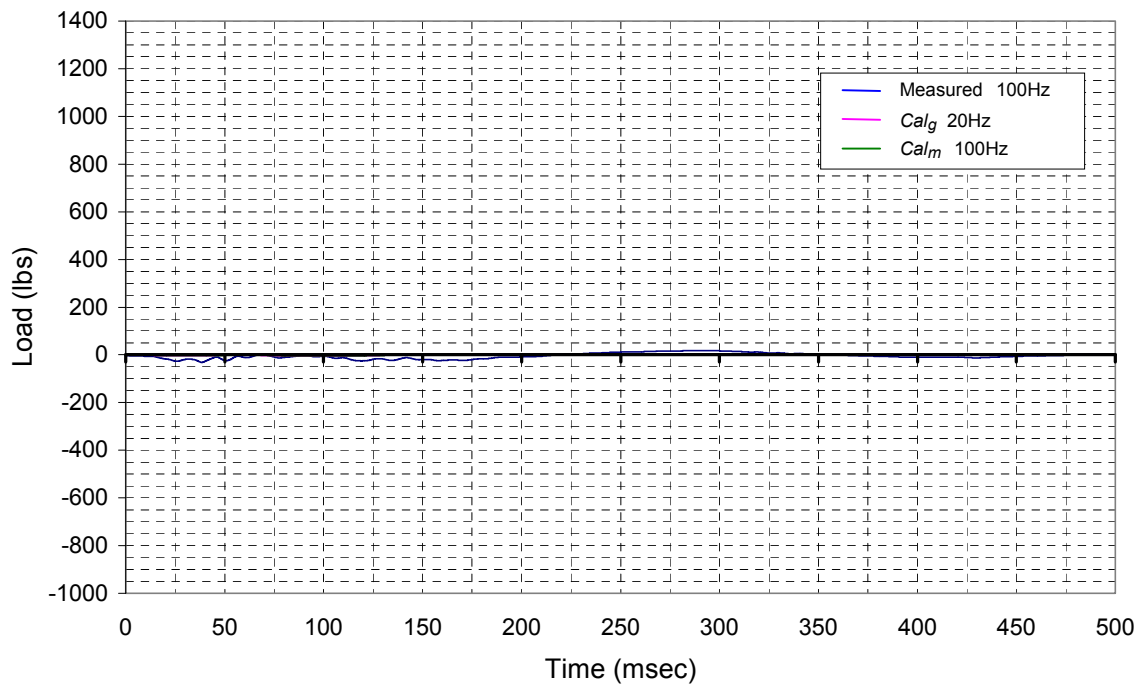


FIGURE B-85. HT7B—VERTICAL VECTOR (Z) COMPONENT LOAD

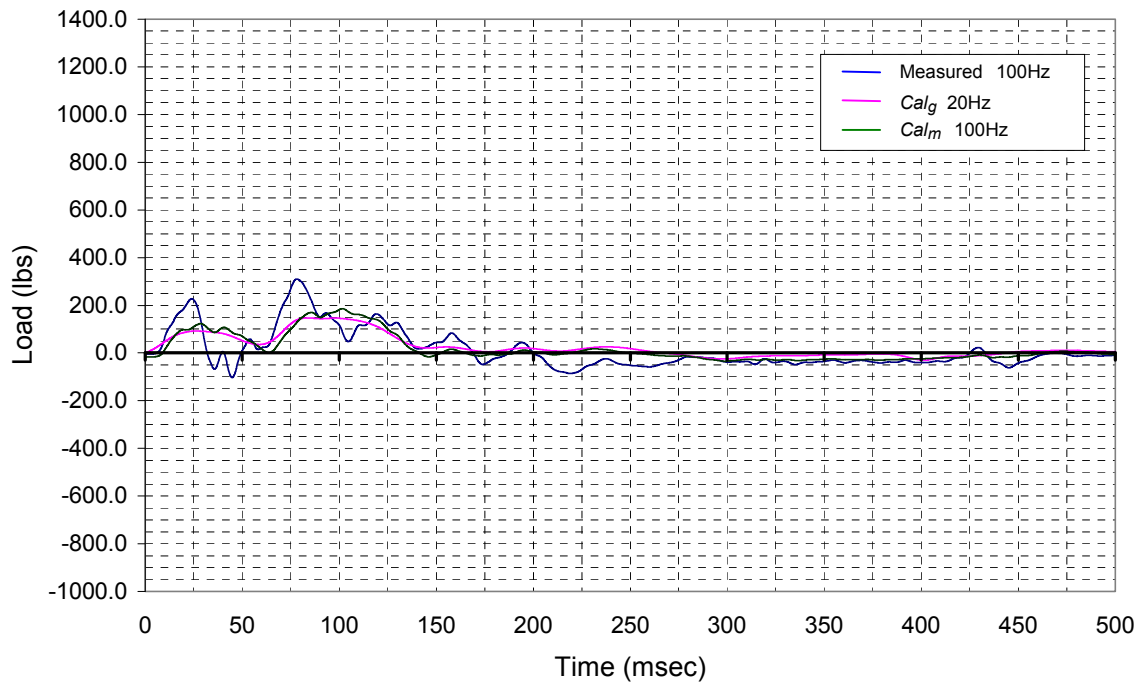


FIGURE B-86. HT8A—VERTICAL VECTOR (Z) COMPONENT LOAD

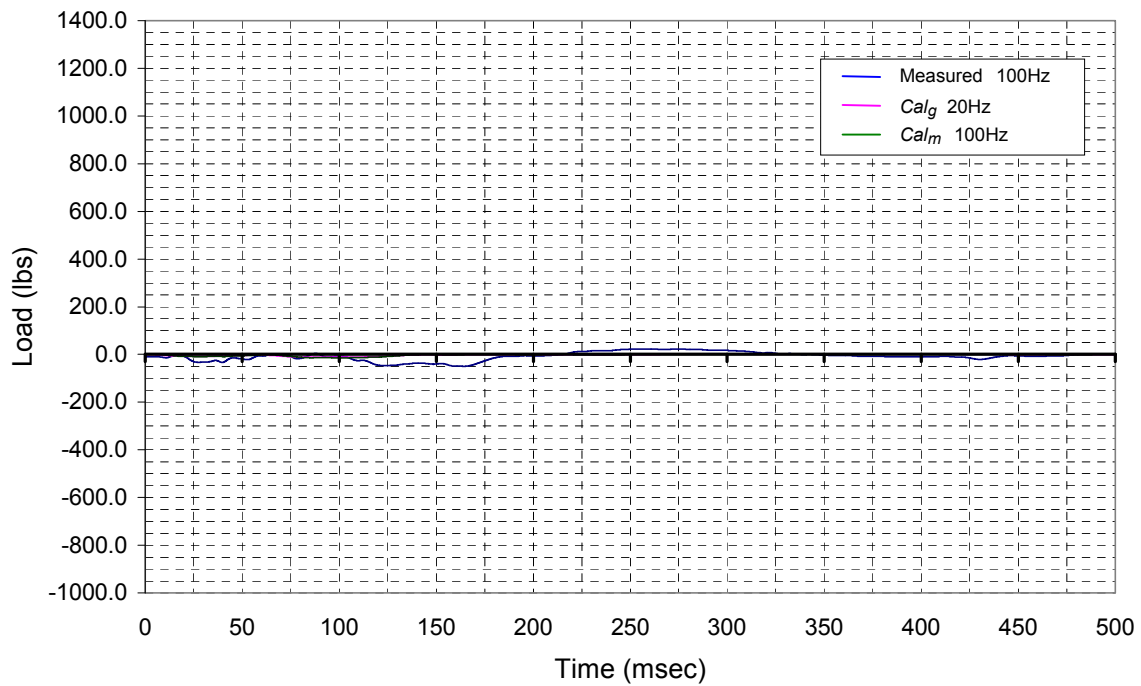


FIGURE B-87. HT8B—VERTICAL VECTOR (Z) COMPONENT LOAD

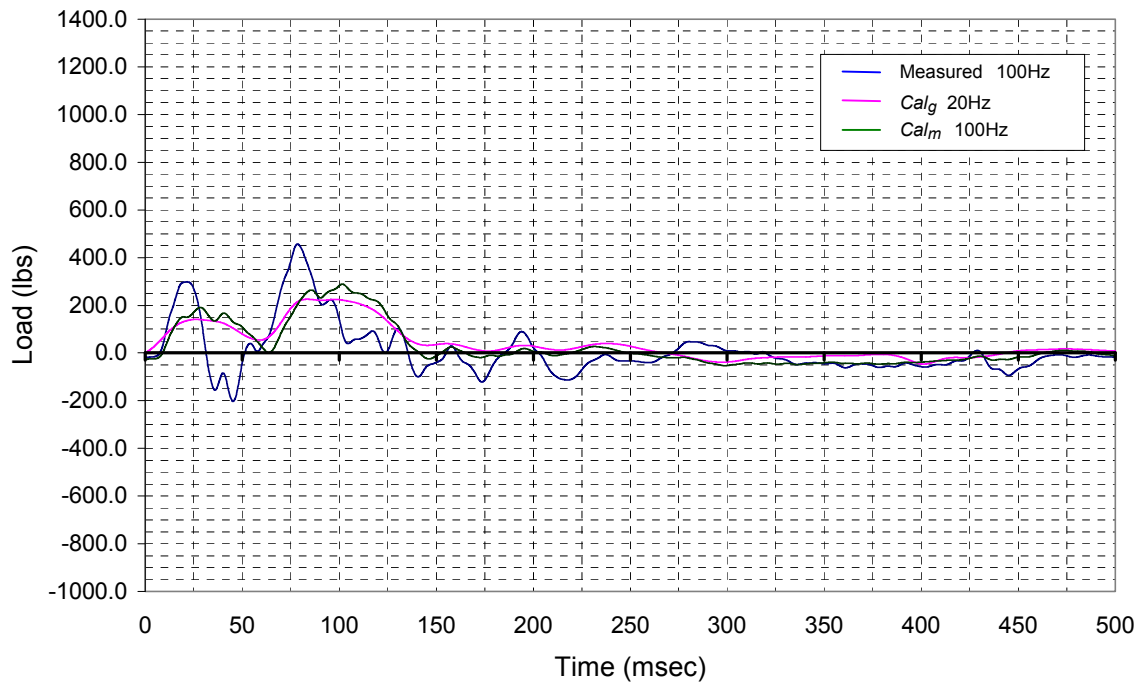


FIGURE B-88. HT9A—VERTICAL VECTOR (Z) COMPONENT LOAD

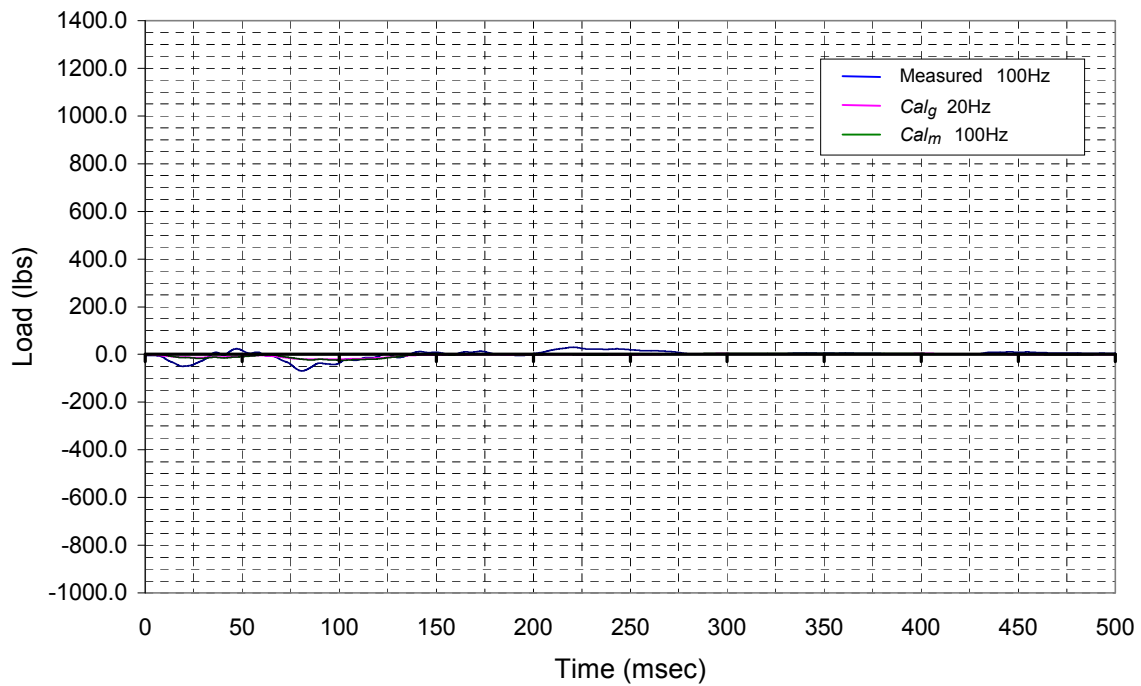


FIGURE B-89. HT9B—VERTICAL VECTOR (Z) COMPONENT LOAD

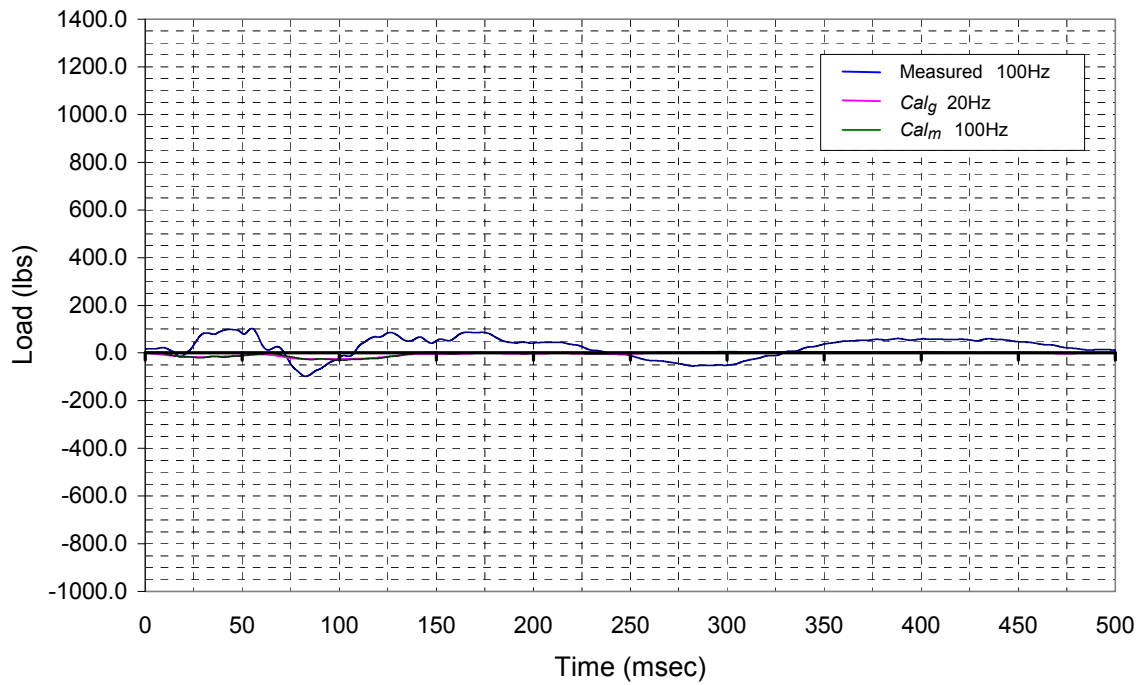


FIGURE B-90. HT10A—VERTICAL VECTOR (Z) COMPONENT LOAD

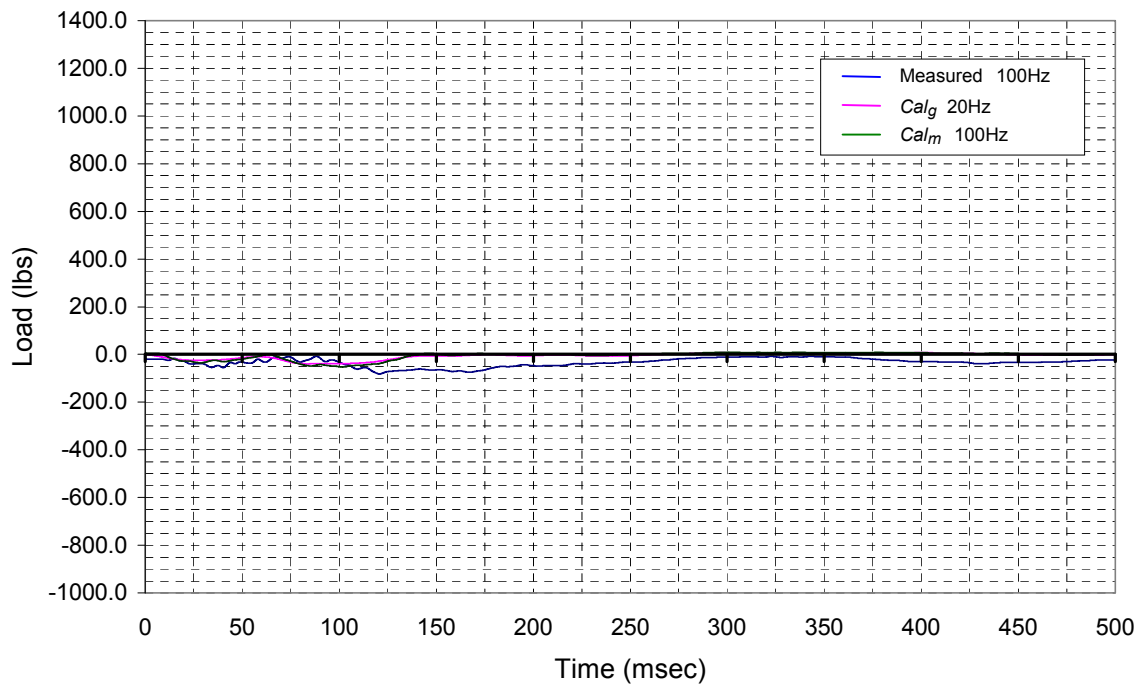


FIGURE B-91. HT11A—VERTICAL VECTOR (Z) COMPONENT LOAD

B.8 HEATH TECNA BIN—ACCELEROMETER DATA

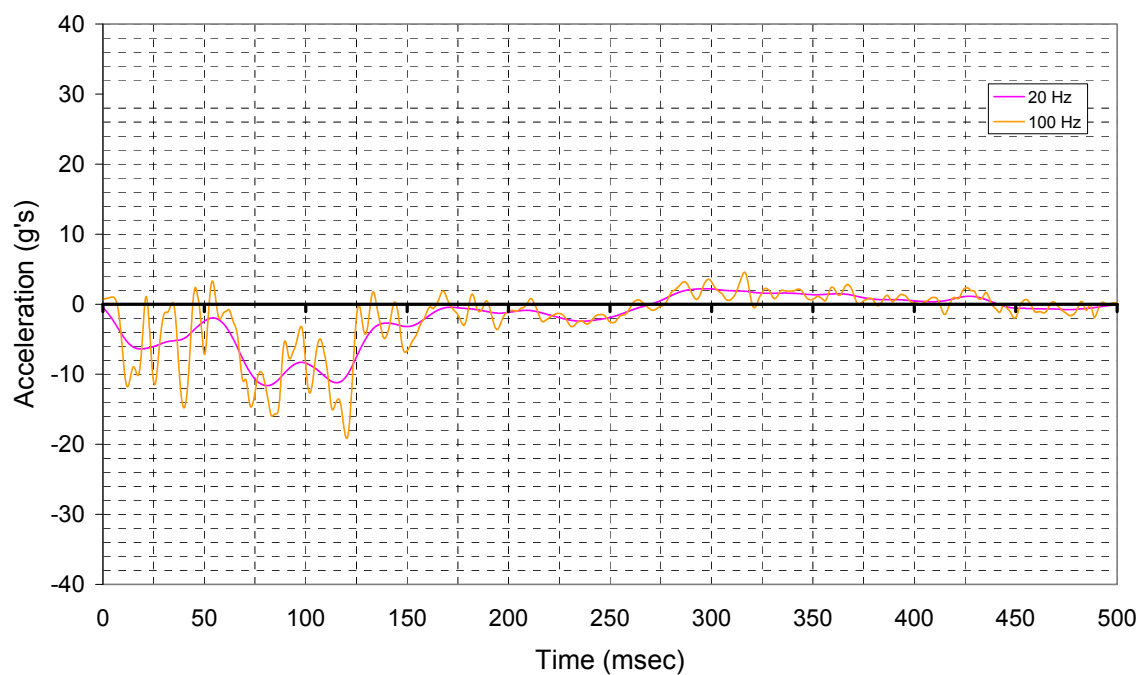


FIGURE B-92. HT BIN ACCEL (1)—FORWARD LOCATION, Z DIRECTION

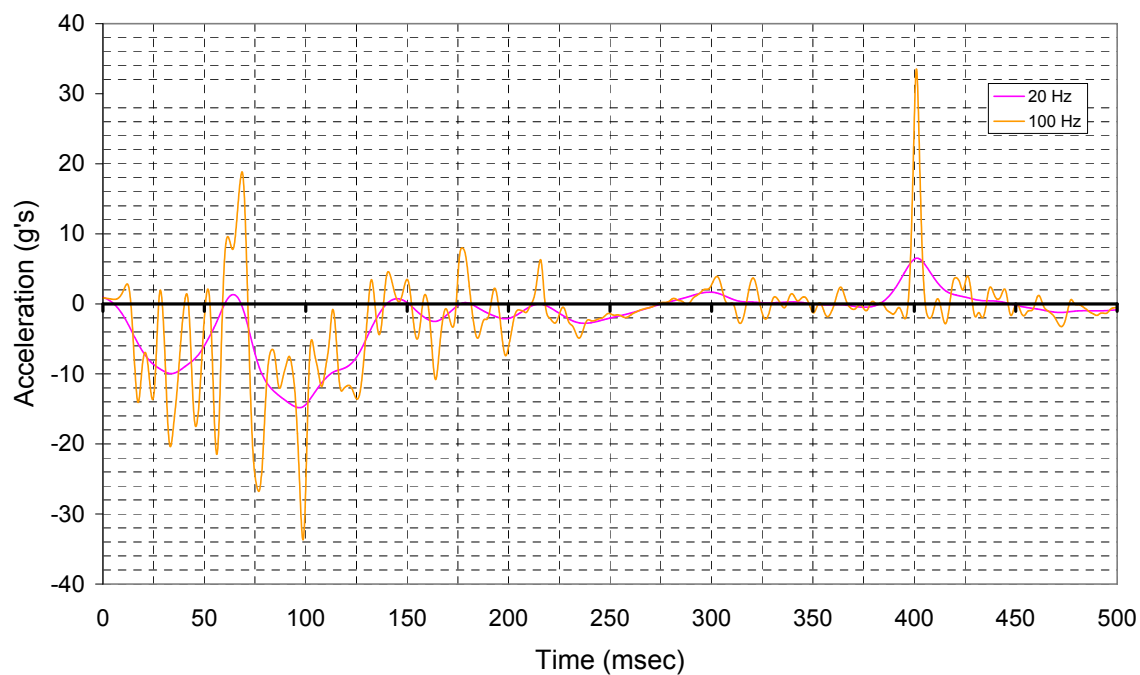


FIGURE B-93. HT BIN ACCEL (4)—CENTER LOCATION, Z DIRECTION

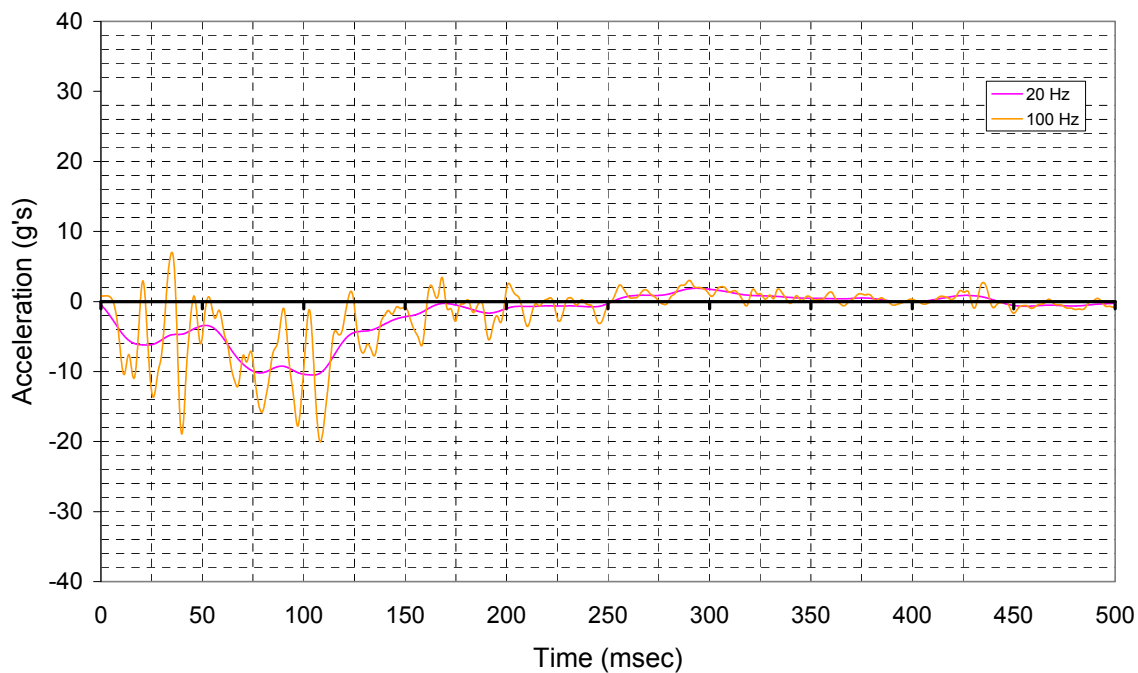


FIGURE B-94. HT BIN ACCEL (5)—AFT LOCATION, Z DIRECTION

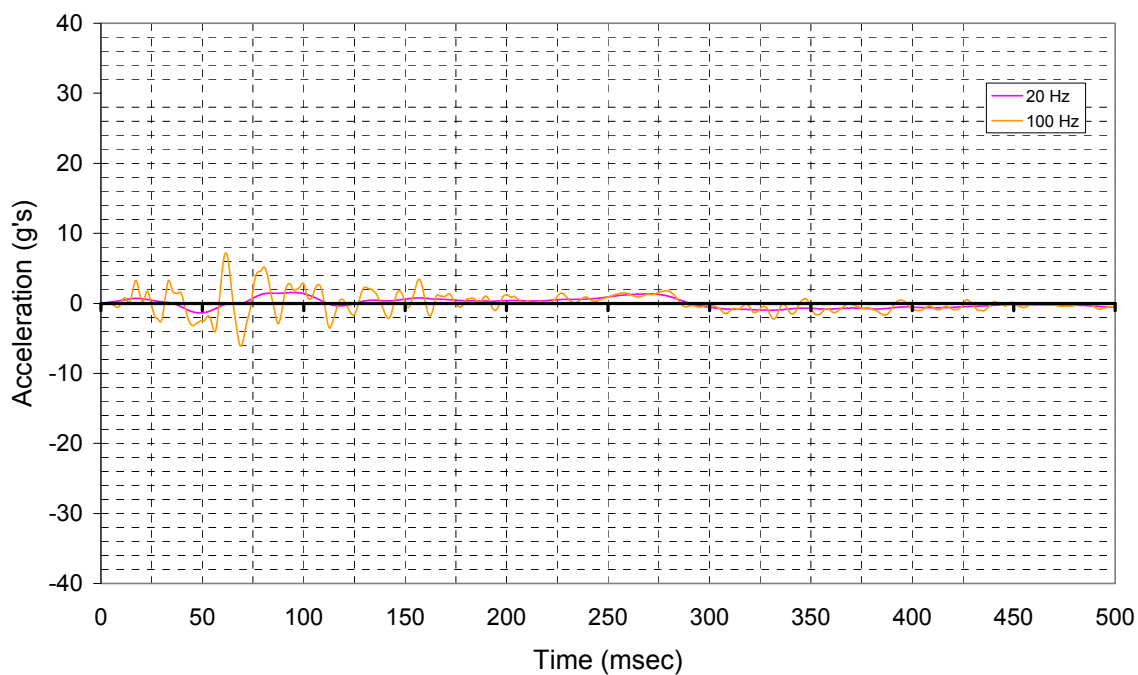


FIGURE B-95. HT BIN ACCEL (2)—CENTER LOCATION, X DIRECTION

