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**CRASHWORTHY GUNNER SEAT TESTING PROGRAM**

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March 1977

Final Report for Period May 1975 - December 1977

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APPLIED TECHNOLOGY LABORATORY  
U. S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES (AVRADCOM)  
Fort Eustis, Va. 23604

## APPLIED TECHNOLOGY LABORATORY POSITION STATEMENT

This report was prepared by the Boeing Vertol Company, a division of the Boeing Company, under the terms of Contract DAAJ02-75-C-0032. The objective of this effort was to demonstrate the validity and practicality of a proposed draft military specification for crashworthy helicopter gunner's seats. Swivelling and fixed side-facing gunner's seats designed and mocked-up under previous contracts were fabricated and statically and dynamically tested. While the proposed draft military specification contained in this report has yet to be coordinated, finalized, and published, once implemented it will ensure that occupants of gunner's seats in future Army troop transport helicopters will be afforded a higher probability of survival during a crash impact.

This report has been reviewed by this Laboratory and is considered to be technically sound. The technical manager for this program was Mr. William J. Nolan, Safety and Survivability Technical Area, Military Operations Technology Division.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A crashworthy gunner seat swivel concept developed under a previous contract was refined and detail drawings were made. Six seats were fabricated, four for static testing and two for dynamic testing. Modifications were made after the first four static tests. Additional static tests were successfully performed on two of the modified seats. A vertical drop test and a horizontal dynamic test were performed on the remaining two modified		

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seats. The vertical test was successful but the horizontal test resulted in failure due to the seat not automatically rotating to a forward-facing position.

Five seats were refurbished and modified to eliminate the deficiencies found in testing and to convert four seats to a fixed side-facing configuration. The swivel seat was dynamically tested in the horizontal plane with the seat facing 30 degrees to the direction of impact. The test results were successful and the dummy accelerations were reduced to well within human tolerance limits.

A fixed side-facing seat was successfully static tested under a simulated forward crash loading. Horizontal dynamic tests were successfully performed on two seats, one oriented 90 degrees to the impact direction and the other oriented 60 degrees to impact. The fourth seat was successfully tested on the drop tower.

Both types of seats tested have advantages as well as disadvantages. The swivel seat can place the side-facing gunner in a forward direction, the direction where the occupant has a high tolerance to longitudinal impact forces. However, the seat must be physically rotated to this position. The fixed side-facing seat requires no repositioning; however, the human tolerance in a lateral direction is low and the recorded accelerations were at or above the assumed lateral human tolerance limits. More work is necessary to determine actual lateral limits.

Recommended changes to the draft gunner seat military specification and to the Crash Survival Design Guide (USAAMRD-TR-71-22) are presented.

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## INTRODUCTION

### BACKGROUND

The poor crash/impact performance of seats designed to current military specifications was revealed by the U.S. Army in the early 1960's. It was discovered that numerous seat occupants were being injured during moderate impacts because of inadequate upper torso restraint, inadequate seat strength, absence of any meaningful vertical crash/force attenuation, and inadequate testing criteria. Following extensive design and testing efforts, improved crashworthiness design and testing criteria were developed for Army aircraft seating systems. However, due to priorities, primary emphasis was placed on developing improved pilot/copilot seats. A program was needed to develop designs, design criteria, and testing criteria for seats occupied by gunners manning window, pintle-mounted weapons in Army helicopters. In addition to being crashworthy, all designs and criteria must be operationally suitable and economically feasible. The necessity for such criteria and designs is punctuated by the fact that Army aircraft, presently in use, do not have seats designed for gunners operating pintle-mounted machine-guns.

An investigation was made, under U.S. Army Air Mobility Research and Development Laboratory\* Contract DAAJ02-73-C-0021, "Crashworthy Helicopter Gunner's Seat Investigation", to determine the proper mix of all gunner seat design parameters; that is, weight, cost, human factors, operational constraints, ballistic protection, etc. The most effective mix of parametric design criteria was established not only for unarmored seats, but also for integral-armor and modular-armor seats. Data attained through literature surveys and visits to Government, technical, and operational agencies led to an understanding of overall requirements so that trade-offs could be made to balance the operational simplicity requirements with the requirements for crashworthiness. A number of seat concepts and restraint system designs were configured and evaluated. A selection was made, and a mockup seat was designed and built for human factors evaluation, using gunners with various clothing and equipment. These evaluations permitted the formulation of a draft military specification for crashworthy gunner's seat systems.

\*Redesignated Applied Technology Laboratory, U.S. Army Research and Technology Laboratories (AVRADCOM), 1 September 1977.

The selected concept was a swivel seat which attached to the ceiling and floor by swivel rings. This concept was selected because of the many side-facing seat concepts tested to date, none had withstood the required forward impact loading. In addition, human tolerance to lateral acceleration is less than half the tolerable acceleration in a forward direction.

The swivel seat concept was intended to permit the gunner to position the seat in a forward-facing position during take-off and landing and during an in-flight emergency. Normal flight operations would be performed with the seat swiveled to a side-facing position. Dentents would maintain the seat in the desired position. If a crash occurred with the seat in a side-facing position, it is desirable that the seat automatically swivel and face the direction of impact. This development is discussed in USAAMRDL Report TR-74-98 (Reference 1).

A follow-on contract was awarded by USAAMRDL to design and test a crashworthy swivel gunner seat similar to that mocked-up under the previous contract and is the subject of this report.

#### PROGRAM OBJECTIVES

The principal objectives of the crashworthy helicopter gunner's seat testing program are:

- To perform an analysis of the swivel gunner's seat mocked up under the previous contract, and to prepare detailed design drawings.
- To fabricate seats and perform static tests to determine seat rotational capability, stability, stroking, and integrity under loading.
- To perform dynamic tests to determine seat function and strength under crash impulse conditions.
- To determine seat's capability to attenuate crash impulse to tolerable levels on the dummy occupant.
- To substantiate or revise the draft Military Specification; Seat, Helicopter, Gunner.

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<sup>1</sup>Reilly, M.J., CRASHWORTHY HELICOPTER GUNNER'S SEAT INVESTIGATION, Boeing Vertol Company, Philadelphia, Pennsylvania, USAAMRDL Technical Report 74-98, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, January 1975, AD A005563.

## SCOPE

The crashworthy helicopter gunner's seat testing program was divided into the following tasks:

Task I - System analysis and detail design

Task II - Fabrication, static testing and analysis

Task III - Dynamic testing, analysis, and documentation.

Task IV - Fixed side facing seat development (added by contract modification).

## CRASHWORTHY GUNNER SEAT TESTING - TASK I

### TASK I REQUIREMENTS

The required Task I effort was as follows:

1. Review the data, from Contract DAAJ02-73-C-0021, that is applicable to the design of a side-facing swivel gunner seat.
2. Design a restraint system based on the systems evaluated under the above contract.
3. Prepare detailed designs of a side-facing swivel gunner seat similar to that mocked-up under the above contract.

### DATA REVIEW

In reviewing the previous contract, it was determined that the swivel gunner's seat mocked up and demonstrated in a UTTAS aircraft mock-up was suitable for the development of detailed designs (Figure 1). The swivel ring feature, with the center of rotation behind the centerline of the seat, would be maintained to induce automatic rotation of the seat from a side to a forward-facing position, during forward impacts. The diagonal strut energy attenuators would be oriented toward the front of the seat on the mock-up seat. An attenuator adequate for the high forward impact loads would be designed for the seat when rotated to a forward-facing position. The energy attenuating cables, capable of relatively short stroking, would be maintained as lateral stabilizing braces and would also serve to provide attenuation during the transition of the seat from a side-facing to a forward-facing position during forward impacts. Transition functioning is to be verified during static and dynamic testing.

The restraint system configurations demonstrated in the first and second mock-up reviews were not satisfactory as configured. The first configuration consisted of a single reel for the inverted Y double shoulder straps and a lapbelt which was integral with a waist band. Inertia reels attached the lapbelt to each side of the seat (Reference 1). The second configuration consisted of double shoulder straps, each with an independent inertia reel and a conventional lapbelt. Inertia reels attached the lapbelt to each side of the seat. A thigh strap attached to one-half of the lap belt was looped under the thigh and hooked to the bottom of the lapbelt buckle.



Figure 1. Swivel gunner seat mock-up.

The first configuration was difficult to put on and would ride up on the gunner while he was operating the gun. The second configuration's shoulder straps tended to slip off the gunner's shoulders as he moved from side to side during azimuth gunnery operations. Restraint system improvements were determined to be necessary by the review.

#### RESTRAINT SYSTEM DESIGN

A suitable restraint system design, which would provide crash-worthy restraint for the gunner during a crash and which would also permit the gunner to stand to operate the gun, would be a composite of the acceptable features of the two systems reviewed. The inverted Y shoulder strap arrangement with a single inertia reel can be used to prevent the straps from slipping off the shoulders during gunnery operations. The conventional lapbelt with thigh strap attachment would be easy to put on and would prevent the lapbelt from riding up during operation of the gun.

#### SWIVEL SEAT DESIGN

The basic seat concept, mocked up during USAAMRDL Contract DAAJ02-73-C-0021, was used by Boeing for installation in a UTTAS contender aircraft. Detailed designs were made of the concept without the swivel features and adapted for a fixed, side-facing installation. The seat back and seat pan frame drawings and the fabric drawing were adaptable for use on the swivel seat. A new energy attenuation system was designed, and the seat pan drawing was modified for attachment of the system. Swivel rings and turntables were designed for attaching the seat to the floor and ceiling (Figure 2).

The seat design consists of a tubular seat pan frame and a tubular back frame covered with polyester fabric. A pocket in the back cover accommodates a troop combat pack. Webbing straps, attached to the top of the seat back, support the seat pan by attachments located on the seat pan 5 inches from the rear of the seat. This provides a cantilevered seat pan of sufficient unobstructed depth to permit lateral movement in the seat for gunnery operations.

Wire-bending energy attenuators are located at the top of the two vertical seat back tubes. Rollers are installed inside the flattened tube ends, and the wires extend down inside the tubes. The wire is looped through a turnbuckle eye and the turnbuckle, used for tensioning the seat, is attached to a swivel trolley on the ring track at the ceiling.

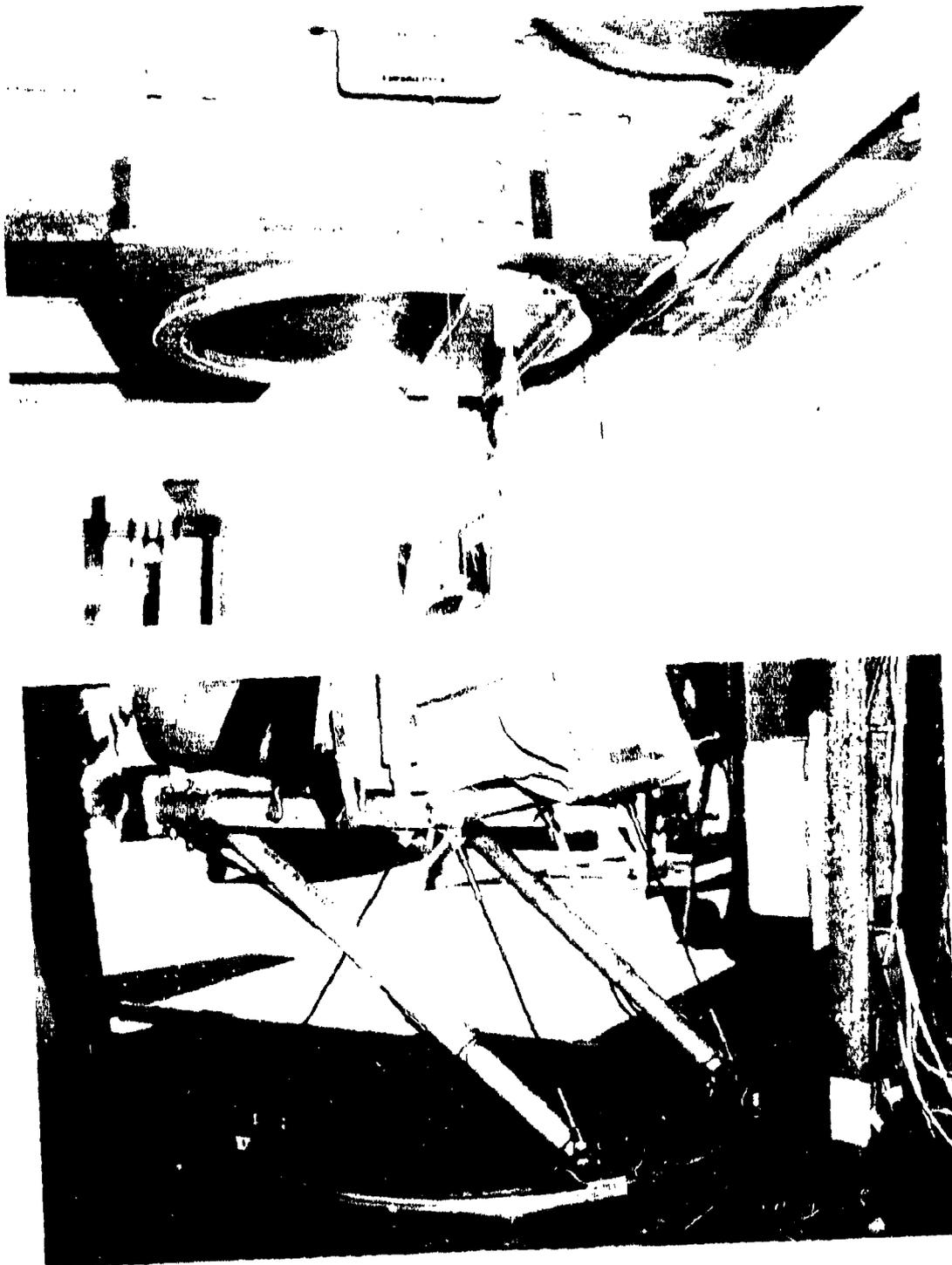


Figure 2. Ceiling and floor swivel rings.

A ring track is bolted to the floor and swivel carriage with guides and rollers swivels on the ring. Attachment is made between the carriage and seat with two diagonal strut energy attenuators attached to the front of the seat. Diagonal cables, between the seat and the carriage, provide stabilization.

The diagonal struts are telescoping tube energy attenuators with wire-bending energy-absorbing elements. A cap is placed on the inner end of the inner tube. Music wire of 0.100 inch diameter, in the shape of a hairpin, is looped through the cap, and the two free ends are secured to a stud in the outer end of the inner tube. A trolley consisting of three rollers sandwiched between two plates bends the wire as it moves back and forth on the wire. The trolley is pinned to the outer tube, and a slot is provided in the inner tube to allow the trolley to move relative to the inner tube (Figure 3).

#### TASK I SUMMARY

Review of the work performed under USAAMRDL Contract DAAJ02-73-C-0021 verified that the selection of a swivel seat concept was the more favorable approach. A swivel seat permitted the gunner to position himself in a forward or rearward facing position during takeoff and landing and during an impending crash emergency. These orientations placed the gunner in positions where a forward crash pulse could be tolerated that was twice the magnitude of that which can be tolerated laterally on the occupant. The inability of previously tested side-facing seats to withstand the forward crash impact requirements also influenced the selection of a swivel seat concept.

The swivel seat concept, mocked up under the previous contract, would be used and some of the gunner seat detail drawings prepared for a UTTAS aircraft, under another Army contract, would be adapted to the swivel seat design. A restraint system with an inverted Y shoulder strap and a conventional lapbelt would be used. The shoulder strap and lapbelt were fixed to the seat rather than using inertia reels or retractors because compact reels meeting the 6000 lb load requirement were not available.

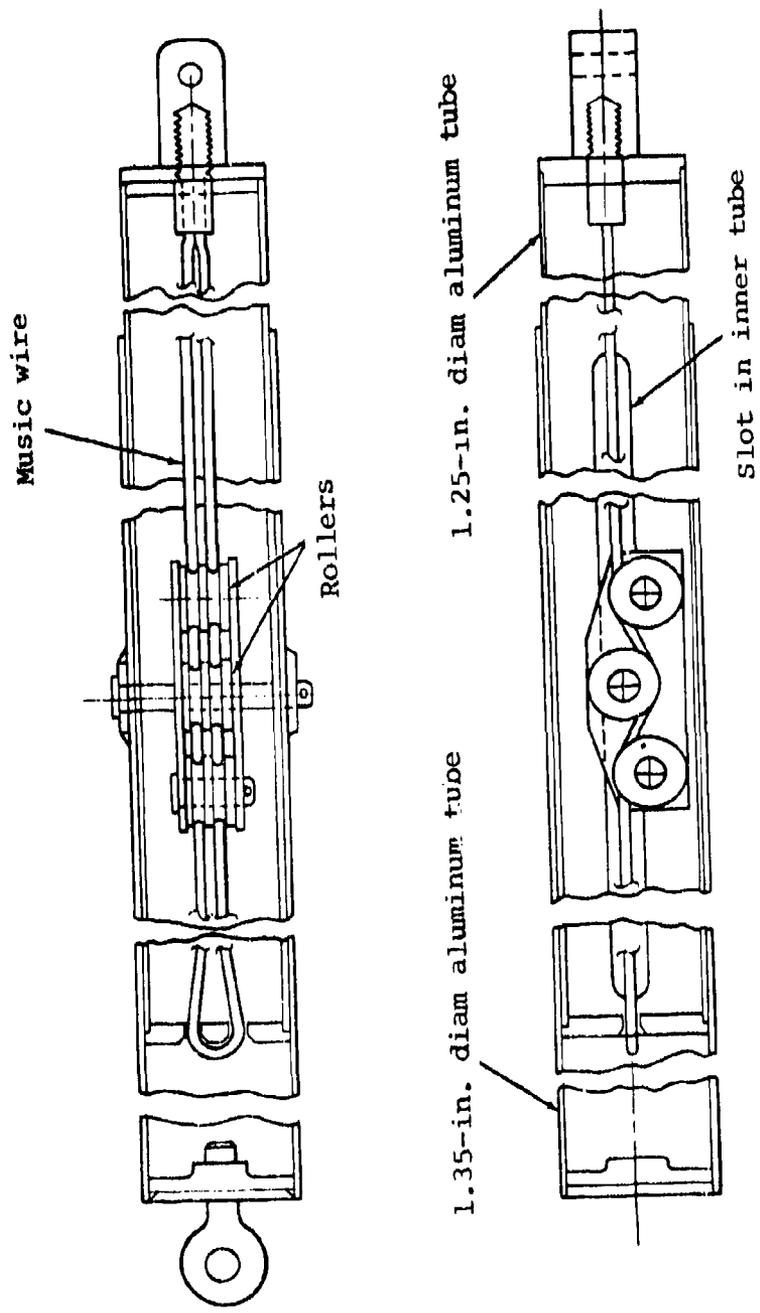


Figure 3. Wire-bending tension/compression energy attenuator.

## CRASHWORTHY GUNNER SEAT TESTING - TASK II

### TASK II REQUIREMENTS

Static tests were accomplished during the Task II phase. The required effort under Task II was as follows:

- The fabrication and assembly of swiveling gunner seat systems in accordance with the approved detailed design developed in Task I.
- The preparation of seat system and test fixtures to perform static testing in accordance with the approved static test plan (Appendix A).
- The performance of static tests on seat systems in accordance with the approved static test plan.
- The analysis of data obtained in static tests and verification of the capability of the seat systems tested to meet the static performance criteria contained in the draft Military Specification; Seat, Helicopter, Gunner.
- The performance of detailed redesign of those seat system components that fail to meet the static test requirements.
- The performance of additional static tests for those conditions in which the test objectives were not met.
- The preparation of a test plan for dynamic testing the gunner seat system in accordance with the draft Military Specification; Seat, Helicopter, Gunner.

### FABRICATION OF SEAT SYSTEMS

Six seats were fabricated during this phase of the test program. Four seats were for static testing and two seats were for dynamic testing.

### STATIC TEST PREPARATION

A test fixture was designed and fabricated to support the seat test specimens as they would be supported in the aircraft (Figure 4). The fixture was designed to support the seat under test load application without deflecting. Provisions were made for bolting the swivel ring tracks to a simulated floor and ceiling.

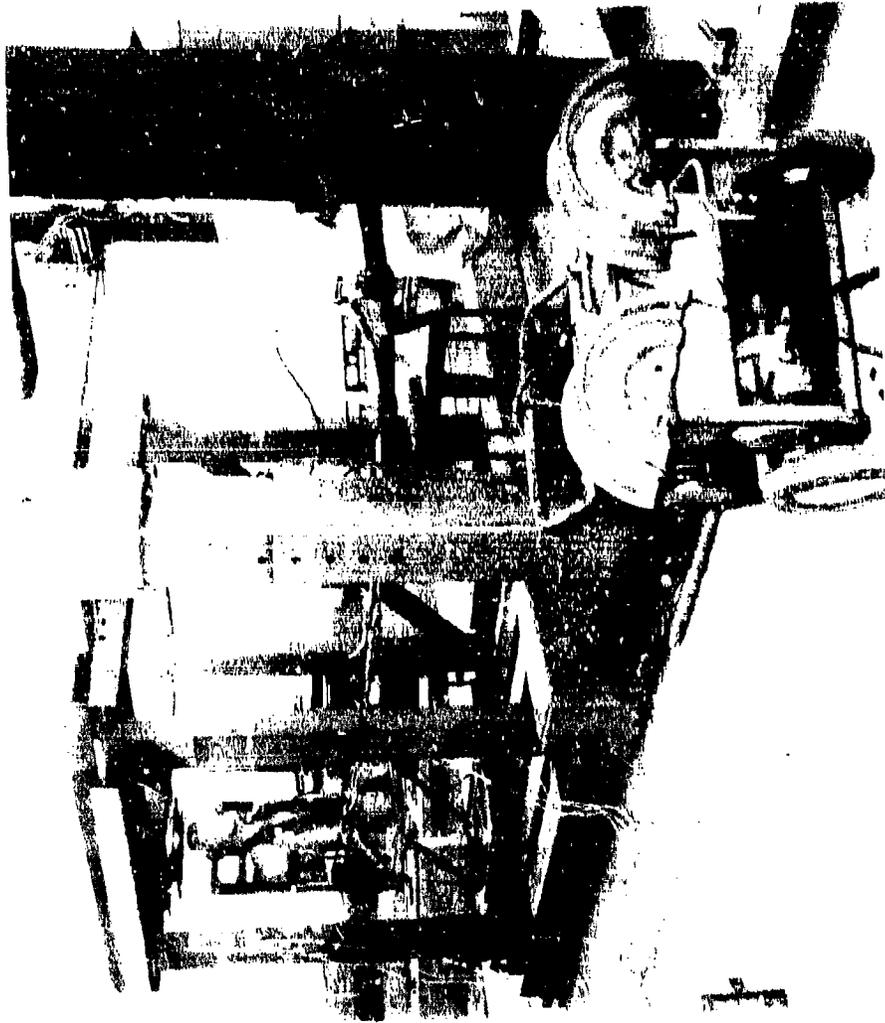


Figure 4. Static test fixture.

The test fixture was designed to be adaptable to orient the test specimens for the various angles of impact force application. Force application angles were varied by horizontal rotation of the fixture, by tilting the fixture, or by a combination of both.

#### STATIC TEST REQUIREMENTS

Static tests were required to simulate impact forces for four impact attitudes. Tests were to be conducted for vertical loading, forward loading, lateral loading, and a combined loading condition of forward, vertical and lateral components. Testing was to be conducted in accordance with the approved static test plan (Appendix A).

#### STATIC TESTS AND DATA ANALYSIS

Six static tests were performed using four seats. Four tests were performed, and two retests were necessary due to component failures.

##### Static Test 1 - Vertical Loading

The seat was installed in the test fixture in a vertical attitude, then the entire test fixture was rotated 90 degrees onto its back (Figure 5). The fixture was placed in this position to facilitate direct load application, rather than employing a system of pulleys.

An aluminum body block was installed in the seat and restrained by a four-point lapbelt shoulder harness system (Figure 5). Seat loading was accomplished by attaching a cable between the body block and a hydraulic cylinder. The cable was attached to a fitting on the body block at the representative center of gravity of a 95th percentile occupant. The hydraulic cylinder was attached to a trolley that was used to minimize the load application angle change as the seat stroked vertically (Figure 4). A minimum load of 15 G was to be applied.

Loading was applied gradually to the body block by the hydraulic cylinder. Force versus deflection was recorded by the instrumentation. The energy attenuators attaching the seat to the track at the ceiling stroked until the seat pan reached the floor (Figure 6). Loading was stopped at this time. Force on the upper attenuators was measured by strain gages attached to the turnbuckle (Figure 7).

Examination of the seat after the test revealed no failures or structural deformation. However, excessive elongation of the seat pan support strap caused the front of the seat to contact the floor before the full stroking potential of the

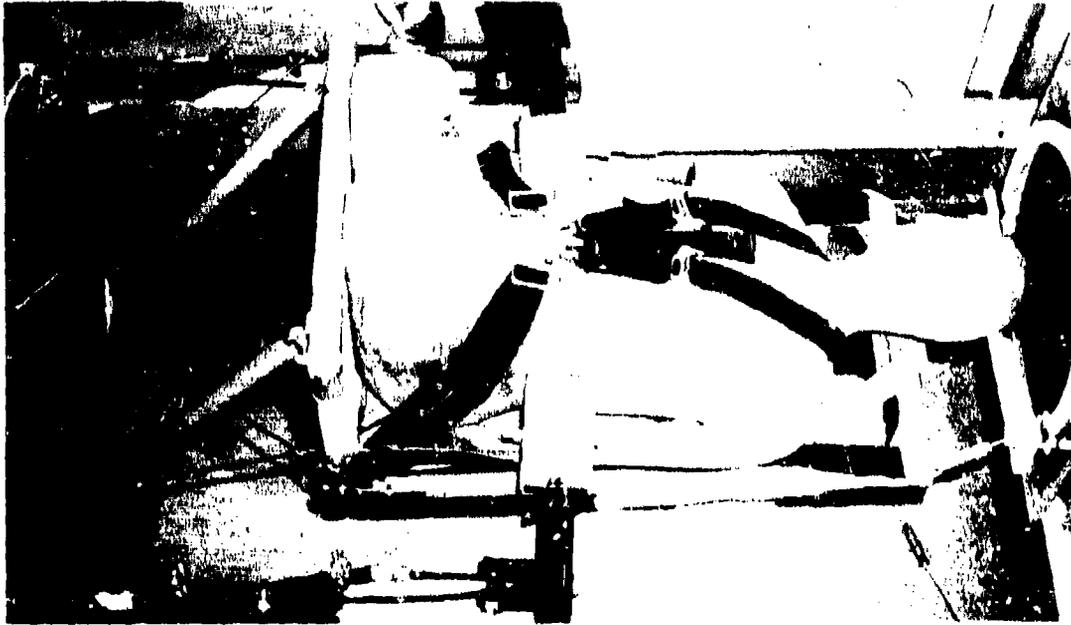


Figure 5. Pre-test 1, vertical loading.