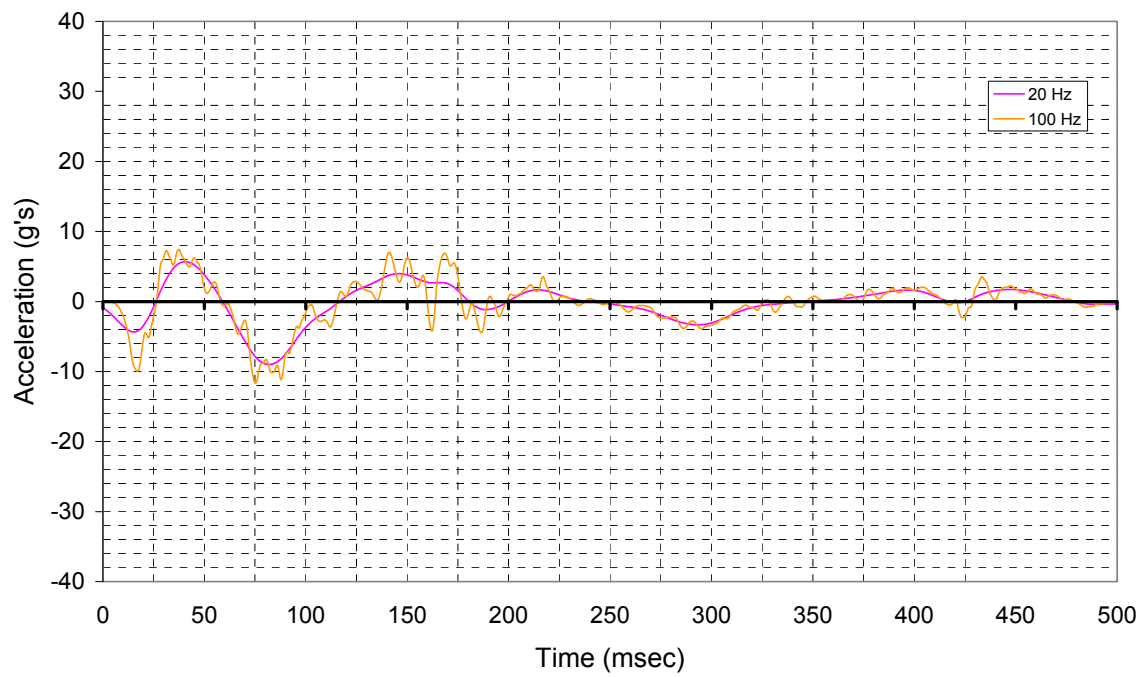


FIGURE B-96. HT BIN ACCEL (3)—CENTER LOCATION, Y DIRECTION

B.9 ANTHROPOMORPHIC TEST DUMMY DATA

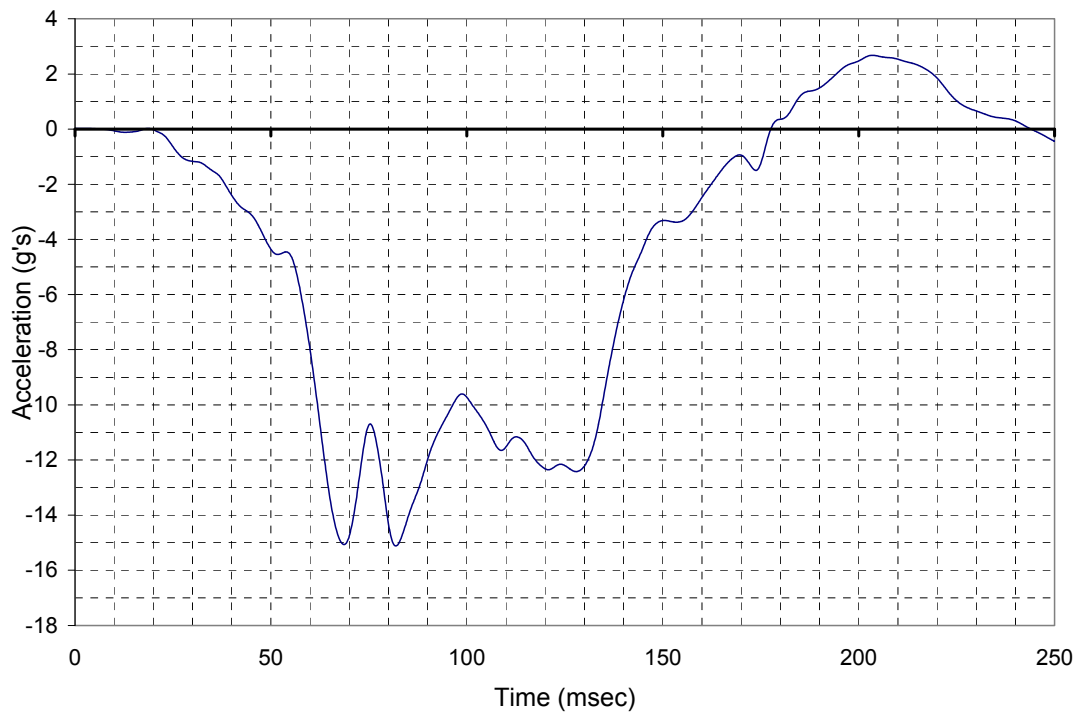


FIGURE B-97. FS 406 ATD NO. 1, ACCELEROMETER, ROW 1 SEAT B (100 Hz)

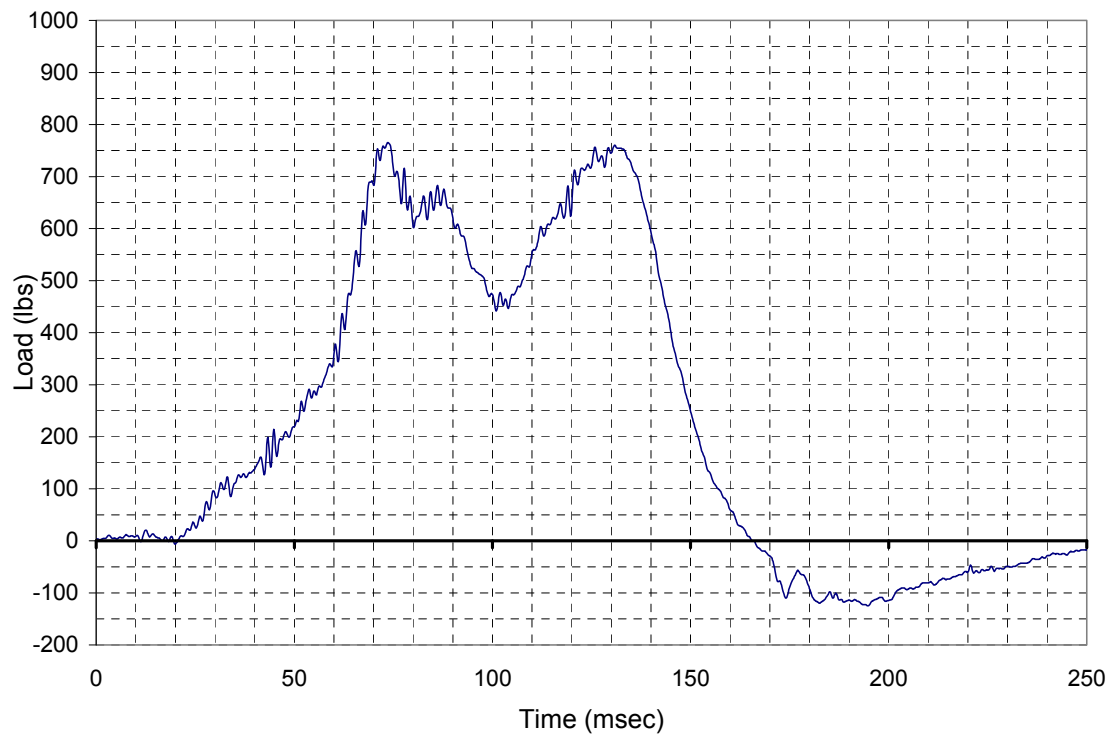


FIGURE B-98. FS 406 ATD NO. 1, LOAD CELL, ROW 1 SEAT B (1000 Hz)

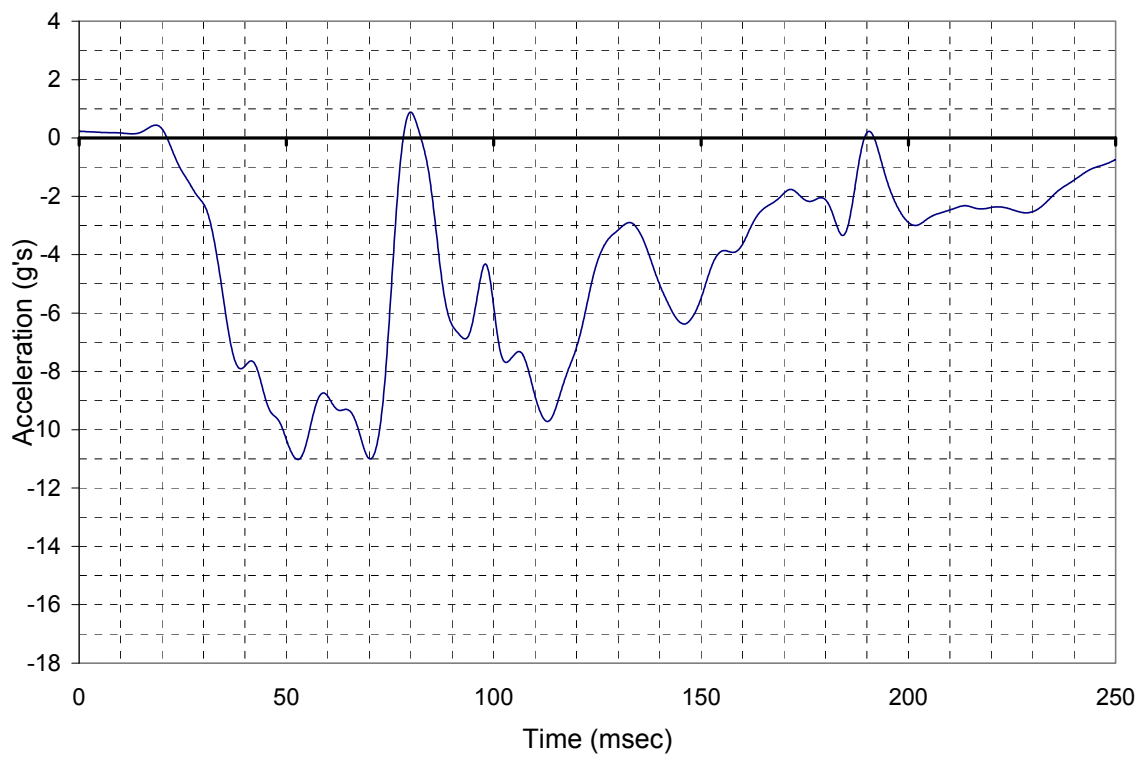


FIGURE B-99. FS 406 ATD NO. 2, ACCELEROMETER, ROW 1 SEAT E (100 Hz)

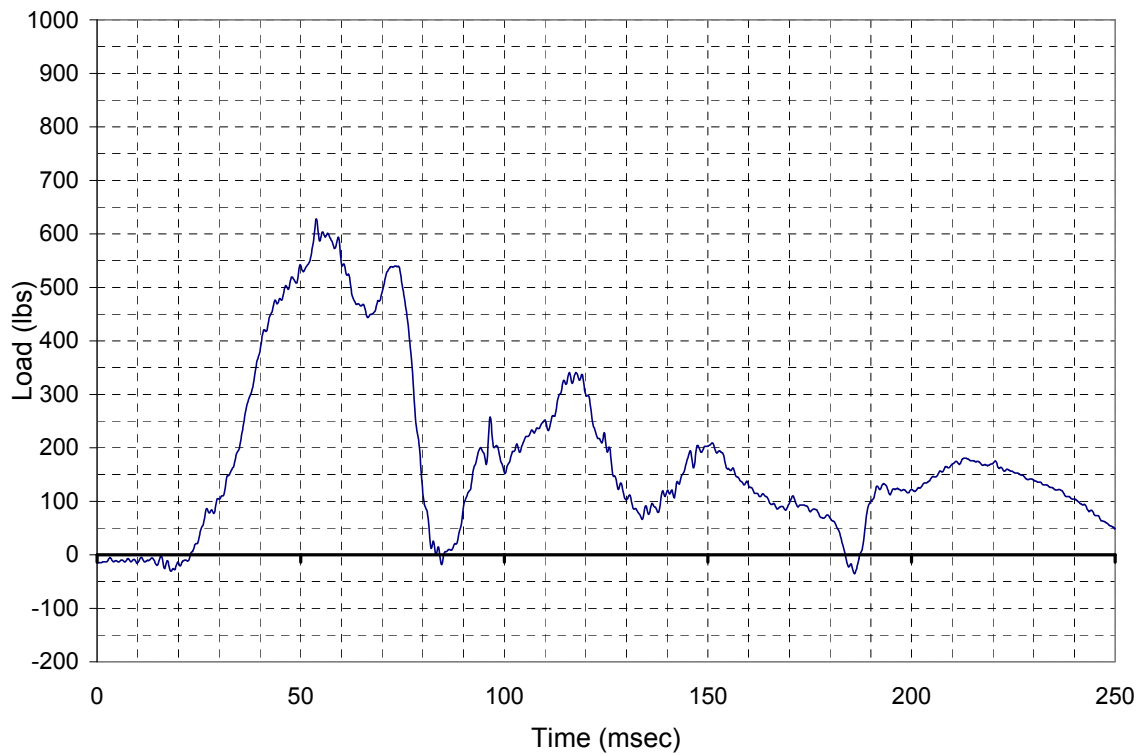


FIGURE B-100. FS 406 ATD NO. 2, LOAD CELL, ROW 1 SEAT E (1000 Hz)

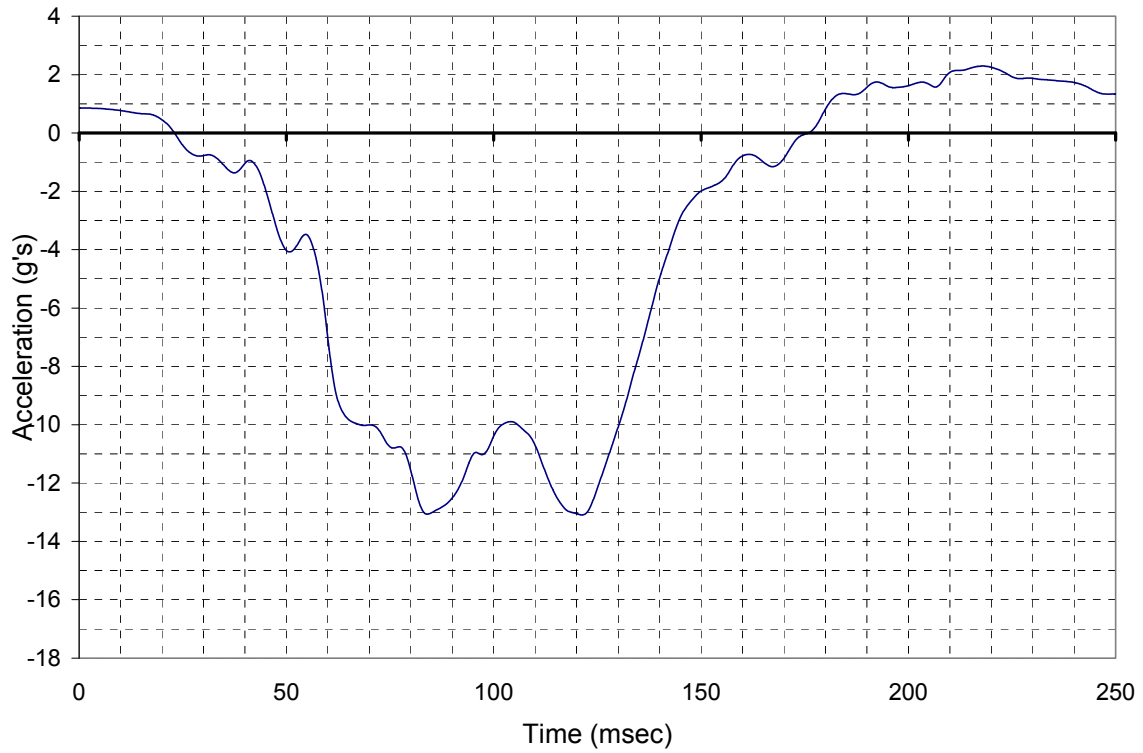


FIGURE B-101. FS 442 ATD NO. 3, ACCELEROMETER, ROW 2 SEAT B (100 Hz)

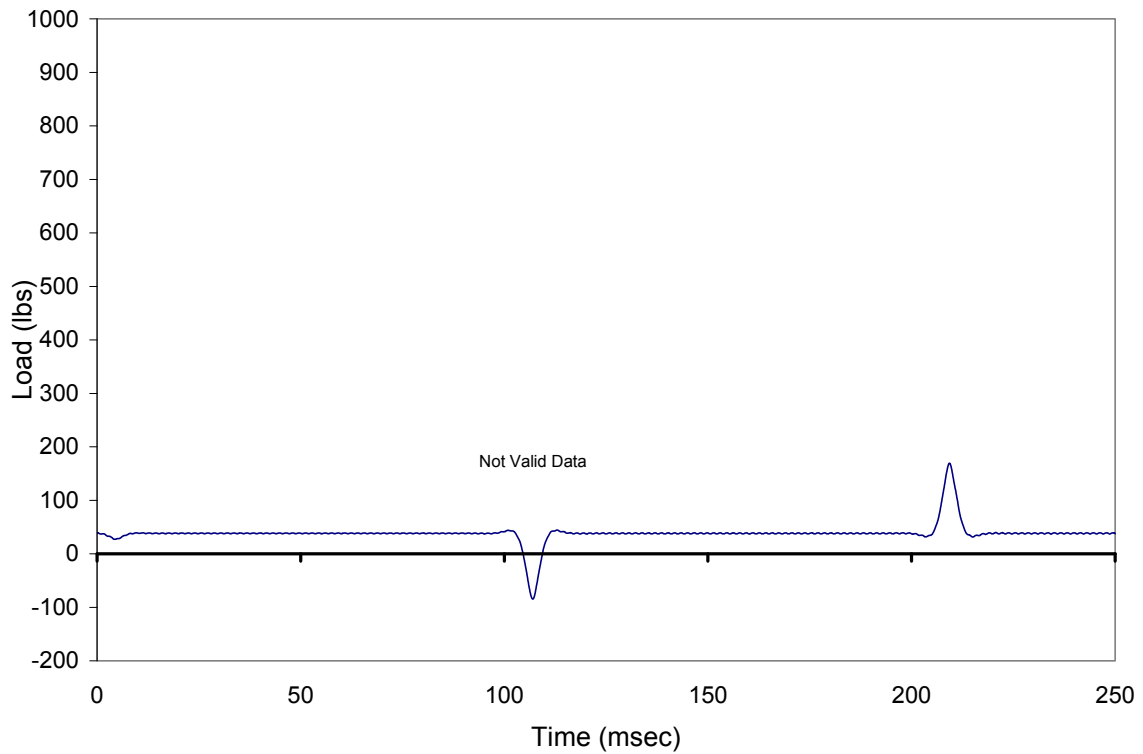


FIGURE B-102. FS 442 ATD NO. 3, LOAD CELL, ROW 2 SEAT B (1000 Hz)

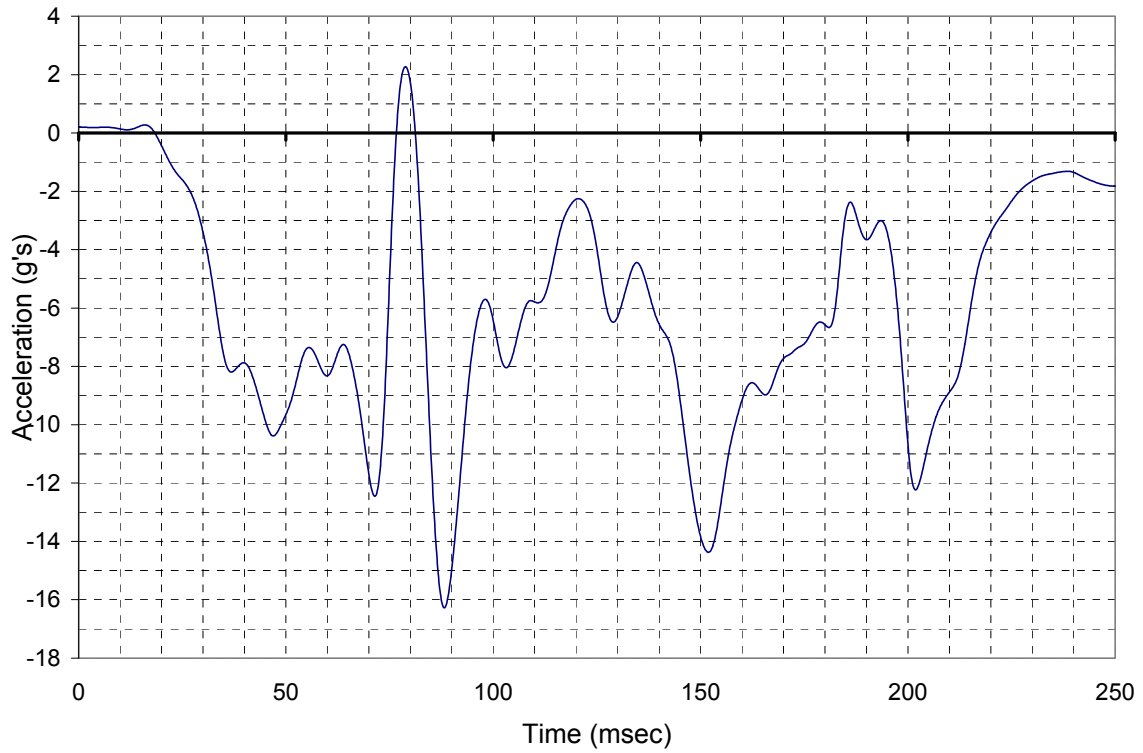


FIGURE B-103. FS 442 ATD NO. 4, ACCELEROMETER, ROW 2 SEAT E (100 Hz)

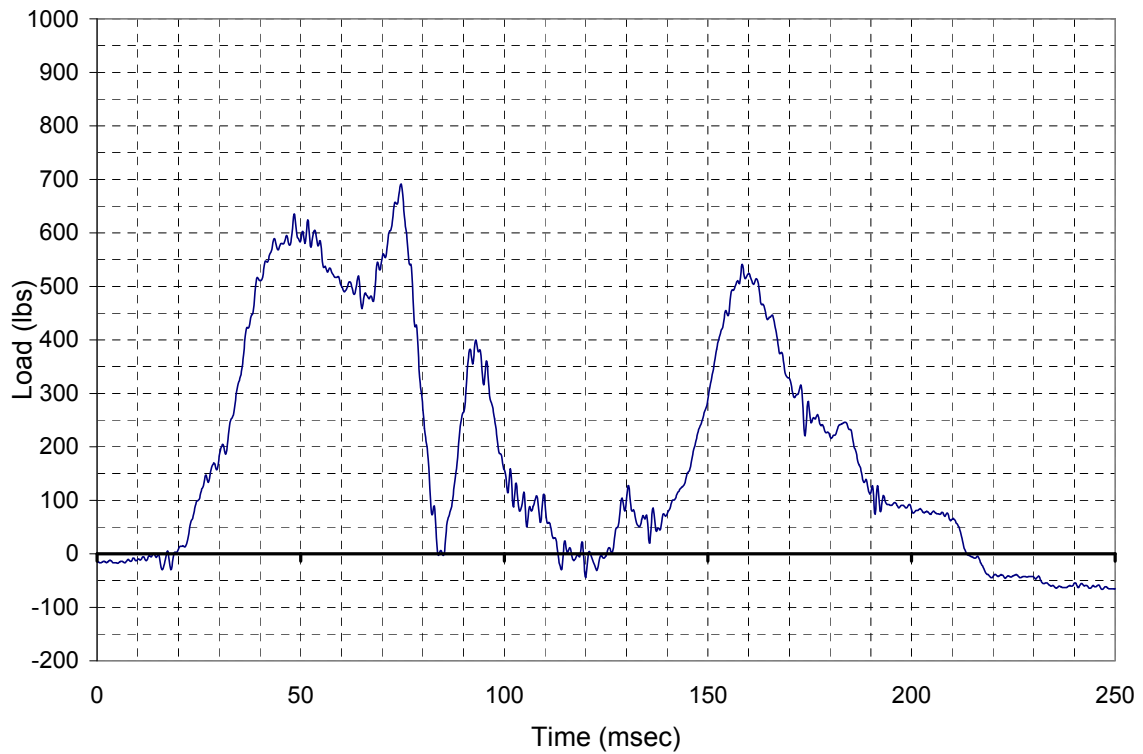


FIGURE B-104. FS 442 ATD NO. 4, LOAD CELL, ROW 2 SEAT E (1000 Hz)

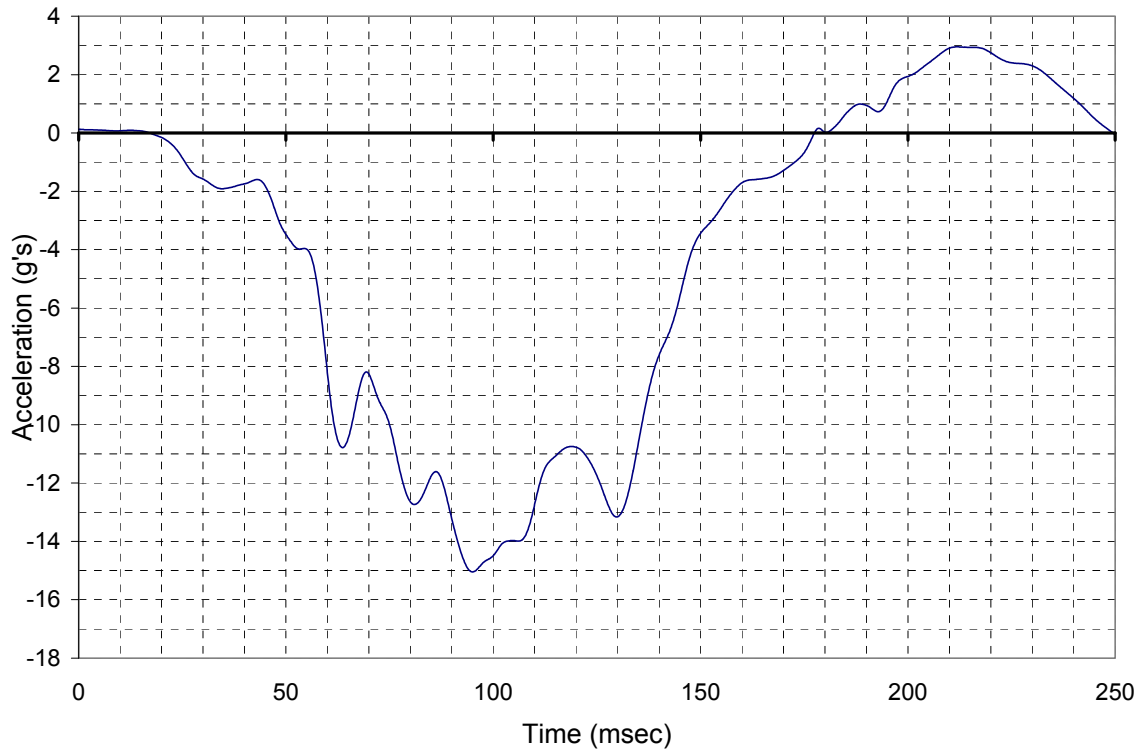


FIGURE B-105. FS 478 ATD NO. 5, ACCELEROMETER, ROW 3 SEAT B (100 Hz)

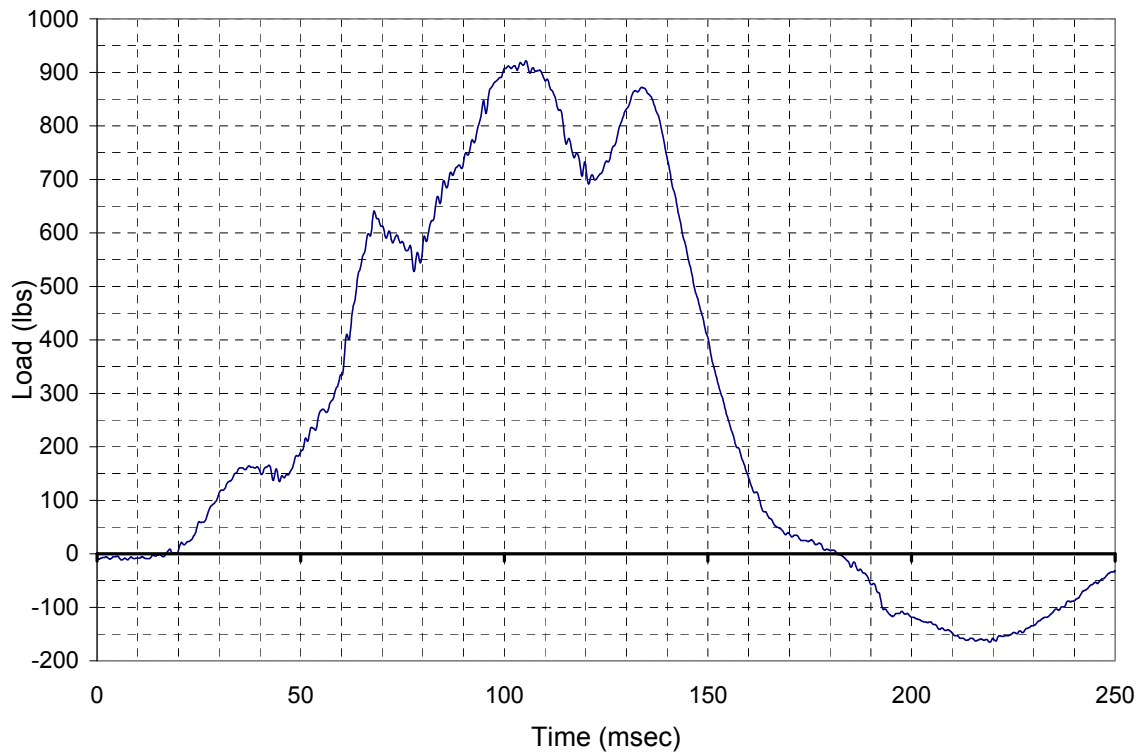


FIGURE B-106. FS 478 ATD NO. 5, LOAD CELL, ROW 3 SEAT B (1000 Hz)

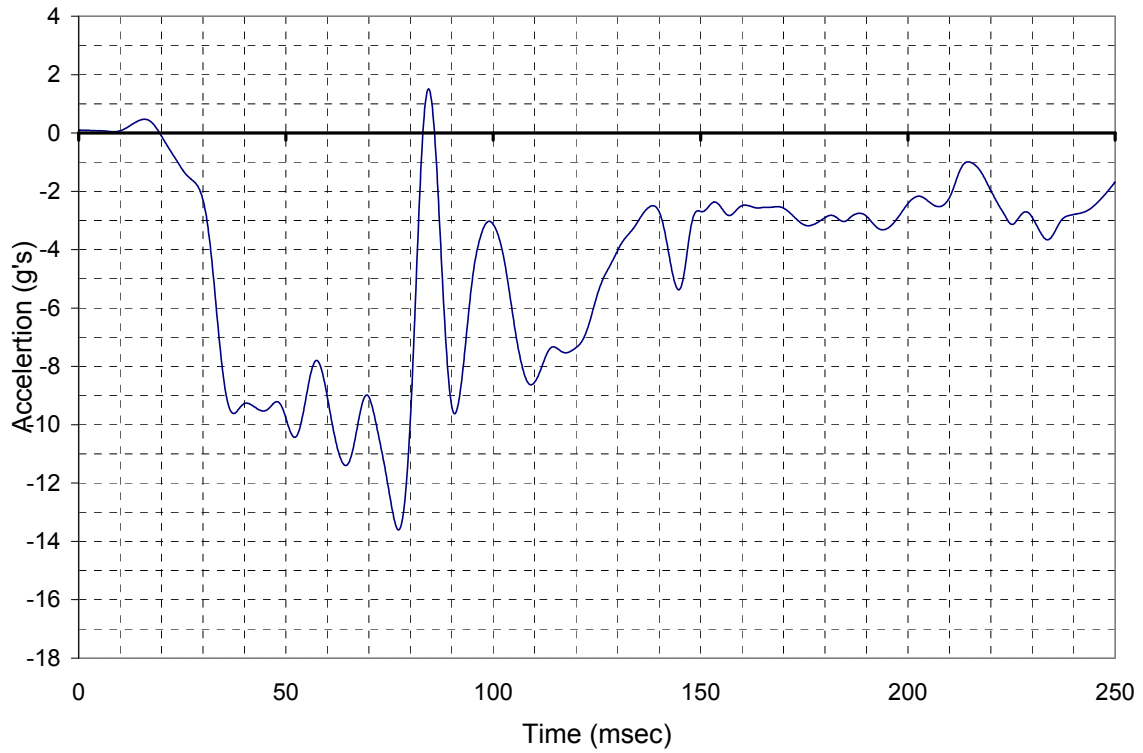


FIGURE B-107. FS 442 ATD NO. 6, ACCELEROMETER, ROW 3 SEAT E (100 Hz)

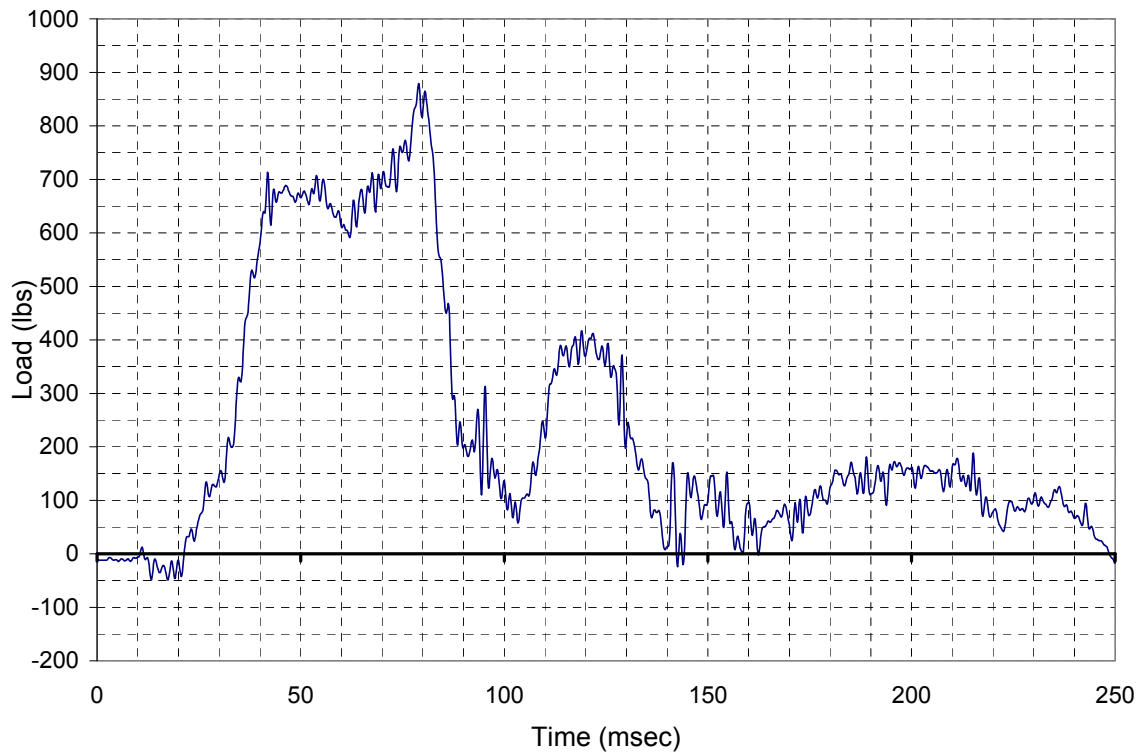


FIGURE B-108. FS 442 ATD NO. 6, LOAD CELL, ROW 3 SEAT E (1000 Hz)

B.10 DROP TEST PLATFORM DATA—ACCELEROMETER DATA

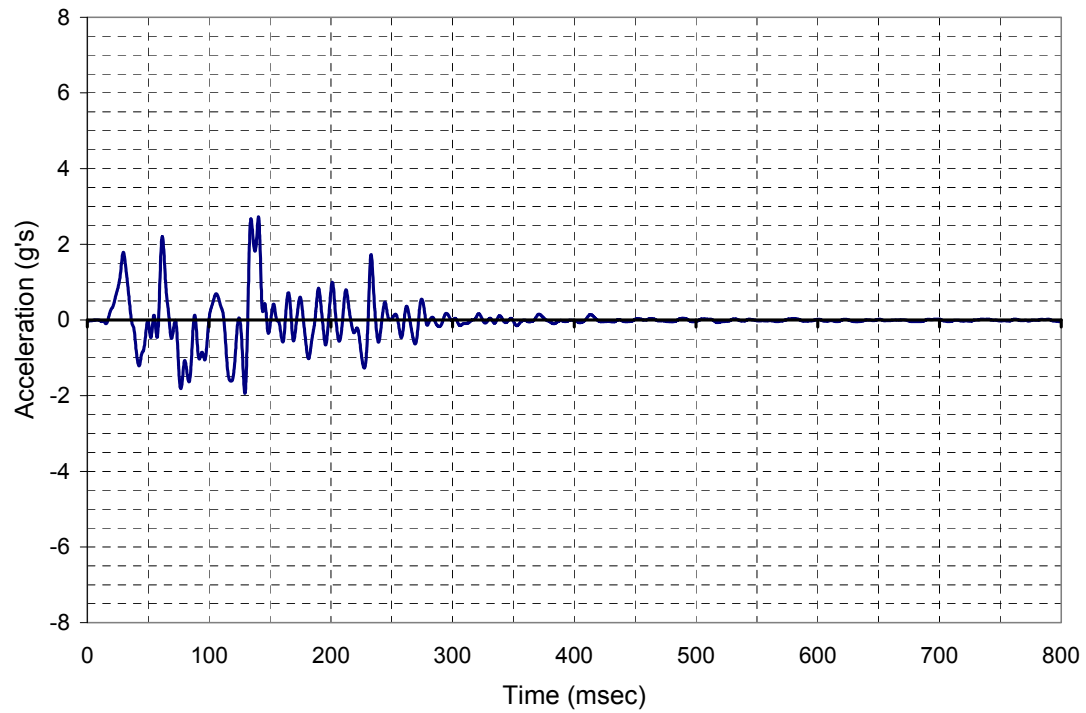


FIGURE B-109. PLATFORM ACCELEROMETER NO. 1 (100 Hz)

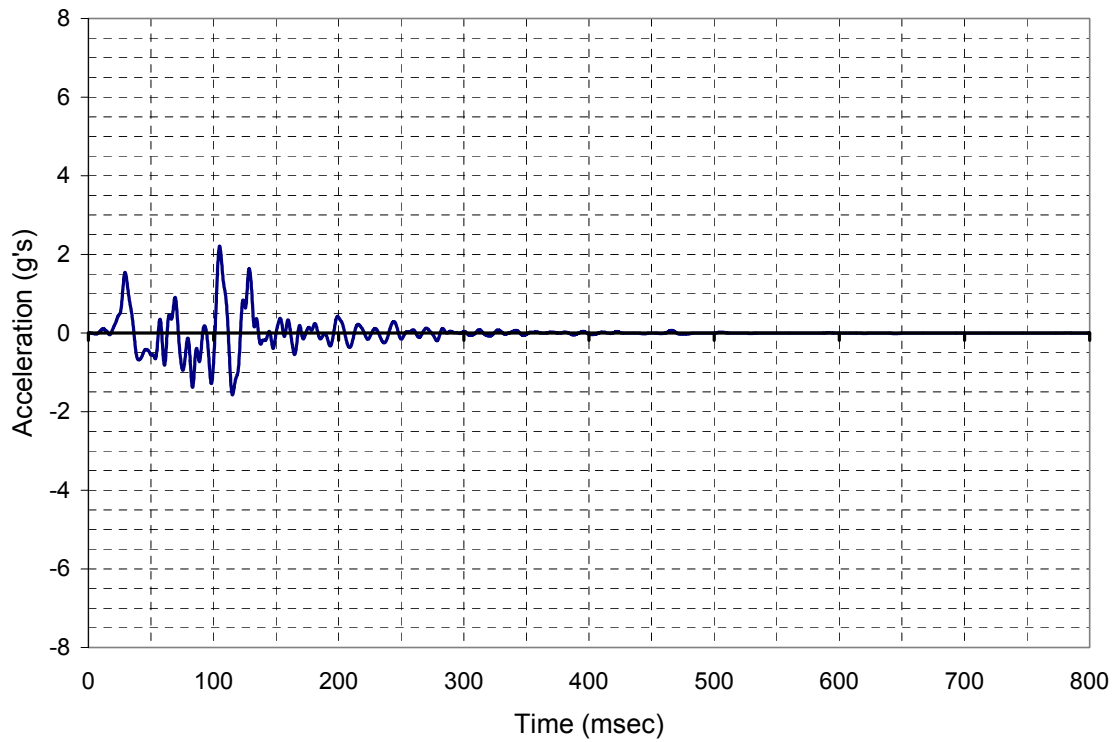


FIGURE B-110. PLATFORM ACCELEROMETER NO. 2 (100 Hz)

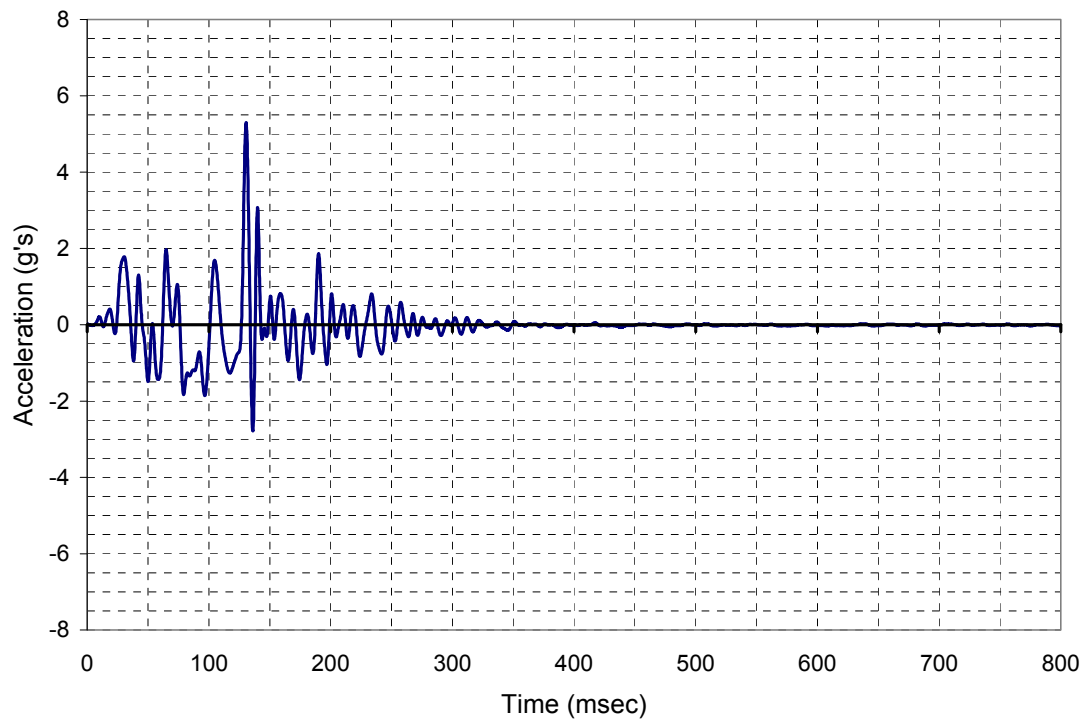


FIGURE B-111. PLATFORM ACCELEROMETER NO. 3 (100 Hz)

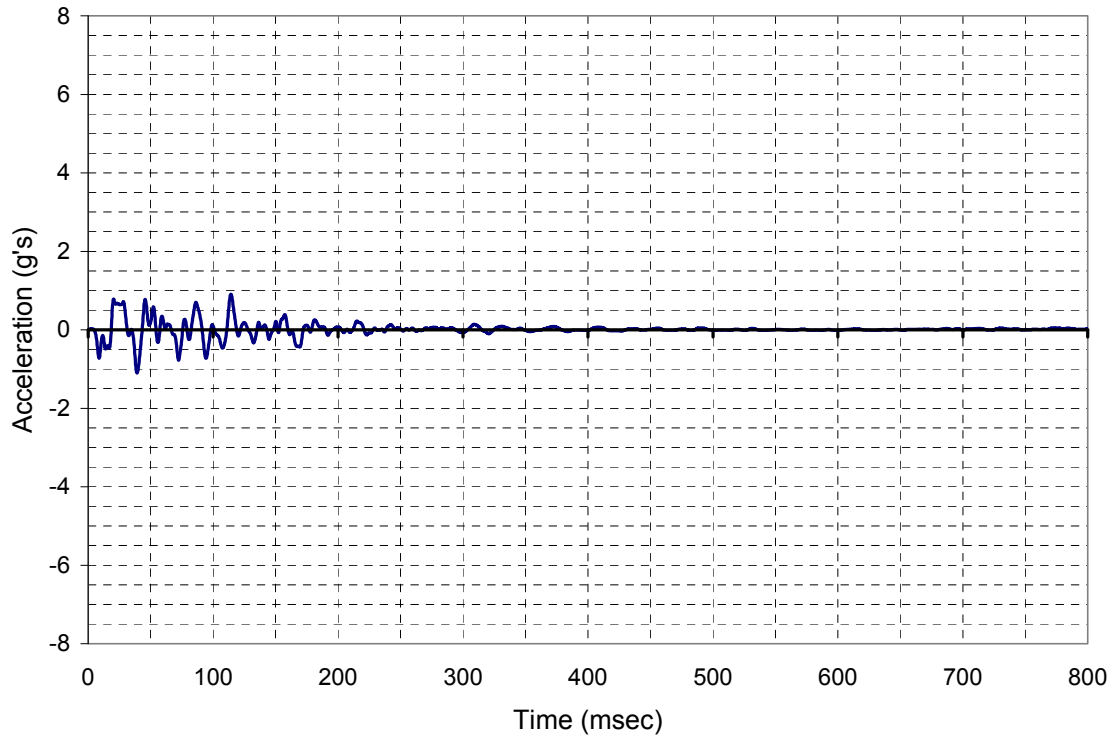


FIGURE B-112. PLATFORM ACCELEROMETER NO. 4 (100 Hz)

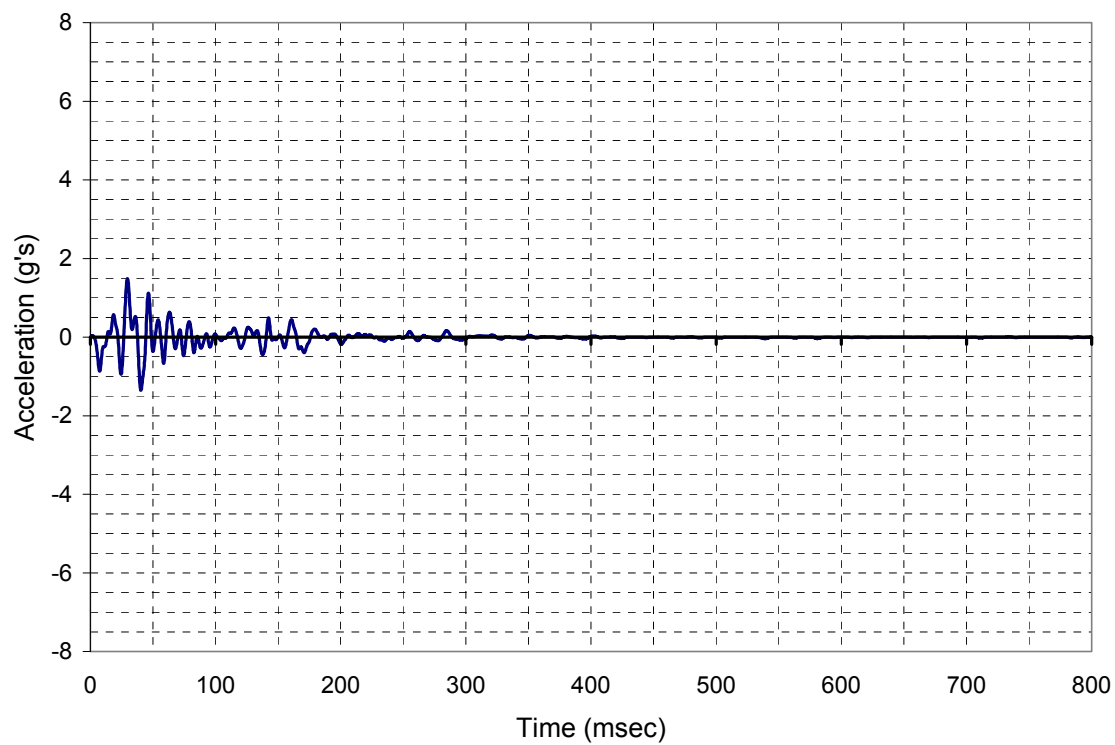


FIGURE B-113. PLATFORM ACCELEROMETER NO. 5 (100Hz)

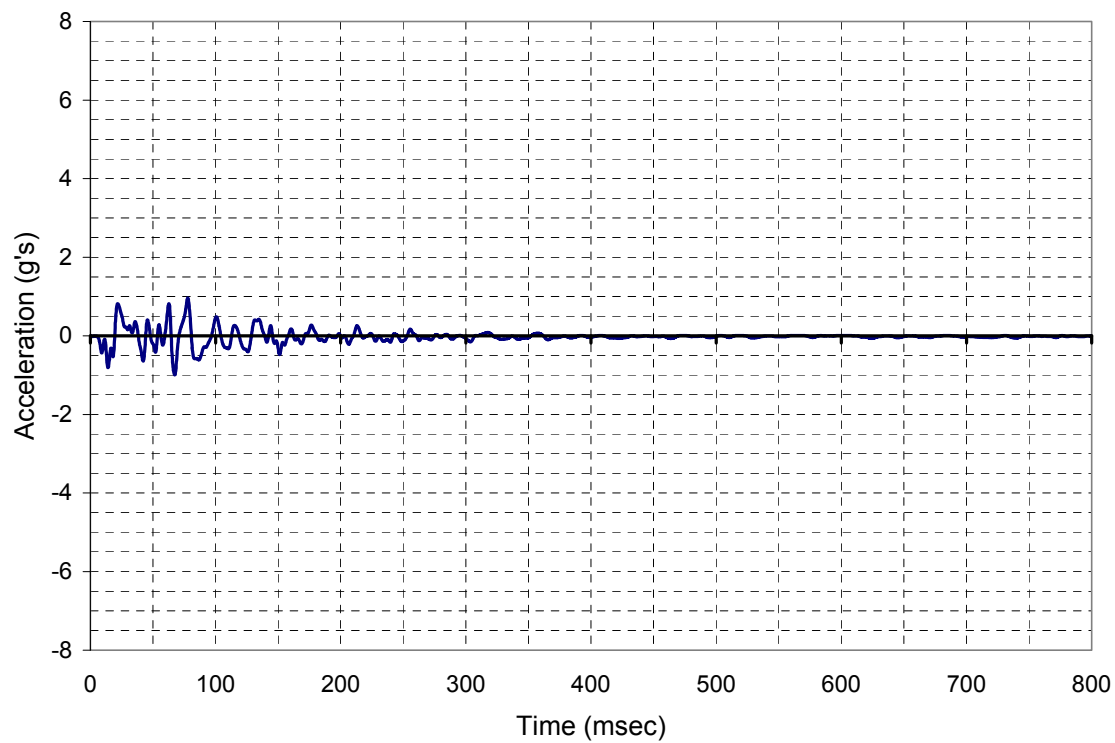


FIGURE B-114. PLATFORM ACCELEROMETER NO. 6 (100 Hz)

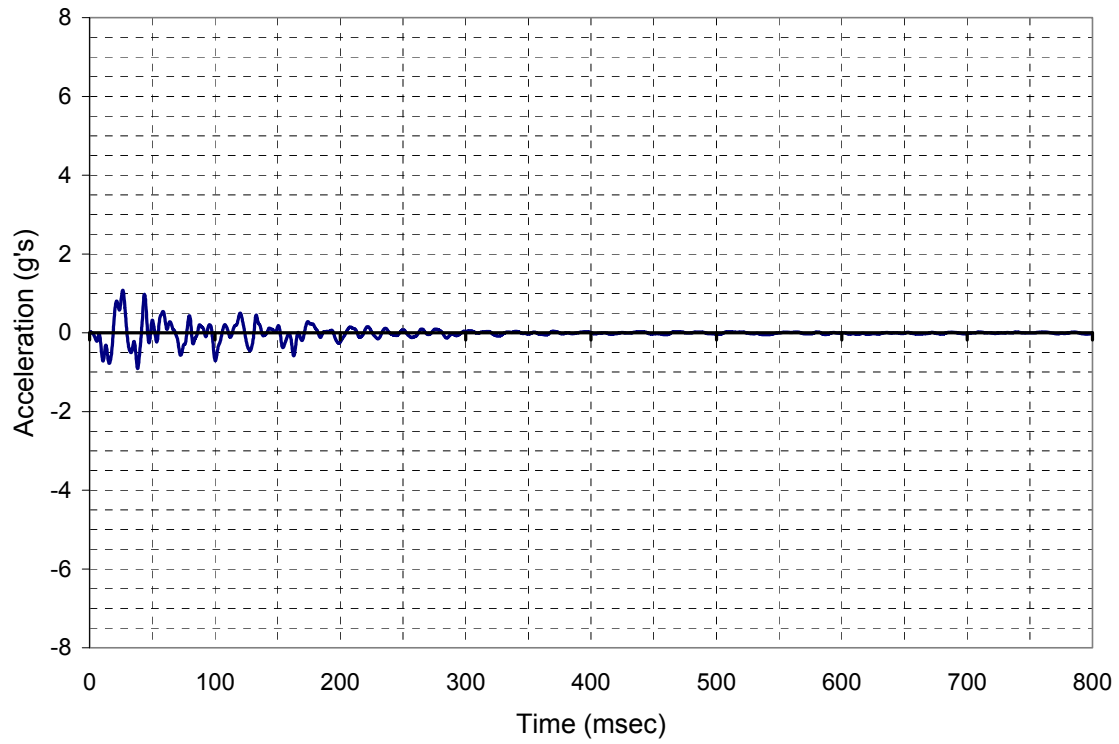


FIGURE B-115. PLATFORM ACCELEROMETER NO. 7 (100 Hz)

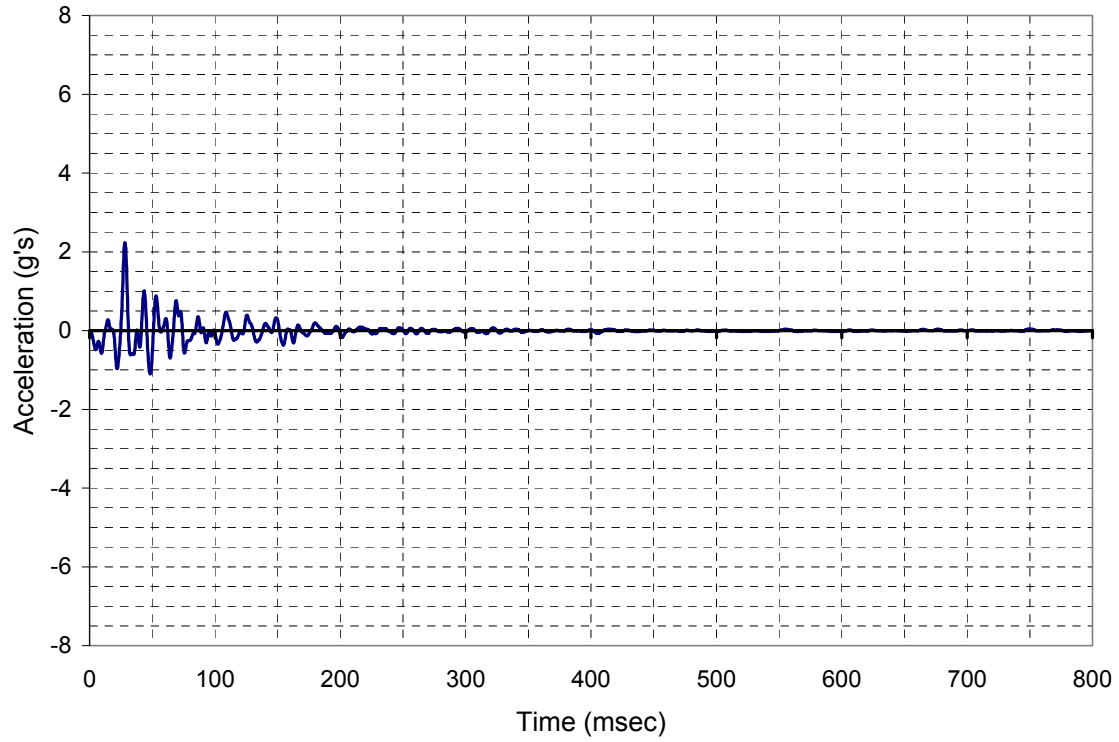


FIGURE B-116. PLATFORM ACCELEROMETER NO. 8 (100 Hz)