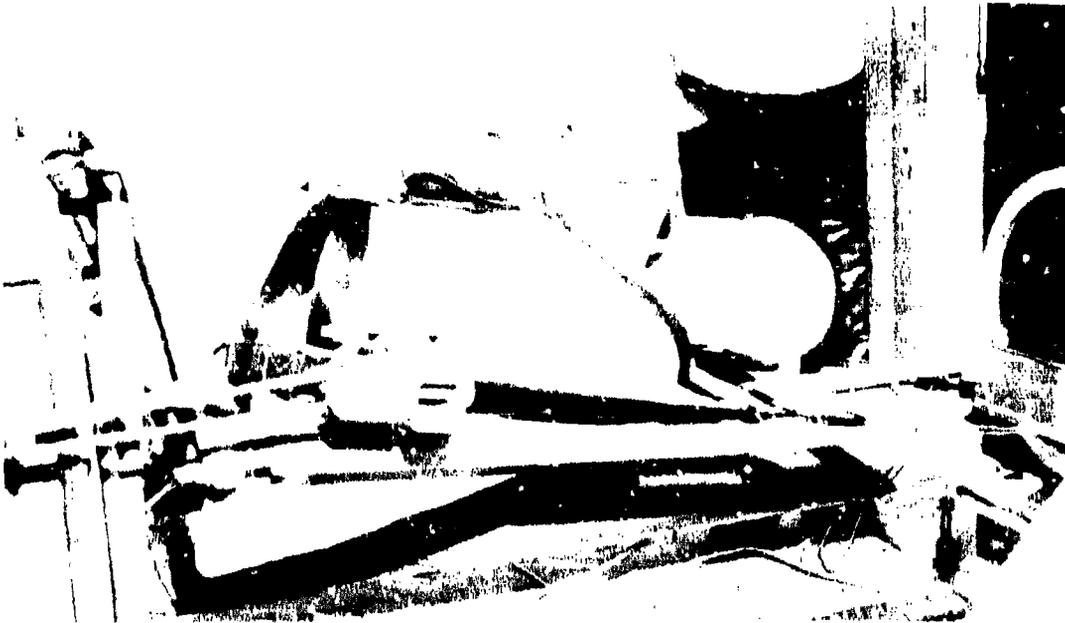


Figure 6. Post-test 1, seat fully stroked.

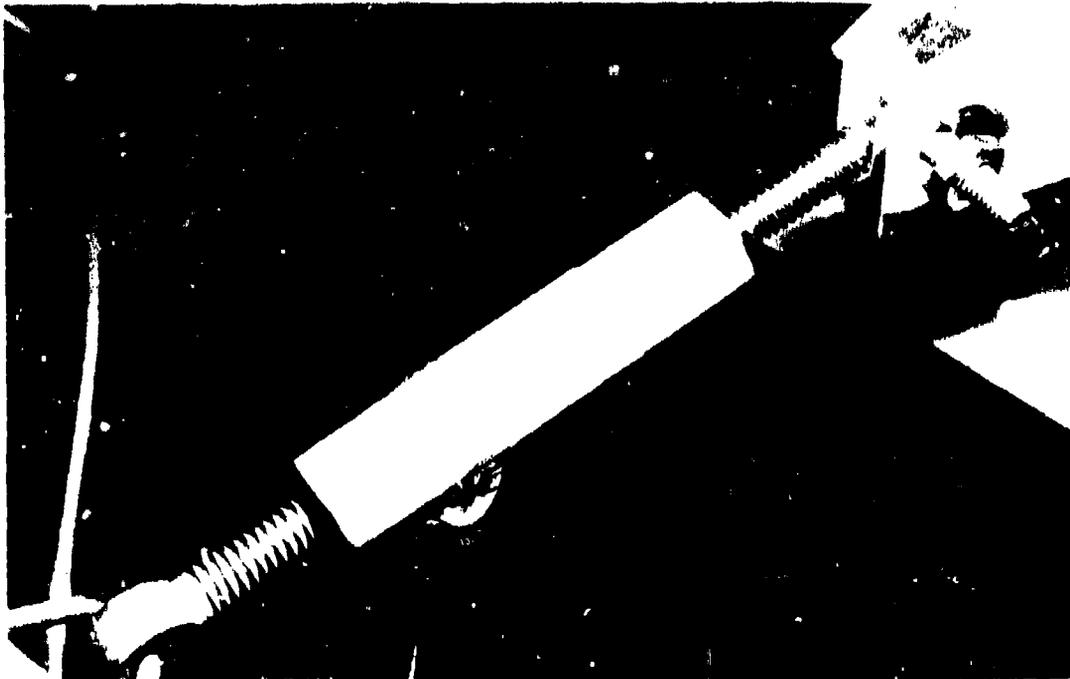


Figure 7. Strain-gaged turnbuckle, vertical attenuator.

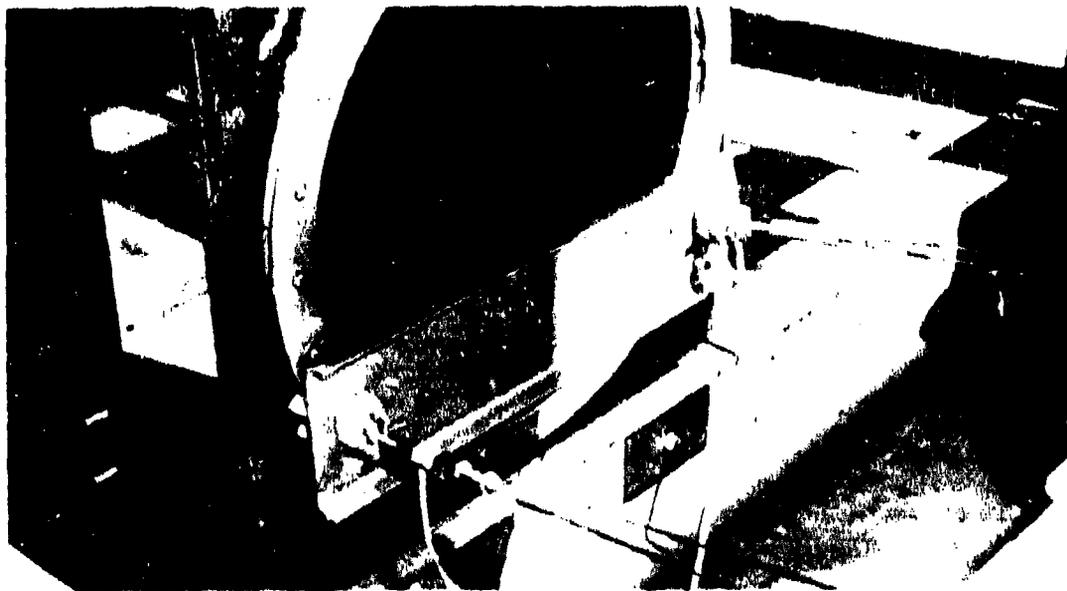


Figure 8. Stroked vertical attenuators.

seat was utilized. The upper attenuators stroked 11.2 inches (Figure 8), while the front of the seat moved down 13.5 inches. Diagonal strut attenuators did not stroke, as they are not intended to stroke under predominantly vertical loading.

Instrumentation data showed that the stroking load of the seat was within the plus or minus 1 G of the 14.5 G design level (Figure 9). The strain gage on the upper attenuator showed a stroking load of 1400 lb. Lower attenuators and restraint systems were not instrumented because of the negligible loading experienced during vertical impact conditions.

The test conclusions are that all test objectives were met. Improvement could be made in stroking distance by reducing strap elongation through the use of thicker webbing.

#### Static Test 2 - Forward Loading

The seat was installed in the test fixture supported by the swivel ring at the ceiling and attached to a swivel ring at the floor. Orientation of the seat was such that it simulated the seat swiveled to a forward facing position during a forward crash impact. The load was to be applied toward the front of the seat.

A 95th percentile aluminum body block was installed in the seat and restrained by a four-point lapbelt shoulder harness system (Figure 10). Seat loading was accomplished by attaching a cable between the body block and a hydraulic cylinder. The cable was attached to a fitting on the body block at the representative center of gravity of a 95th percentile occupant. A vertically moving roller assembly was used for mounting the hydraulic cylinder so that the load application angle would not change as the seat stroked vertically. A minimum loading of 15 G was to be applied.

Loading was applied gradually to the body block by the hydraulic cylinder. Force versus deflection was recorded by the instrumentation. Excessive stretch of the seat pan support strap and deflection of the seat pan side tubes caused the seat pan to tip forward (Figure 11). Deflection of the seat pan prevented the diagonal energy attenuator struts from being loaded to the point where they would stroke and forward deflection of the seat, which exceeded 7 inches, was due to seat deformation and was not the result of diagonal struts stroking, as intended. The vertical hold-down cables were taking the bulk of the load rather than the diagonal struts.

Loading was continued above the design stroking load of 4140 lb until a load of 5650 lb was reached. At this point, the vertical hold-down cable attachment to the lower swivel ring failed, and the test was stopped (Figure 12).

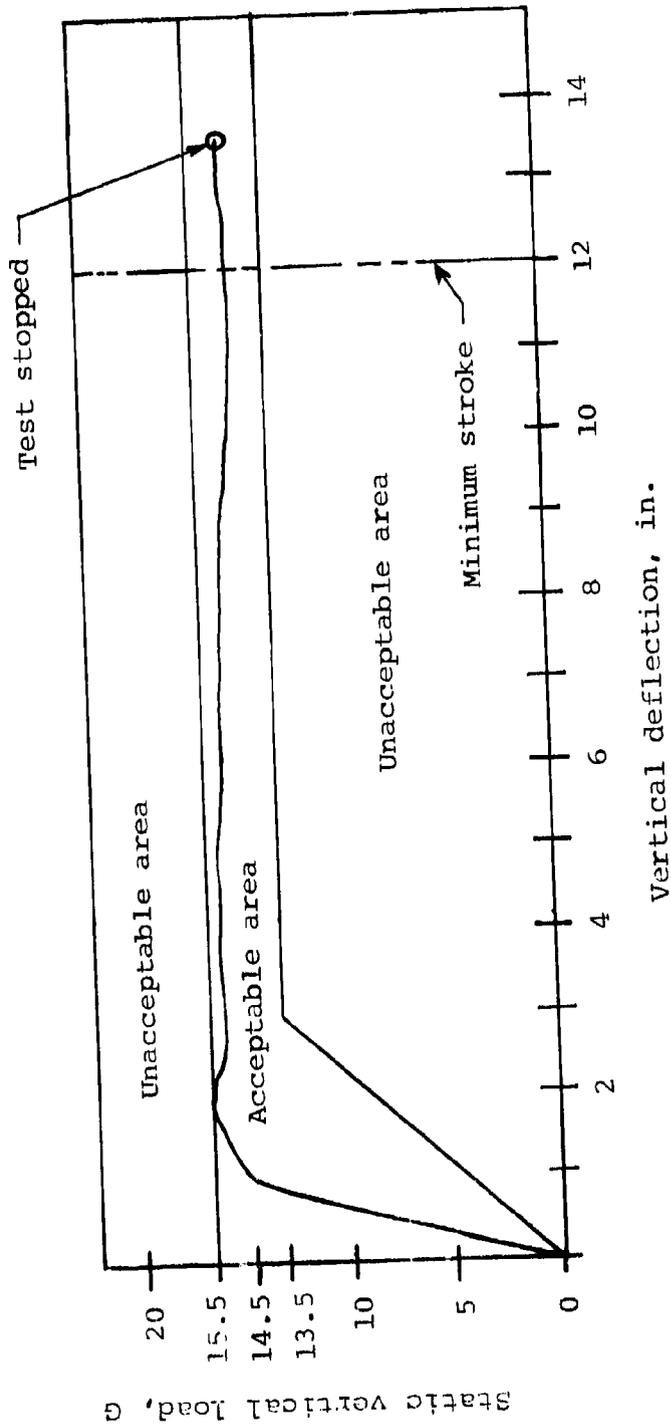


Figure 9. Test 1 - Downward load and deflection for 50th percentile.

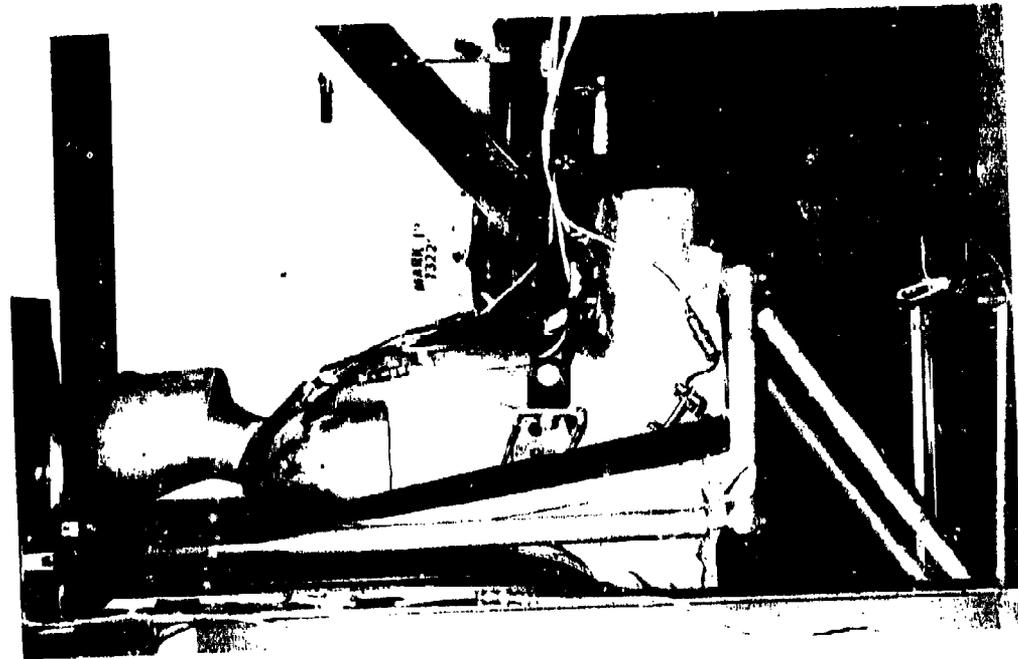


Figure 10. Pre-test 2, forward loading.

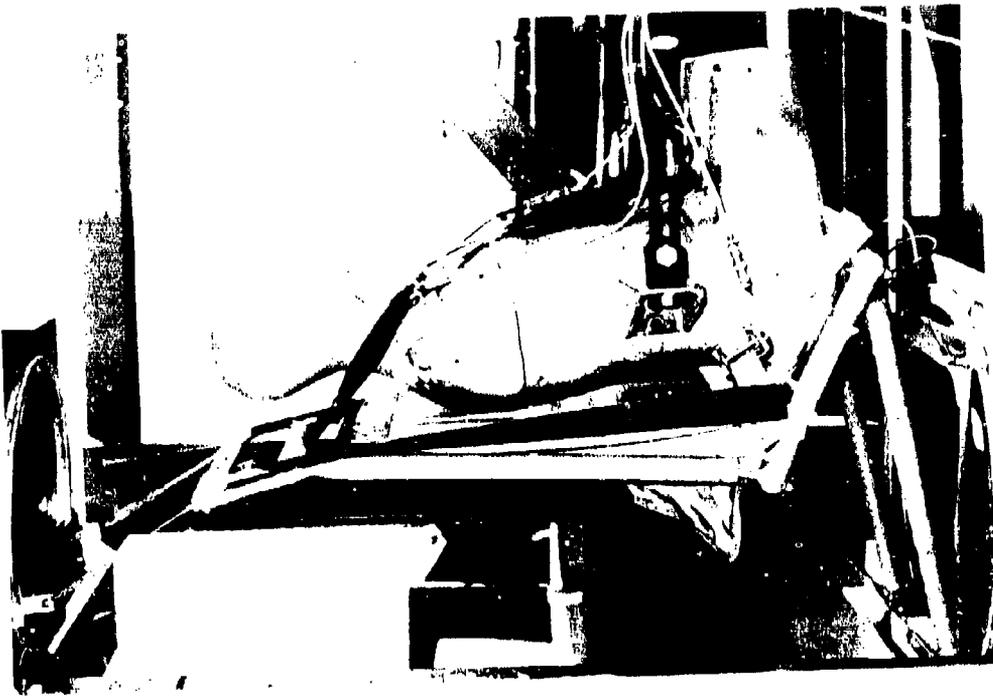


Figure 11. Post-test 2, seat pan deflection.

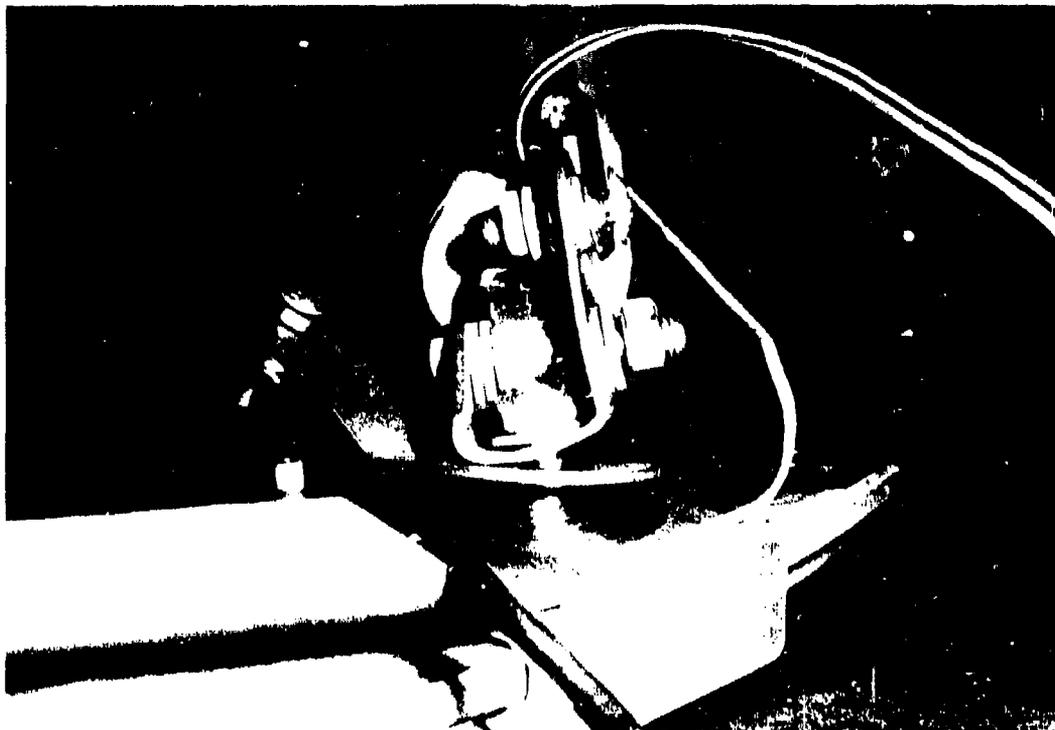


Figure 12. Right and left floor ring attachment failures.

Plotting the force deflection curve on the requirements curve (Figure 13) showed that failure occurred above the minimum acceptable failure line. However, seat deformation caused the curve to pass through the unacceptable base area.

Instrumentation data showed the following maximum loading:

<u>Instrumented item</u>	<u>Force - lb</u>	<u>Stroke - in.</u>
Upper attenuators	1396	6.0
Left diagonal attenuator	1006	0
Right diagonal attenuator	1004	0
Left shoulder strap	1750	--
Right shoulder strap	1325	--
Left lapbelt	2640	--
Right lapbelt	2570	--

A quick analysis of the test results indicated that the seat pan was being restrained from stroking due to the resistance of the vertical hold-down cables. On similar seats, the hold-down cable is vertical. However, on the swivel seat, the hold-down cable is at an angle of 24 degrees to vertical, to permit attachment to the swivel ring. It was concluded that the deformation of the seat pan was caused by the increased restraint of the non-yielding hold-down cable; and by replacing it with an energy attenuating or yielding cable, the problem would be alleviated. The hold-down cable was replaced with a yielding cable for the next test.

#### Static Test 3 - Forward Impact, Lateral Loading

A seat modified with energy attenuating hold-down cables was installed in the test fixture. The seat was oriented such that it simulated a seat facing the side of an aircraft during a forward crash impact. The load was to be applied toward the side of the seat such that the seat rotated to a forward-facing position.

A 95th percentile aluminum body block was installed in the seat and restrained by a four-point lapbelt shoulder harness system (Figure 14). Seat loading was accomplished by attaching a cable between the body block and a hydraulic cylinder. The cable was attached to the side of the body block in a manner such that the load passed through the representative center of gravity of a 95th percentile occupant (Figure 14). A minimum loading of 15 G or 4140 lb was to be applied.

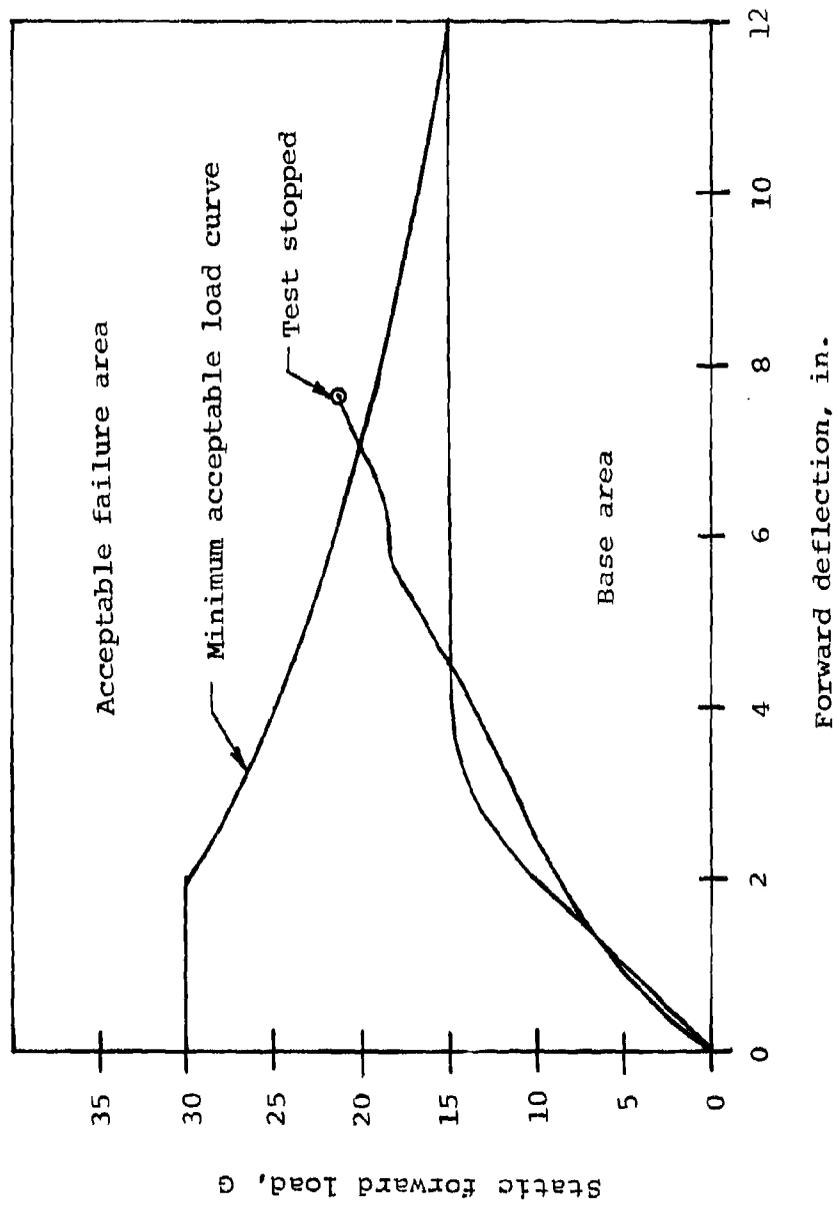


Figure 13. Test 2 - Forward load and deflection for 95th percentile.

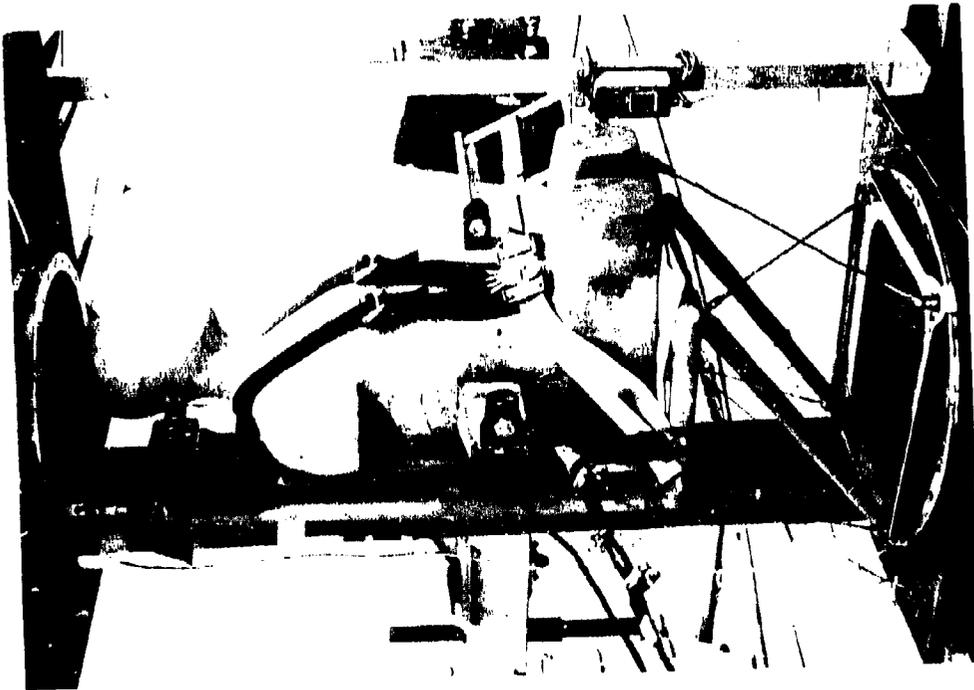


Figure 14. Pre-test 3, forward impact.



Figure 15. Post-test 3, deflected seat pan.

Loading was to be applied by the hydraulic cylinder from a forward direction with the seat facing sideward. However, only a few pounds were needed to swivel the seat from a side facing position to a forward-facing position. The slack weight of the cable and cylinder was more than needed to swivel the seat. The seat rotated easily, as intended, to face in the direction of impact.

With the seat swiveled to a forward-facing position, loading was applied gradually, and the seat began to deform toward the forward direction. There was no stroking of the upper attenuators. Replacement of the vertical hold-down cables with energy attenuating cables did not prevent excessive deflection of the seat pan as anticipated. Similar downward sloping of the seat pan occurred, and the diagonal attenuators again failed to stroke. Most of the forward deflection of the seat was due to seat deformation and hold-down cable yielding (Figure 15). Loads on the seat did not reach the high levels that were recorded in Test 2 because of the vertical hold-down cables yielding. As soon as the applied load began to drop off, the test was stopped.