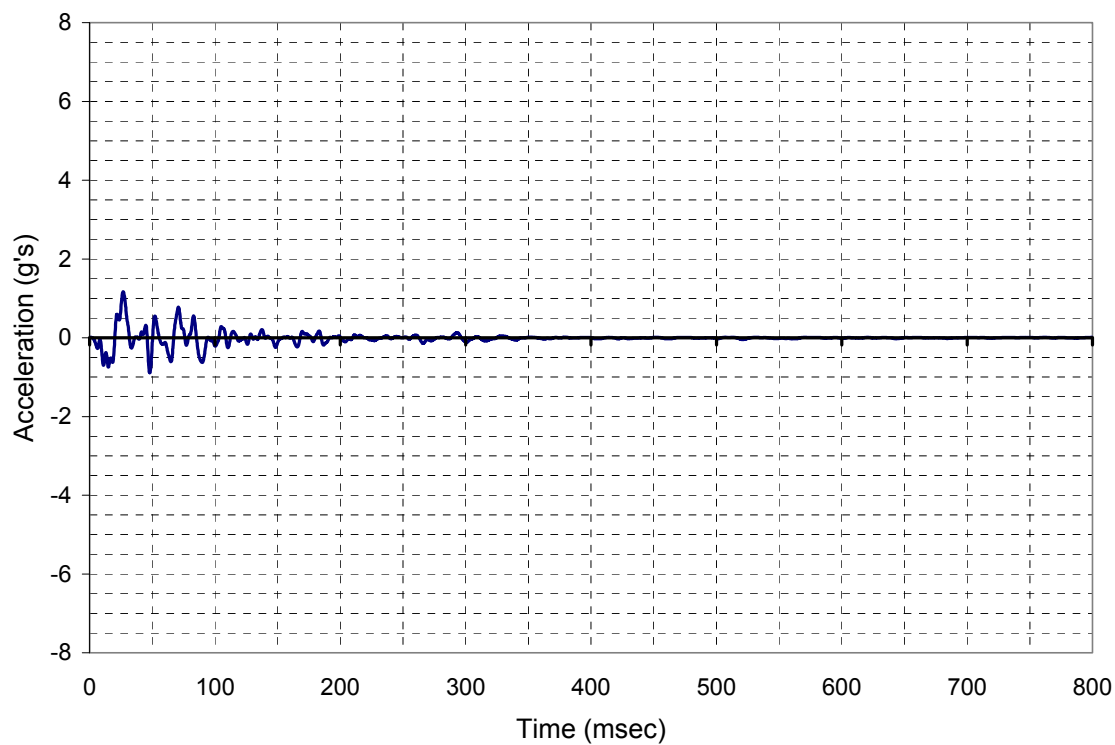


FIGURE B-117. PLATFORM ACCELEROMETER NO. 9 (100 Hz)

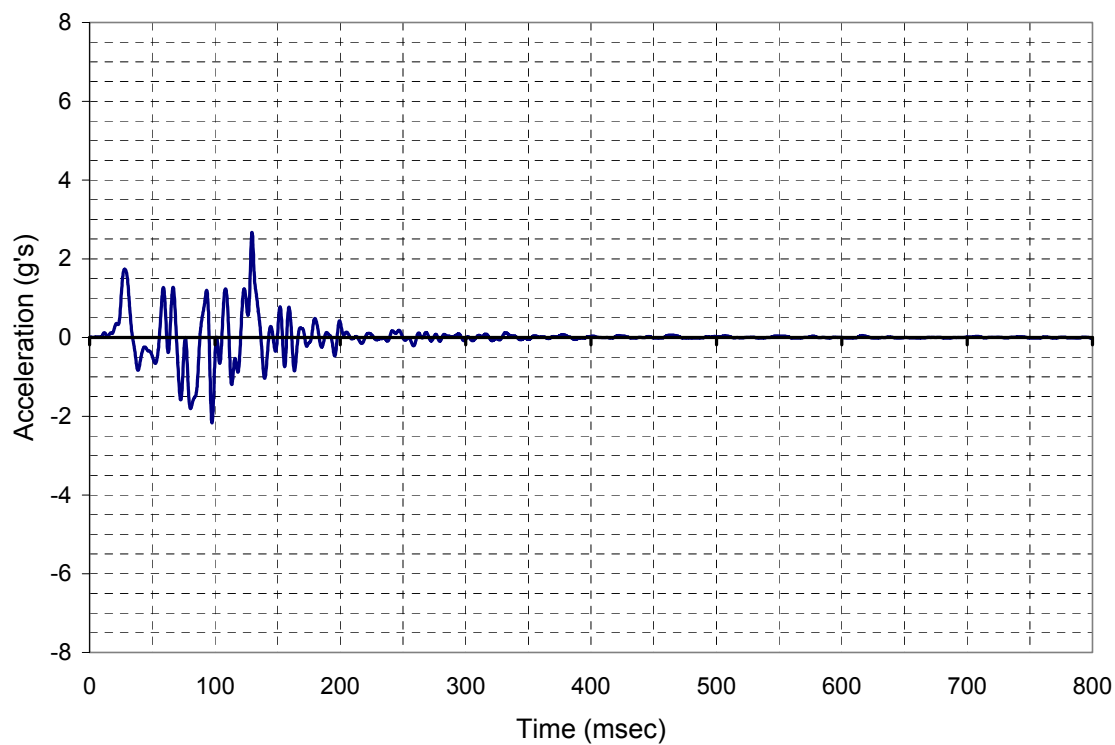


FIGURE B-118. PLATFORM ACCELEROMETER NO. 10 (100 Hz)

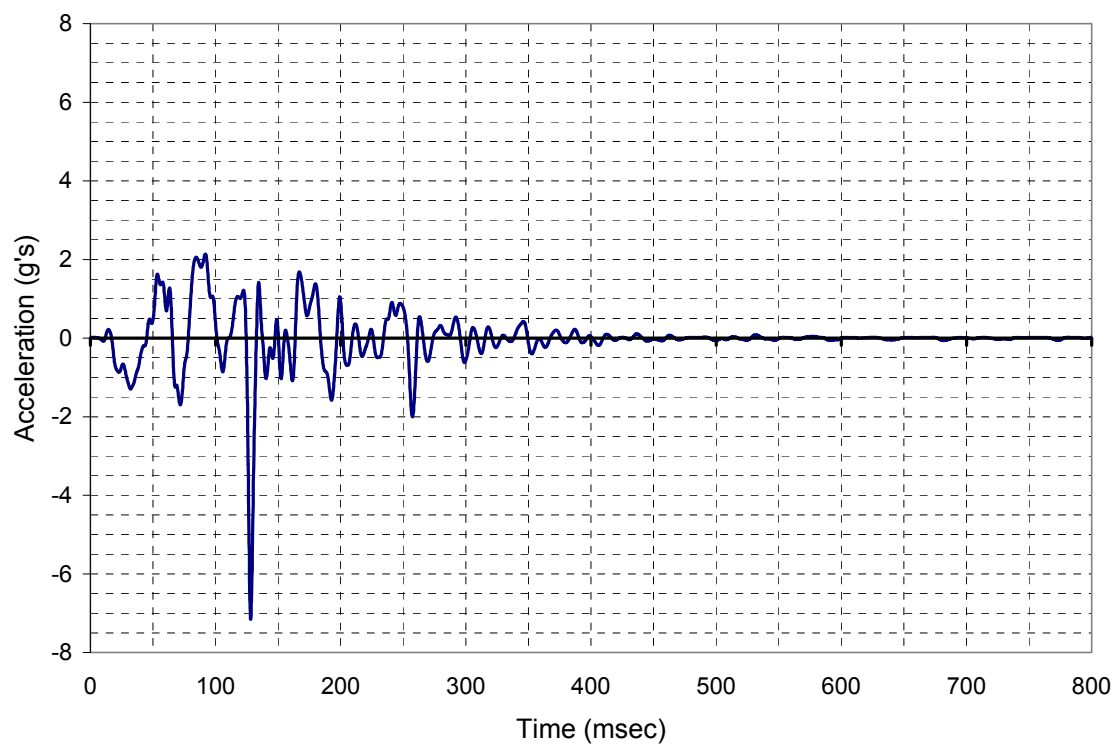


FIGURE B-119. PLATFORM ACCELEROMETER NO. 11 (100 Hz)

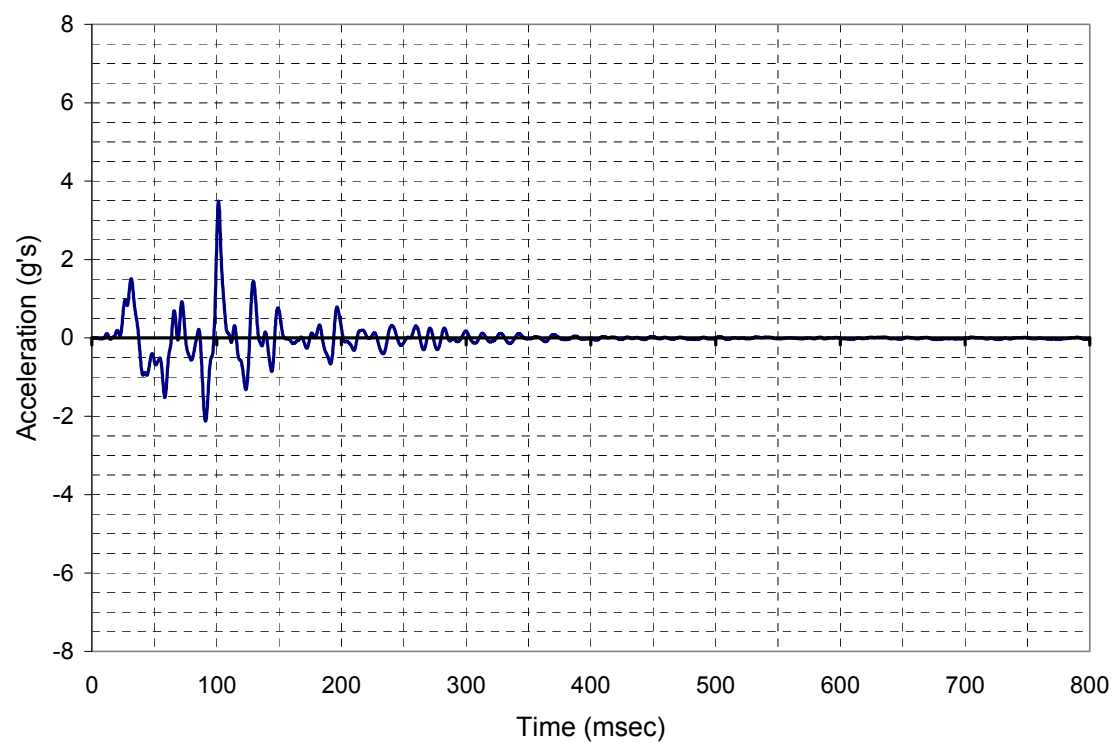


FIGURE B-120. PLATFORM ACCELEROMETER NO. 12 (100 Hz)

B.11 DROP TEST PLATFORM DATA—LOAD CELL DATA

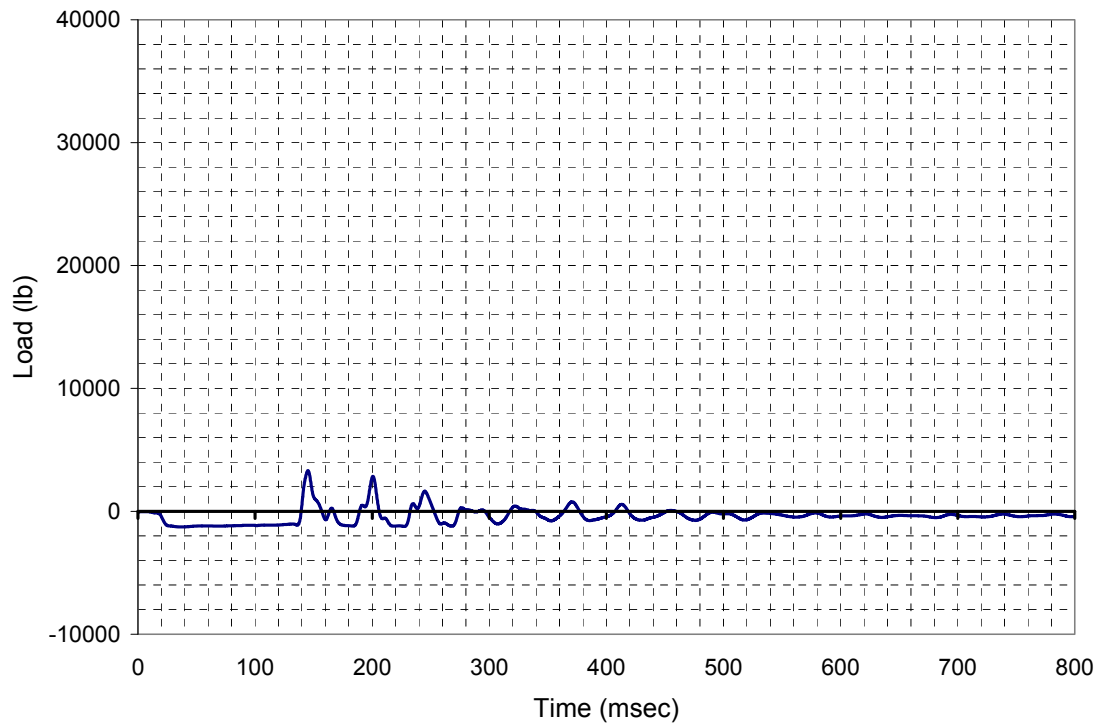


FIGURE B-121. PLATFORM LOAD CELL NO. 1 (100 Hz)

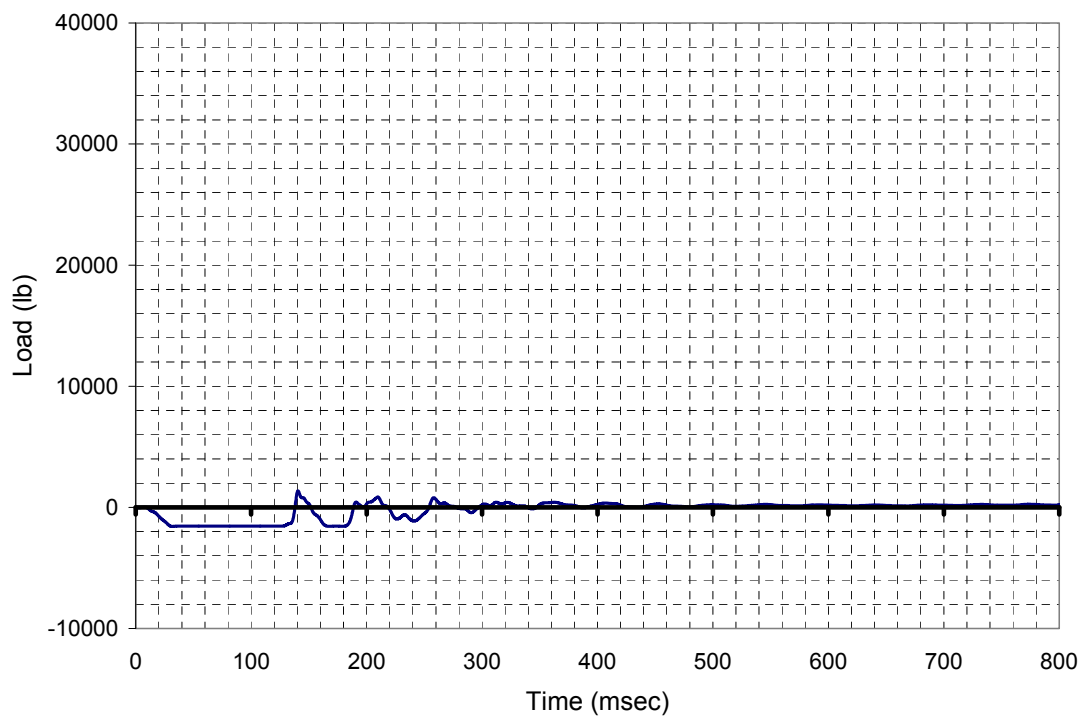


FIGURE B-122. PLATFORM LOAD CELL NO. 2 (100 Hz)

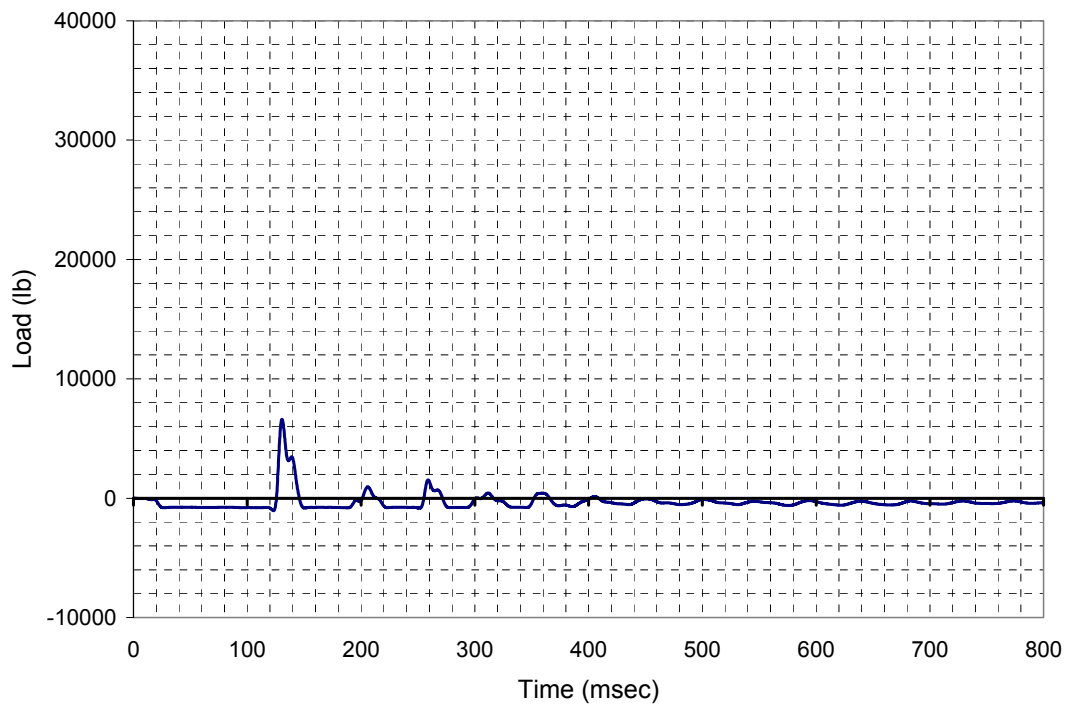


FIGURE B-123. PLATFORM LOAD CELL NO. 3 (100 Hz)

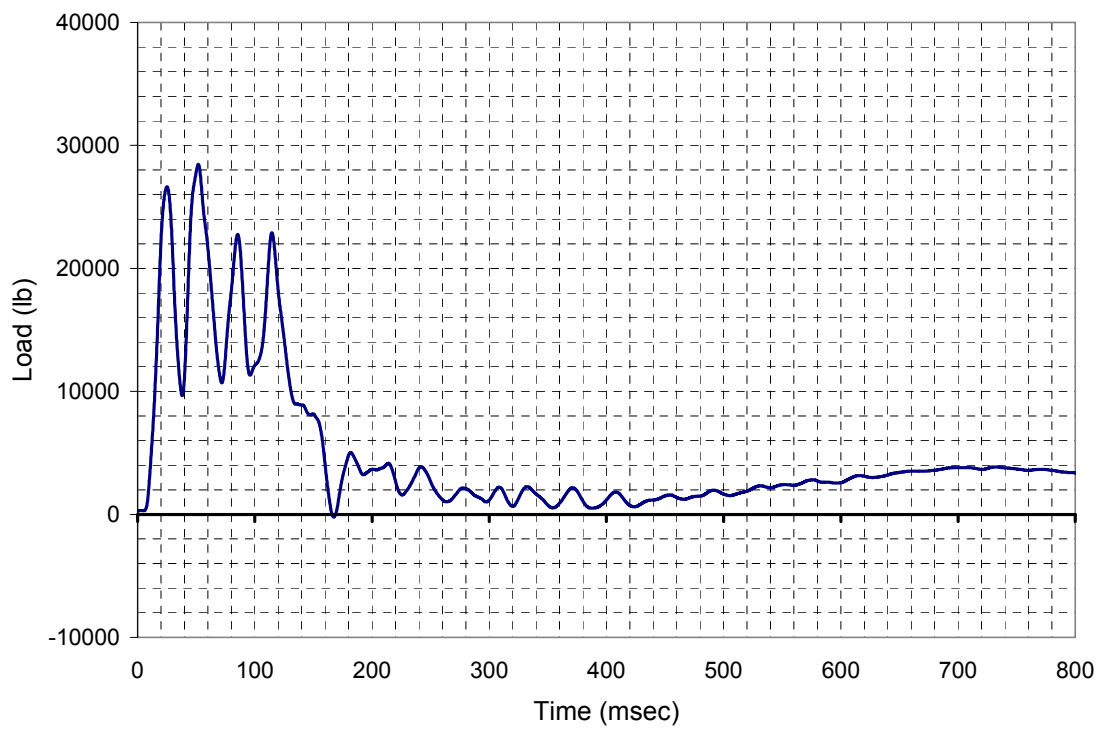


FIGURE B-124. PLATFORM LOAD CELL NO. 4 (100 Hz)

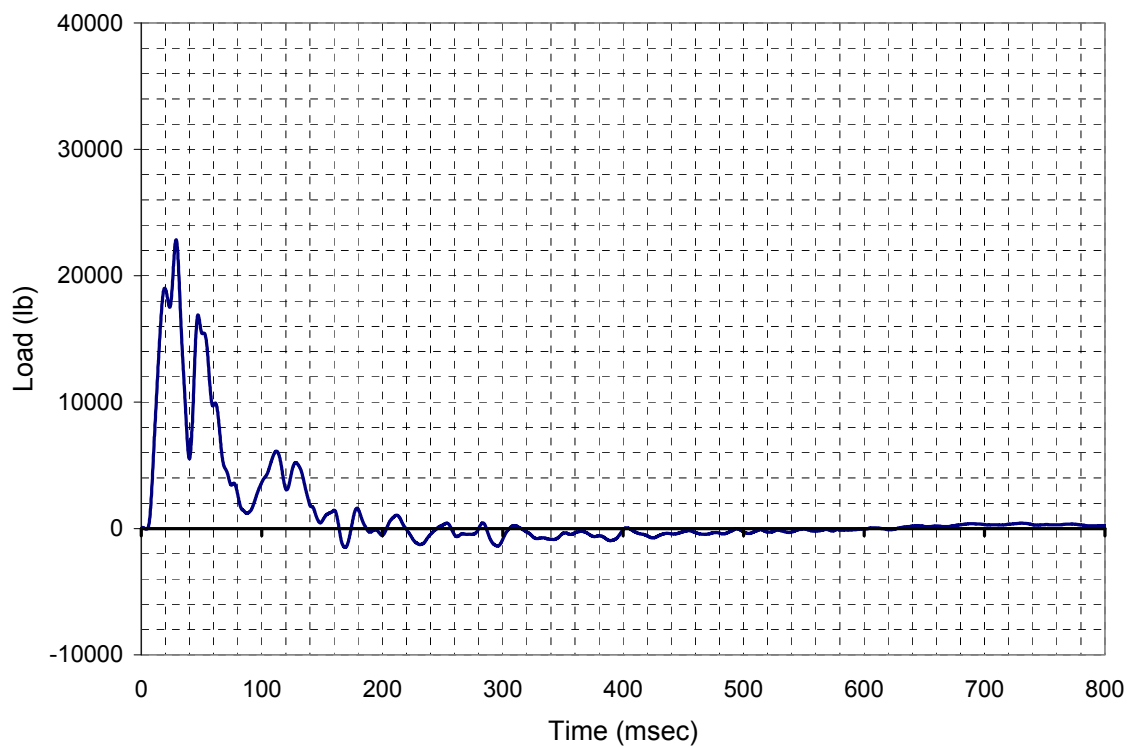


FIGURE B-125. PLATFORM LOAD CELL NO. 5 (100 Hz)

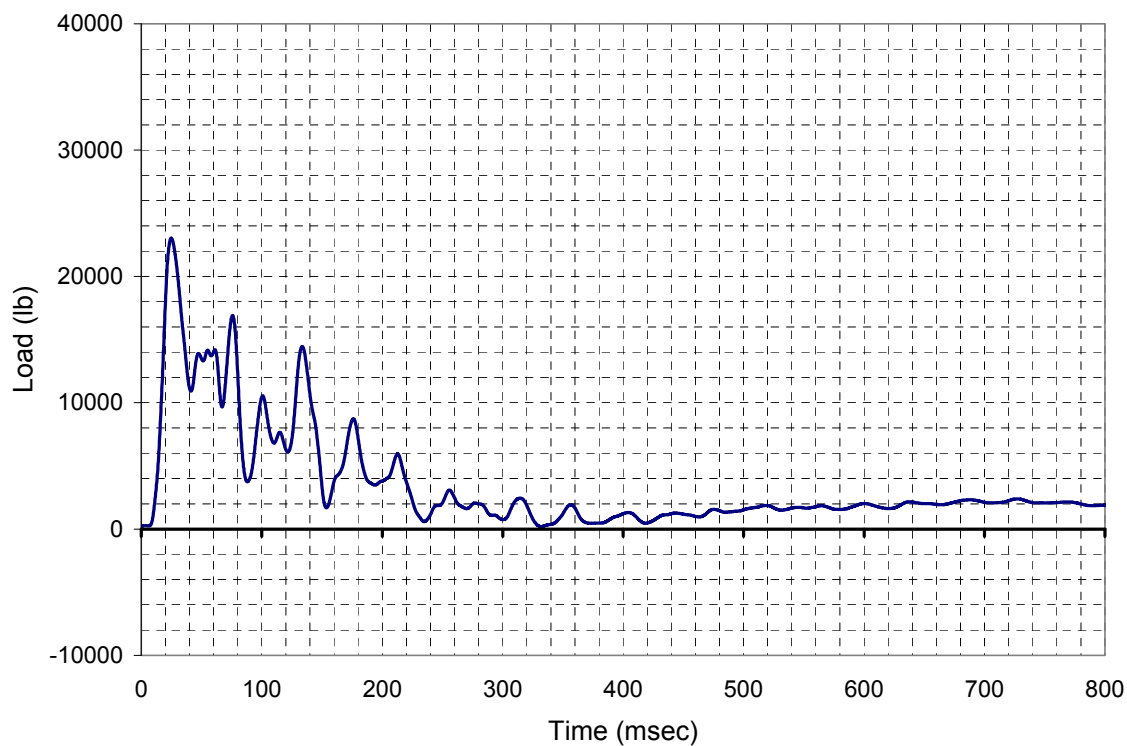


FIGURE B-126. PLATFORM LOAD CELL NO. 6 (100 Hz)

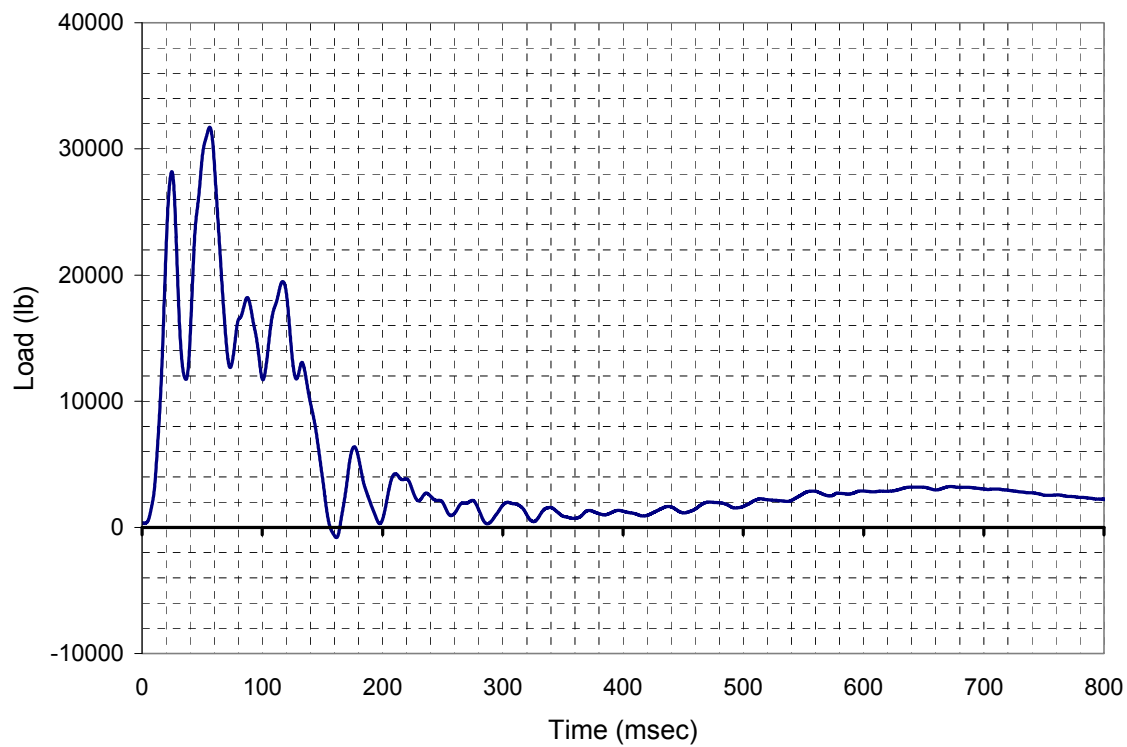


FIGURE B-127. PLATFORM LOAD CELL NO. 7 (100 Hz)