Plotting the applied force and deflection curve on the requirements curve (Figure 16) shows that the force level fell short of the minimum 15 G level. Excessive deflection caused the curve to pass through the unacceptable base area.

Instrumentation data showed the following maximum loadings:

<u>Instrumental items</u>	<u>Force - lb</u>	<u>Stroke - in.</u>
Upper attenuators	1320	0
Left diagonal attenuator	920	0
Right diagonal attenuator	750	0
Left shoulder strap	1450	--
Right shoulder strap	1180	--
Left lapbelt	1550	--
Right lapbelt	1500	--

Post-test analysis showed that the hold-down cable was not causing excessive loading of the seat pan and resulting in the seat pan sloping downward. Most of the deflection was attributed to the inadequate strength of the seat pan support straps.

#### Static Test 4 - Combined Three-Axis Loading

To minimize seat pan deflection, resulting from support strap stretch, lapbelts were used to reinforce the support straps (Figure 17). The seat, modified with reinforced seat pan

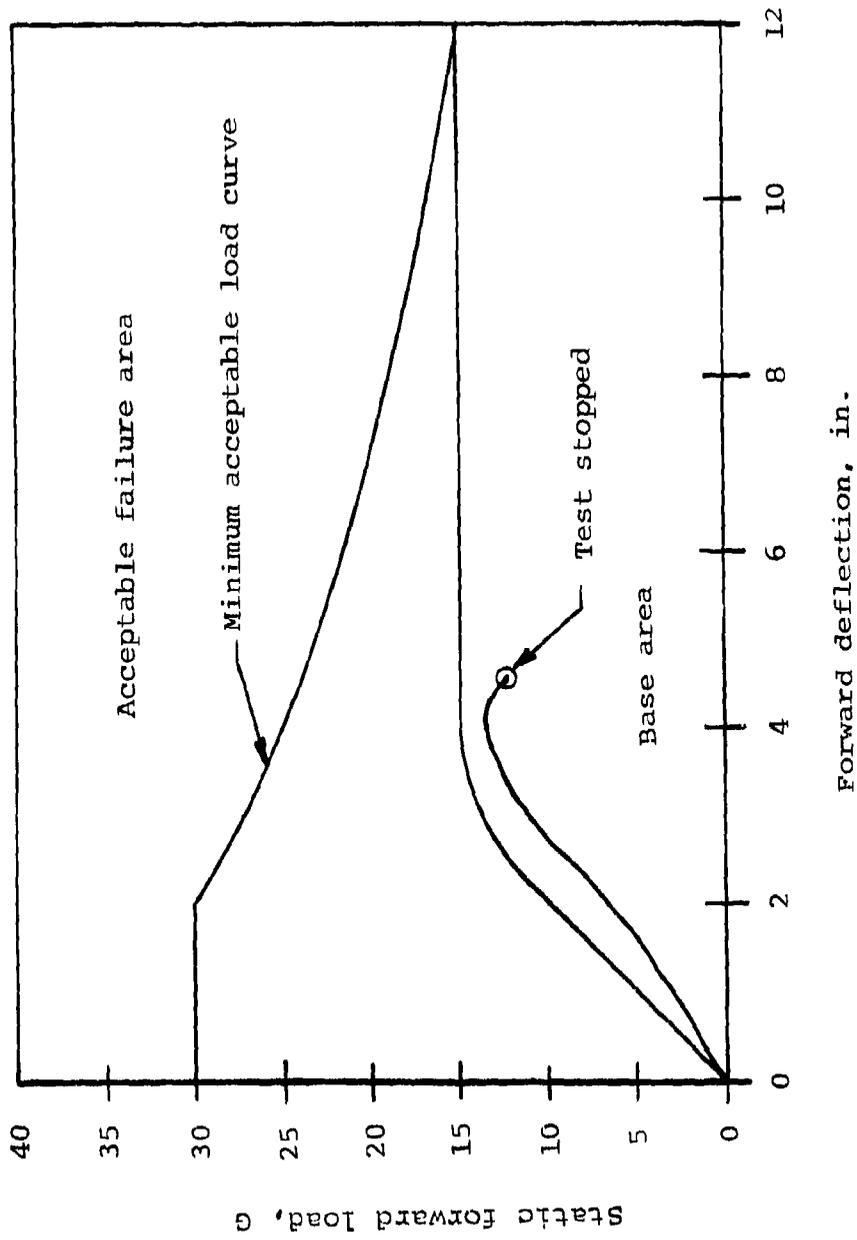


Figure 16. Test 3 - Lateral load and deflection for 95th percentile.



Figure 18. Test fixture and loading cylinder.

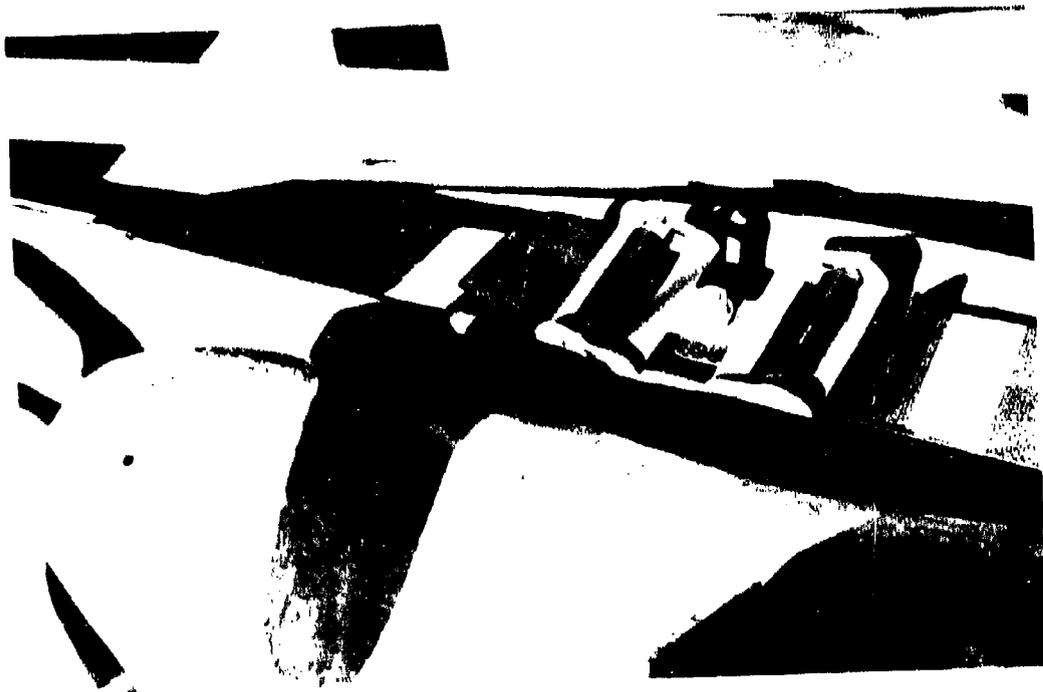


Figure 17. Reinforced seat pan strap.

support straps, was installed in the test fixture. The original non-yielding hold-down cables were used instead of the energy attenuating cables used in Test 3. The seat was oriented for three-axis loading by pitching the test fixture up and applying the load at an angle to the centerline of the test fixture (Figure 18). The load was to simulate a vertical crash impact with the aircraft pitched down 30 degrees and rolled 10 degrees and with the seat facing the side of the aircraft.

A 95th percentile aluminum body block was installed in the seat and restrained by a four-point lapbelt shoulder harness system (Figure 19). Seat loading was accomplished by attaching a cable between the body block and a hydraulic cylinder. The cable was attached to a fitting on the body block at the representative center of gravity of a 95th percentile occupant. A 50-foot-long cable was used to minimize the load application angle change as the seat stroked vertically (Figure 18). The resultant load to be applied was determined by using the following load vectors:

14.5 G downward	x	194*	=	2813 lb
15 G forward	x	276**	=	4140 lb
9 G lateral	x	276**	=	2484 lb

\* 50th percentile fully equipped gunner effective vertical weight plus 12 lb effective seat weight.

\*\* 95th percentile fully equipped gunner weight plus 12 lb effective seat weight.

The seat was oriented in a side-facing position. However, the weight of the slack cable swiveled the seat to a position in line with the applied force, as intended.

Loading was applied gradually to the body block by the hydraulic cylinder. Force versus deflection was recorded by the instrumentation. The reinforced seat pan support strap minimized the downward sloping of the seat (Figure 20). However, another weak point developed. The strength of the seat pan tube at the support strap attachment was inadequate and the attaching bolt pulled through the tube (Figure 21). When this tearing started to develop, the test was stopped to prevent further damage to the seat.

A required force deflection limitation curve for the combined loading condition has not been published. However, in plotting the force deflection for both vertical and horizontal deflections in Test 4 (Figure 22), it is evident that the minimum forces of 2813 lb vertically and 4140 lb horizontally were not achieved.



Figure 19. Process of three-axis loading.



Figure 20. Post-test, seat in failure.



Figure 21. Failed seat pan attachment.

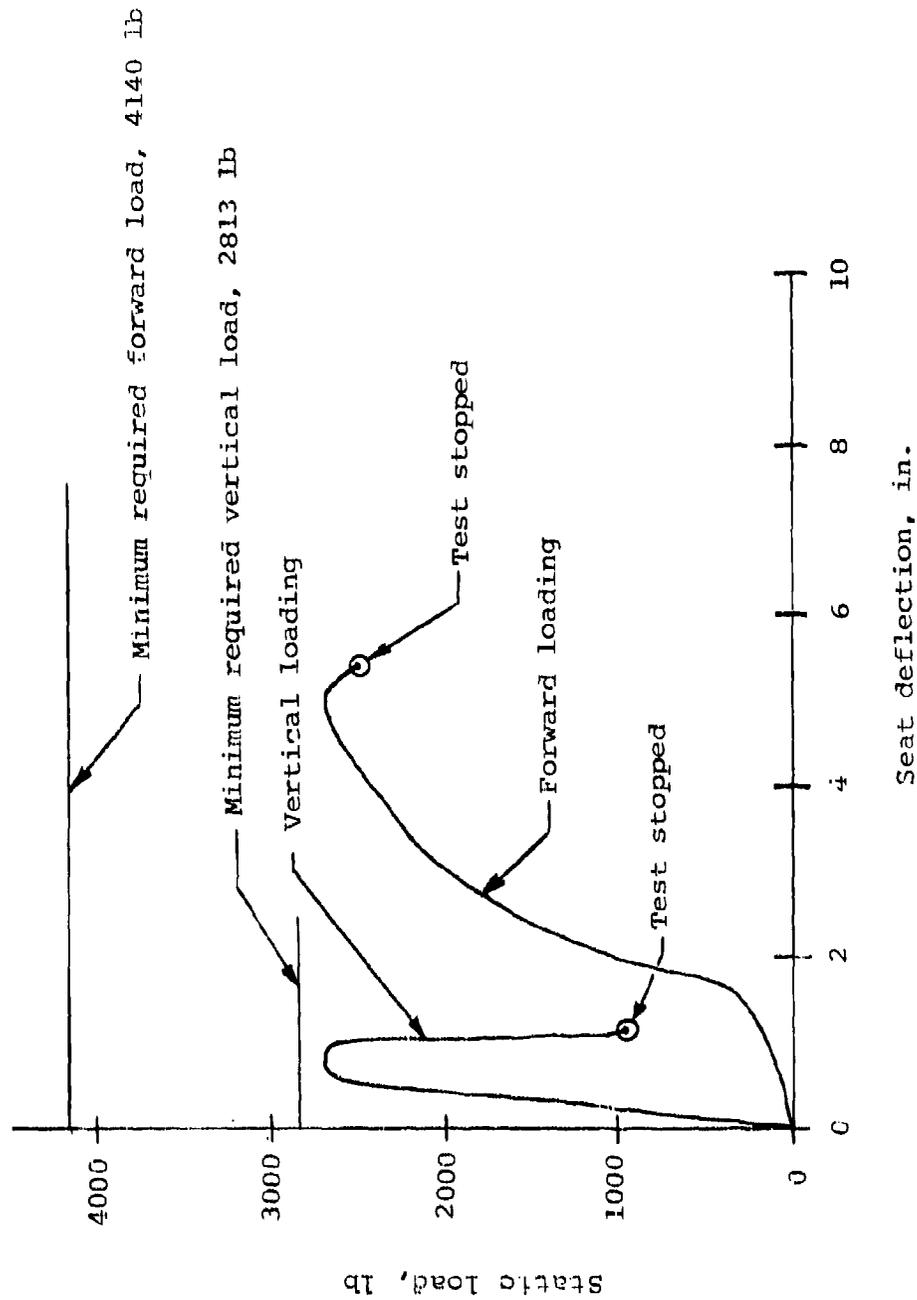


Figure 22. Test 4 - Combined three-axis loading.

Other instrumentation data showed the following maximum loadings:

<u>Instrumented item</u>	<u>Force - lb</u>	<u>Stroke - in</u>
Upper energy attenuators	1460	1.0
Left diagonal attenuator	275	0
Right diagonal attenuator	380	0
Left shoulder strap	750	--
Right shoulder strap	1150	--
Left lapbelt	820	--
Right lapbelt	900	--

#### FIRST SERIES STATIC TEST SUMMARY

The results of the four static tests are summarized below:

1. The seat functioned as intended in the vertical loading test, and both vertical attenuators stroked at the desired force level.
2. The seat swiveled freely to a forward-facing position as desired when a load was applied in a lateral direction.
3. The seat pan rotated downward excessively under a forward applied load due to the inadequate strength and excessive elongation of the seat pan support straps.
4. Bending of the seat pan side tubes occurred as a result of inadequate tube strength.
5. Tear-out of the seat pan support attachment occurred as a result of bearing failure at the side tube attachment point.

## SECOND SERIES STATIC TESTING

As a result of the failures experienced during the first series of static tests, additional static tests were required, using modified seats. The following structural modifications were made to the seats:

1. Increased the seat pan support straps from two-ply to five-ply polyester webbing.
2. Reduced the moment on the seat pan tube 20 percent by moving the seat pan support point forward 1 inch.
3. Replaced the seat pan 6061T6 tubing with higher strength 2024T4 tubing.
4. Increased the bearing strength at the seat pan support point by adding a plug insert in the seat pan tube.
5. Improved the strength of the seat pan support attachment by replacing the single shear anchor fitting with a double shear loop fitting.

Two additional static tests were conducted during the second series of testing. The test number will be the same for similar tests of both series; a letter suffix designates the repeat of a given test.

### Test 2A - Forward Loading

The modified seat was installed in the test fixture in a manner similar to test number 2 (Figure 23). Non-yielding vertical hold-down cables were used on the seat. The seat was oriented in a forward-facing position and a forward load was applied to the body block, strapped to the seat. Loading was applied gradually and the upper attenuators began stroking first as anticipated. When the load became balanced, the lower attenuators began stroking. Force leveled off at approximately 4600 lb (17 G) as the lower attenuators began stroking at a point when the seat had deflected forward 3 in. The load began to rise rapidly at the 6-in. deflection point. The test was stopped when the force reached 5700 lb and the seat had stroked 7.5 in. forward (Figure 24). The upper attenuators had stroked 8.3 in. and the diagonal strut attenuators had stroked 1.75 in.

The load rise was attributed to the deformation of the seat back at the shoulder strap reaction point (Figure 24) causing the angle of the seat to change, which increased the restraining action of the non-yielding vertical hold-down cables. The need for a yielding hold-down cable was demonstrated.

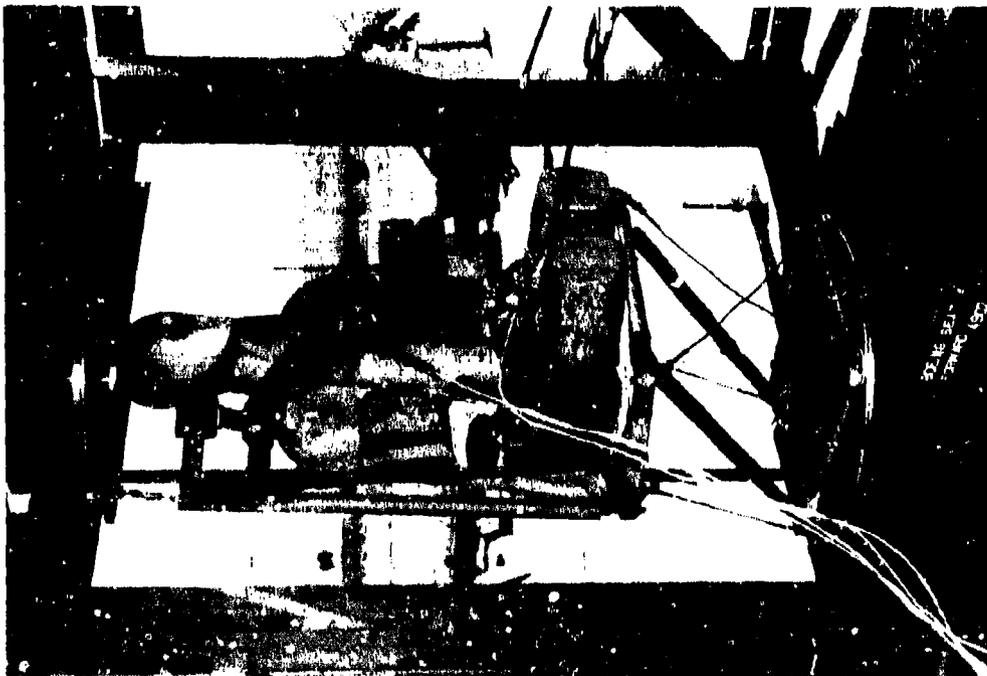


Figure 23. Pre-test 2A, forward loading.

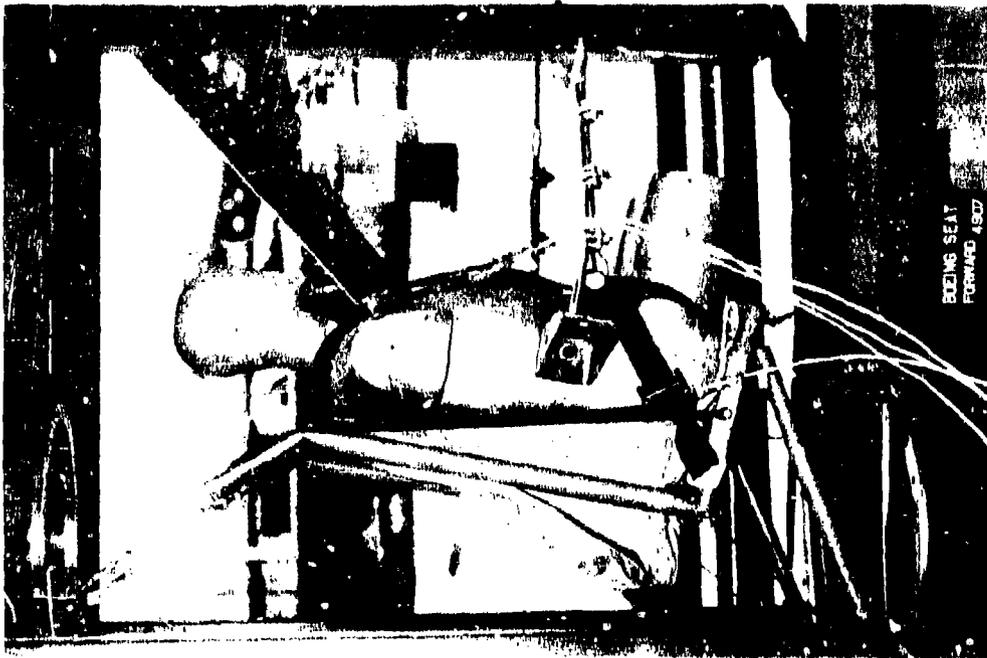


Figure 24. Post-test 2A, back deformation.

Modifications made to the seat in the area of the seat pan support straps and the seat pan side tubes proved to be satisfactory, withstanding the load with minimal deflection. The new attachment fitting at the seat pan support also proved to be satisfactory.

Plotting the force deflection curve on the requirements curve (Figure 25), it was found that the curve fell within the acceptable limits even though the test was stopped before the desired 10 in. stroke distance was achieved. Using an increased strength seat back and energy attenuating hold-down cables would have increased the stroking capability at the 17G plateau level.

Instrumentation data showed the following maximum loading.

<u>Instrumented item</u>	<u>Force - lb</u>	<u>Stroke - in.</u>
Left shoulder strap	1620	-
Right shoulder strap	1970	-
Left lapbelt	1780	-
Right lapbelt	2100	-
Left diagonal attenuator	1150	1.75
Right diagonal attenuator	1100	1.75
Left upper attenuator	1450	8.3
Right upper attenuator	1480	8.3

An analysis of the test results showed that the force/deflection requirements had been achieved. However, some modifications to the seat are necessary. A strengthened seat back is needed to prevent deformation at the shoulder strap reaction point. An energy attenuating cable is needed for the hold-down cables in place of the non-yielding cables.

#### Static Test 4A - Combined 3-Axis Loading

The modified seat was installed in the test fixture in a manner similar to test number 4 (Figure 26). An additional modification was made by the replacement of the vertical hold-down cable with an energy attenuating cable. A front diagonal cable, though longer than the hold-down cable, was adapted to the seat. It was passed over the rear tube of the seat pan and attached to the side tube with a plate (Figure 27).

The test fixture was elevated at the front so that the applied force would simulate a crash impact with roll, pitch and yaw attitudes. A force was gradually applied to the seat, through the restrained body block, by a hydraulic cylinder. The upper attenuators began stroking first until a balance was established with the stroking load of the lower diagonal strut attenuators. Upper and lower attenuators began stroking simultaneously, and loading was continued until the seat had stroked

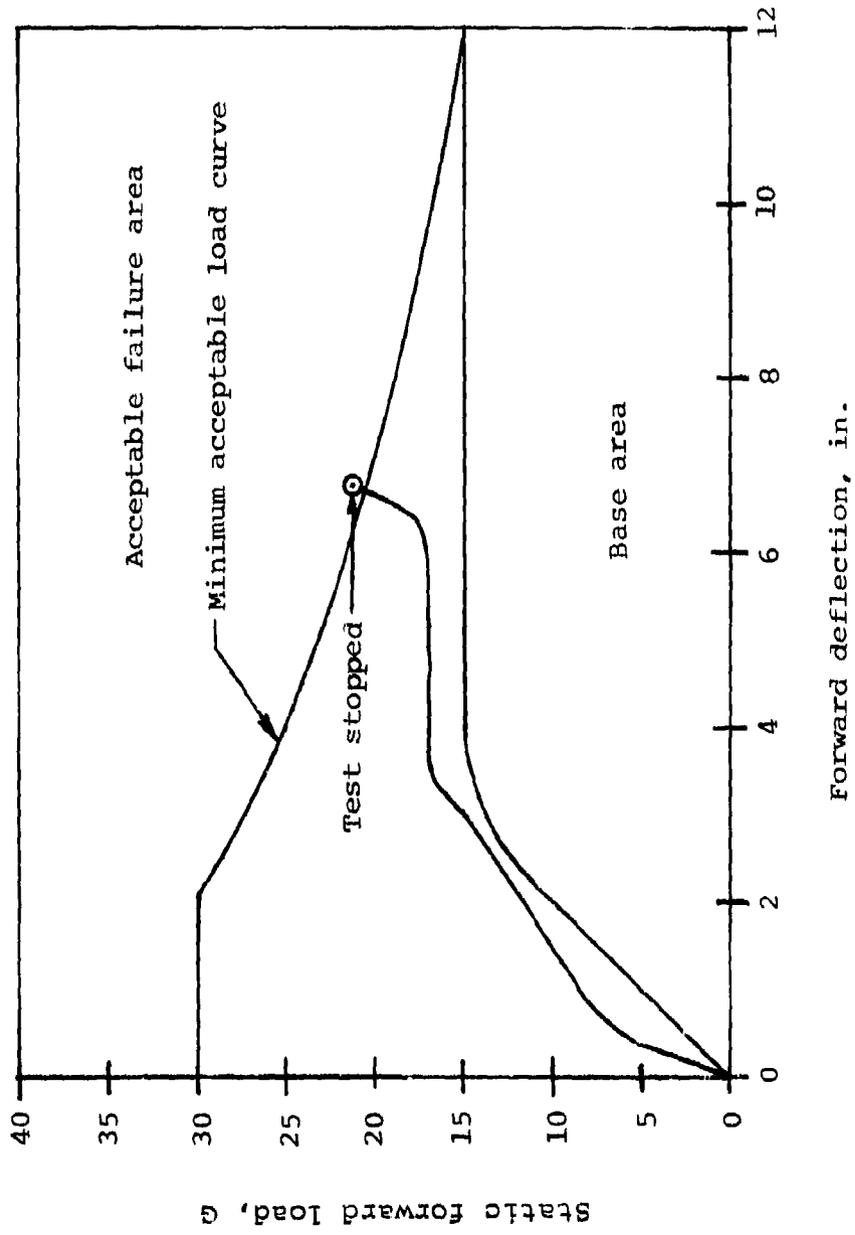


Figure 25. Test 2A - Forward load and deflection for 95th percentile.

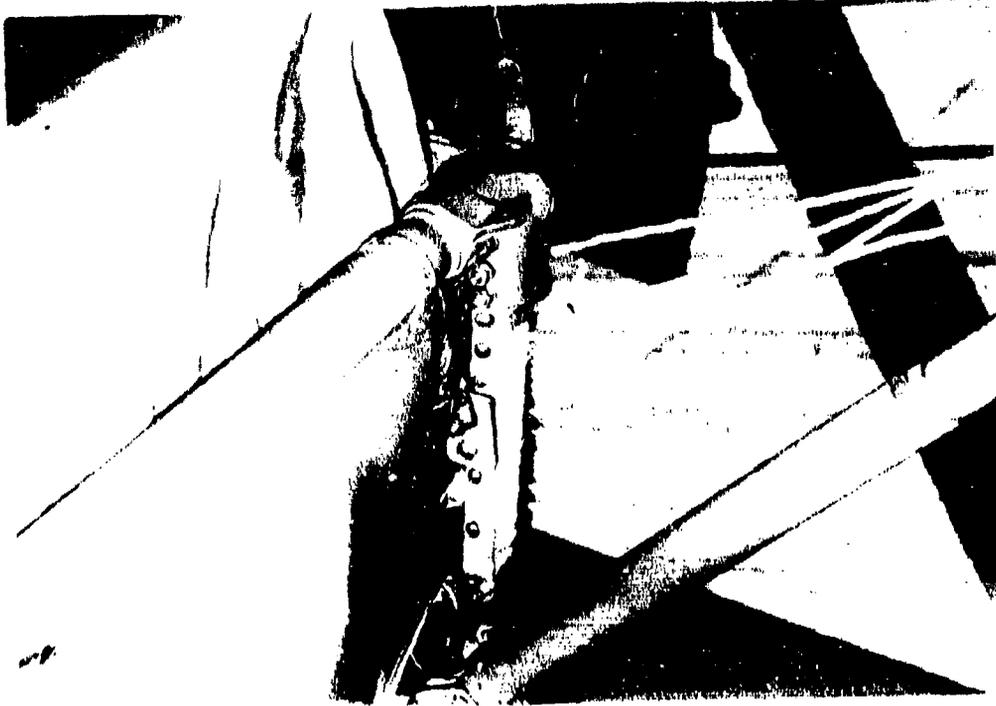


Figure 27. Attenuator cable adapter.