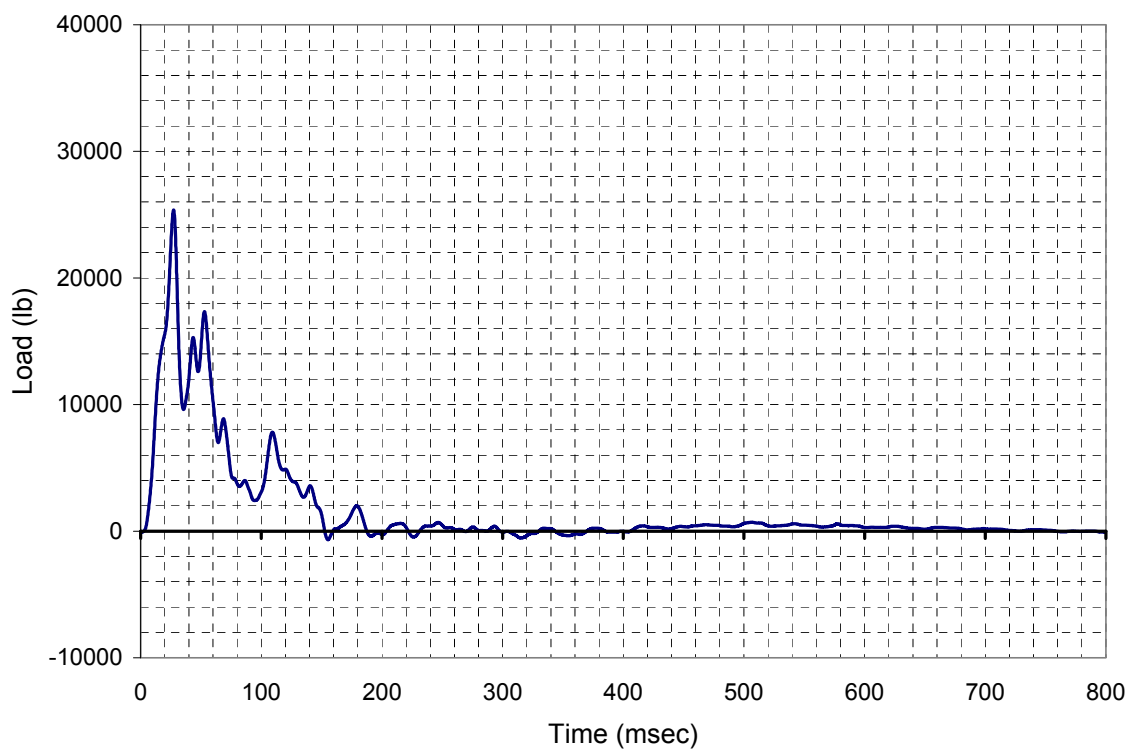


FIGURE B-128. PLATFORM LOAD CELL NO. 8 (100 Hz)

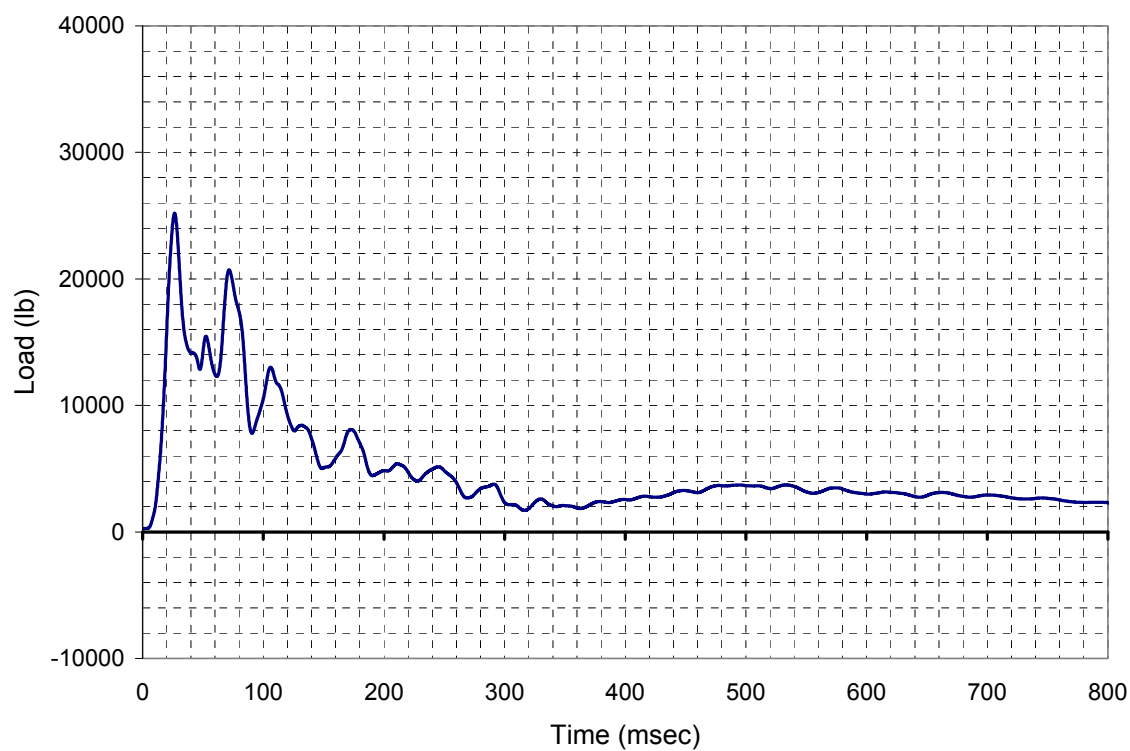


FIGURE B-129. PLATFORM LOAD CELL NO. 9 (100Hz)

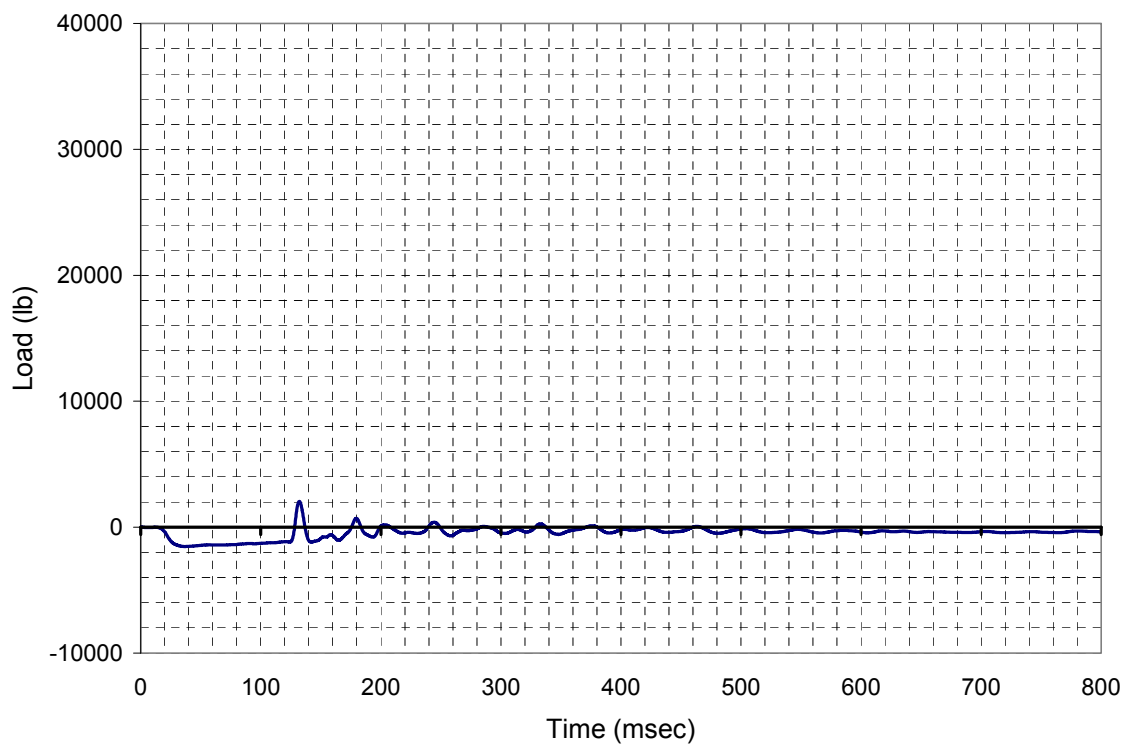


FIGURE B-130. PLATFORM LOAD CELL NO. 10 (100 Hz)

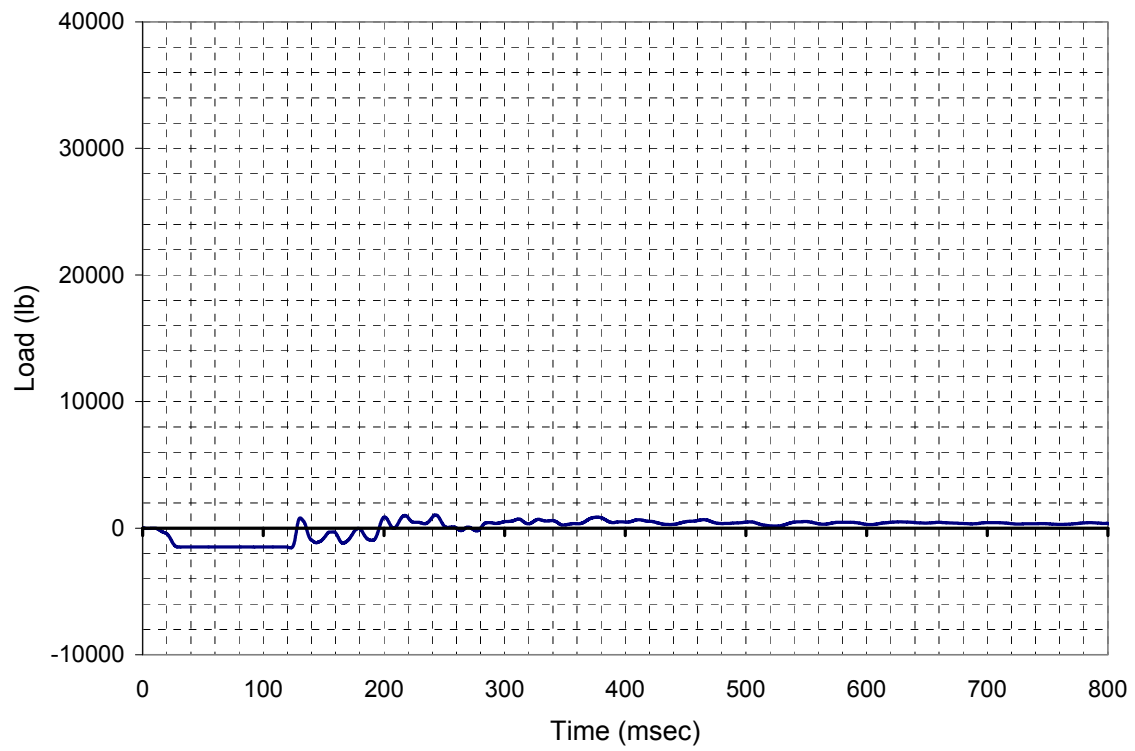


FIGURE B-131. PLATFORM LOAD CELL NO. 11 (100 Hz)

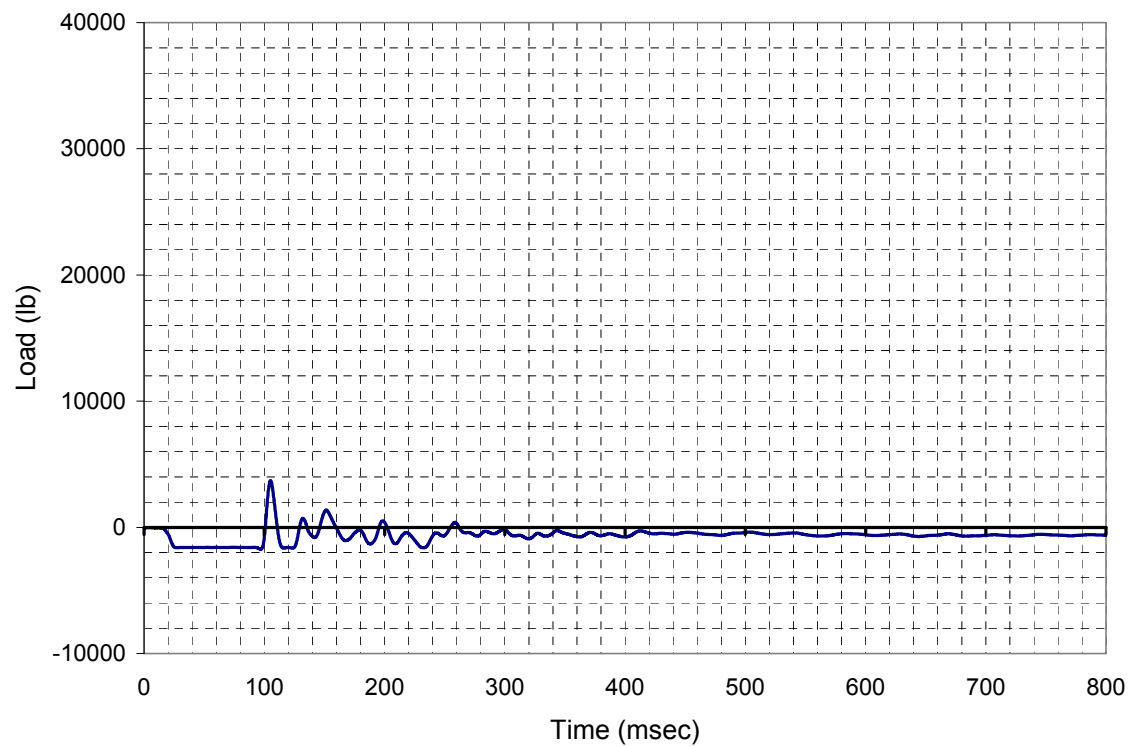


FIGURE B-132. PLATFORM LOAD CELL NO. 12 (100 Hz)

B.12 DROP TEST PLATFORM DATA—STRING POTENTIOMETER DATA

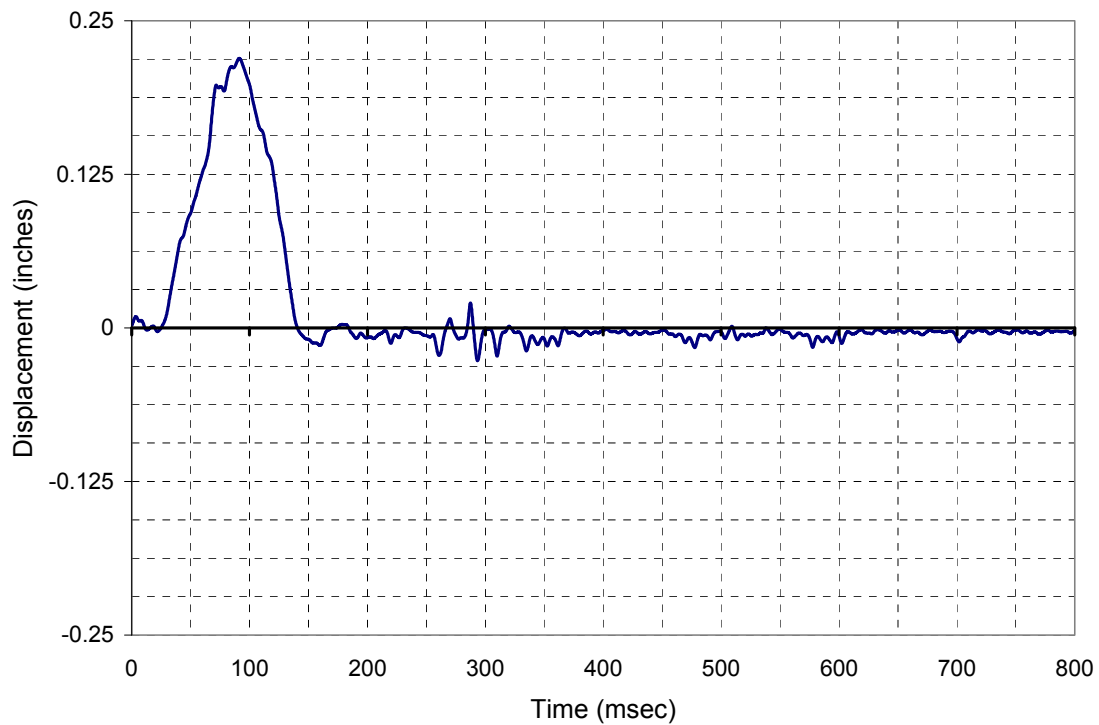


FIGURE B-133. PLATFORM STRING POTENTIOMETER NO. 1 (100 Hz)

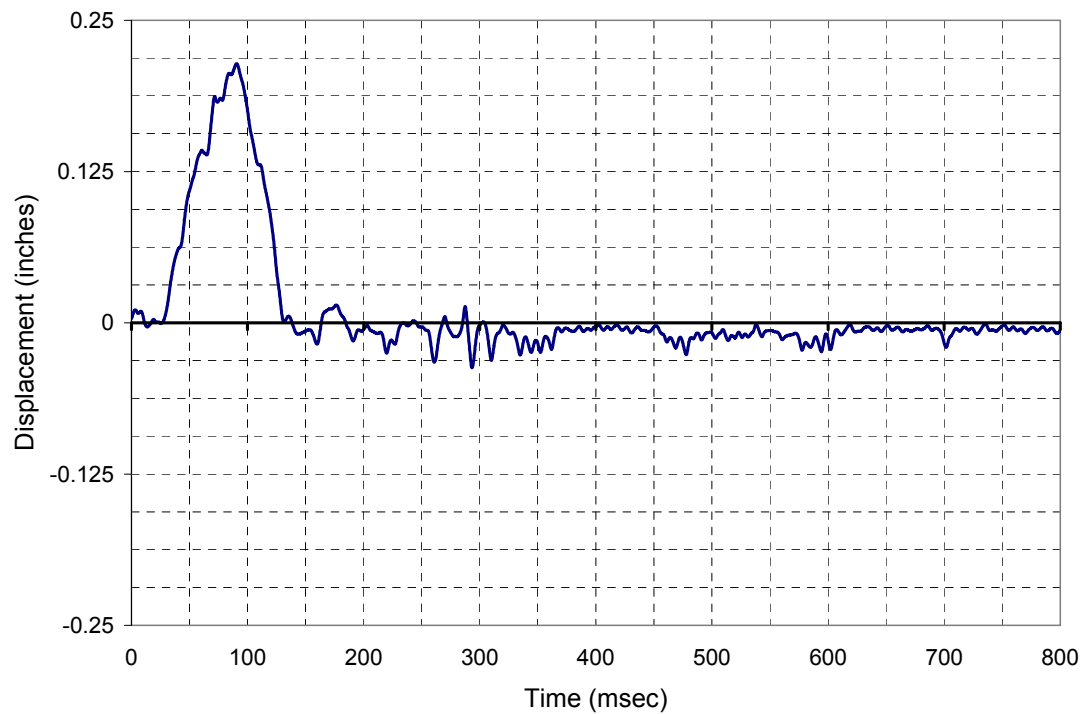


FIGURE B-134. PLATFORM STRING POTENTIOMETER NO. 2 (100 Hz)

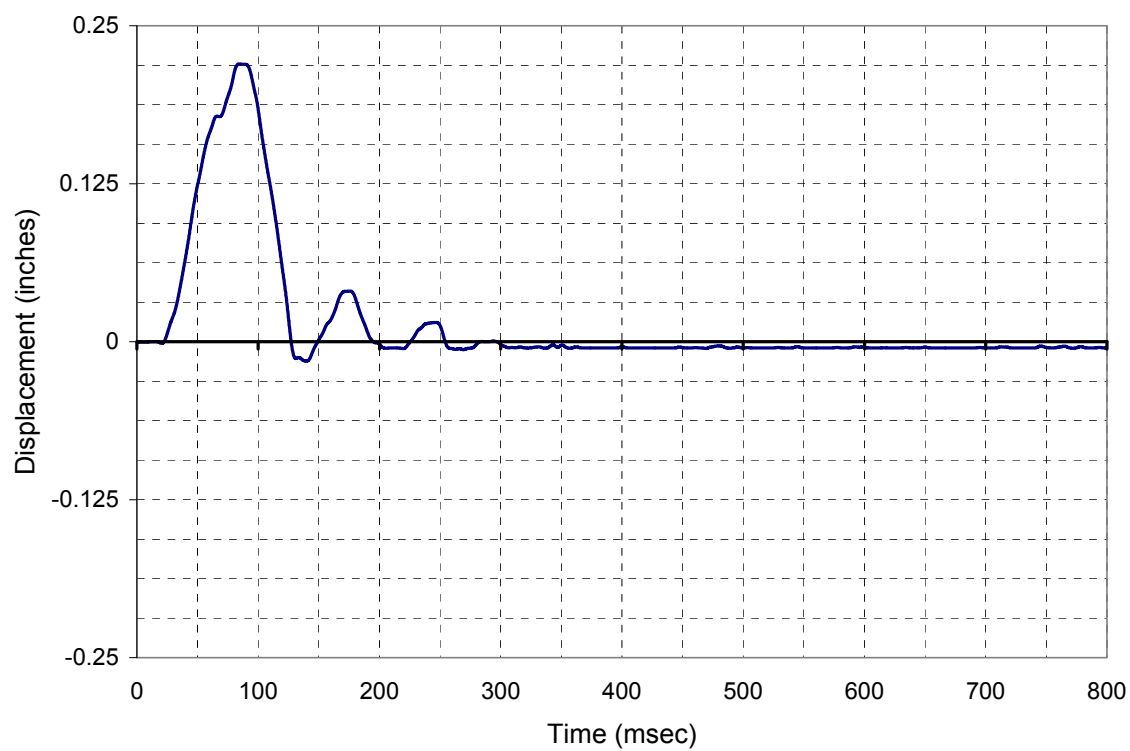


FIGURE B-135. PLATFORM STRING POTENTIOMETER NO. 3 (100 Hz)

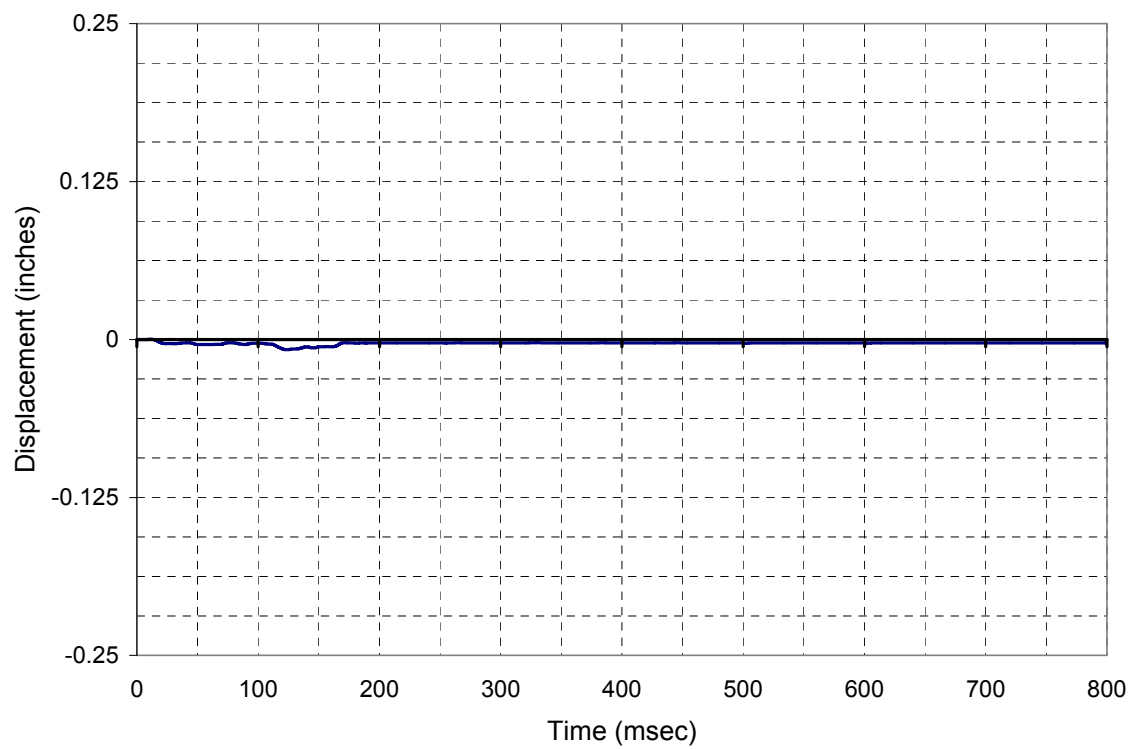


FIGURE B-136. PLATFORM STRING POTENTIOMETER NO. 4 (100 Hz)

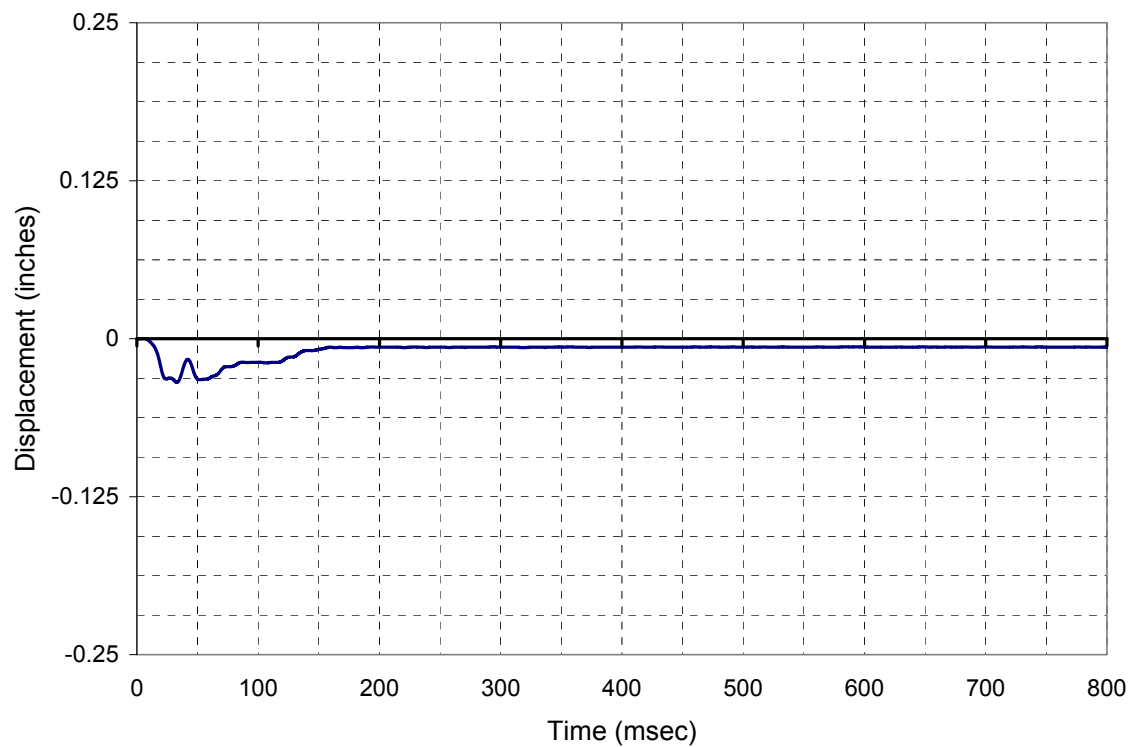


FIGURE B-137. PLATFORM STRING POTENTIOMETER NO. 5 (100 Hz)

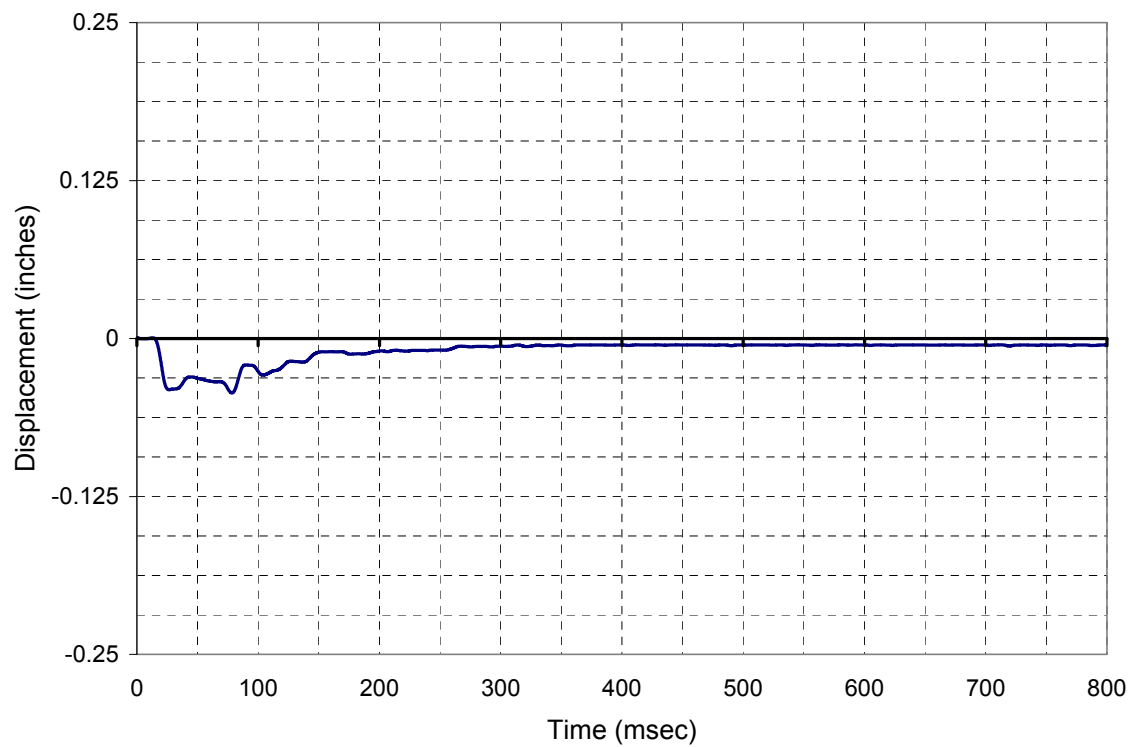


FIGURE B-138. PLATFORM STRING POTENTIOMETER NO. 6 (100 Hz)

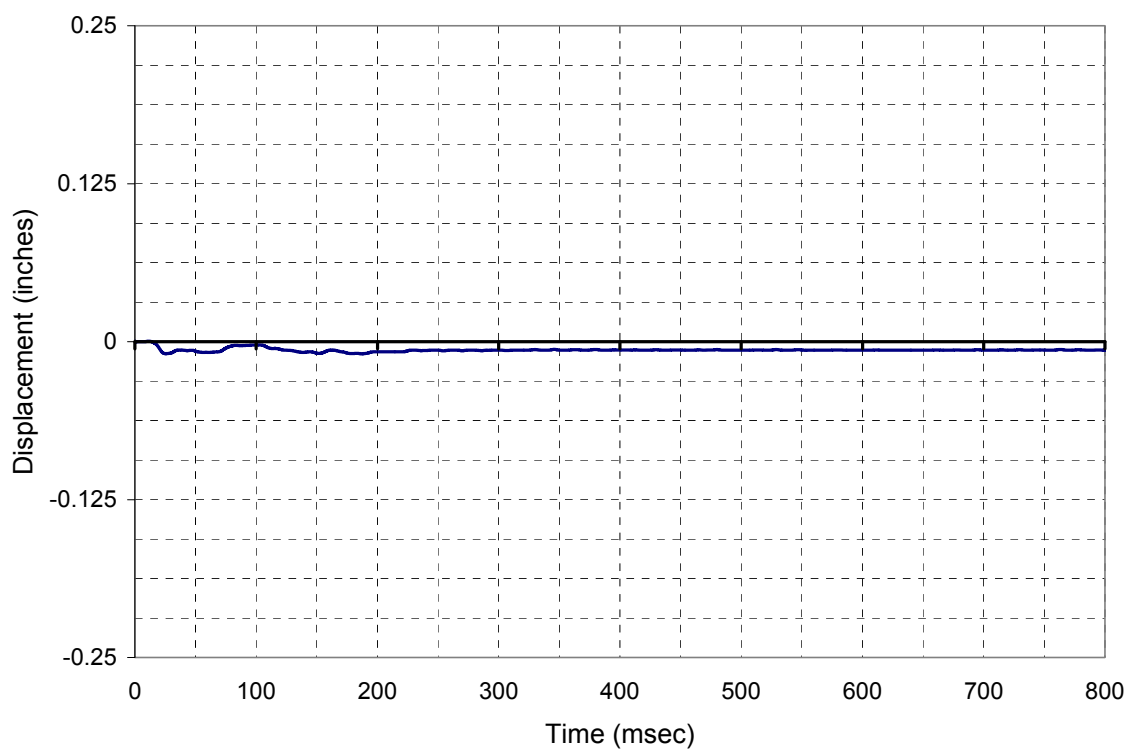


FIGURE B-139. PLATFORM STRING POTENTIOMETER NO. 7 (100 Hz)

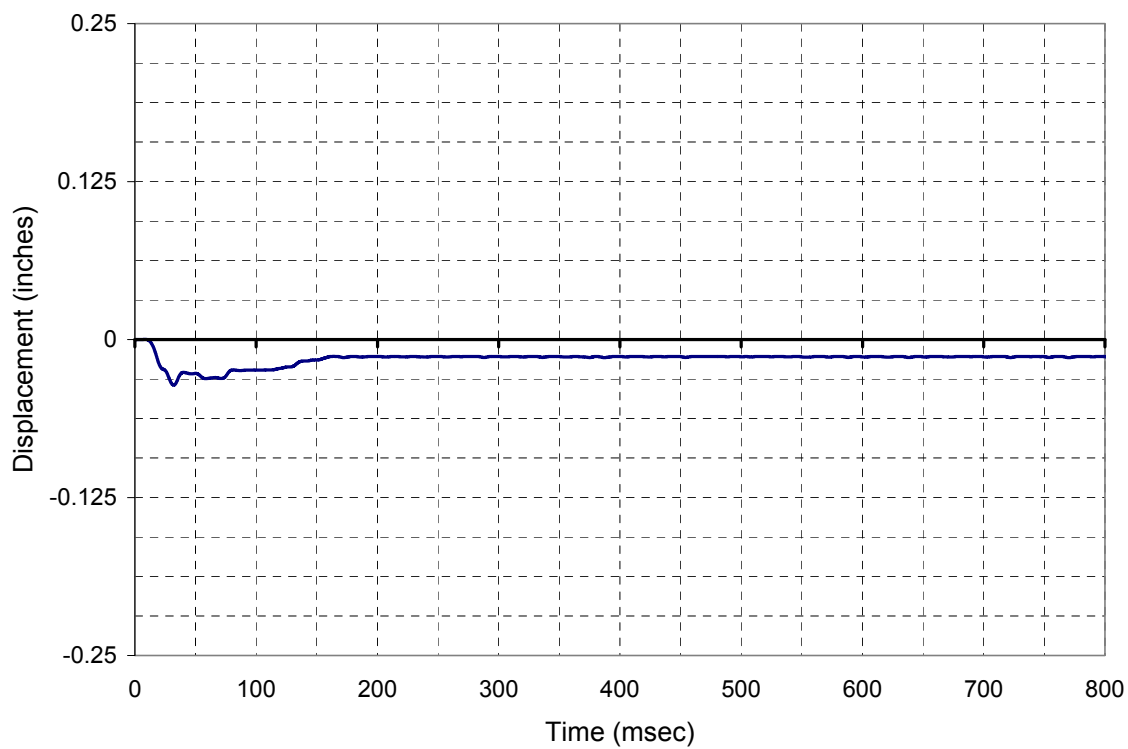


FIGURE B-140. PLATFORM STRING POTENTIOMETER NO. 8 (100 Hz)

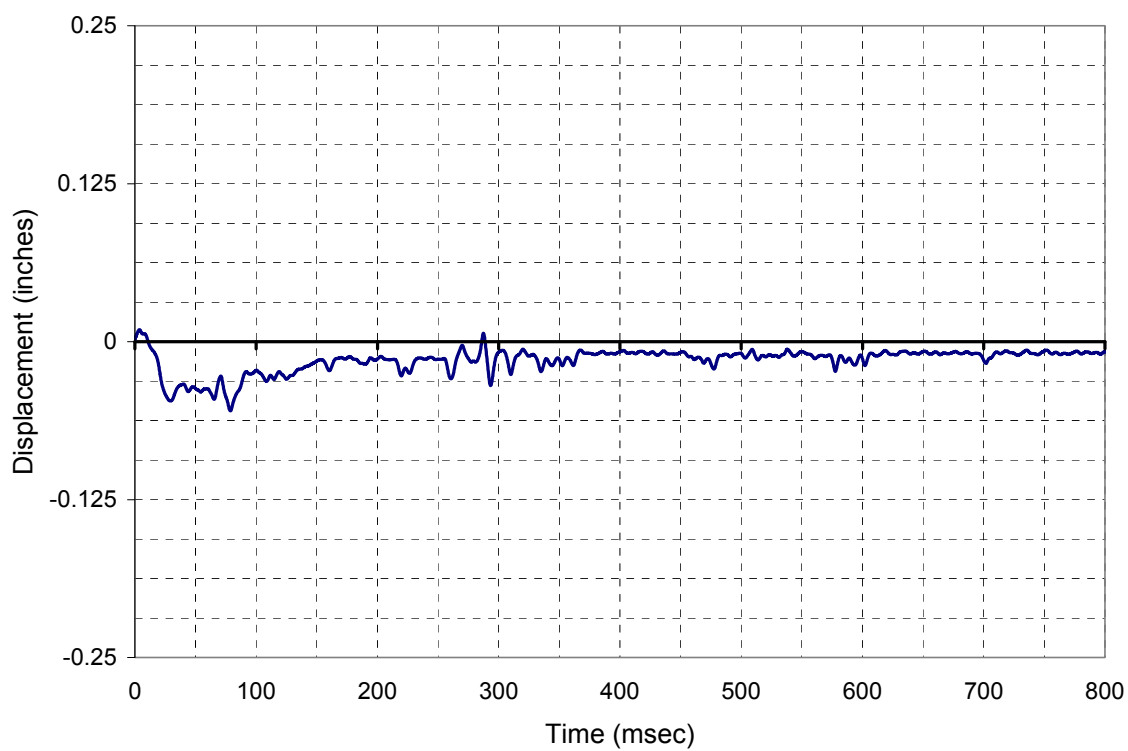


FIGURE B-141. PLATFORM STRING POTENTIOMETER NO. 9 (100 Hz)

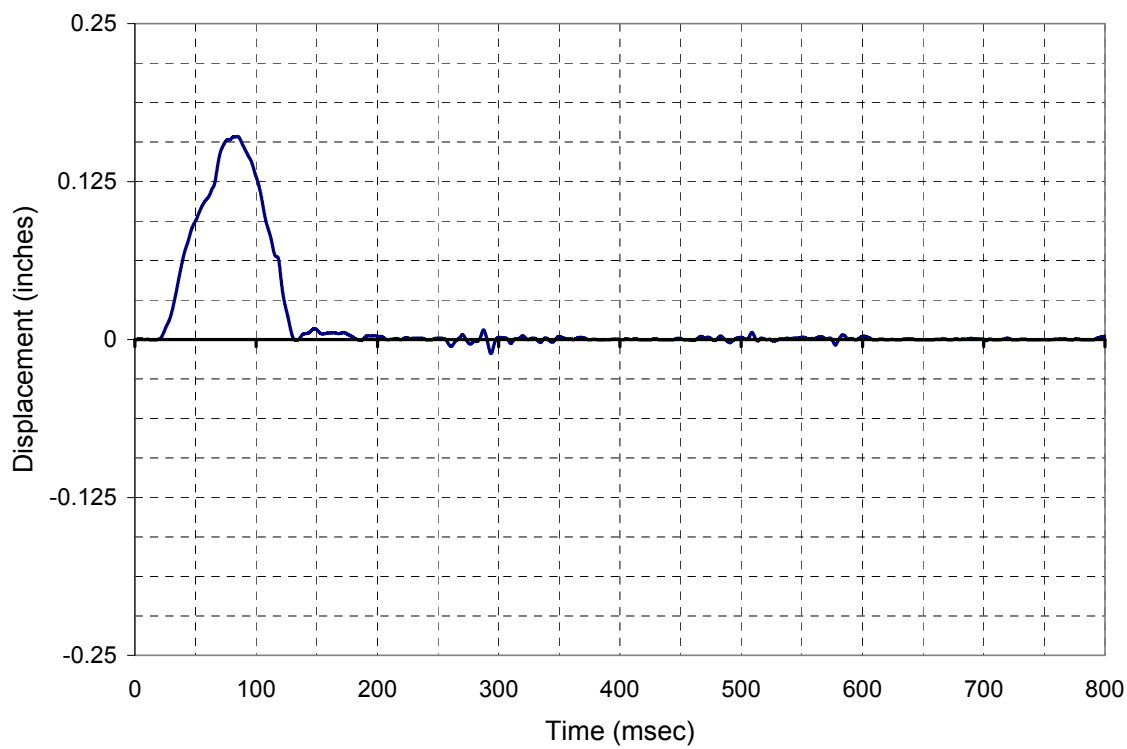


FIGURE B-142. PLATFORM STRING POTENTIOMETER NO. 10 (100 Hz)

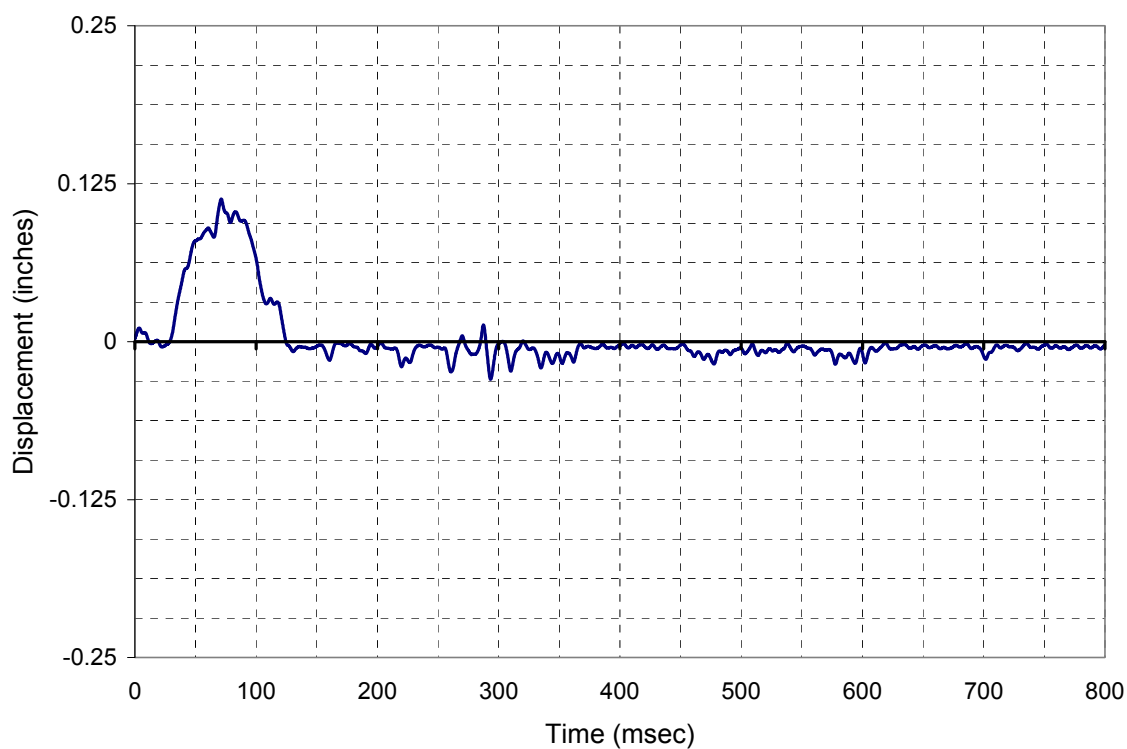


FIGURE B-143. PLATFORM STRING POTENTIOMETER NO. 11 (100 Hz)

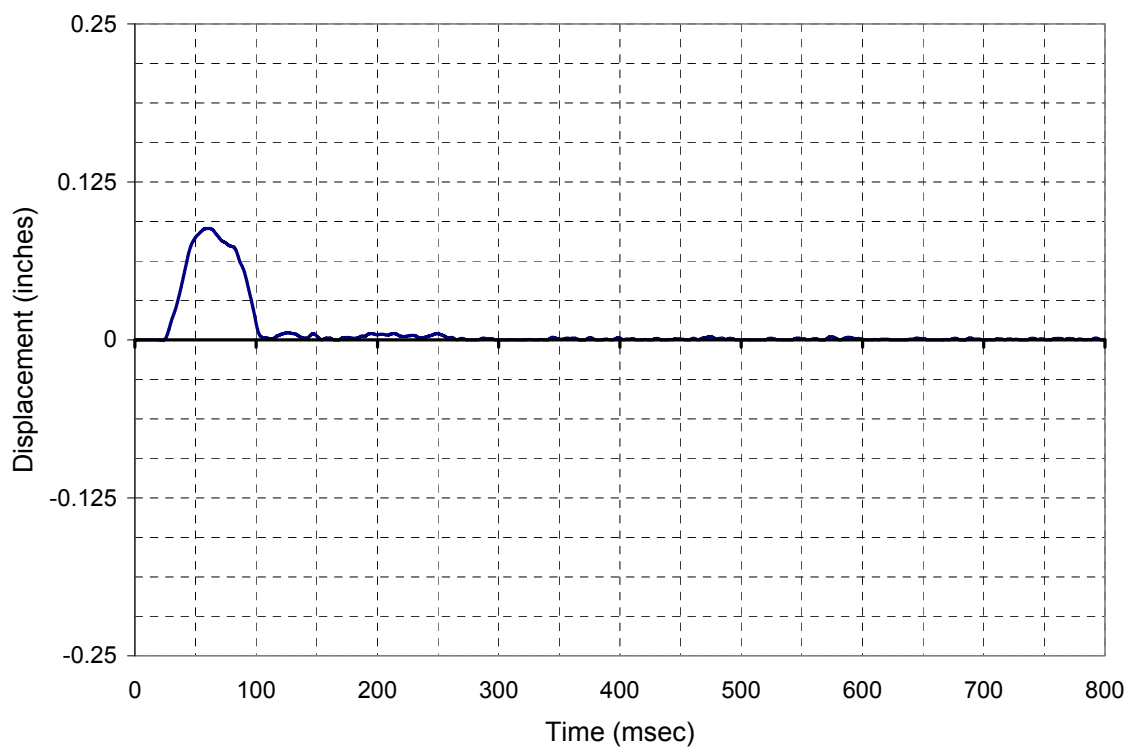


FIGURE B-144. PLATFORM STRING POTENTIOMETER NO. 12 (100 Hz)

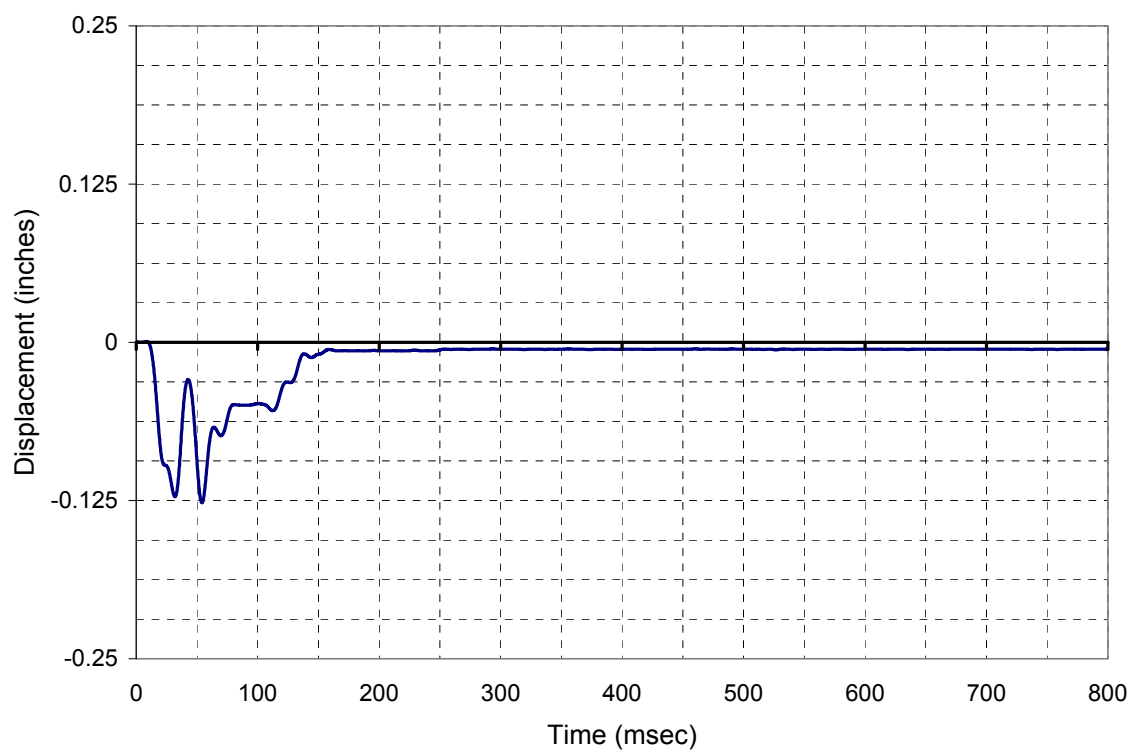


FIGURE B-145. PLATFORM STRING POTENTIOMETER NO. 13 (100 Hz)