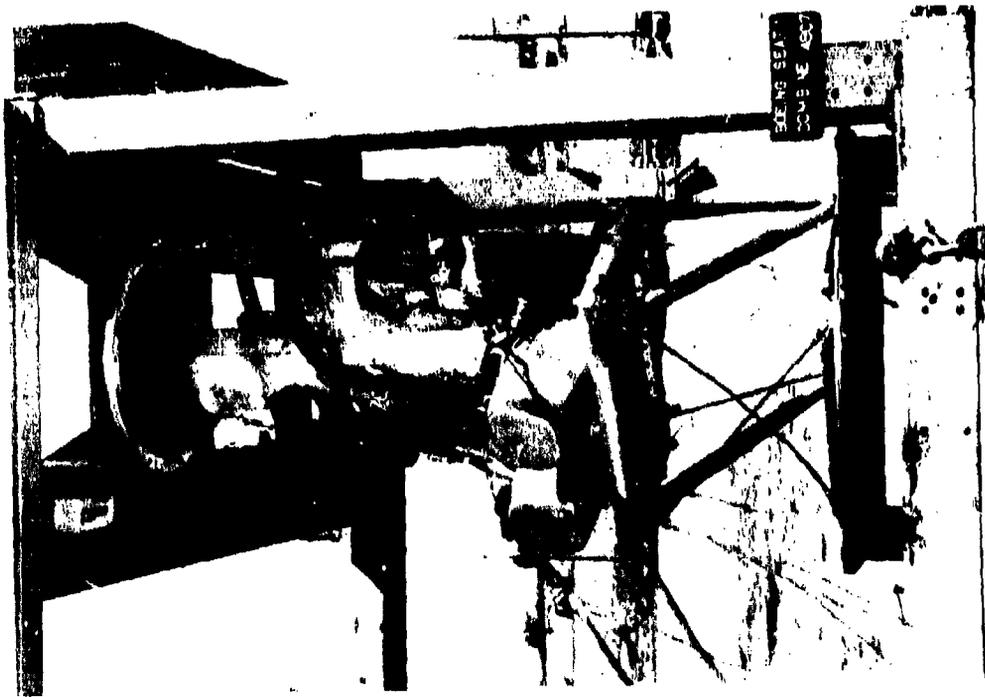


Figure 26. Pre-test 4A, three-axis loading.

10.5 in. in a forward direction. The test was stopped at this point and the load maintained for several minutes while a visual inspection was made (Figure 28).

The left and right upper attenuators had stroked 13.5 and 14 in. respectively (Figure 29). The lower diagonal strut attenuators had stroked 4 in. and the vertical hold-down cables had stroked 1 in. (Figure 29). The seat had minimum deformation and the occupant was maintained in a satisfactory attitude.

Instrumentation data showed the following maximum loading.

<u>Instrument item</u>	<u>Force - lb</u>	<u>Stroke - in.</u>
Left shoulder strap	1100	-
Right shoulder strap	2100	-
Left lapbelt	600	-
Right lapbelt	1000	-
Upper right attenuator	1400	14.0
Upper left attenuator	1400	13.5
Diagonal strut attenuators	1100	4.0
Hold-down cables	-	1.0

Analysis of the test data showed that the force deflection requirements had been achieved (Figure 30). The horizontal stroking distance of the seat measured at the seat pan was 10.25 in. A maximum force of 6500 lb had been reached as compared to the minimum required resultant force of 5650 lb. Aside from the seat back deformation at the shoulder strap reaction point, the seat functioned as required, without failure, meeting all objectives.

#### SECOND SERIES STATIC TEST SUMMARY

Analysis of the static test data shows that the seat functioned properly under vertical, forward, lateral, and combined 3-axis loading. Under lateral and combined loading conditions, the seat swiveled easily to the direction of the applied load. Stroking of the upper and lower attenuators occurred when necessary. Applied loads reached levels above the minimum acceptable base levels of the required force deflection curves.

The modifications made to the seats proved to be satisfactory, and all functional and strength objectives were accomplished under the static load environment. These tests and analyses show that the swivel gunner seats were ready for verification of their crashworthiness functions by dynamic testing.



Figure 28. Post-test 4A, fully stroked seat.

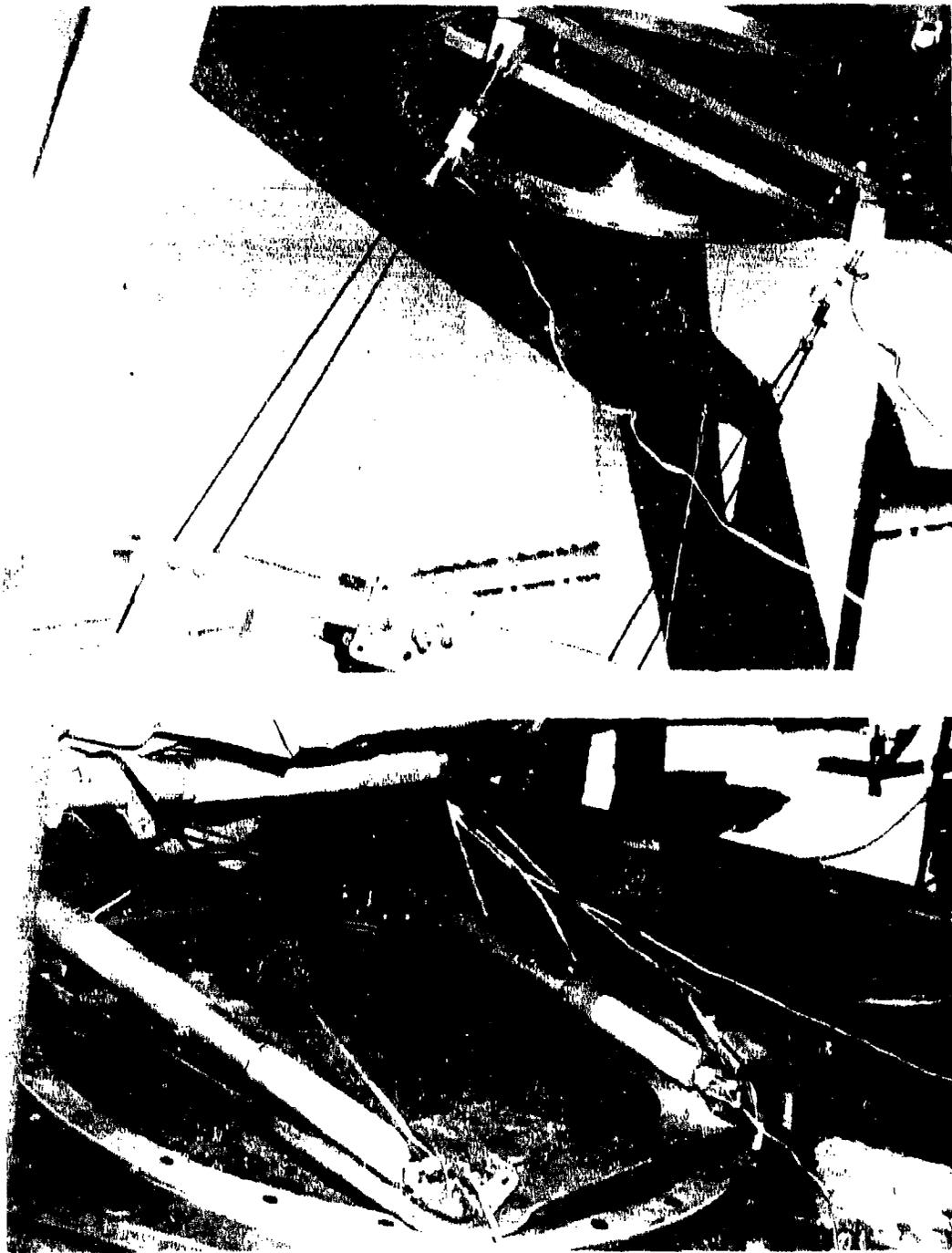


Figure 29. Stroked upper and lower attenuators.

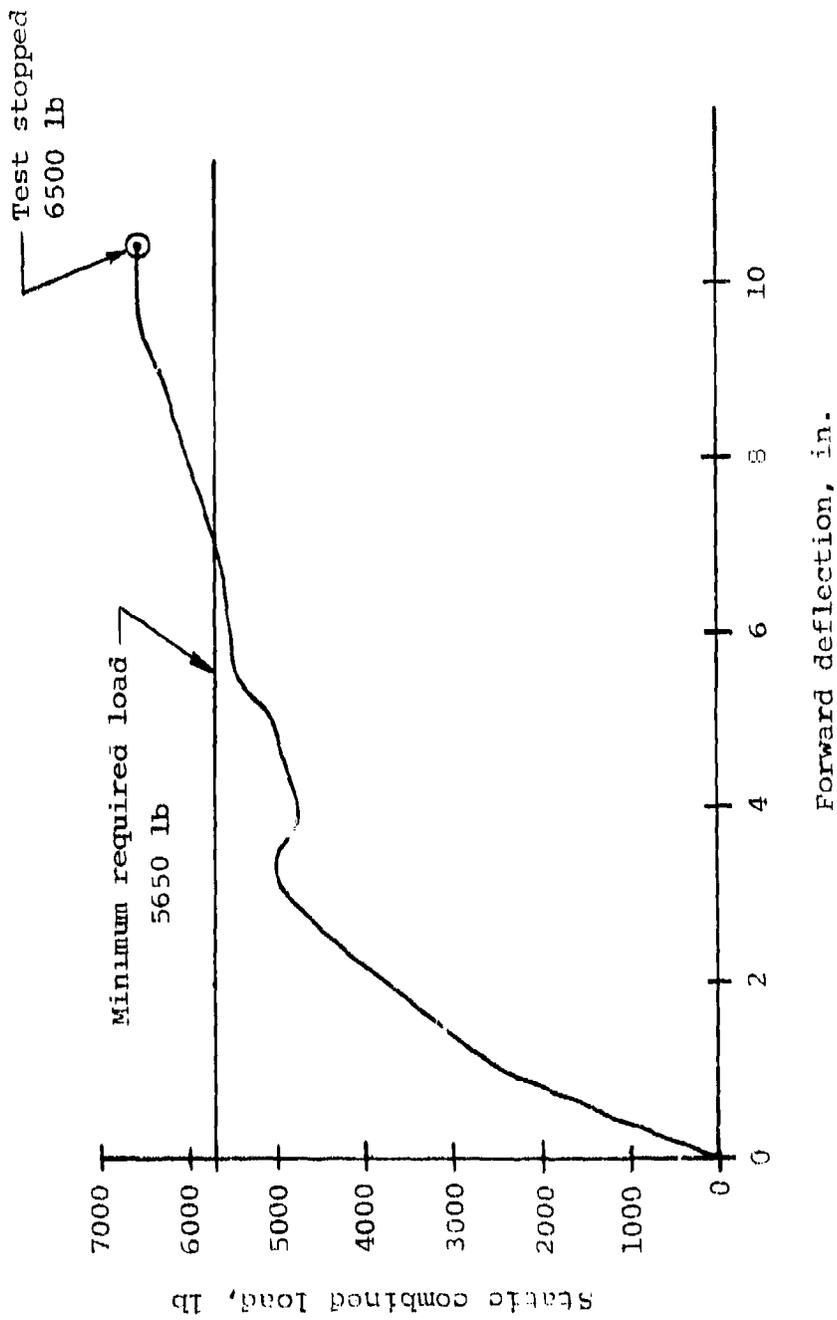


Figure 30. Test 4A - Combined three-axis loading, forward deflection.

## CRASHWORTHY GUNNER SEAT TESTING - TASK III

### TASK III REQUIREMENTS

Dynamic testing was to be accomplished during the Task III phase. The required effort under Task III was as follows:

- The fabrication, modification, and assembly of two gunner seat systems in accordance with the approved detailed design developed in Task I and the refinements determined to be necessary as a result of Task II static testing.
- The preparation of seat system and test fixtures to perform dynamic testing in accordance with the dynamic test plan (Appendix B).
- The performance of dynamic tests on seat systems in accordance with the dynamic test plan.
- The analysis of data obtained in dynamic tests for the purpose of verifying the adequacy and feasibility of the design criteria contained in the proposed Military Specification, Seat, Helicopter, Gunner, and in References 2 and 3. Those requirements and/or criteria that were insufficient to insure gunner seat occupant protection throughout the 95th percentile survivable accident were to be identified, as well as those requirements and/or criteria that exceed the strength or performance criteria necessary to provide gunner seat occupant protection during the 95th percentile survivable aircraft accident, or which, because of practical considerations, are proven too stringent to be feasibly met by current technology.
- Criteria and requirements contained in the proposed military specification and in References 2 and 3 were to be substantiated, or changes recommended.

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<sup>2</sup>CRASH SURVIVAL DESIGN GUIDE, Dynamic Science; USAAMRDL Technical Report 71-22, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, October 1971, AD 733358.

<sup>3</sup>MIL-STD-1290, Military Standard, Light Fixed- and Rotary-Wing Aircraft Crashworthiness

## FABRICATION AND MODIFICATIONS OF SEAT SYSTEMS

Seats for dynamic testing were fabricated prior to static testing and were modified to incorporate the changes found to be necessary following the first series of static tests. The only change made as a result of second series static testing was the replacement of the high strength hold-down cables with energy attenuating cables.

### DYNAMIC TEST PREPARATION

Dynamic testing was performed at Dynamic Science Inc., Phoenix, Arizona. Predominantly horizontal crash impacts were simulated on a horizontal track. The test seat was mounted on a wheeled vehicle (Figure 31). The vehicle was accelerated down the track by a continuous loop cable driven by a gasoline engine and impacted a paper honeycomb stack attached to a barrier.

Predominantly vertical crash impacts were simulated by using a drop tower. The tower consists of two vertical poles and a cross member at the top. A carriage which supports the test seat is raised up the tower by a cable, through a pulley attached to the cross member. Cables guide the carriage vertically during the drop (Figure 32). A quick-release hook disconnects the hoisting cable from the carriage for the drop.

A test fixture was designed and fabricated to support the test seats as they would be supported in the aircraft. The fixture was designed to support the seat under dynamic load application without deflecting. Provisions were made for bolting the swivel ring tracks to a simulated floor and ceiling.

The test fixture was designed to be adaptable for horizontal vehicle and drop tower (Figures 31 and 32). A wedge platform was used to adapt the fixture for the three-axis impact attitude of the vertical drop test.

The required pulse shape for vertical and horizontal impact was accomplished by using a stack of paper honeycomb (Figure 33). Various honeycomb configurations and thicknesses were tested until the desired pulse was obtained.

### DYNAMIC TEST DATA ACQUISITION

#### System Reliability

Overall reliability of the total data acquisition system is ensured through total system redundancy in signal conditioning equipment and data recording. The signal-conditioning equipment used in on-board configurations was designed for ruggedness and system reliability sufficient to withstand a crash environment.

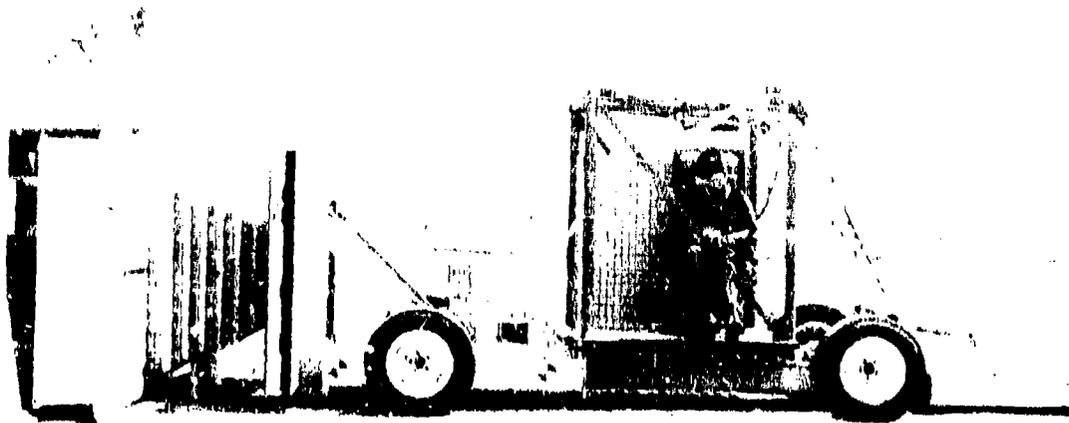


Figure 31. Wheeled horizontal test vehicle.

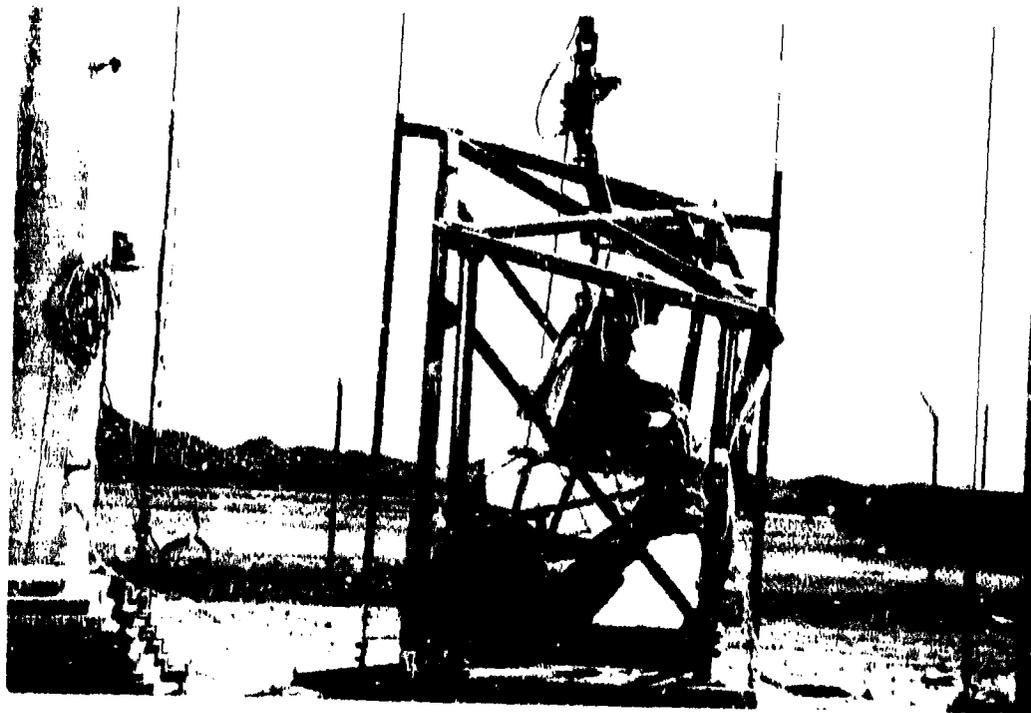


Figure 32. Vertical impact drop tower.

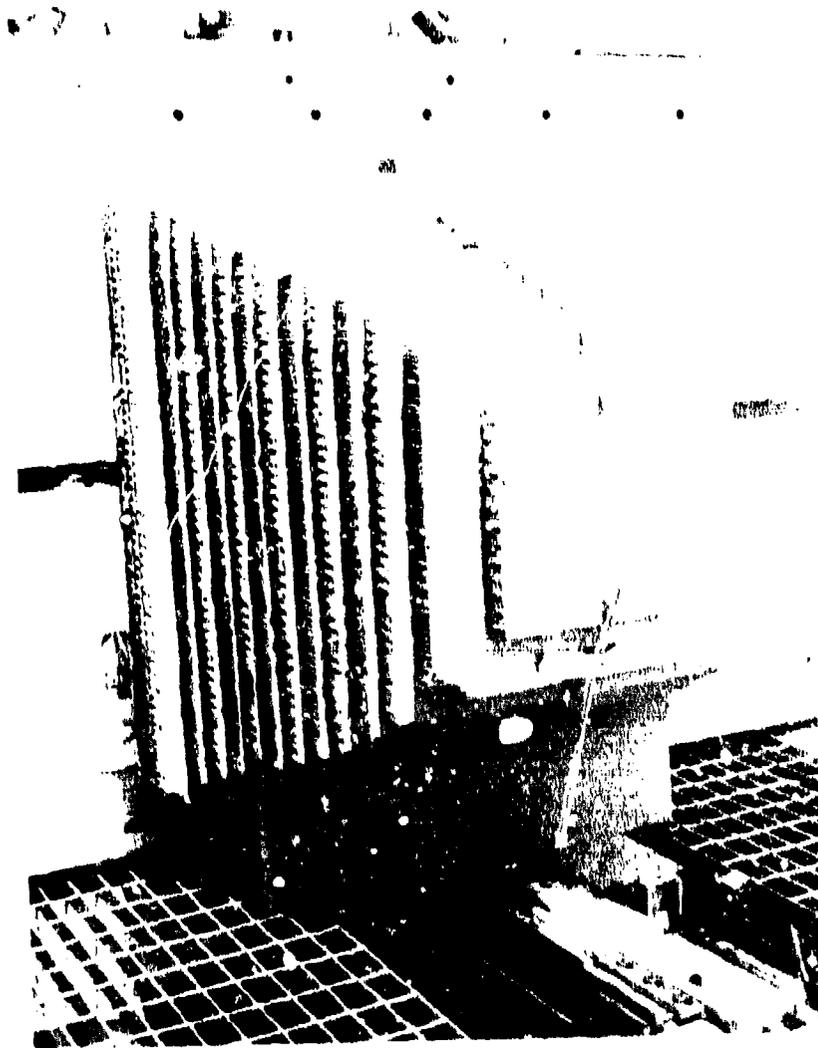


Figure 33. Impact barrier with paper honeycomb stack.

## Signal Conditioning Equipment

The basic unit of the signal conditioning equipment is the Remote Signal Conditioning Module (RSCM) which consists of all the necessary functions required to take the basic transducer information and store it on magnetic tape. Internally, the RSCM contains the components required to signal condition, system calibrate, modulate onto IRIG constant bandwidth FM channels, and transmit a transducer output signal to a remote tape recorder.

Transducer bridge balancing is accomplished through a separate balance network capable of offsetting the unbalanced output from the unloaded and unbalanced bridge network. Two sets of cal resistors are used to provide 50 percent and 100 percent of full-scale calibration. This provides a five-step calibration sequence of -100 percent, -50 percent, 0, +50 percent, and +100 percent.

The signal conditioning amplifiers in the RSCM are designed to provide stable gain and balance, to normalize all transducer outputs into common formats, and to drive the voltage controller oscillators (VCO). The VCOs convert analog voltages to a frequency modulated (FM) unbalanced signal. The center frequencies of the VCOs are set at values defined by IRIG 106-71 for constant bandwidth channels. The +2.5-volt outputs from the amplifier provide +100-percent deviation of the VCOs. By using a mix of A and B channels, an optimum combination of data frequency response, resolution, percentage deviation, and channel density in each multiplex is provided. The system is designed to provide 1,000-Hz data channel bandwidth on all channels. The VCO outputs are mixed onto a common bus which provides the output signal to be recorded.

## System Accuracy

System calibration is accomplished through a double-shunt, five-step sequence which provides an end-to-end calibration of the entire system. Each calibration resistor set is sized to simulate half- and full-scale output of each transducer. This type of calibration provides an end-to-end amplitude calibration that is an order of magnitude better than the calculated system accuracy, thereby offering a scaling reference which will not appreciably add to inherent system errors.

As there are several information conversions through the system, the component specification is translated into a "common error domain". Each component in the system has a set of parameters that represent its performance in a particular region of the multidimensional space; e.g., an accelerometer converts acceleration into a voltage (actually an energy conversion) with some nonlinearity of information conversion.

There is a conversion from analog voltage to frequency with a corresponding nonlinearity in the VCO. The tape recorder has to handle the information mechanically with high accuracy because a change in tape speed represents a change in frequency which, in turn, represents a change in the original analog voltage.

Four instrumentation-quality tape recorders are available. Capstan speed accuracy of 0.01 percent is obtained by use of a tape speed compensator system while flutter is held to 0.22 percent. Time base and dynamic slew are 0.5 and 0.25 microsecond, respectively.

#### Data Processing

The data reduction equipment includes: (1) analog playback recorder, (2) FM subcarrier demodulator, (3) patching system, (4) oscillograph, (5) computer, (6) paper tape reader, (7) analog-to-digital converter, (8) teletype, and (9) digital recorder and various other test equipment.

#### Data Filtering

Most electronically acquired data contain "noise" associated with the electronics. This "noise" is usually at a frequency higher than the highest data frequency. Analysis of data is easier if the undesired "noise" is filtered out. Furthermore, if the data are to be digitized, it is essential that some filtering be done to prevent aliasing. Digital filtering may also be necessary before analysis of the data can be undertaken. All data filtering conforms to the SAE specification J211b.

The analog filters are an integral part of the FM discriminators. These filters are of the linear phase of Bessel type, providing constant time delay through the pass band and negligible overshoot in response to a step or pulse input.

Digital filtering is accomplished by applying a Fast Fourier Transform to transform tape digital data into the frequency domain. Filtering is achieved by multiplying the frequency domain data with the desired filter transfer function. The data product is then transferred back to the time domain where the analysis is performed.

#### Data Reduction Procedure

After the completion of a test, the analog tape is mounted on the playback tape recorder. A data configuration sheet which indicates the tape track and the FM channel for each transducer accompanies the tape. Using the patch panel, the system is configured and each transducer is played through the appro-

priate discriminator and filter and recorded on the oscillograph along with the instrument pre- and post-test calibrations. These "quick-look" data are then scaled into engineering units and delivered to the responsible engineer(s).

## DYNAMIC TESTING

### Dynamic Test Requirements

Dynamic tests were required to simulate impact forces for two impact attitudes. The tests were to simulate a combined three-axis impact with a predominantly vertical component and a horizontal impact simulating a forward impact of an aircraft with the seat facing the side. Testing was to be conducted in accordance with the approved dynamic test plan (Appendix B).

A minimum of two dynamic tests of the swivel gunner seat were to be performed. However, due to seat failure in the horizontal test an additional dynamic test, with revised test requirements, was scheduled.

### Dynamic Test 1 - Swivel Seat, Three-Axis Vertical Drop

A swivel seat was installed in the dynamic test fixture on the drop tower. A 95th percentile dummy with equipment and armor, weighing a total of 264 lb, was strapped into the seat (Figure 34). The seat was oriented to simulate 30-degree pitch down and 10-degree roll of the aircraft and to simulate facing the side of the aircraft. Impact was to be at a velocity of 50 fps with an impulse of 48G.

The seat in the test fixture was raised up the test tower and dropped onto a stack of paper honeycomb. Visual inspection of the seat after the test revealed no seat structure or fabric failures. The seat had swiveled 45 degrees and the dummy's legs had contacted the test fixture structure (Figure 35). Vertical attenuators were measured and the right attenuator had stroked 18.5 inches and the left attenuator had stroked 13.3 inches (Figure 35). Neither of the lower diagonal strut attenuators had stroked, which was anticipated.

A review of the instrumentation data showed that the desired vertical impact velocity of 50 fps was exceeded, having reached 52.4 fps. The excess velocity contributed to the seat stroking fully to the floor.

The input pulse to the seat was recorded by accelerometers installed on the test bed. As the bed impacted the barrier and decelerated, the deceleration level was measured in the direction of the impact. Accelerometers on the bed measured the force in G while a timing device measured the bed velocity at the time of impact. The G force was plotted with respect

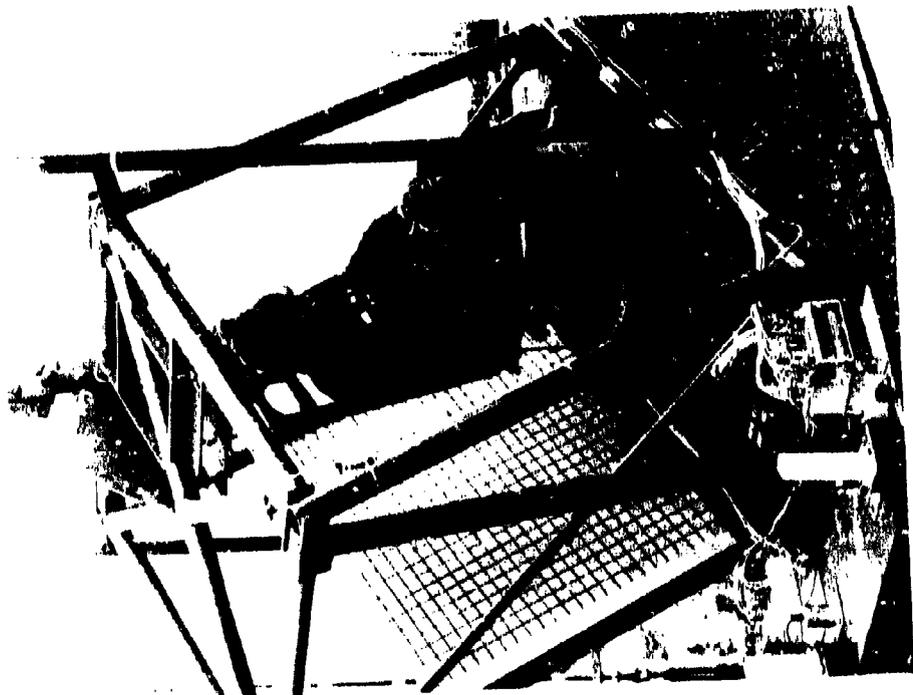


Figure 34. Pre-test 1, three-axis loading.

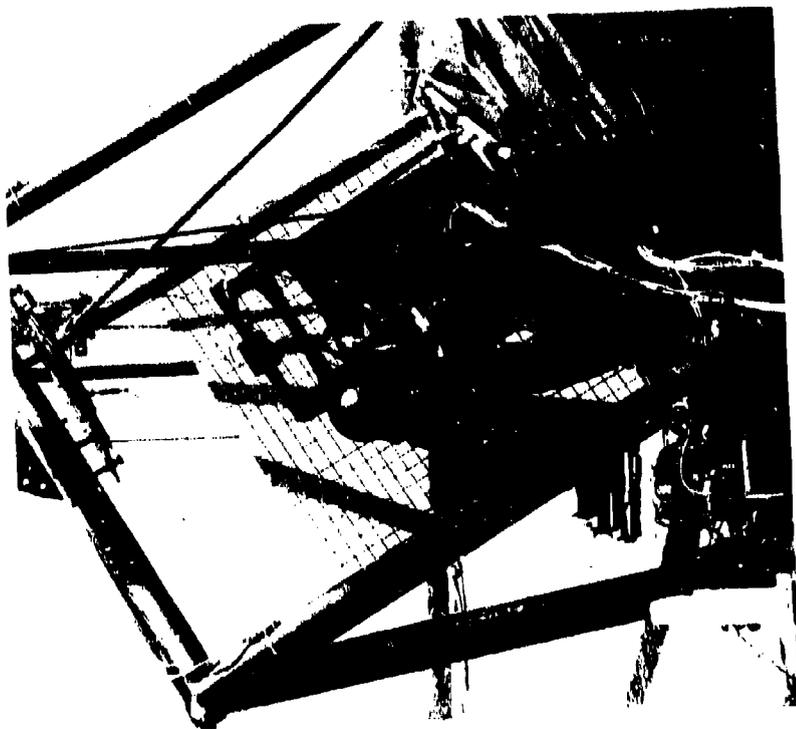


Figure 35. Post-test, seat fully stroked.

to time (Figure 36). A peak G value of 48 G was specified, however, this is a theoretical value. Only the maximum G, which was 48.4 G, is recorded and plotted, while the peak G must be calculated. Knowing the velocity and the time base, which are recorded by instrumentation, the theoretical peak G can be determined as follows:

$$32.2 \text{ G}_{pk} = \frac{2 \cdot v}{t} = \frac{2(52.4)}{.065}$$

$$G_{pk} = 50.0$$

The peak G is superimposed over the recorded pulse data (Figure 36).

Test data showed that bottoming occurred and an overshoot pulse was recorded on the pelvis accelerometer in the vertical axis (Figure 37). The overshoot pulse was mild and of short duration and was within the spinal acceleration human tolerance limits. The acceleration on the occupant prior to bottoming reached a plateau of 13 G, which is satisfactory for a 95th percentile gunner with full equipment including chest armor.

Both vertical energy attenuators performed as required, producing flat force deflection curves (Figure 38). The forces on the attenuators were within a few pounds of each other, demonstrating the consistency of wire bending attenuators. The right attenuator load was 1500 lb compared to the left attenuator load of 1510 lb.

Other instrumentation data showed the following maximum loadings:

<u>Instrumented item</u>	<u>Force - lb</u>	<u>Stroke - in.</u>
Right shoulder strap	589	-
Left shoulder strap	920	-
Right lapbelt	1484	-
Left lapbelt	1614	-
Right diagonal attenuator	1351	0
Left diagonal attenuator	1367	0
Upper right attenuator	1500	18.5
Upper left attenuator	1510	13.3

An analysis of the test results showed that the seat system performed as desired. The seat swiveled in the direction of the impact force and the vertical attenuators stroked. The acceleration on the occupant was reduced to the desired level for a 95th percentile occupant. Excessive velocity contributed to the seat bottoming-out, but the peak pulses produced on the occupant's pelvis appeared to be tolerable when reviewing the

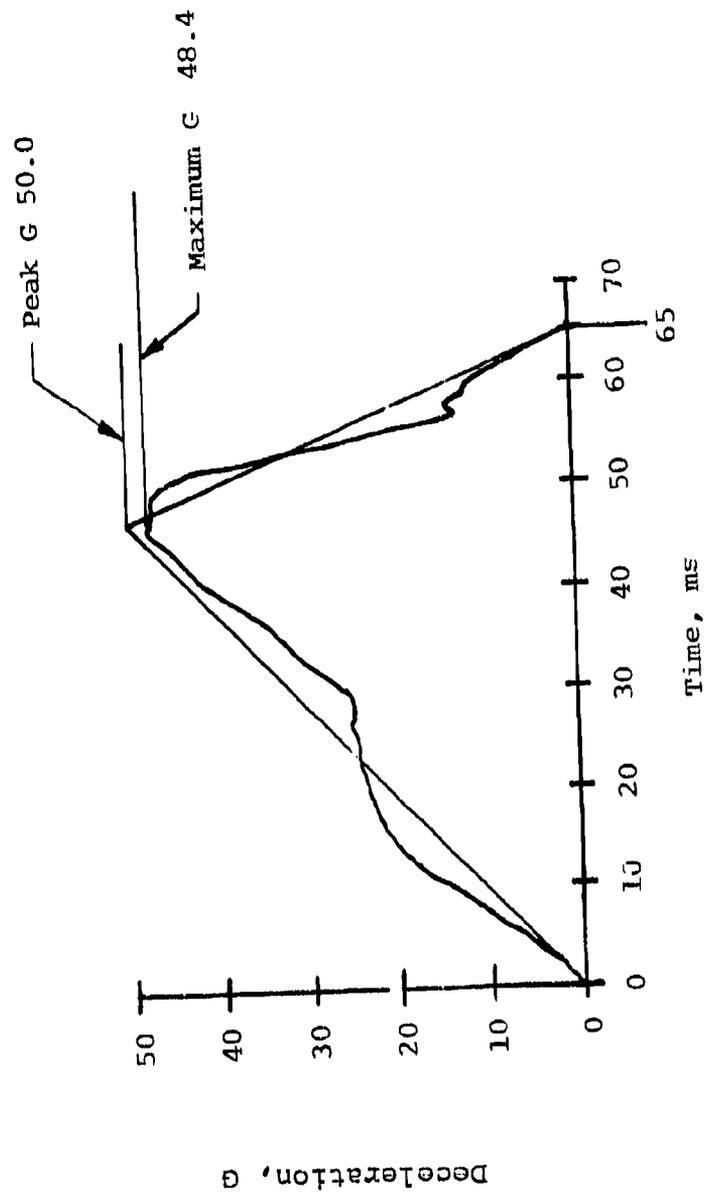


Figure 36. Test 1 - Carriage deceleration time history.

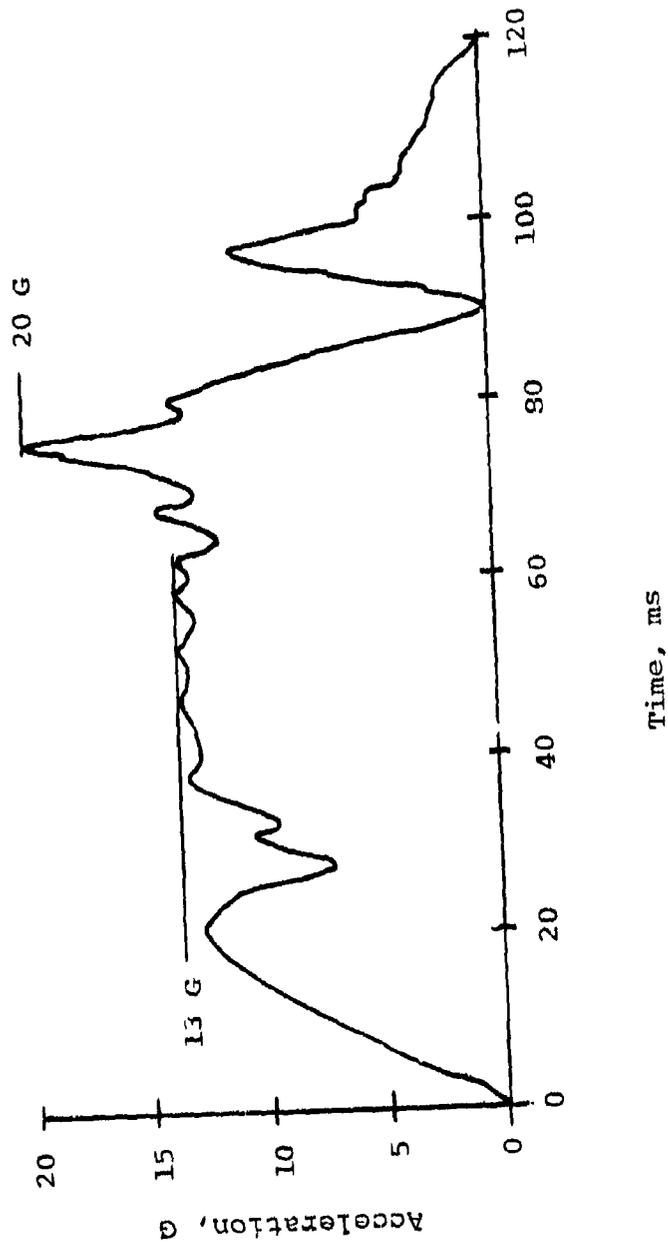


Figure 37. Test 1- Vertical acceleration, dummy pelvis.

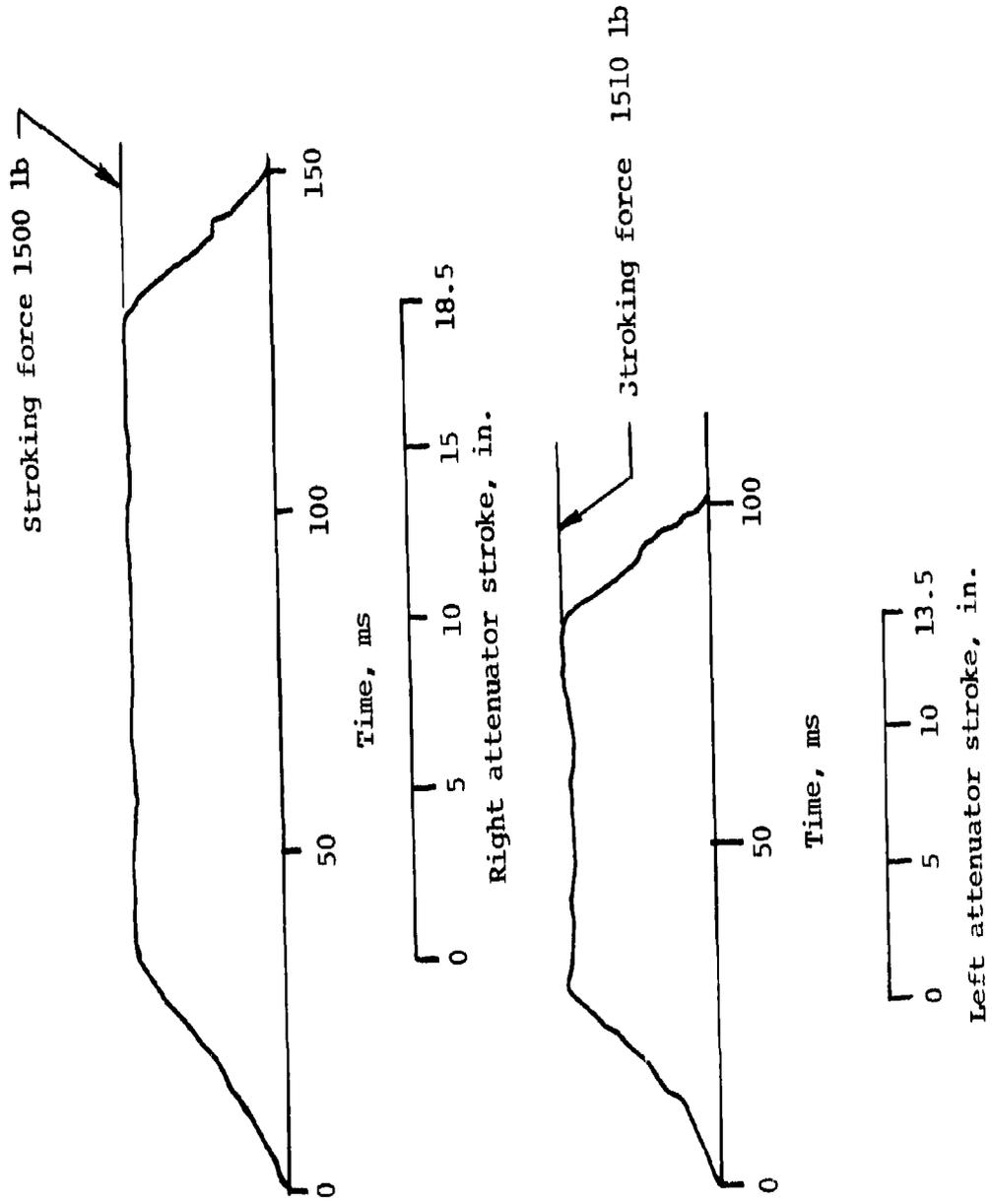


Figure 38. Upper wire-bending attenuators, force/deflection.

Eiband curve (Reference 2), because of the short duration and small peak. The seat, however, is designed for a 50th percentile occupant in a vertical crash impact of 42 fps. Had this combination been used, bottoming should not have occurred. Bottoming of the seat can be expected when the seat stroke is limited to that available in a 17-inch-high seat and the pulse is produced by an impact at 50 fps with an acceleration of 48 G. Experience of previous testing programs (Reference 4) has shown that bottoming will occur under these pulse conditions and that more energy must be absorbed by the aircraft, such as by energy absorbing landing gear.

#### Dynamic Test 2 - Side-Facing Swivel Seat, Forward Impact

The seat was installed in the horizontal test fixture and a 95th percentile dummy with full equipment and chest armor weighing 264 lb was strapped into the seat. The seat was oriented to simulate facing the side of the aircraft (Figure 39). The test was to simulate a forward crash impact of an aircraft at a velocity of 50 fps with an impulse of 24 G.

The seat in the test fixture, mounted on a rubber tired vehicle, was moved back along the guide rail to a point 800 feet from the impact barrier. A stack of paper honeycomb was placed on the barrier into which the vehicle was accelerated (Figure 33).

A visual inspection of the seat after impact revealed that the left lappelt had been severed at the point where it passed through the adjuster (Figures 40 and 41). The seat had been torn from the upper swivel ring trolley of the two turn-buckle fittings (Figure 42). Both turn-buckle eyes had failed in bending. Failure also occurred at the attachment of the left diagonal strut to the lower swivel trolley (Figure 41).

A review of the instrumentation data showed that the impact velocity was 51.5 fps and a maximum acceleration of 25 G was recorded (Figure 43). The data also shows the sequence of failures. Loads increased on the upper right attenuator turn-buckle to 1303 lb and failure occurred at 75 ms. The left turn-buckle reached a load of 1538 lb and failed at 113 ms. All load was transferred to the lappelt, and the left strap reached a maximum of 2186 lb and failed at 188 ms. The vertical hold-down strap was not instrumented but the time it pulled

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<sup>4</sup>Reilly, M. J., CRASHWORTHY, TROOP SEAT TESTING PROGRAM, Boeing Vertol Company, Philadelphia, Penna.; USAAMRDL Technical Report 77-13, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, August 1977.



Figure 40. Lapbelt failure.

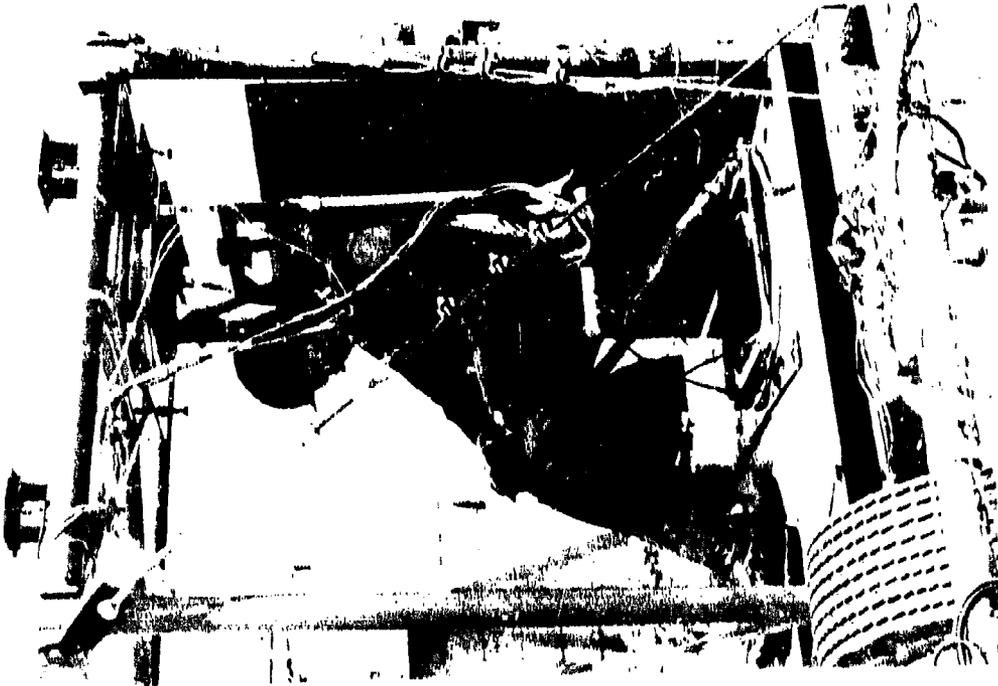


Figure 39. Pre-test 2, 90° to impact.



Figure 41. Failed lapbelt and floor ring attachment.

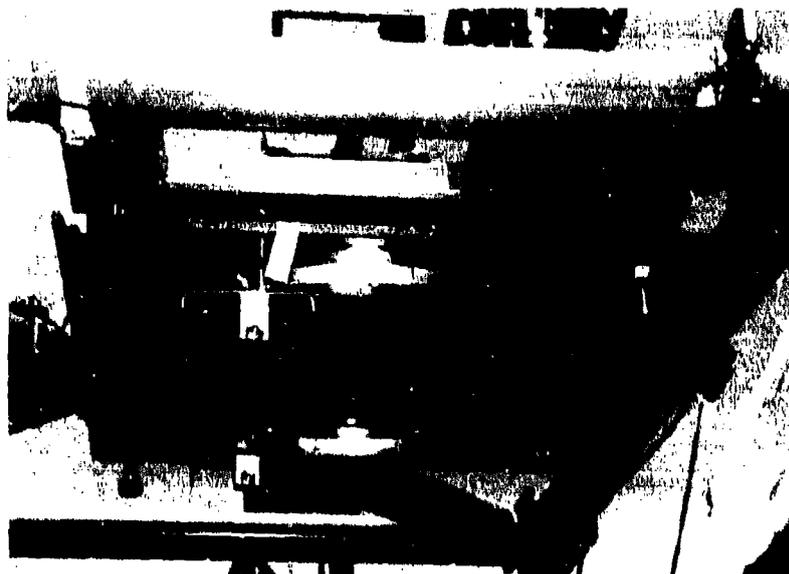


Figure 42. Failed turn-buckle, ceiling ring attachment.

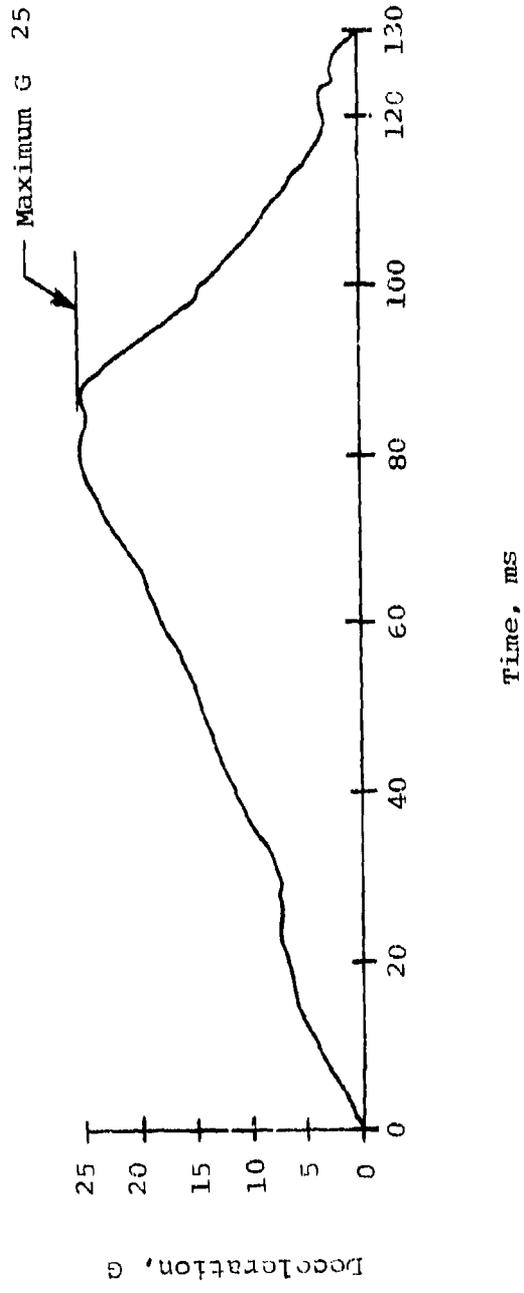


Figure 43. Test 2 - Vehicle deceleration time history.

out of the attachment to the lower swivel trolley can be determined by loss of load on the diagonal attenuator. This occurred at 113 ms, the same time as the upper left turn-buckle failure. Loads on the right and left shoulder straps reached maximum loads of 964 and 535 lbs respectively. Acceleration on the dummy's pelvis and chest, in a lateral direction, peaked at 31 and 27 G respectively at the time the left turn-buckle broke.

An analysis of the test results and the motion picture film revealed that the seat tended to swivel counterclockwise at the top and clockwise at the lower section. This was due to the seat's lack of torsional stiffness. As a result, the seat did not swivel, as intended, to a position where the attenuators became effective. The weakness of the upper turn-buckle attachments contributed to the premature failure before stroking of the upper attenuators occurred. Sharpness of the lap-belt knurled adjuster bar contributed to the webbing failure. Use of 0.045-in.-thick webbing, in place of the more desirable 0.065-in.-thick webbing, increased the ease of the lap-belt severance.

#### FIRST SERIES DYNAMIC TEST SUMMARY

Test 1, predominantly vertical three-axis impact, resulted with satisfactory energy attenuation and maintenance of seat integrity. The forward crash test, with the seat in a side-facing attitude, resulted in structural failure.

An analysis was made of the static and dynamic test data, the dynamic test high-speed film, and especially the forward crash condition which resulted in seat failure. A design investigation was made in an effort to resolve the problems causing the failure. The seat had worked perfectly in the static test under similar orientation and loading conditions. Seat rotation occurred and all energy attenuators stroked as planned when the static load was applied. The one element missing in the static test, that was present in the dynamic test, was the inertia loading on the upper ring trolley.

Various seat modifications were studied in an effort to resolve the inertia loading problem as follows:

1. The center of rotation of the seat was moved to the center of the upper trolley so that the inertia load on the trolley would not tend to torque the seat.
2. The center of rotation of the seat was moved toward the front of the seat so that the occupant C.G. would be behind the center of rotation and forward crash accelerations would cause the seat to rotate to an aft-facing position.

3. A linkage arrangement was studied to replace the existing track and trolley guide system for seat rotation.
4. Increasing seat strength and rigidity to withstand torque loading was considered.

These studies resulted in several possible approaches. Each approach has advantages as well as disadvantages as follows:

1. Moving the center of rotation of the seat in line with the upper trolley would increase, by 13 in., the arc that the seat would swing.
2. Moving the center of rotation toward the front of the seat so that the seat would rotate to a rear-facing position, under forward crash acceleration, would require extension of the rotation ring forward of the front of the seat. This would cause an encumbrance with the gunner's legs.
3. Maintaining the existing seat geometry and placarding the seat to be rotated to a forward-facing position during takeoff and landing and in the event of an emergency, would entail an active effort on the part of the occupant.
4. Increasing seat strength, such that the torque loads can be withstood during seat rotation, would increase seat weight.