APPENDIX C—PHOTOGRAPHIC DOCUMENTATION

C.1 PRETEST PHOTOS—TEST SECTION AND TEST FACILITY



FIGURE C-1. DYNAMIC DROP TEST AREA



FIGURE C-2. DYNAMIC DROP TEST FACILITY



FIGURE C-3. TEST SECTION—FRONT
RIGHT QUARTER



FIGURE C-4. TEST SECTION—FRONT
LEFT QUARTER

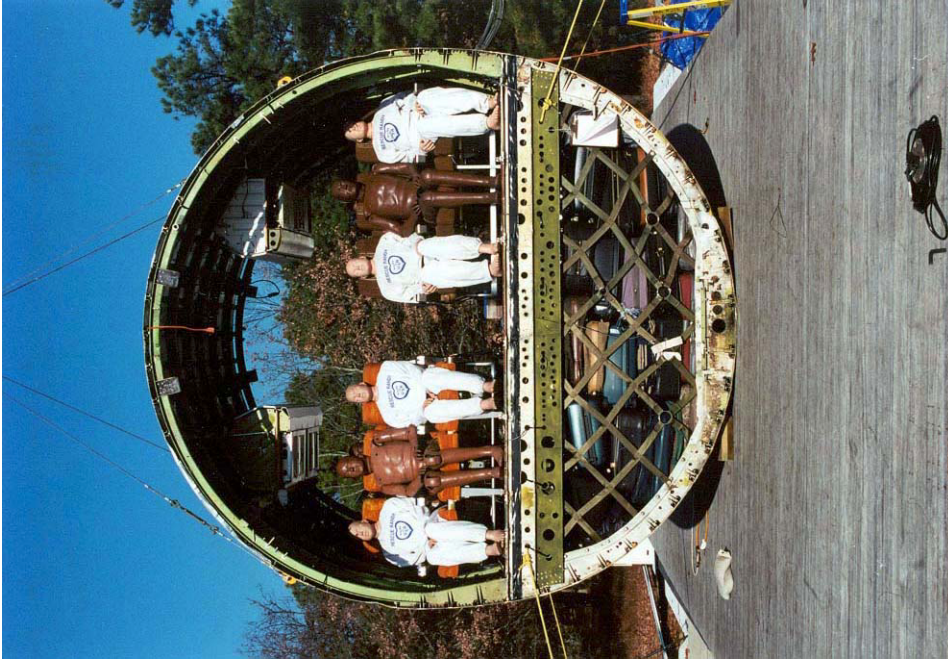


FIGURE C-5. TEST SECTION—FRONT



FIGURE C-6. TEST SECTION—REAR

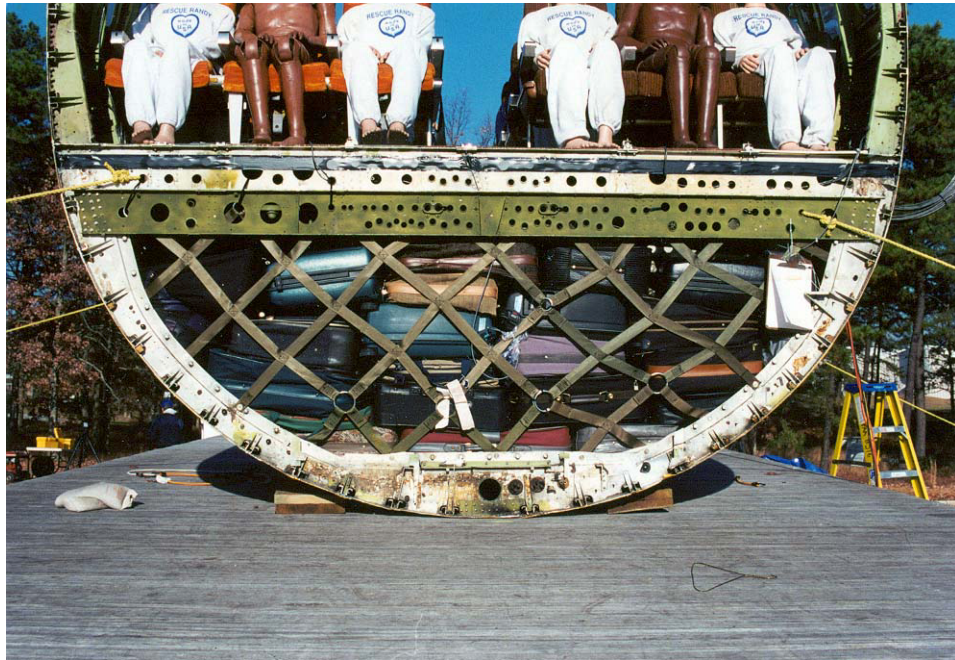


FIGURE C-7. CARGO AREA—LUGGAGE, FRONT

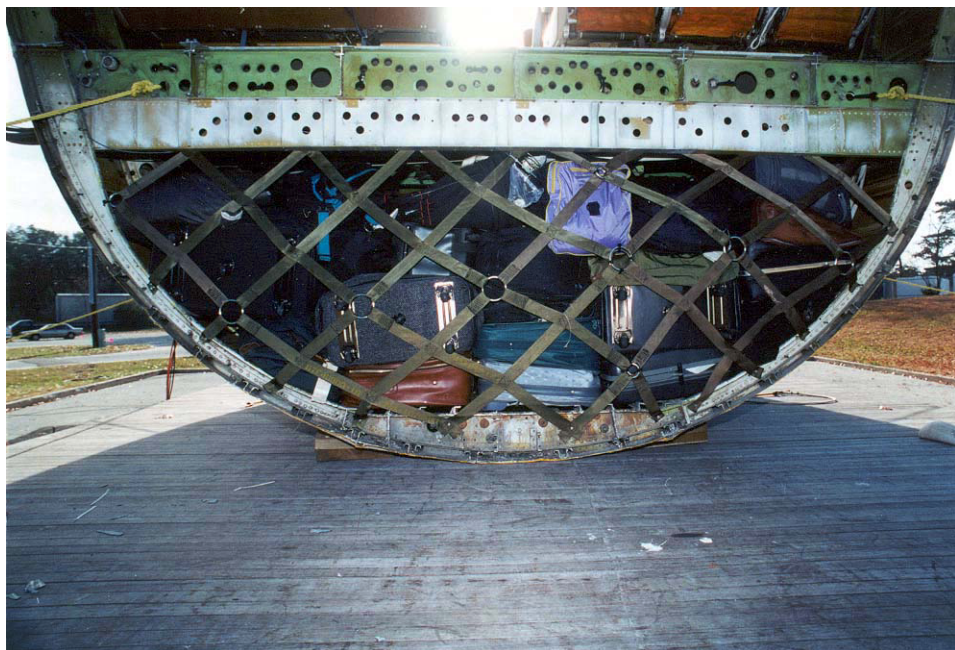


FIGURE C-8. CARGO AREA—LUGGAGE, REAR



FIGURE C-9. TEST SECTION—LOWER RIGHT SIDE



FIGURE C-10. TEST SECTION—LOWER LEFT SIDE

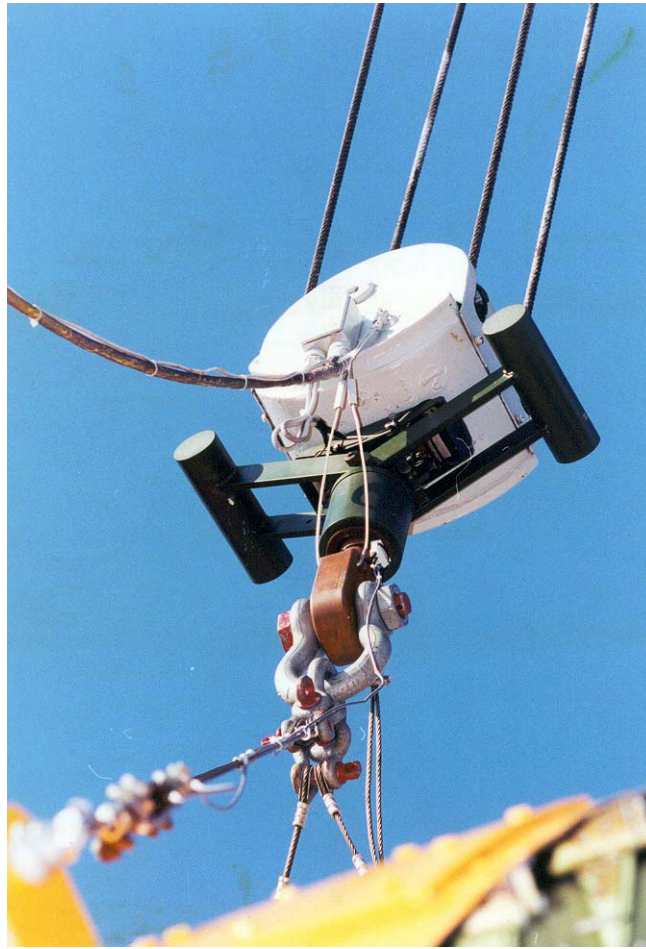


FIGURE C-11. RELEASE HOOK—CABLE/TURNBUCKLE ASSEMBLY

C.2 PRETEST PHOTOS—HITCO BIN



C-12. HITCO BIN—FRONT QUARTER



C-13. HITCO BIN—REAR QUARTER



FIGURE C-14. HITCO BIN—FRONT

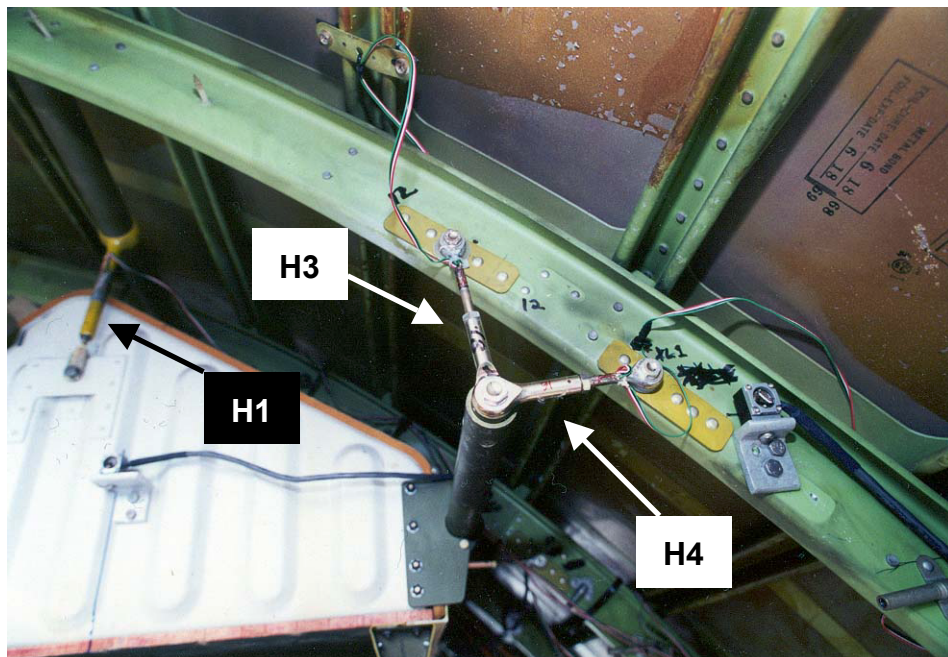


FIGURE C-15. HITCO BIN—LINKS H1, H3, AND H4

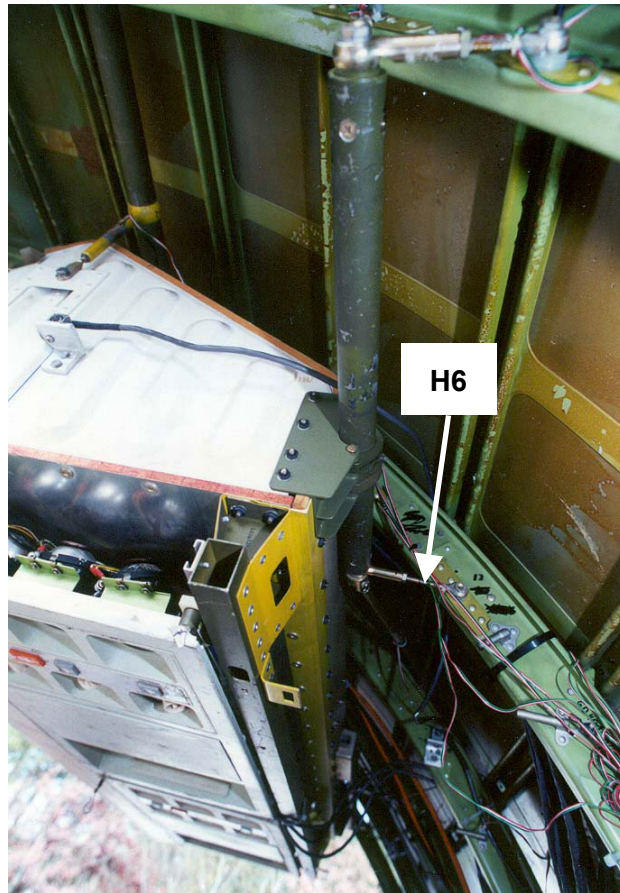


FIGURE C-16. HITCO BIN—LINK H6

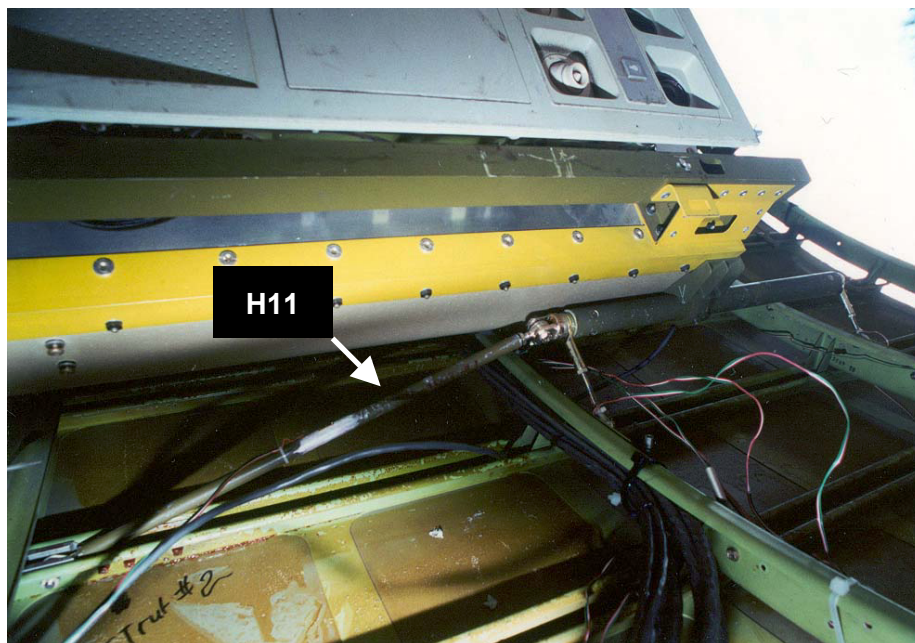


FIGURE C-17. HITCO BIN—LINK H11

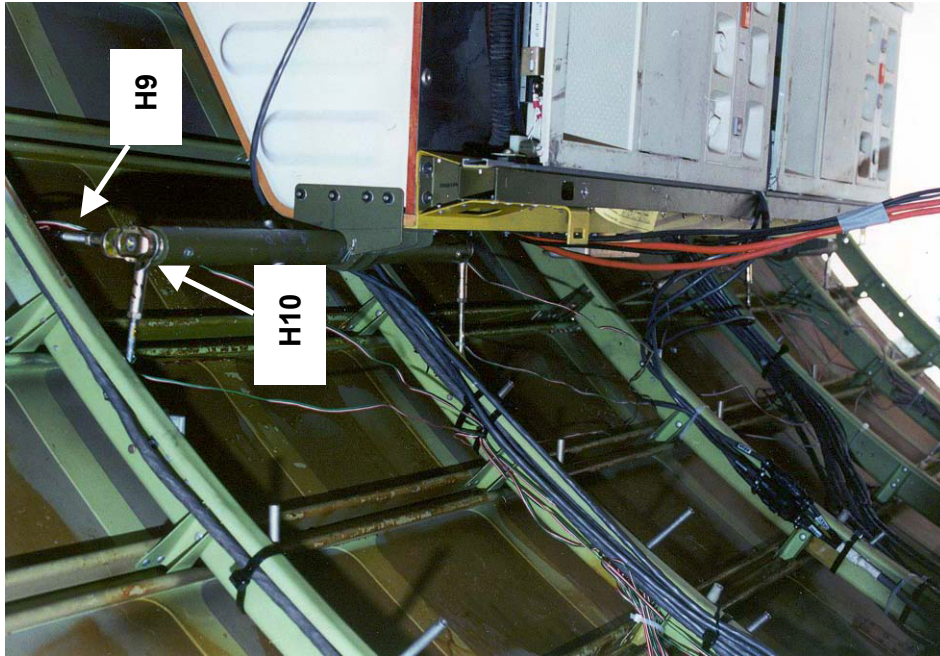


FIGURE C-19. HITCO BIN—LINKS H9 AND H10

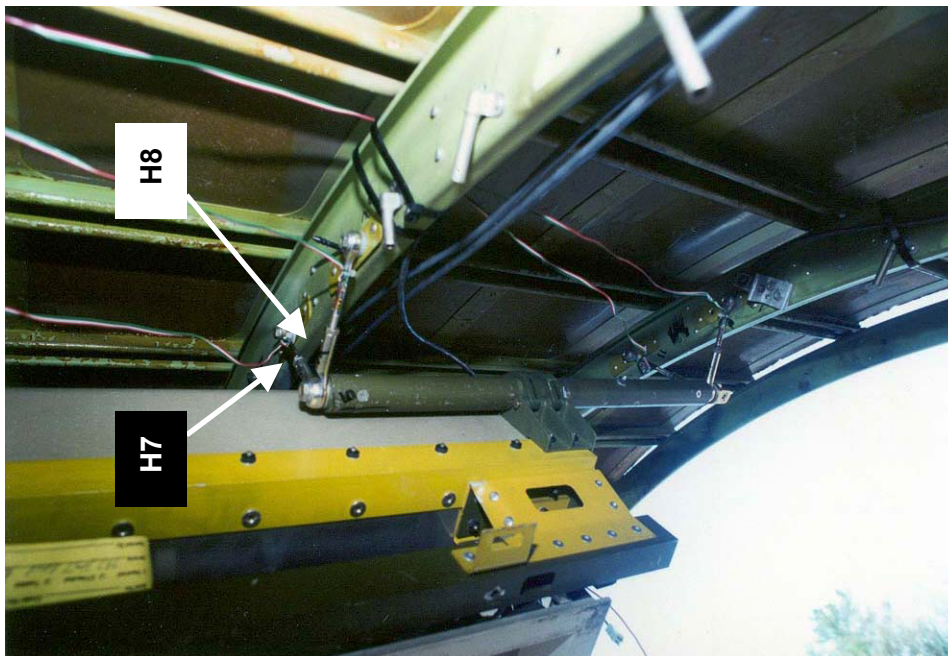


FIGURE C-18. HITCO BIN—LINKS H7 AND H8

C.3 PRETEST PHOTOS—HEATH TECNA BIN



FIGURE C-20. HEATH TECNA BIN



FIGURE C-21. HEATH TECNA BIN—FRONT QUARTER



FIGURE C-22. HEATH TECNA BIN—REAR QUARTER

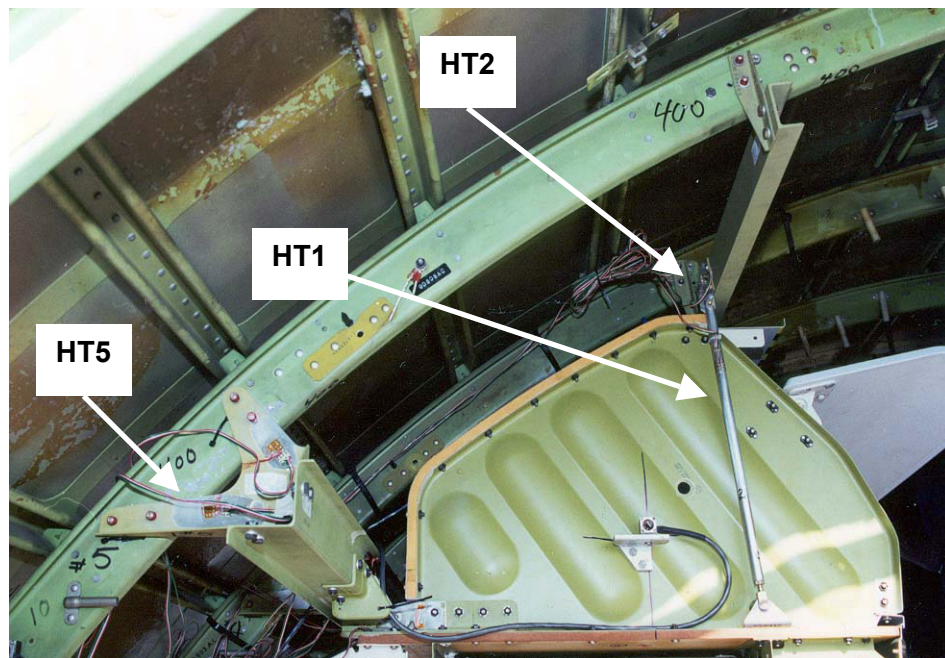


FIGURE C-23. HEATH TECNA BIN—SUPPORTS HT1, HT2, AND HT5

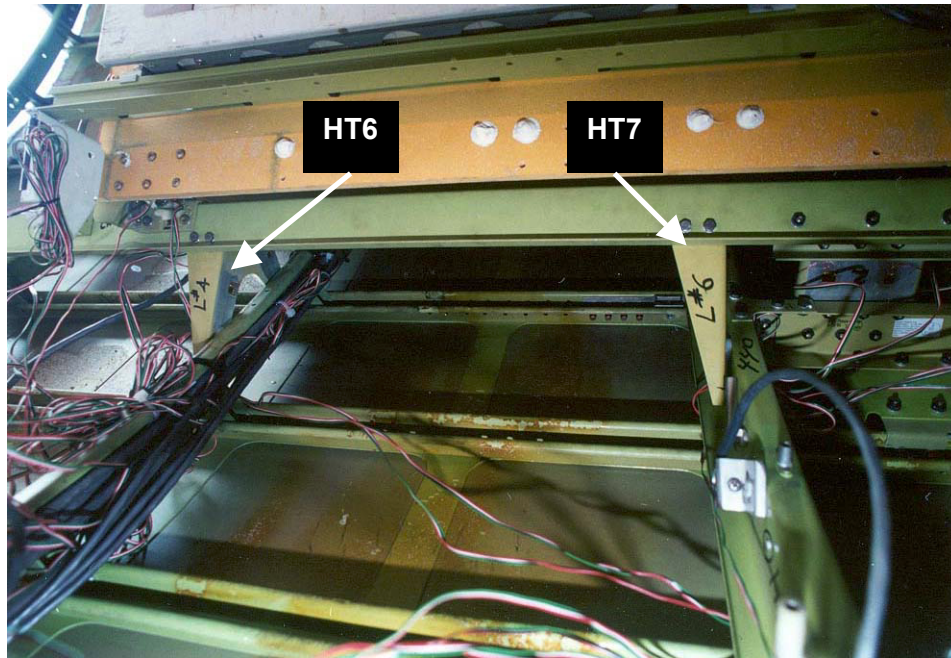


FIGURE C-24. HEATH TECNA BIN—SUPPORTS HT6 AND HT7

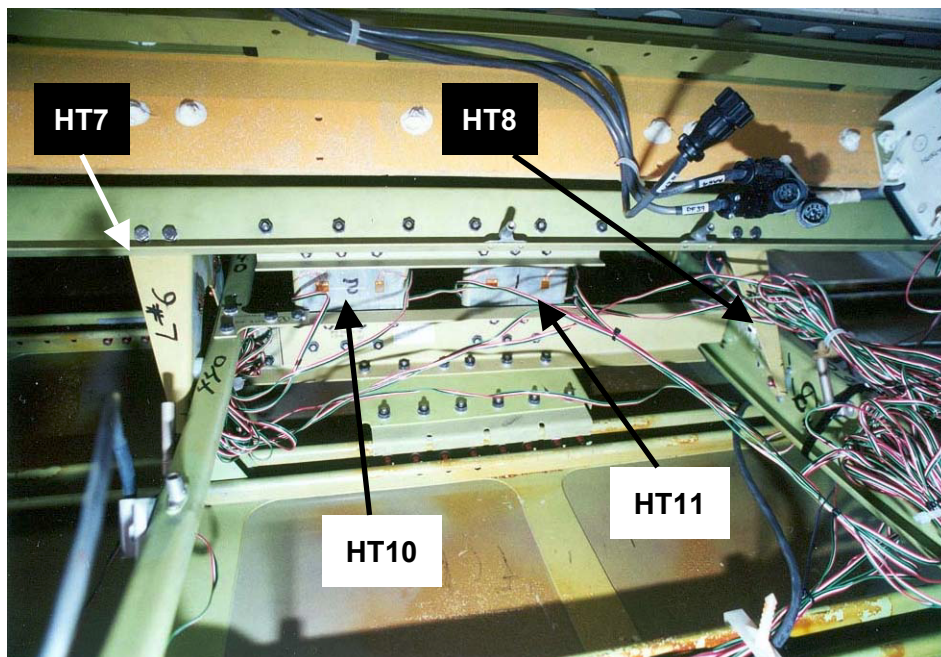


FIGURE C-25. HEATH TECNA BIN—SUPPORTS HT7, HT8, HT10, AND HT11

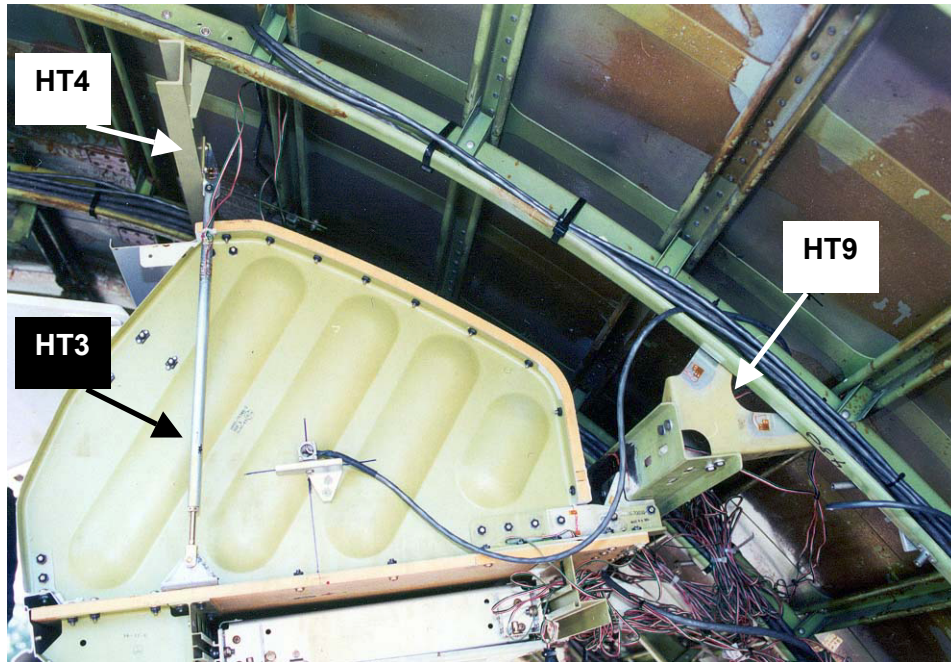


FIGURE C-26. HEATH TECNA BIN—SUPPORTS HT3, HT4, AND HT9

C.4 POSTTEST PHOTOS—TEST SECTION



FIGURE C-27. TEST SECTION—FRONT



FIGURE C-28. TEST SECTION—REAR



FIGURE C-29. PASSENGER CABIN—FRONT



FIGURE C-30. PASSENGER CABIN—REAR



FIGURE C-31. TEST SECTION—RIGHT FRONT QUARTER



FIGURE C-32. TEST SECTION—LEFT FRONT QUARTER

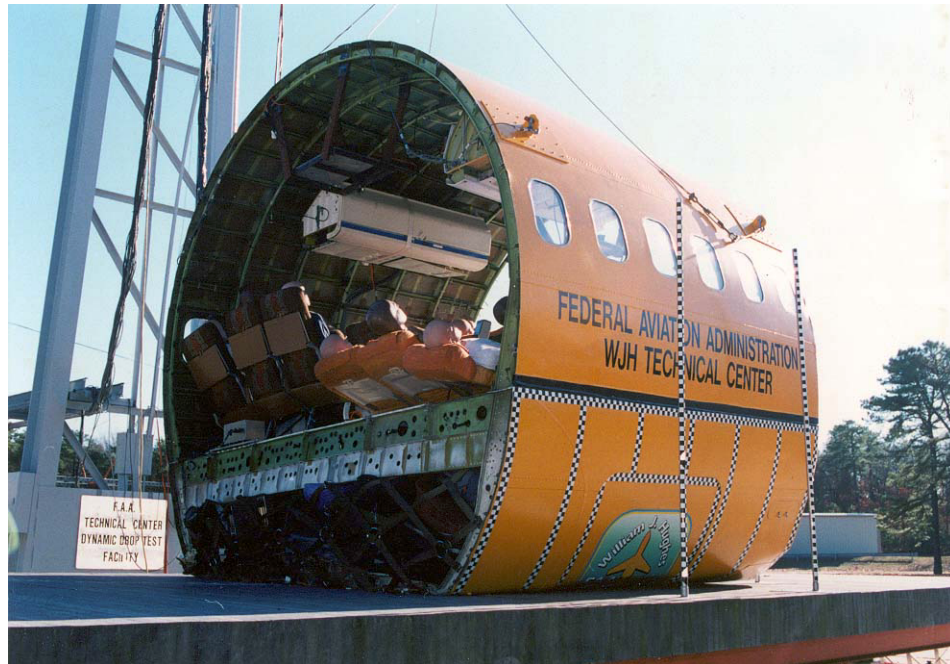


FIGURE C-33. TEST SECTION—RIGHT REAR QUARTER



FIGURE C-34. TEST SECTION—LEFT REAR QUARTER



FIGURE C-35. TEST SECTION—RIGHT SIDE



FIGURE C-36. TEST SECTION—LEFT SIDE

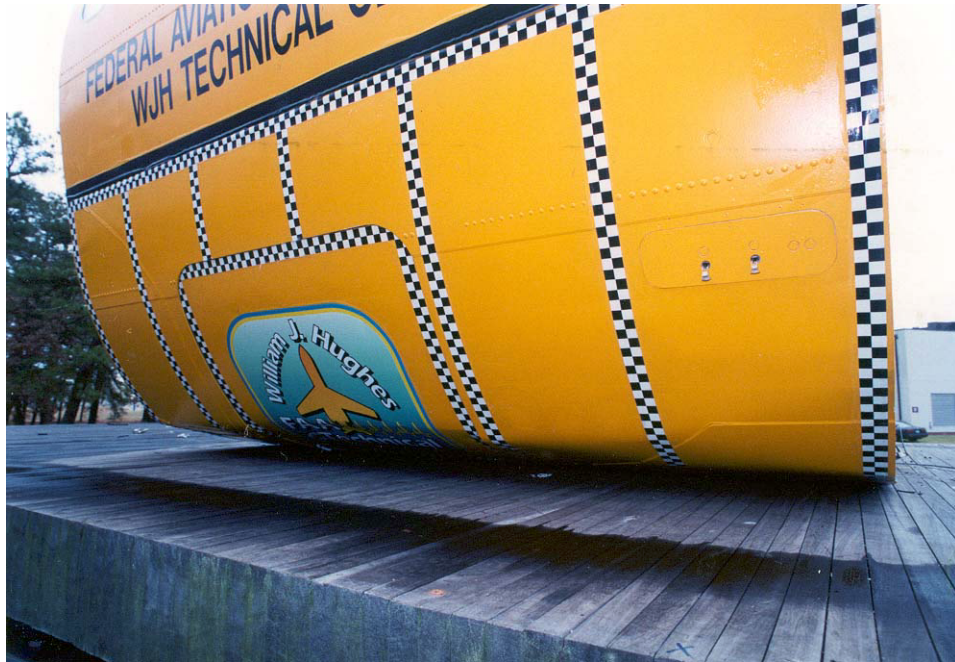


FIGURE C-37. TEST SECTION—LOWER RIGHT SIDE



FIGURE C-38. TEST SECTION—LOWER LEFT SIDE



FIGURE C-39. TEST SECTION—RIGHT BOTTOM



FIGURE C-40. TEST SECTION—LEFT BOTTOM



FIGURE C-41. TEST SECTION—FRONT, LIFTED

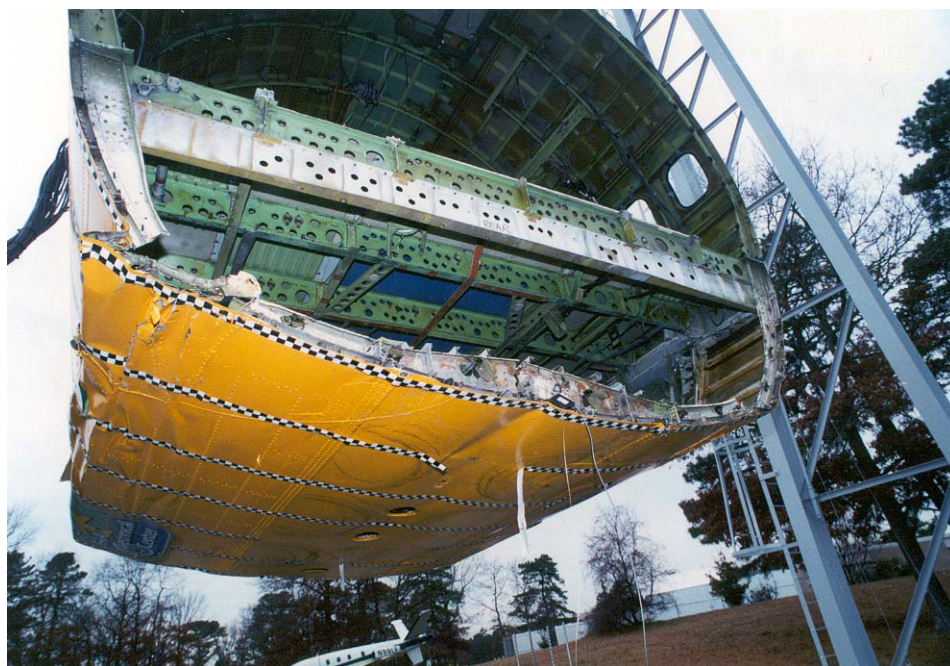


FIGURE C-42. TEST SECTION—REAR BOTTOM

C.5 POSTTEST PHOTOS—HITCO BIN

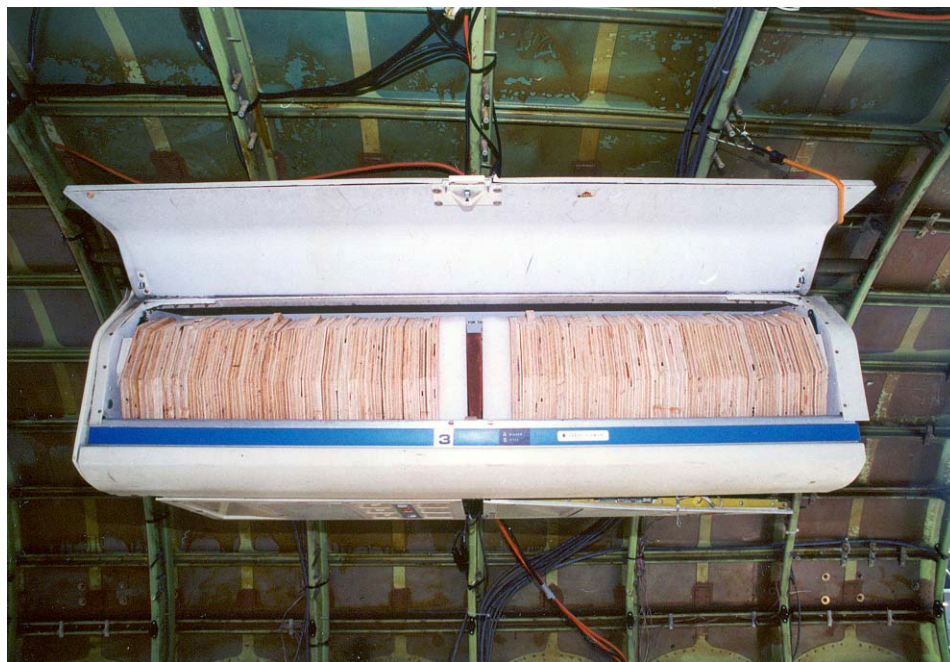


FIGURE C-43. HITCO BIN CONTENTS



FIGURE C-44. HITCO BIN—FRONT BOTTOM