After a review of the motion picture film of the dynamic tests and consideration of the four alternatives, the Eustis Directorate decided on the No. 3 approach—placarding the existing configuration. The decision was based on the following factors:

1. The seat worked well in a crash impact with combined three axis vertical, forward, and lateral load components. This is the predominant impact condition in a helicopter crash.
2. Crash impacts with predominant forward accelerations generally are associated with sufficient warning time to permit the traditional announcement from the pilot over the intercom, "Going-in." This will allow the crew chief and gunner time to swivel their seats to a forward-facing position.

## SWIVEL SEAT DYNAMIC TESTING AND ANALYSIS (SECOND SERIES)

Additional dynamic testing was required after seat modifications and revisions to the dynamic test requirements. The following modifications were made to the seat and test requirements:

1. Redesign of the upper attachment fitting to the swivel trolley.
2. Increase the strength of turnbuckles, attaching the seat to the upper swivel trolley.
3. Redesign of the seat back tube to eliminate the transition point where excessive bending has occurred on previous tests.
4. Provide a stop on the upper track to prevent excessive seat twisting, which occurred on a previous dynamic test.
5. Salvage usable parts from previously tested seats, and construct refurbished seats.
6. Conduct an additional dynamic test for forward acceleration with the seat oriented at a 30-degree angle to the direction of impact.

Revisions to the test requirements were made to reduce the severity of the test. The assumption was made that the seat would be swiveled to a forward-facing position prior to impact. A similar impact requirement used for fixed forward-facing seats would be used for the swivel seat. This requirement was for forward impact in a 30-degree yaw attitude.

The test objectives were to determine the effectiveness of the modifications on maintaining seat integrity and the revised test requirements effect on improving seat functioning.

### Dynamic Test 3 - Swivel Seat, Forward Yaw Impact

A modified swivel seat was installed on the test fixture and oriented in a 30-degree yawed position. A 95th percentile dummy with chest and back armor was strapped into the seat; it weighed a total of 250 lb (Figure 44). The vehicle was accelerated horizontally and impacted the barrier at 49.1 fps.

A visual inspection of the seat was made after the test, and the seat was found to be essentially intact, and the dummy was restrained in the seat. Rotation of the seat had occurred to align itself in the direction of impact. Modified



Figure 44. Pre-test 3, 30° to impact.



Figure 45. Post-test 3, lost shoulder restraint.

vertical tubes of the seat back withstood the test without bending or failing at the transition as occurred on all previous tests. The new turnbuckles also withstood the impact. Horizontal tubes in the seat back, to which the shoulder straps were attached, had separated from the back. However, the lap-belt restrained the dummy, and the dummy remained in an upright position after the test (Figure 45). The length of the stroked upper attenuator indicates that the back tube, supporting the shoulder strap, remained attached through most of the test. Complete separation occurred on rebound. The shoulder strap support tube separated from the left vertical back tube early in the test, resulting in the upper left attenuator stroking only 2.5 in. Shoulder strap loads were taken through the attachment to the right vertical tube, which remained attached until rebound. The upper right attenuator taking most of the load stroked 11.0 in. (Figure 46). The unequal stroking of the upper attenuators allowed the seat to tip sideways. Each of the diagonal strut attenuators stroked 3.0 in. (Figure 47).

A review of the instrumentation data showed that the crash impulse, measured at the floor, was a maximum of 24 G. The calculated triangular peak was 25.4 G for a time base of .120 second (Figure 48). Plateau peak accelerations measured on the dummy were well within limits. The acceleration in the frontward direction (X axis) was 1.6 G on the chest. The plateau peak acceleration to the side (Y axis) was 9.8 G (Figure 49).

Instrumentation data showed that the maximum loads and attenuator strokes recorded were as follows:

<u>Instrumented item</u>	<u>Maximum load - lb</u>	<u>Stroke - in.</u>
Right lapbelt	3327	--
Left lapbelt	3120	--
Right shoulder strap	1200	--
Left shoulder strap	508	--
Right diagonal strut	1122	3.0
Left diagonal strut	1188	3.0
Right ceiling attenuator	--	11.0
Left ceiling attenuator	--	2.5

#### SECOND SERIES DYNAMIC TEST SUMMARY

The swivel gunner seat met the test objectives in spite of the shoulder strap attachment tube failure. Complete severance of the tube from the seat back occurred during rebound and had minimal effect on the dynamics of the dummy and functioning of the seat. All attenuators stroked, reducing

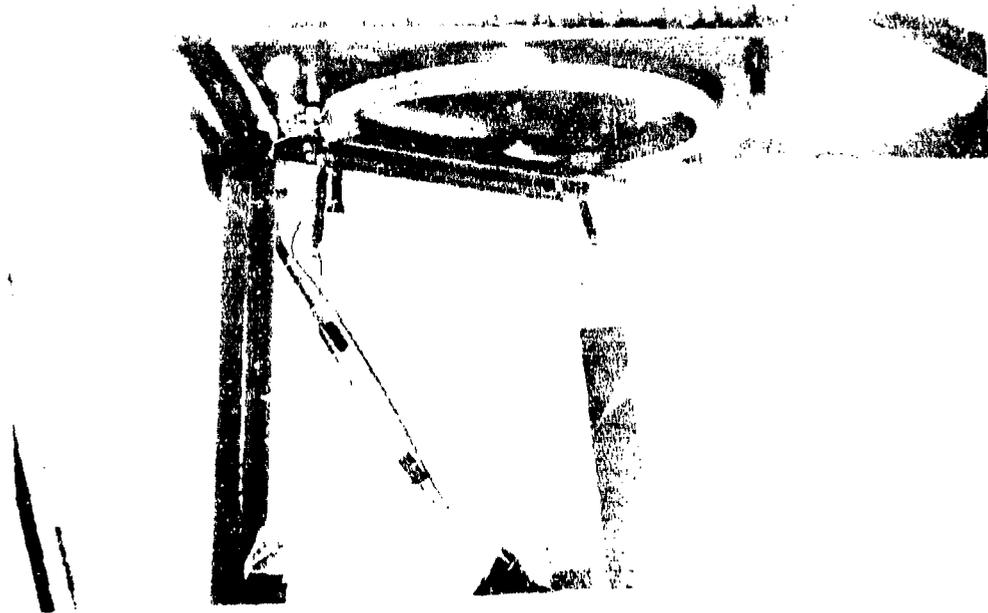


Figure 46. Failed shoulder strap support and stroked attenuators.

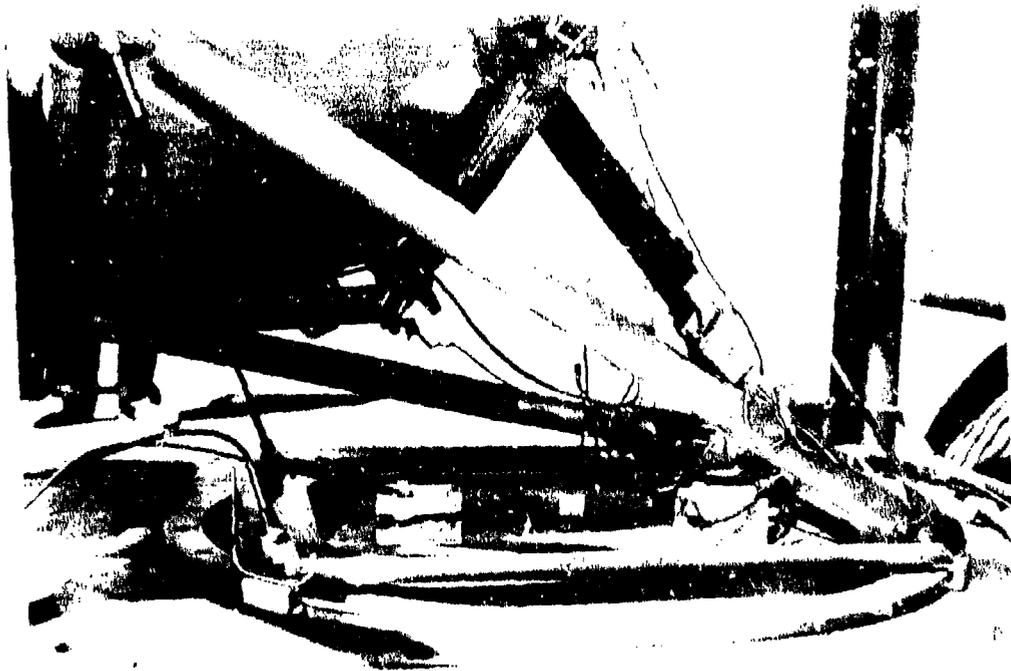


Figure 47. Stroked diagonal strut attenuators.

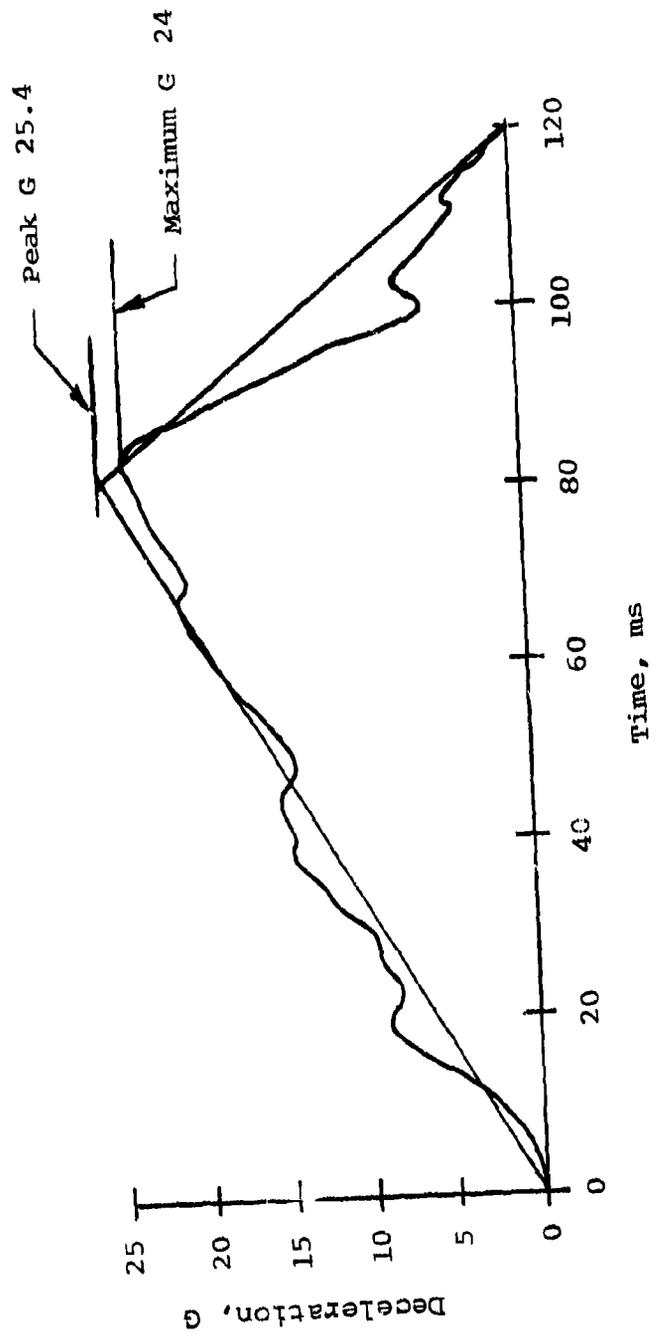
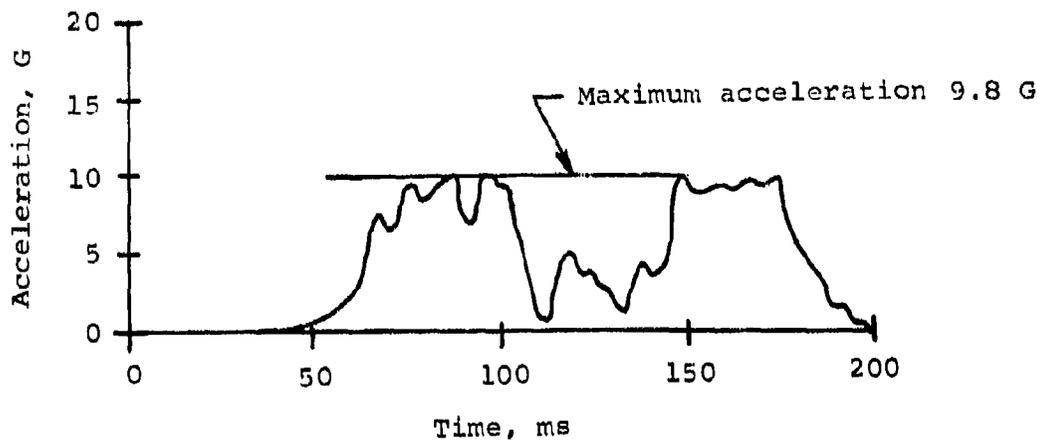
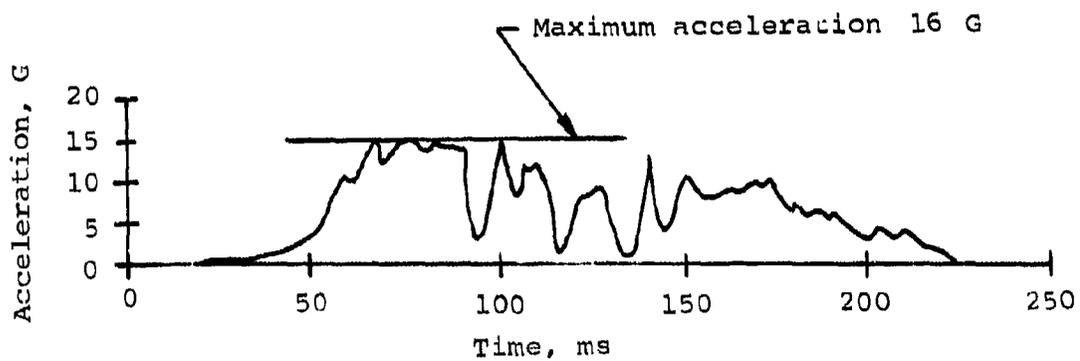


Figure 48. Test 3 - Vehicle deceleration time history.



Lateral acceleration



Forward acceleration

Figure 49. Test 3 - Dummy chest acceleration.

the acceleration on the occupant to the desired level. The seat rotated to align itself in the direction of the impact load. The dummy was restrained by the seat and remained in an essentially normal position during and after the test.

The swivel seat concept tested, however, has some limitations. The seat must be rotated to a predominantly forward-facing position to withstand the forward impact loading conditions. This is necessary because the seat has insufficient torsional strength to withstand the counter rotating tendency of the upper and lower portions of the seat during crash accelerations. The seat can be designed to provide the necessary torsional stiffness; however, this would increase the seat weight. Another approach would be to provide manually controlled locks to the upper and lower swivel rings to prevent the seat from counter rotating. This would require a minimal weight increase.

## FIXED SIDE-FACING SEAT DEVELOPMENT - TASK IV

### INTRODUCTION

Due to the marginal success of the swivel seat development, and the desire of the using agencies of the Army for a simple and lighter weight-side-facing gunner seat, a decision was made by the Eustis Directorate to develop a fixed side-facing gunner seat. It was requested that components from previously tested swivel seats and other similar components be used to make fixed side-facing seats for further testing. Four existing seats were to be modified and refurbished. Static and dynamic tests were to be performed on these seats.

### SEAT MODIFICATION

Static and dynamic tests performed on the swivel seat concept showed a need for modifications to the seat back because of failures that had occurred. The vertical tubes of the seat back had a transition from round to flat, occurring at a point where the shoulder strap load was applied. Failures had occurred at the transition. New backs were made for the seats with the transition moved closer to the top of the seat back.

Diagonal energy attenuating struts which had been attached to brackets on the front tube of the seat pan had to be attached to the side of the seat, which was toward the forward direction of the aircraft. These struts are the principal forward crash load attenuating devices and must be oriented in the direction of impact. Swivel seats were rotated in a forward-facing direction, and therefore the struts were attached to the front of the seat.

Brackets welded to the front of the seat for attachment of the diagonal struts had to be removed to clear the strut when attached to the side tube. High strength aluminum tubes, needed on the sides of the seat, cannot be welded, so a wrap-around bracket was provided for attachment of the diagonal struts (Figure 50). The wraparound bracket was also convenient for relocating the diagonal strut attachment points during testing. Location of the diagonal struts is critical because the crash load must be properly balanced between the two struts to assure proper stroking.

Stabilizing cables under the seat, quick-disconnect fittings and floor studs, the same as used on the crashworthy troop seats (Reference 2), were used for the fixed side-facing gunner seat. All other seat structure, fabric, and restraint harness were the same as used on the swivel seat.



Figure 50. Wraparound bracket for strut attachment.

## STATIC TEST FIXTURE

The static test fixture used for swivel seat static testing was also used to test the fixed side-facing seat. Modifications were made to the fixture to accept the fixed seat. Swivel rings at the ceiling and floor were removed, and the ceiling plate was lowered 2 inches. Studs were added to the floor plate to accept the quick-disconnect attachments. Fixed brackets attached to the ceiling provided connections for the turnbuckles at the top of the seat.

## STATIC TEST REQUIREMENTS

Static testing of one fixed side-facing seat was required. The test was to simulate aircraft forward impact with the seat oriented in a side-facing position. Loading requirements were to be in accordance with the forward loading specified in the approved static test plan (Appendix A).

## STATIC TEST AND DATA ANALYSIS

### Static Test 5 - Fixed Side-Facing Seat, Forward Loading

The seat was installed in the test fixture oriented in a side-facing position. Suspension from the ceiling was by the two wire-bending energy attenuators attached to turnbuckles. Four quick-disconnect fittings attached the seat to floor studs (Figure 51).

A 95th percentile aluminum body block was installed in the seat and restrained by a four-point lapbelt shoulder harness system (Figure 51). Seat loading was accomplished by attaching a cable between the body block and a hydraulic cylinder. The cable was attached to a fitting on the side of the body block at the representative center of gravity of a 95th percentile occupant. A minimum loading of 15 G was to be applied.

Loading was applied gradually to the body block by the hydraulic cylinder. Force versus deflection was recorded by the instrumentation. Loading on the two diagonal strut attenuators and two vertical attenuators was measured by strain gages located on the attenuators. Loads on the diagonal strut attenuators were carefully monitored to determine load balance. The rear diagonal strut was canted toward the center of the seat (Figure 52), and loads within 50 lb were recorded on the two attenuators. Loading was continued, and stroking of the upper and lower attenuators began. The seat maintained a level and straight attitude during the stroking operation. The test was stopped when the seat had stroked more than the required 10 in. laterally.

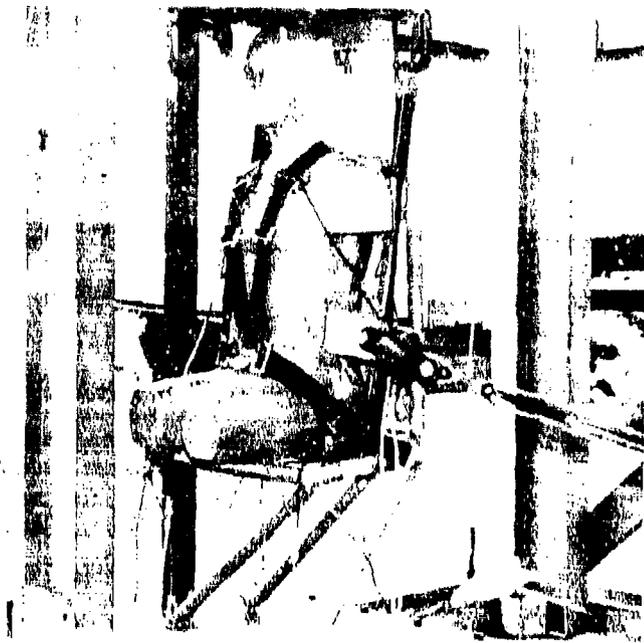


Figure 5L. Pre-test 5, loading 90° to forward impact.

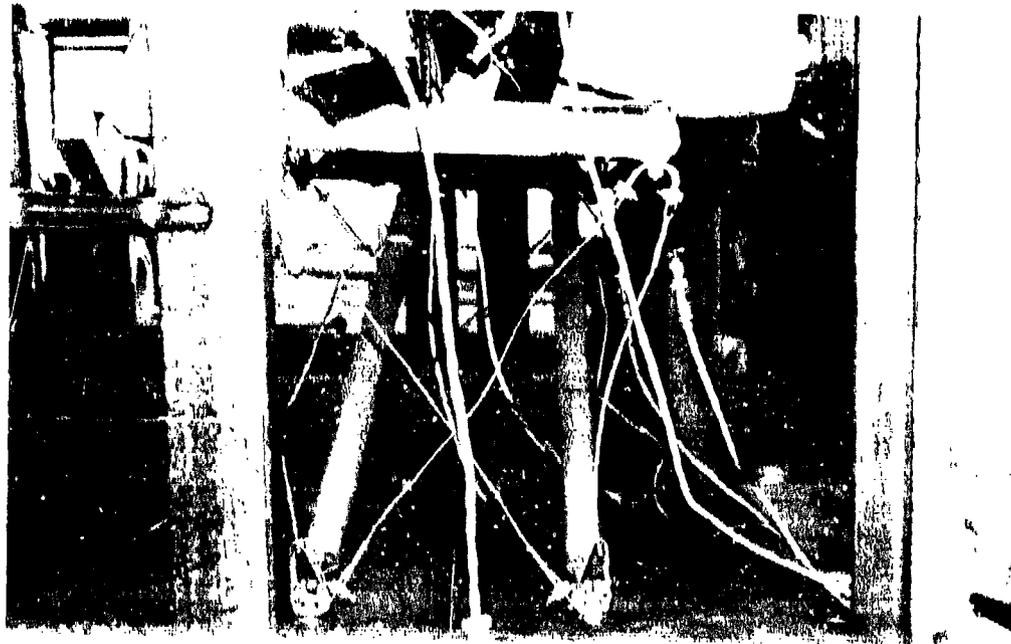


Figure 5M. Diagonal strut installation.

A visual inspection of the seat made after the test revealed no seat structure or fabric failures. Deformations were minimal (Figure 53). The upper right and left attenuators had stroked 4.8 and 5.5 in. respectively, and the lower front and rear diagonal attenuators had stroked 6.9 and 6.7 in. respectively (Figure 54).

Instrumentation data showed the following maximum loading:

<u>Instrumented item</u>	<u>Force - lb</u>	<u>Stroke - in.</u>
Left lapbelt	1675	
Left shoulder strap	1498	
Right lapbelt	914	
Right shoulder strap	777	
Horizontal displacement	--	11.5
Vertical displacement	--	4.4
Rear diagonal strut	1153	6.7
Front diagonal strut	1214	6.9
Right vertical attenuator	--	4.8
Left vertical attenuator	--	5.5

An analysis of the test data shows that the force/deflection requirements had been achieved. The force/deflection curve rose above the base area (Figure 55) and leveled off at a desired level of 16 G. As the seat stroked sideward, the force began to rise slightly, beginning at the 6-inch deflection point and crossing the minimum acceptable load curve at 8.5 inches. Stroking continued above the 10-inch minimum deflection point and the test was stopped when the seat had stroked 11.5 inches. The seat functioned as required, meeting all the test objectives.

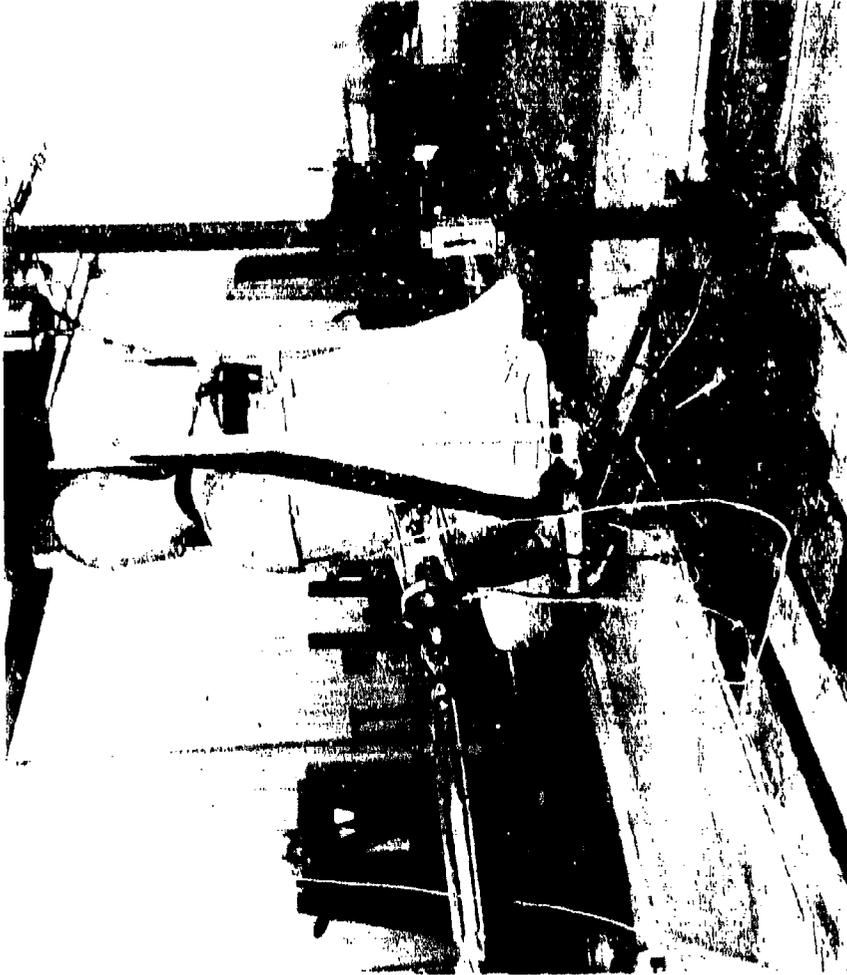


Figure 53. Post-test 5, seat stroked 10 in.

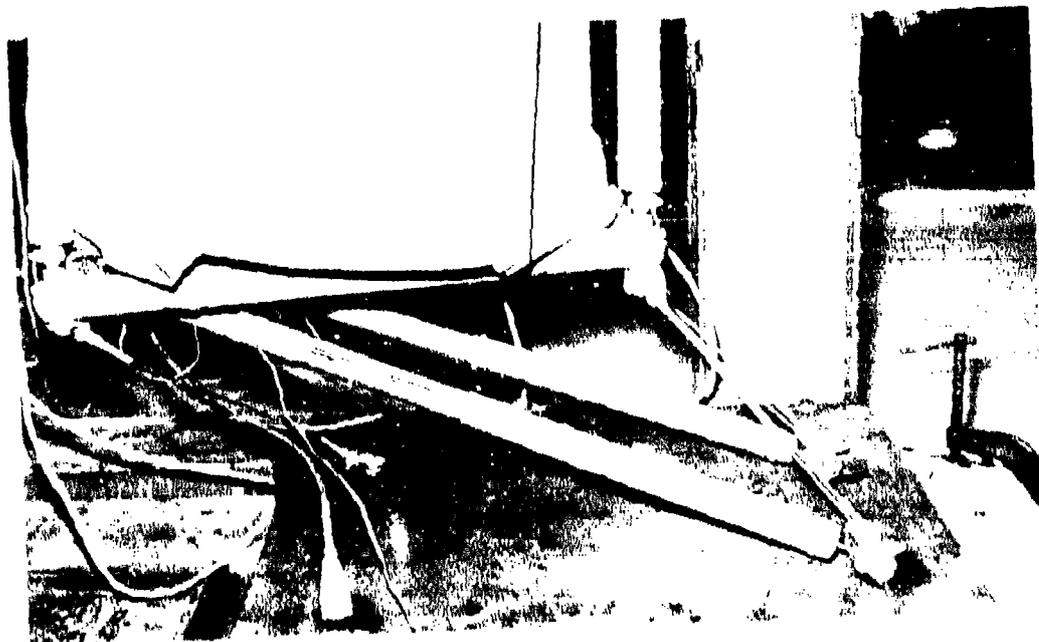
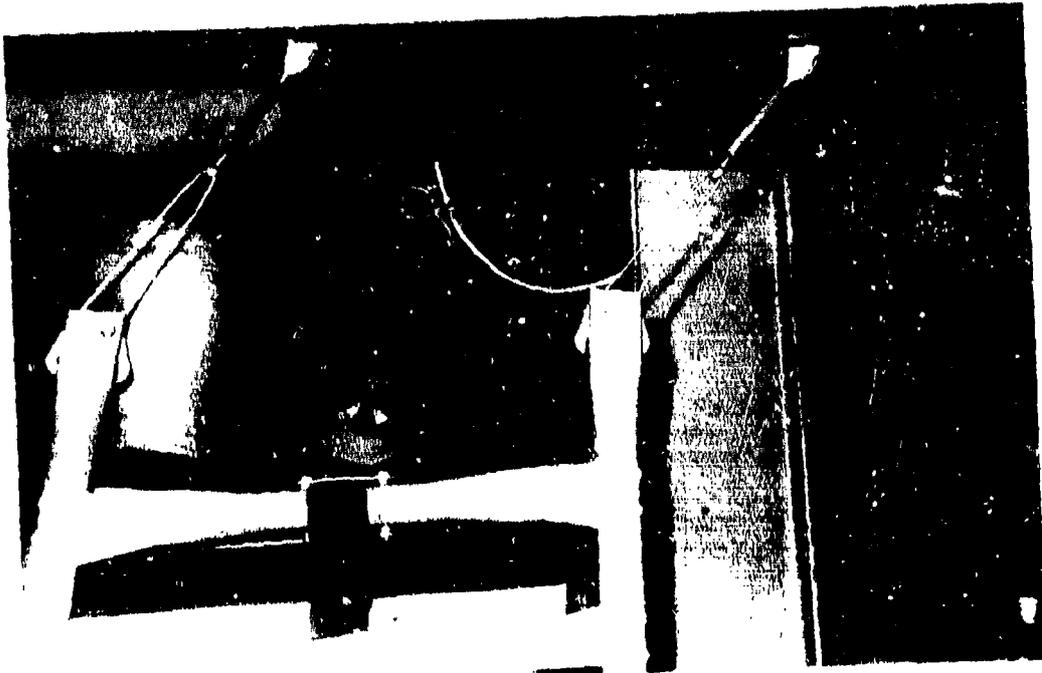


Figure 54. Stroked upper and lower attenuators.

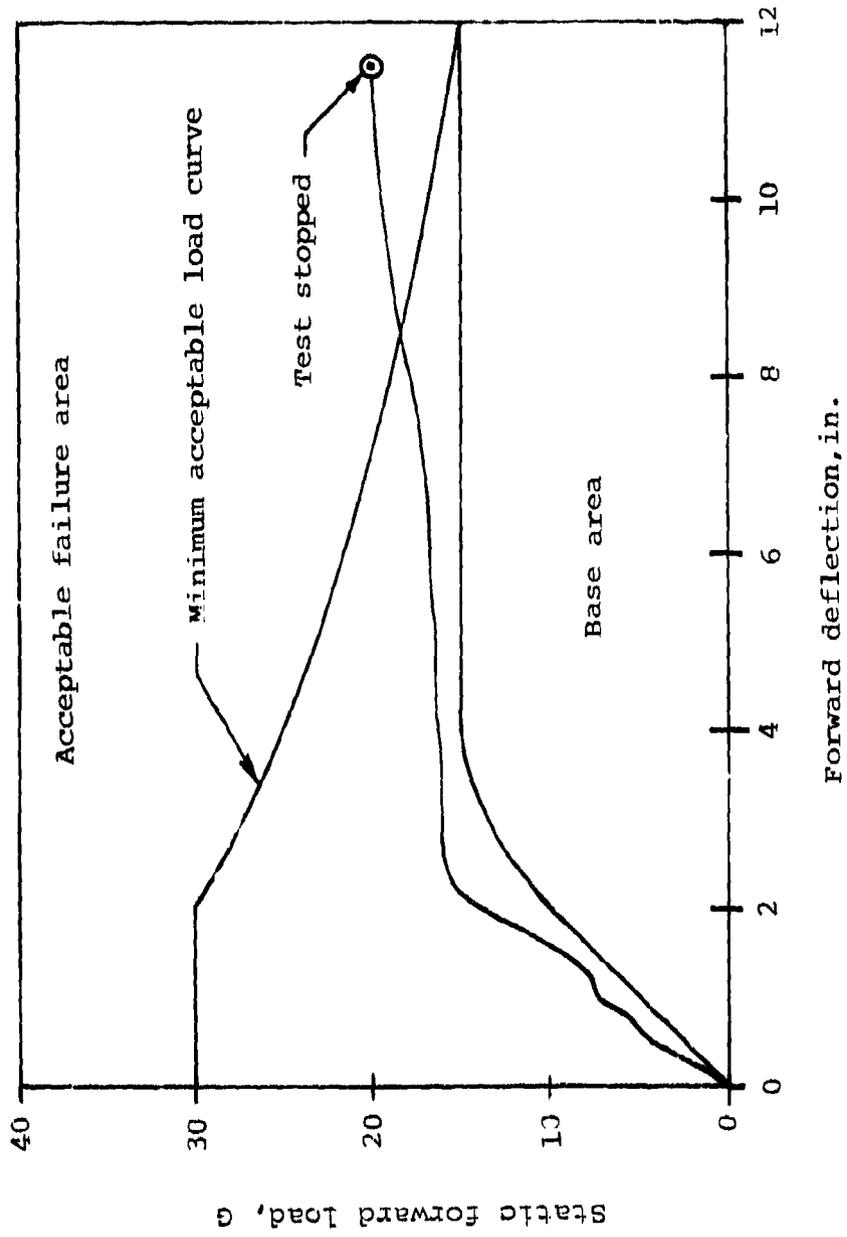


Figure 55. Static test 5, lateral seat deflection with forward loading.

## DYNAMIC TEST REQUIREMENTS

Dynamic testing of a minimum of three fixed side-facing seats was required. The required effort for the tests was as follows:

- The preparation of fixed side-facing seat systems by converting previously tested swivel seats through refurbishment, modifications, and refinements determined to be necessary as a result of swivel seat tests and fixed seat static tests.
- The preparation of seat system and test fixtures to perform dynamic testing in accordance with the dynamic test plan (Appendix B).
- The performance of dynamic tests on seat systems in accordance with the dynamic test plan.
- The analysis of data obtained in dynamic tests for the purpose of verifying the adequacy and feasibility of the design criteria contained in the proposed Military Specification, Seat, Helicopter, Gunner, and in References 2 and 3. Those requirements and/or criteria that were insufficient to insure gunner seat occupant protection throughout the 95th percentile survivable accident were to be identified, as well as those requirements and/or criteria that exceed the strength or performance criteria necessary to provide gunner seat occupant protection during the 95th percentile survivable aircraft accident or which, because of practical considerations, are proven too stringent to be feasibly met by current technology.
- Criteria and requirements contained in the proposed military specification, and References 2 and 3 were to be substantiated, or changes recommended.

## SEAT MODIFICATIONS

Refurbishment and modifications performed on seats, which resulted in the successful fixed seat static test, were considered satisfactory for seats to be dynamically tested. The diagonal strut attenuators were attached to the seat pan tubes in the same location that produced the balanced results during static testing.

## DYNAMIC TEST FIXTURE

The same test fixture modified for the fixed seat static test was used for the dynamic tests. The fixture was mounted on a rubber-tired vehicle for performing horizontal impacts on the horizontal test track. Stacks of paper honeycomb were attached to the impact barrier to obtain the desired pulse shape at impact. Calibration runs were made to verify the pulse by impacting the vehicle into the honeycomb and recording the accelerations registered by accelerometers mounted on the test fixture.

The same fixture used for horizontal tests was removed from the vehicle and suspended from the drop tower for predominantly vertical impacts. A wedge piece of structure was added to the bottom of the fixture to achieve the proper combined three-axis impact attitude.

## DYNAMIC TESTS AND DATA ANALYSIS

### Dynamic Test 4 - Fixed Side-Facing Seat, Forward Loading

A fixed side-facing seat was installed on the horizontal test fixture and oriented 90 degrees to the direction of impact. A 95th percentile dummy with chest and back armor (Figure 56) and weighing a total of 250 lb was strapped into the seat (Figure 57). The test vehicle was accelerated horizontally on the track and impacted the barrier at a velocity of 50.8 fps.

A visual inspection of the seat after impact revealed that the seat functioned properly, and the dummy was restrained in the seat in a proper attitude (Figure 58). There were no structural or fabric failures. The upper seat back tube, over which the shoulder strap passed, had deformed to a point where all the shoulder strap load was taken by the lower tube. The sudden release and subsequent take-up of the shoulder strap had some effect on the dummy's chest acceleration.

The upper and lower energy attenuators stroked, all functioning properly (Figure 59). The upper right and left attenuators had stroked 8.75 and 8.0 in., respectively. The front and back diagonal-strut attenuators had stroked 7.9 and 7.5 in., respectively.

A review of the instrumentation data showed that the impact velocity was 50.8 fps with a time base of 120 ms. The input pulse to the seat was recorded by accelerometers installed on the vehicle. As the vehicle impacted the barrier and decelerated, the deceleration level was measured in the direction of impact. Accelerometers measured the force in G, while a timing device measured the vehicle velocity at the



Figure 56. Body armor.

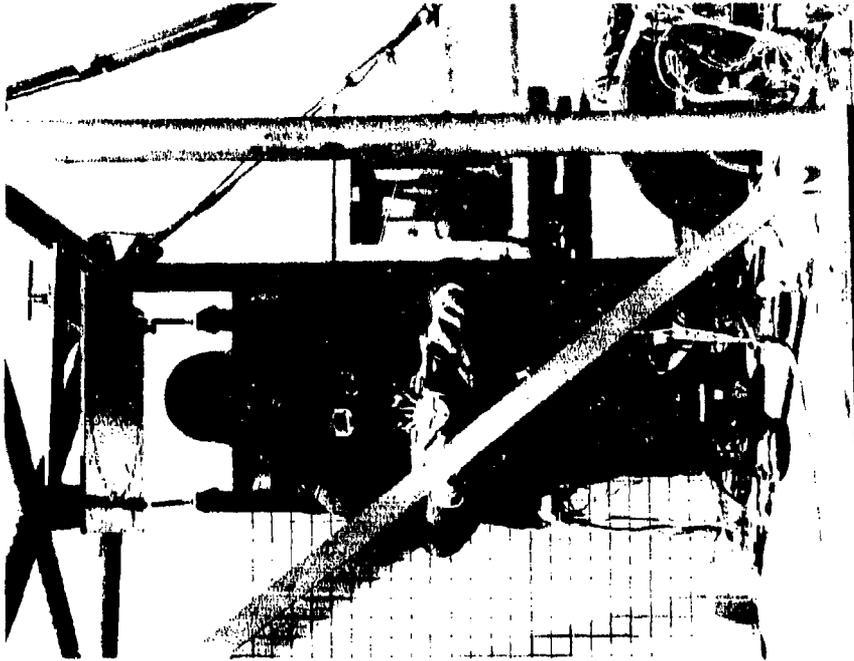


Figure 57. Pre-test 4, 90° to forward impact.

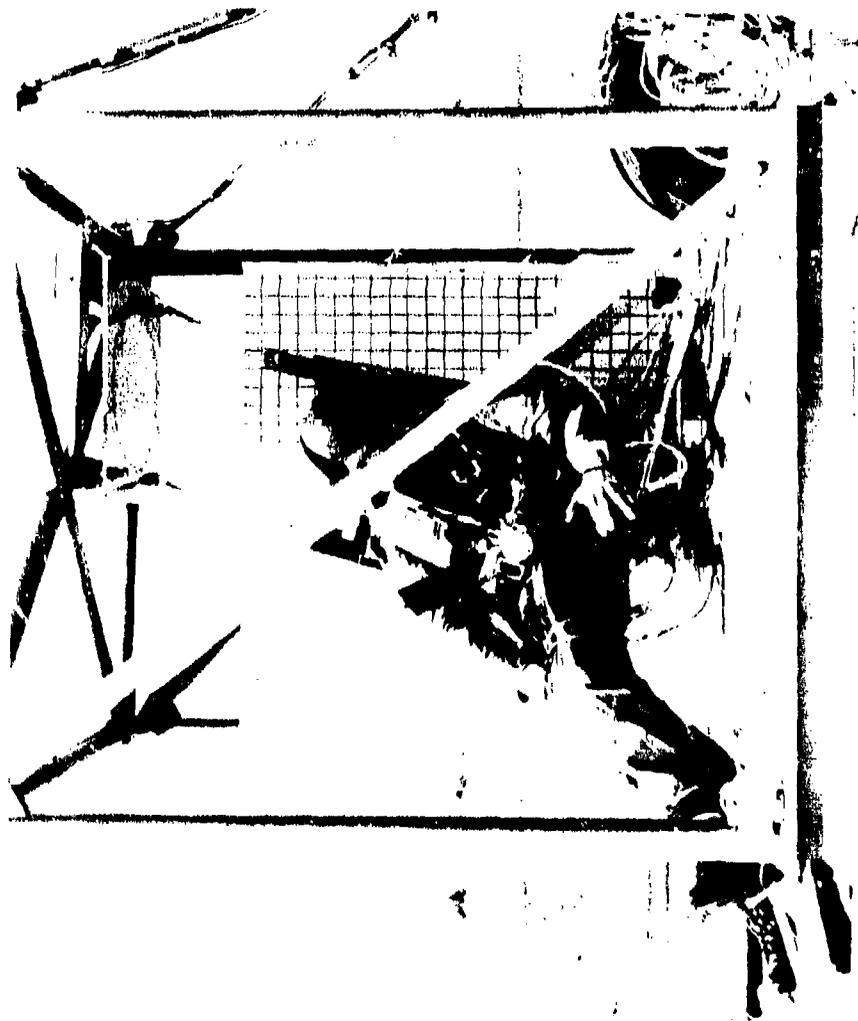


Figure 58. Post-test 4, seat stroked.



Figure 59. Stroked upper and lower attenuators.

time of impact. The G force was plotted with respect to time (Figure 60). A peak G value of 24 G was specified; however, this is a theoretical value. Only the maximum G, which was 23.4 G, is recorded and plotted, while the peak G must be calculated. Knowing the velocity and the time base, which are recorded by instrumentation, the theoretical peak G can be determined as follows:

$$32.2 G_{pk} = \frac{2 V}{t} = \frac{2 (50.8)}{.120}$$

$$G_{pk} = 26.3$$

The peak G is superimposed over the recorded pulse data (Figure 60). Plateau peak accelerations measured on the dummy's chest in the lateral direction were approximately 20 G with a short spike that reached 24 G (Figure 61). This spike occurred at the same time as a spike on the right shoulder strap load curve and was attributed to the sudden deformation of the upper shoulder strap tube and the take-up by the lower tube. Accelerations in the frontward and vertical directions were minimal. A maximum of a 9 G spike was recorded in the vertical direction.

The maximum loads and attenuator strokes recorded were as follows:

<u>Instrumented item</u>	<u>Maximum load - lb</u>	<u>Stroke - in.</u>
Right lapbelt	3383	--
Left lapbelt	2334	--
Right shoulder strap	1867	--
Left shoulder strap	1184	--
Upper right attenuator	--	8.8
Upper left attenuator	--	8.0
Front diagonal strut	1256	7.9
Back diagonal strut	1188	7.5

The test conclusions are that the seat functioned properly, maintaining its integrity during the crash sequence and retaining the dummy in a proper attitude. All energy attenuators stroked as intended, reducing the lateral plateau peak acceleration on the occupant to within the 20 G acceptable limit. An overshoot spike acceleration higher than acceptable, which resulted from shoulder strap release, then take-up, was recorded on the dummy's chest. This condition can be improved by strengthening the shoulder strap attachment provisions on the seat back.

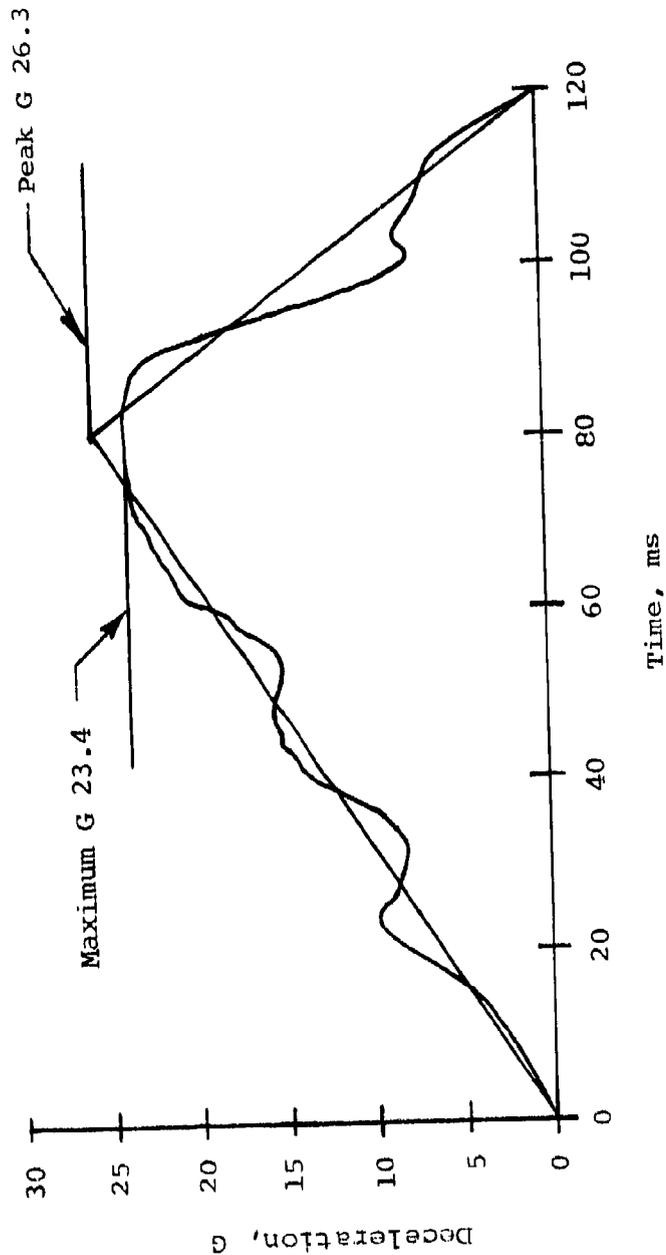
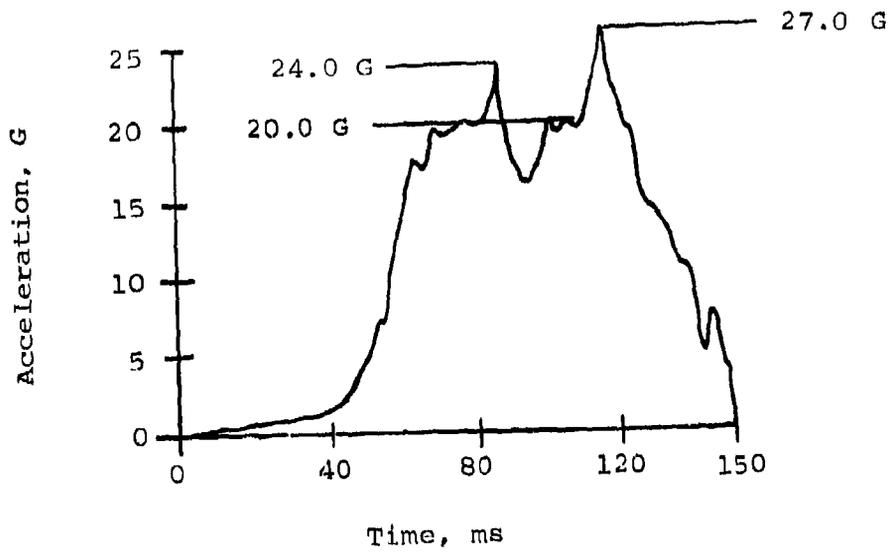
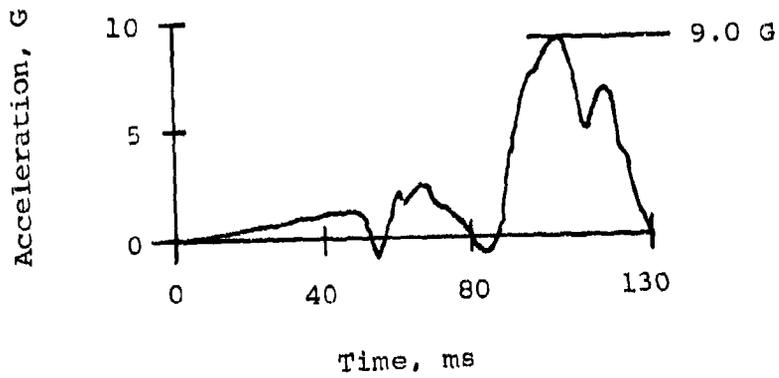


Figure 60. Test 4 -- Vehicle deceleration time history.



Lateral acceleration



Vertical acceleration

Figure 61. Test 4 - Dummy chest acceleration.

### Dynamic Test 5 - Fixed Side-Facing Seat, Forward Yaw Loading

A fixed side-facing seat was installed in the horizontal test fixture and oriented 60 degrees to the direction of impact. This simulated a seat facing the side of the aircraft and the aircraft impacting in a forward direction at a 30-degree yawed attitude. A 95th percentile dummy with chest and back armor, and weighing a total of 250 lb, was strapped into the seat (Figure 62). The test vehicle was accelerated horizontally on the track and impacted the barrier at a velocity of 50.0 fps.

A visual inspection of the seat after impact revealed that the seat functioned properly and the dummy was restrained in the seat in a proper attitude (Figure 63). There were no failures to the primary seat structure or fabric; however, the two horizontal tubes at the top of the seat back, to which the shoulder harness was attached, had separated from the vertical seat back tubes (Figure 64).

The upper and lower energy attenuators stroked, all functioning properly (Figure 65). The upper right and left attenuators had stroked 8.5 and 5.0 in. respectively. The front diagonal strut stroked 6.4 in. and the rear strut stroked 6.0 in. The right diagonal cable had stroked 1.2 in. and the left diagonal cable had stroked 1.5 in.

Review of the instrumentation data showed that the crash impulse at the floor was a maximum of 24 G and the triangular peak G was calculated to be 25.9 G over a time base of .120 second as a result of a 50-fps impact velocity (Figure 66). Accelerometers in the chest recorded accelerations about three axes. The acceleration in the lateral direction showed a plateau peak acceleration of 16.7 G with an overshoot peak of 20 G (Figure 67). The overshoot occurred at the same time as a spike on the shoulder strap load curve (Figure 68). The spike on the chest acceleration and shoulder strap load curve was a result of the deformation of the support tubes for the shoulder strap anchor. The load on the shoulder strap drops as deformation of the upper tube begins, and rises sharply as the load is suddenly taken up by the lower tube. Vertical acceleration recorded on the dummy was well within limits with a plateau of 10.5 G and a short duration spike of 15 G at the end attributed to rebound from the compressible honeycomb (Figure 67).

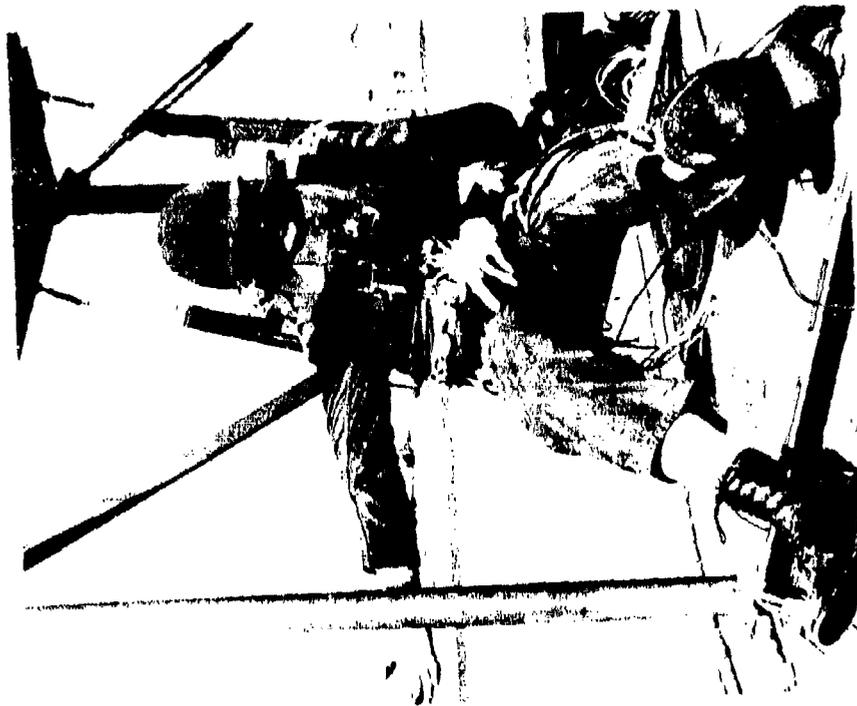


Figure 63. Post-test 5, seat stroked.