FIGURE C-45. HITCO BIN—OPEN FRONT



FIGURE C-46. HITCO BIN—OPEN REAR

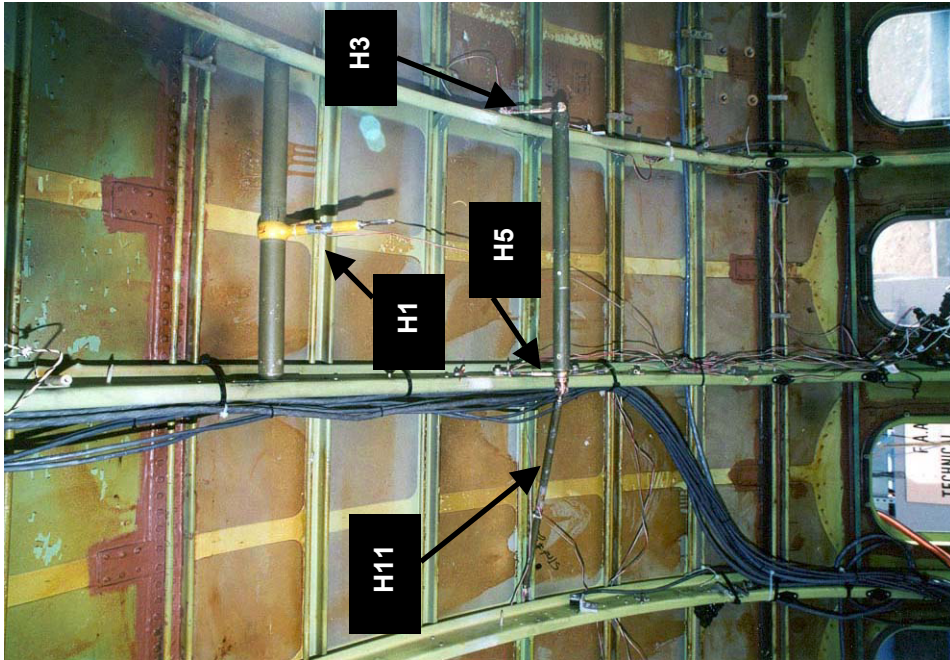


FIGURE C-47. HITCO BIN—FRONT LINKS

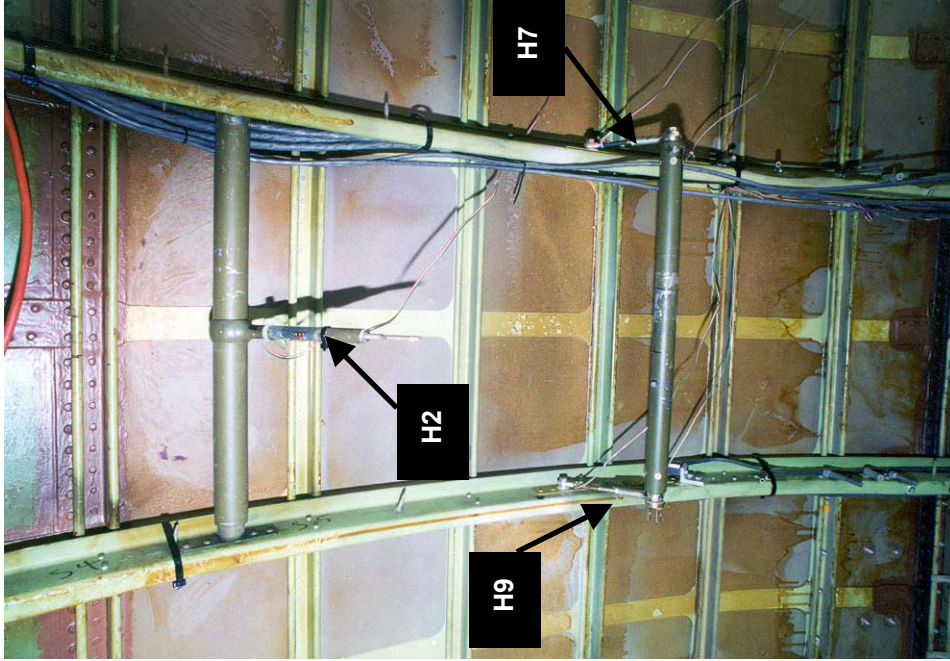


FIGURE C-48. HITCO BIN—REAR LINKS

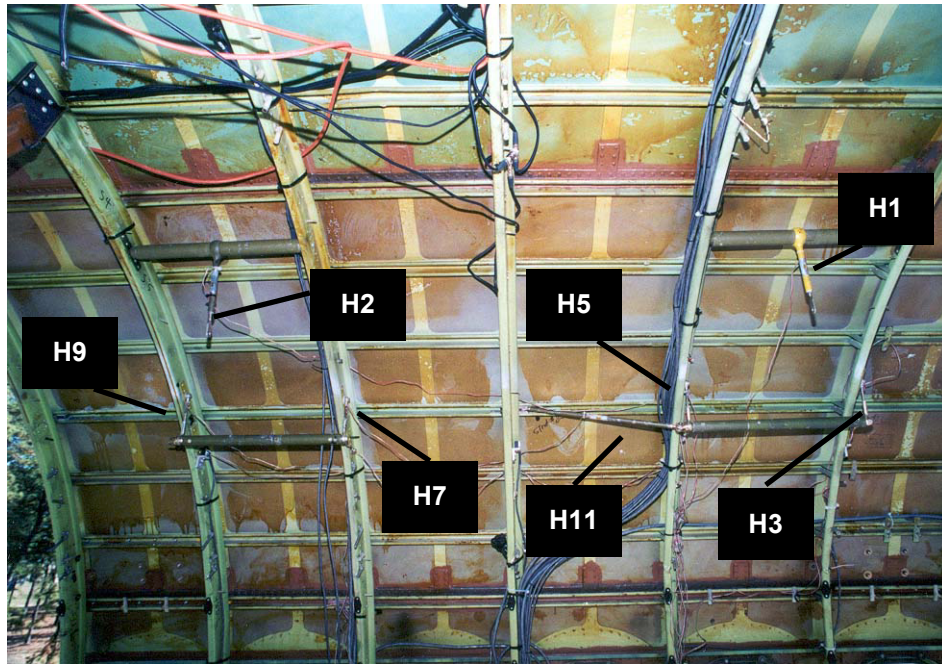


FIGURE C-49. HITCO BIN LINKS

C.6 POSTTEST PHOTOS—HEATH TECNA BIN



FIGURE C-50. HEATH TECNA BIN CONTENTS



FIGURE C-51. HEATH TECNA BIN—BOTTOM



FIGURE C-52. HEATH TECNA BIN—OPEN FRONT



FIGURE C-53. HEATH TECNA BIN—OPEN REAR



FIGURE C-54. HEATH TECNA BIN SUPPORTS

C.7 POSTTEST PHOTOS—FRAME SECTIONS

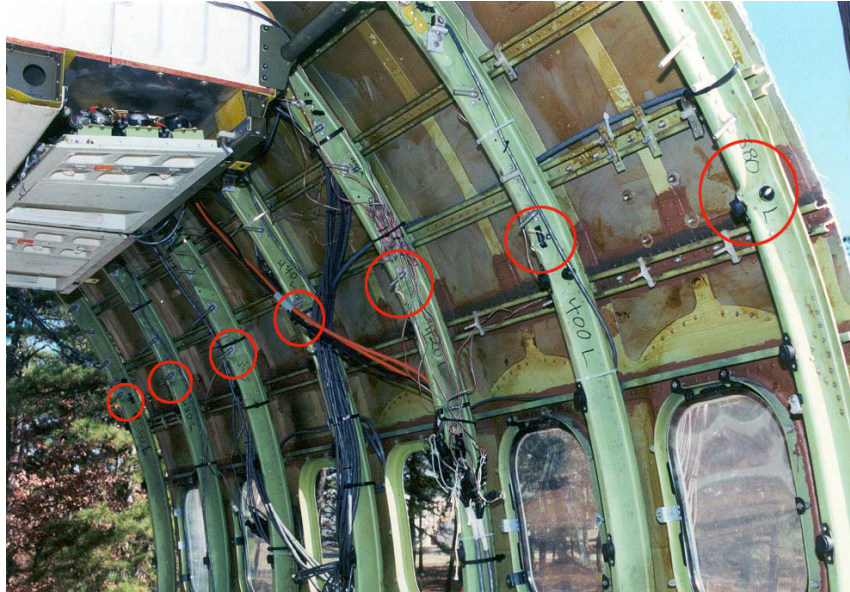


FIGURE C-55. CRACKED FRAME SECTIONS—LEFT SIDE



FIGURE C-56. FS 380—LEFT SIDE

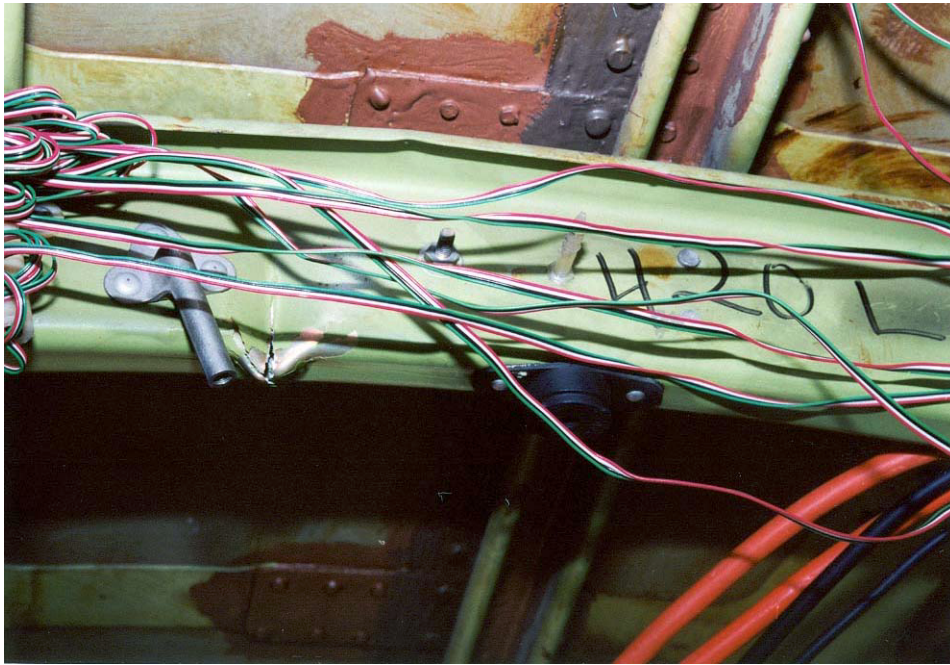


FIGURE C-58. FS 420—LEFT SIDE



FIGURE C-57. FS 400—LEFT SIDE



FIGURE C-60. FS 460—LEFT SIDE

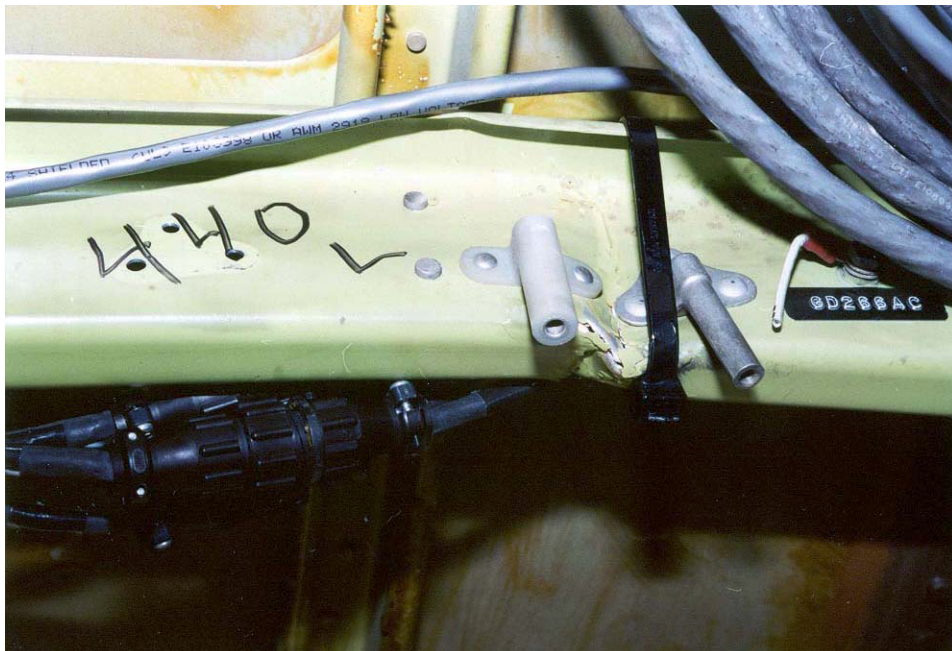


FIGURE C-59. FS 440—LEFT SIDE



FIGURE C-61. FS 480—LEFT SIDE



FIGURE C-62. FS 500—LEFT SIDE



FIGURE C-63. CRACKED FRAME SECTIONS—RIGHT SIDE



FIGURE C-64. FS 380—RIGHT SIDE



FIGURE C-65. FS 400—RIGHT SIDE



FIGURE C-66. FS 420—RIGHT SIDE

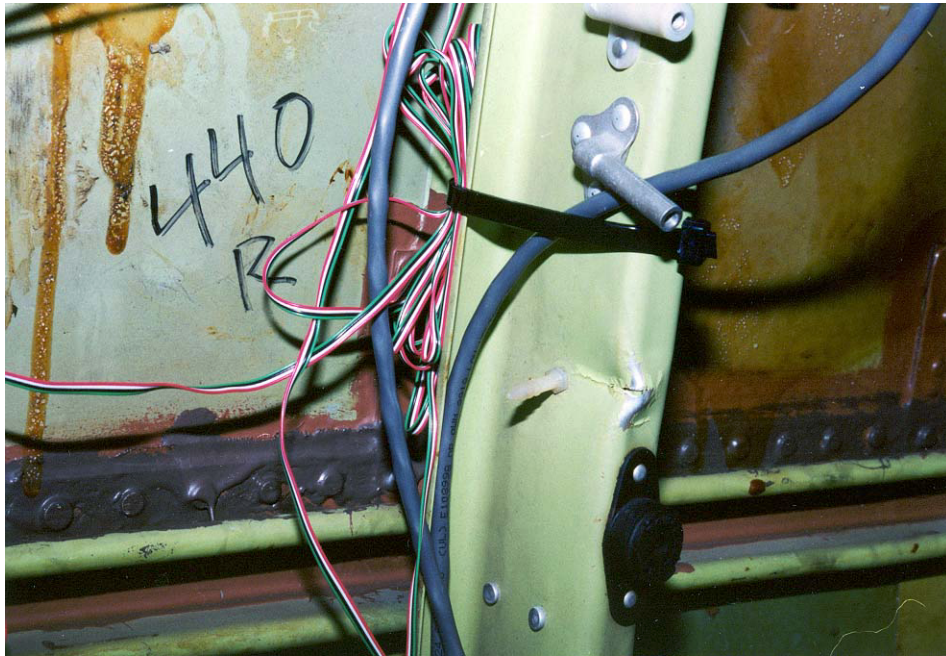


FIGURE C-67. FS 440—RIGHT SIDE



FIGURE C-68. FS 460—RIGHT SIDE



FIGURE C-69. FS 480—RIGHT SIDE



FIGURE C-70. FS 500—RIGHT SIDE

C.8 POSTTEST PHOTOS—CARGO AREA



FIGURE C-71. CARGO CABIN FLOOR BUCKLE—FRONT



FIGURE C-72. CARGO CABIN FLOOR BUCKLE—REAR



FIGURE C-73. CARGO AREA—LOOKING FORWARD

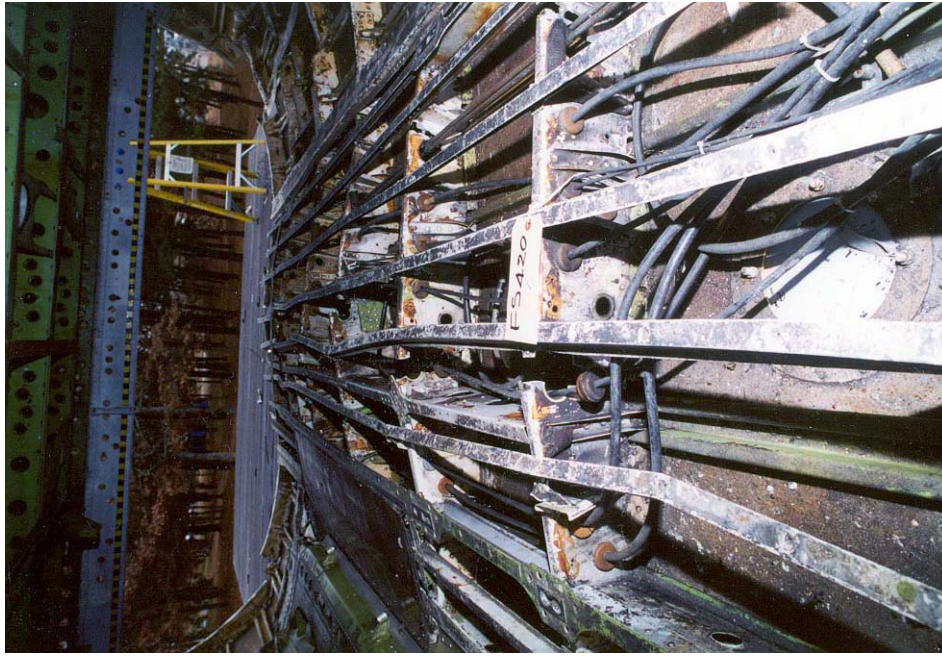


FIGURE C-74. CARGO AREA—LOOKING AFT



FIGURE C-75. CARGO AREA—LEFT SIDE



FIGURE C-76. CARGO AREA—LEFT SIDE CLOSE-UP

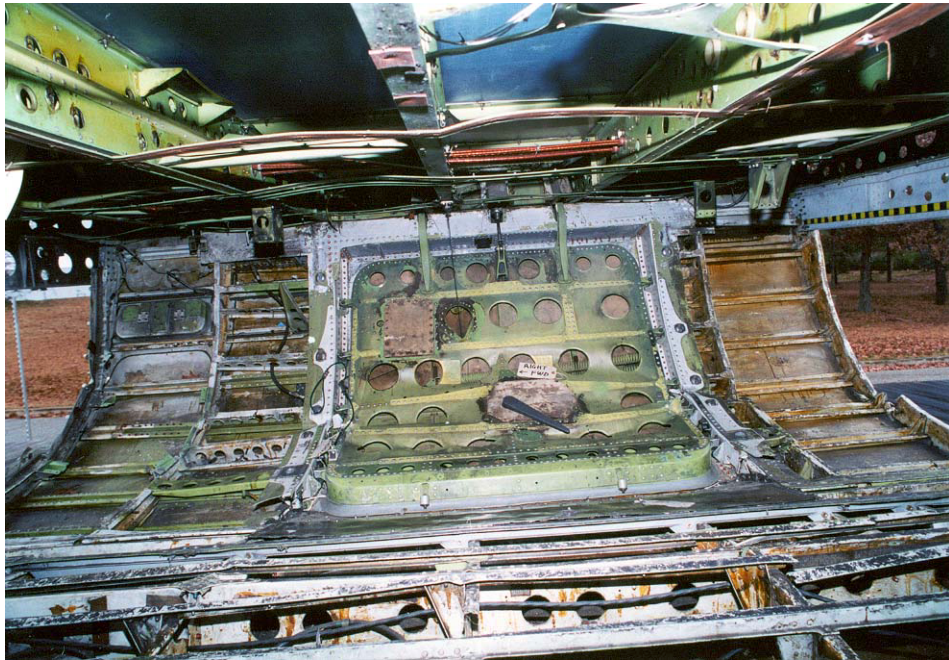


FIGURE C-77. CARGO AREA—RIGHT SIDE



FIGURE C-78. CARGO DOOR—RIGHT FRONT

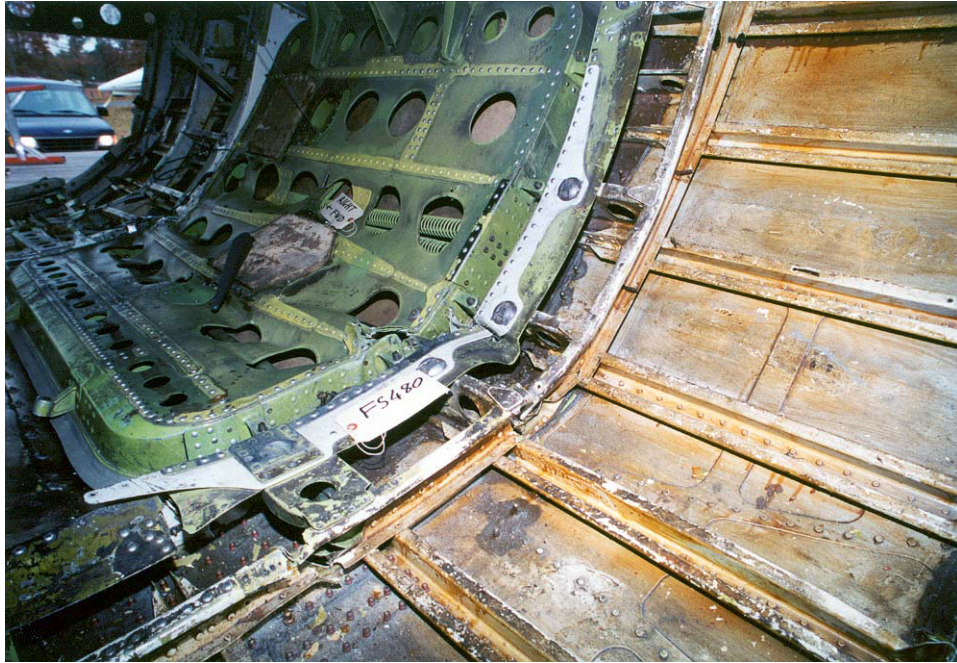


FIGURE C-79. CARGO DOOR—RIGHT REAR

C.9 POSTTEST PHOTOS—SEATS



FIGURE C-80. ROW 1, WEBER SEAT, DUMMIES—LEFT SIDE



FIGURE C-81. ROW 2, WEBER SEAT, DUMMIES—LEFT SIDE



FIGURE C-82. ROW 3, WEBER SEAT, DUMMIES—LEFT SIDE



FIGURE C-83. ROW 1, WEBER SEAT—LEFT SIDE



FIGURE C-84. ROW 2, WEBER SEAT—LEFT SIDE



FIGURE C-85. ROW 3, WEBER SEAT—LEFT SIDE



FIGURE C-86. ROW 1, WEBER SEAT—BOTTOM

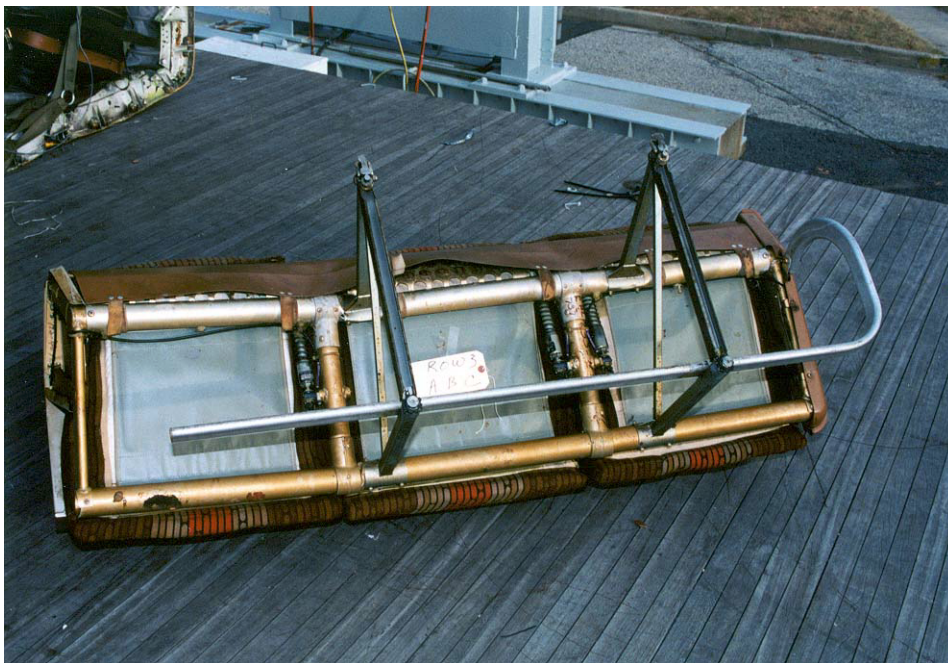


FIGURE C-87. ROW 2, WEBER SEAT—BOTTOM



FIGURE C-88. ROW 3, WEBER SEAT—BOTTOM



FIGURE C-89. ROW 1, UOP SEAT, DUMMIES—RIGHT SIDE



FIGURE C-90. ROW 2, UOP SEAT, DUMMIES—RIGHT SIDE



FIGURE C-91. ROW 3, UOP SEAT, DUMMIES—RIGHT SIDE



FIGURE C-92. ROW 1, UOP SEAT—RIGHT SIDE



FIGURE C-93. ROW 2, UOP SEAT—RIGHT SIDE



FIGURE C-94. ROW 3, UOP SEAT—RIGHT SIDE

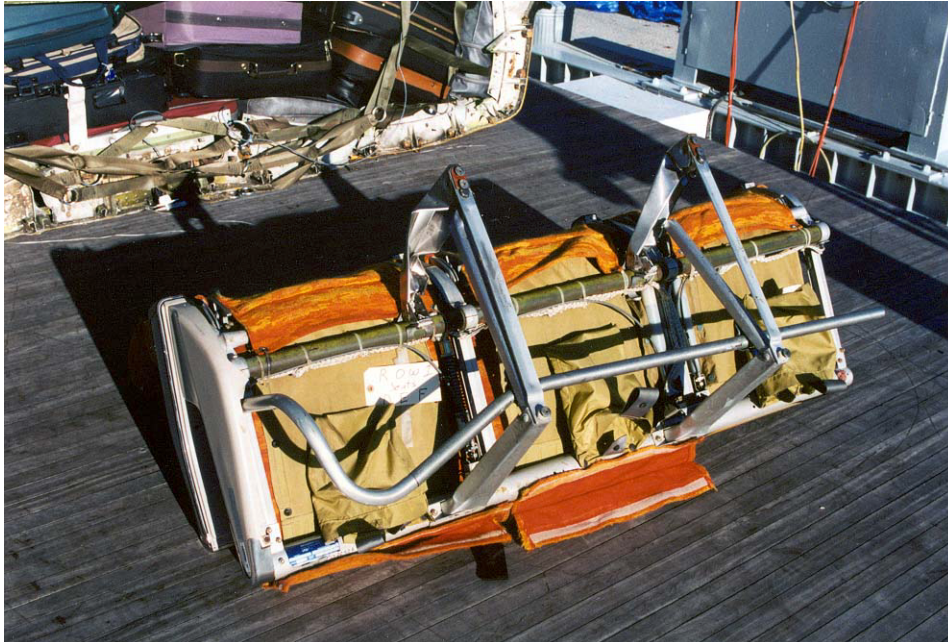


FIGURE C-95. ROW 1, UOP SEAT—BOTTOM



FIGURE C-96. ROW 2, UOP SEAT—BOTTOM



FIGURE C-97. ROW 3, UOP SEAT—BOTTOM