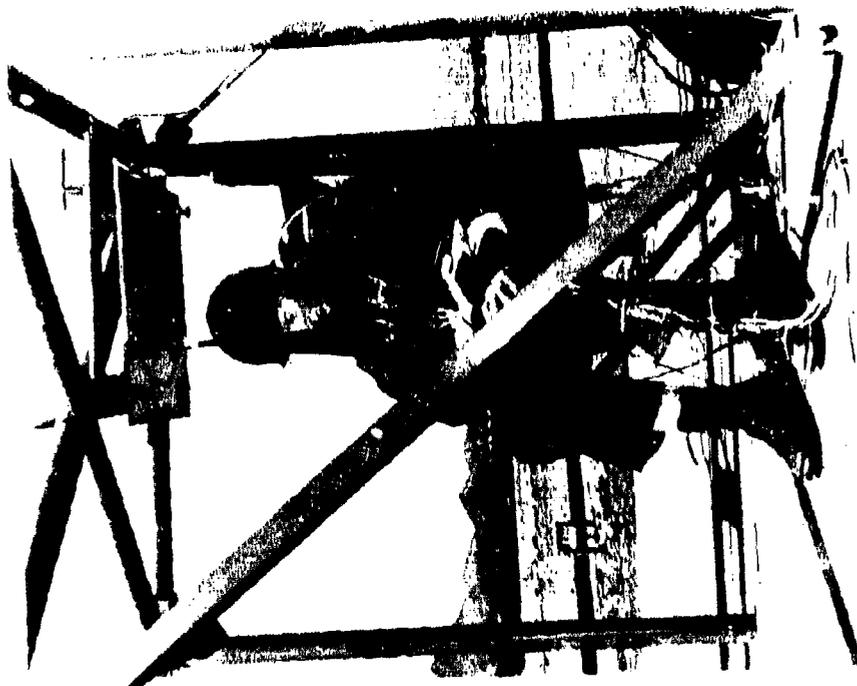


Figure 62. Pre-test 5, 60° to forward impact.



Figure 64. Shoulder strap support failure.

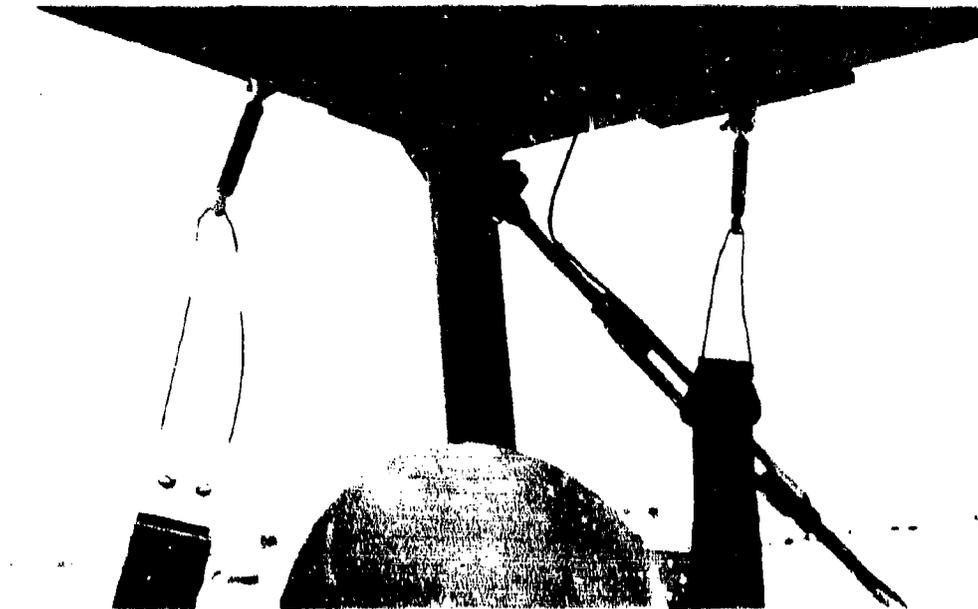


Figure 65. Stroked upper and lower attenuators.

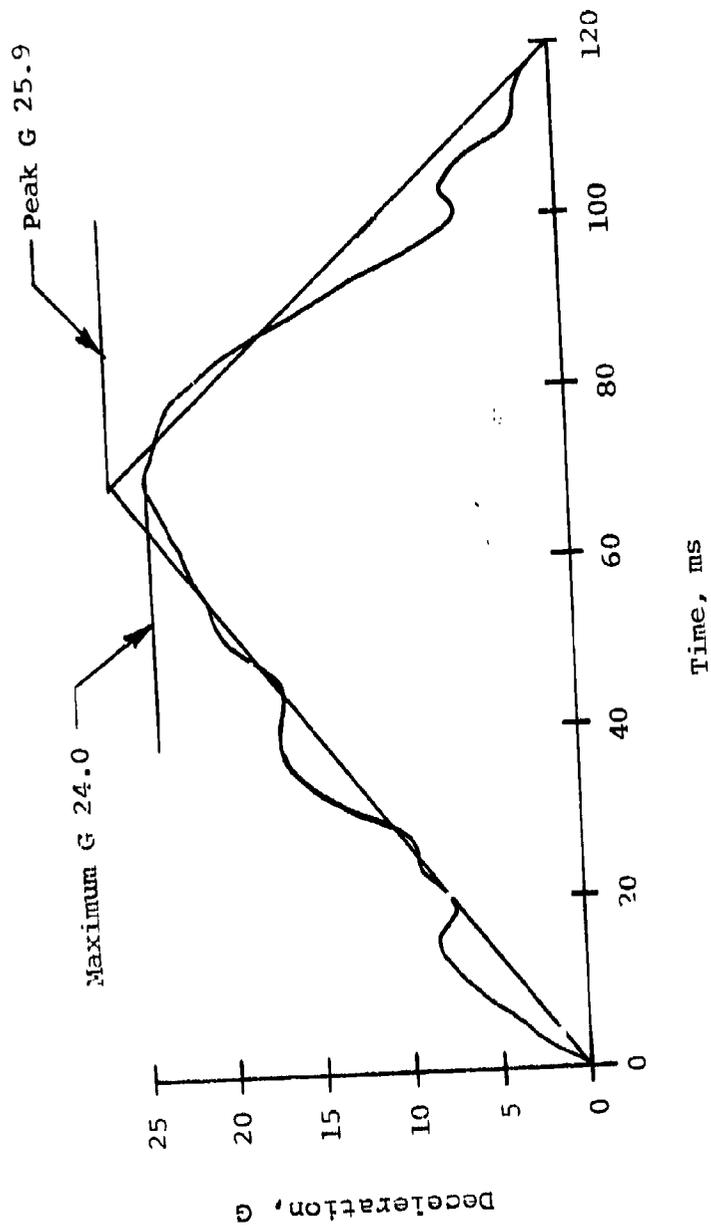
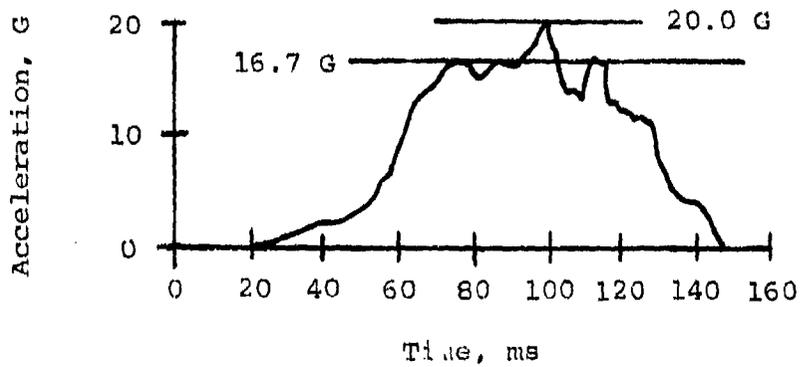
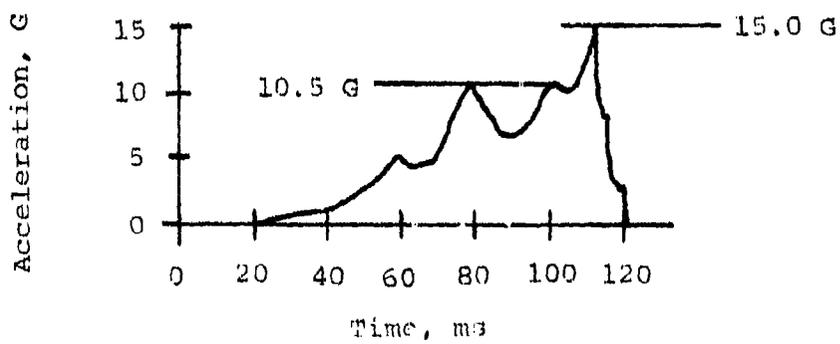


Figure 66. Test 5 - Vehicle deceleration time history.



Lateral acceleration



Vertical acceleration

Figure 67. Test 5 - Dummy chest acceleration.

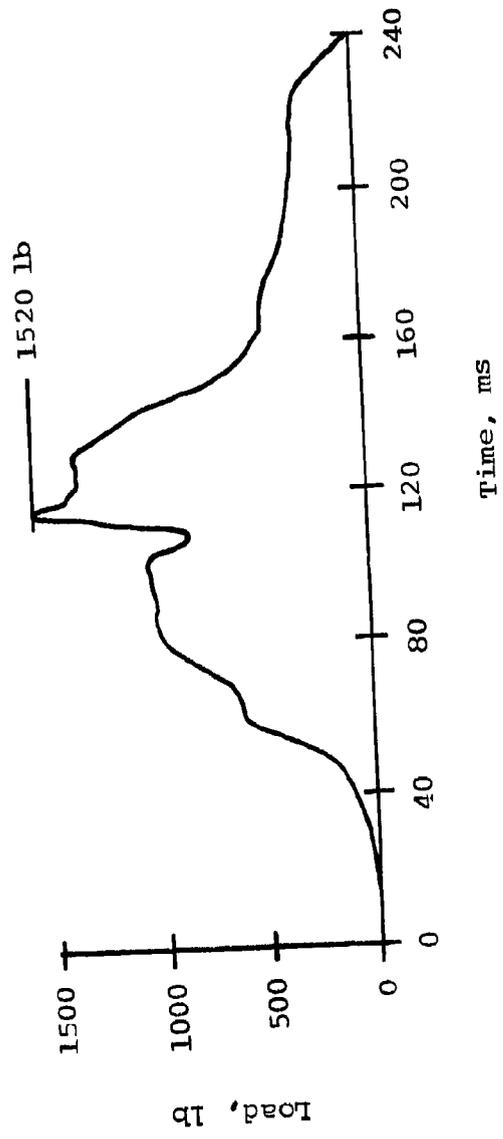


Figure 68. Right shoulder strap load.

The maximum loads and attenuator strokes recorded were as follows:

<u>Instrumented item</u>	<u>Maximum load - lb</u>	<u>Stroke - in.</u>
Right lapbelt	3271	--
Left lapbelt	1284	--
Right shoulder strap	508	--
Left shoulder strap	1520	--
Front diagonal strut	980	6.4
Rear diagonal strut	1008	6.0
Right diagonal cable	--	1.2
Left diagonal cable	--	1.5
Upper right attenuator	--	8.5
Upper left attenuator	--	5.0

The test conclusions are that the seat functioned as required, maintaining its integrity during the crash sequence and retaining the dummy in a proper attitude. All energy attenuators stroked as intended, reducing lateral plateau peak accelerations to an acceptable level of 16.7 G. Structural deformation of the shoulder strap support tube occurred, which can be corrected by improved design.

#### Dynamic Test 6 - Fixed Side-Facing Seat, Vertical Three-Axis Loading

A fixed side-facing seat was installed in the drop tower test fixture and a 95th percentile dummy with equipment, weighing a total of 250 lb, was strapped into the seat (Figure 60). The seat was oriented to simulate facing the side of an aircraft in a 30-degree pitch down and 10-degree roll attitude. The test fixture was dropped on a stack of paper honeycomb and impacted at 48.0 fps. A visual inspection of the seat after the test revealed that the seat had stroked fully, bottoming out on the floor (Figure 70). One of the seat back tubes had failed at a point where it extends above the shoulder strap support tube (Figure 71). Failure is attributed to torsion resulting from the unsupported extension. The left vertical energy attenuator is attached to the tube, and the attenuator stopped stroking when the tube failed. However, the seat had nearly reached maximum stroke when failure occurred.

The upper and lower attenuators stroked, all functioning properly (Figure 71). The upper right and left attenuator had stroked 18.0 and 14.5 in., respectively. The diagonal strut energy attenuators stroked 2.3 and 1.0 in., respectively, for the front and back attenuators.

Instrumentation data on the test fixture acceleration showed that a peak G of 40.0 with a time base of .075 second was

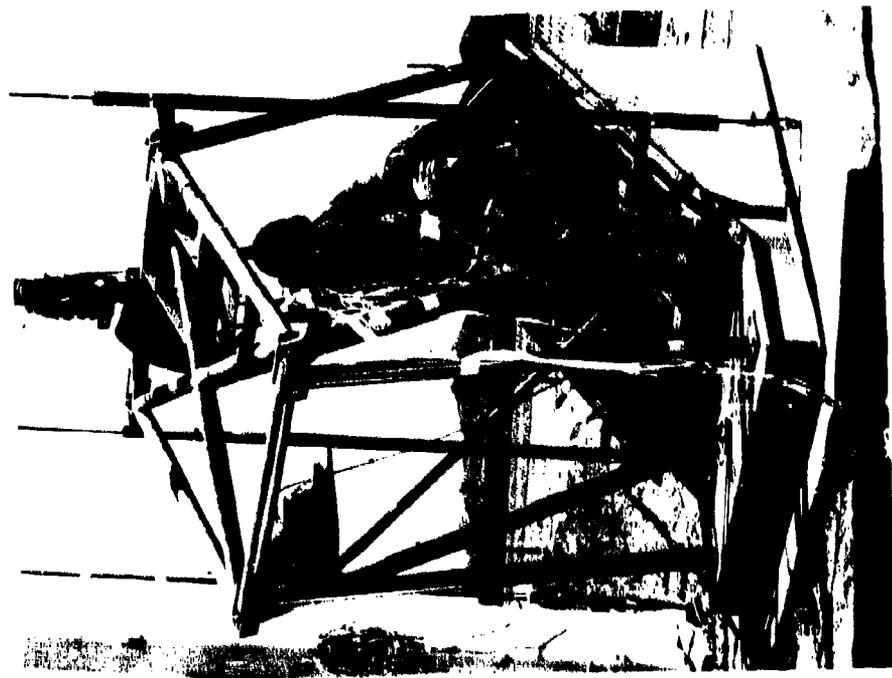


Figure 69. Pre-test 6, three-axis loading. Figure 70. Post-test 6, full stroking.



Figure 71. Failed seat back tube and stroked upper and lower attenuators.

recorded (Figure 72). The impact velocity was 48.0 fps. In spite of the fact that the seat bottomed, the critical lateral and vertical accelerations recorded on the dummy were within human tolerances. This would indicate that most of the energy had been dissipated when the seat back tube failure occurred. The energy attenuator attached to the failed tube had stroked 14.5 in. which should be within adequate stroke limits. Plateau peak accelerations recorded in the lateral direction was 17.3 G and in the vertical direction 13.0 G. An initial overshoot to 15.5 G occurred in the vertical direction and is partially attributed to the body armor bottoming out on the dummy (Figure 73).

The maximum loads and attenuator strokes recorded were as follows:

<u>Instrumented item</u>	<u>Maximum load - lb</u>	<u>Stroke - in.</u>
Right lapbelt	1030	--
Left lapbelt	930	--
Right shoulder strap	850	--
Left shoulder strap	820	--
Front diagonal strut	1000	2.3
Rear diagonal strut	990	1.0
Upper right attenuator	--	18.0
Upper left attenuator	--	14.5

The test conclusions are that the seat functioned as required during the crash sequence and maintained the occupant in a proper attitude. In spite of the seat back tube failure that occurred just prior to the end of normal stroking, which allowed the seat to bottom out, accelerations on the dummy were reduced to within tolerable limits. The plateau peak accelerations in the more critical directions of vertical and lateral were reduced to 13.0 G and 17.3 G, respectively. Failure of the back tube can be prevented by providing a member across the top of the seat back to eliminate torsion in the vertical tube extensions.

A summary of the test conditions for the swivel and fixed seats is shown in Table 1. Dummy responses in the tests are shown for the more critical acceleration on the dummy. Vertical accelerations on the dummy are given for predominantly vertical three-axis impacts and lateral dummy accelerations are given for forward impacts.

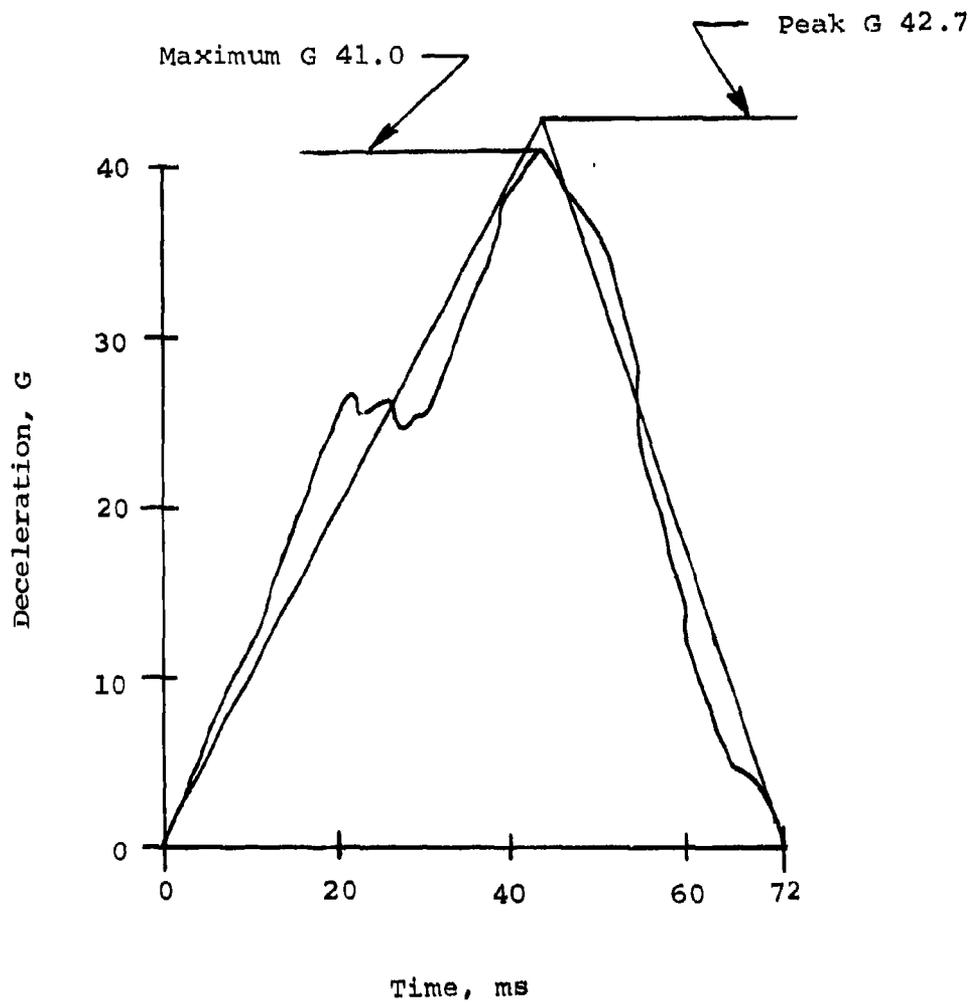
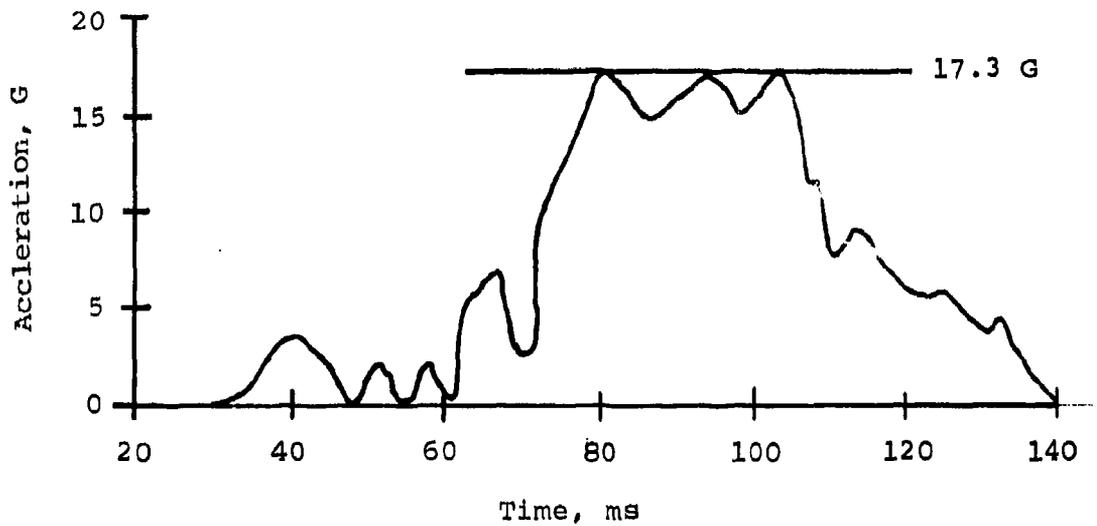
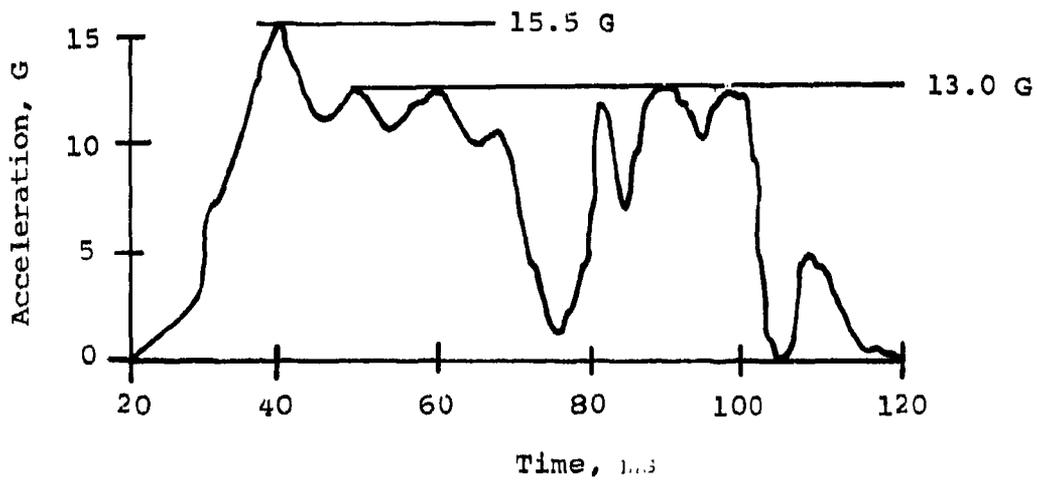


Figure 72. Test 6 - Vehicle deceleration time history.



Lateral acceleration



Vertical acceleration

Figure 73. Test 6 - Dummy chest acceleration.

TABLE 1. SUMMARY OF DYNAMIC TEST CONDITIONS

Test No.	Seat Type	Carriage Impact Attitude	Seat Attitude To Fwd	Dummy Percentile	Total Weight (lb)	Impact Velocity (fps)	Peak G	Max E/A Stroke (in.)	Critical Dummy Response (G)		Restraint Load (lb)		
									Plateau	Overshoot	Lap	Shoulder	
1	Swivel	3-axis Vertical	90°	95th	264	52.4	50.0	18.5	13.0 Vert	20.0 Vert	1640	420	
2	Swivel	Fwd	90°	95th	264	51.5	24.6	Seat failure				2186	964
3	Swivel	Fwd	30°	95th	250	49.1	25.1	3.0	9.8 Lat	0 Lat	3327	1200	
4	Fixed	Fwd	90°	95th	250	50.8	26.3	7.9	20.0 Lat	27.0 Lat.	3383	1867	
5	Fixed	Fwd	60°	95th	250	50.0	25.9	6.4	16.7 Lat	20.0 Lat	3271	1520	
6	Fixed	3-axis Vertical	90°	95th	250	47.5	42.7	18.0	13.0 Vert	15.5 Vert	1030	850	

NOTES: Vertical attenuator load setting - 1450 lb.

Horizontal attenuator load setting - 1100 lb.

Total weight includes dummy, clothing, and equipment weights.

95th percentile dummy - Sierra Model 895

E/A (energy attenuator) stroke is for the vertical E/A in three-axis tests and for longitudinal E/A in forward tests.

## CONCLUSIONS

The crashworthy gunner seat testing program demonstrated that two types of seats have potential for reducing the 95th percentile crash accelerations to within human tolerances. Both seat concepts functioned satisfactorily during final testing; however, both seats have deficiencies. The swivel seat is better for positioning the occupant in a forward direction, a direction in which human tolerance is maximum to forward crash impact. This seat, however, is more complex and weighs approximately 30 percent more than the fixed seat. Also, design refinements are required to improve the swivel seat's torsional strength capability.

The fixed side-facing seat is less complex and is lighter in weight than the swivel seat. The major disadvantage of the fixed side-facing seat is that the occupant is positioned 90 degrees to the forward impact, causing lateral acceleration on the occupant, for which human tolerance is less than half that for frontward acceleration. The Crash Survival Design Guide (Reference 2) discusses lateral acceleration tests on occupants for accelerations up to 11.5 G, with a duration of 0.1 second, at which point testing was discontinued due to possible cardiovascular involvement. A possible limit of 20 G for 0.1 second was stated but further human testing is required to verify this assumption.

Lateral accelerations of 20 G were reached, during fixed seat testing, using a 95th percentile occupant with full equipment. Lighter weight occupants and occupants without full equipment would be subject to higher lateral accelerations. Using a ratio of occupant weight and acceleration, a fifth percentile occupant without equipment could experience lateral acceleration of 37 G. This acceleration would probably produce fatal injury.

Increasing seat stroke in the forward direction will reduce occupant acceleration. However, sufficient space must be provided in the aircraft into which the seat can stroke. Before stroking requirements are established, further work must be done in the aeromedical field to better define the human tolerance limitation to lateral acceleration.

## RECOMMENDATIONS

A requirement of the crashworthy gunner seat testing program was for the contractor to recommend appropriate modifications to the proposed draft specification MIL-S-XXXX(AV), Seat, Helicopter, Gunner, and USAAMRDL TR 71-22, Crash Survival Design Guide. Recommended modifications to these documents follow.

### DRAFT GUNNER SEAT MILITARY SPECIFICATION

Changes were recommended to the draft specification titled MIL-S-XXXX(AV), Seat, Helicopter, Troop by AVSCOM, USAARL, USAAMRDL, and Boeing Vertol. Due to the similarity of this specification to the draft specification, which is the subject of this report, titled MIL-S-XXXX(AV), Seat, Helicopter, Gunner, the troop seat specification was used as a baseline in preparing the gunner seat specification. The recommended reorganization of the specification and the numerous comments prohibited use of the normal procedure of cross hatching deleted items and underlining added items. The specification has been reproduced in a modified form.

The specification, as presented, is still in a preliminary status and remains to be coordinated and finalized before it is officially released.

MILITARY SPECIFICATION SEAT, HELICOPTER, GUNNER, GENERAL  
SPECIFICATION FOR

1. SCOPE

1.1 This specification establishes the performance, design, development and test requirements for standard lightweight side-facing, crashworthy seats for use by gunners in utility- and cargo-type helicopters.

1.2 Classification. Gunner seats shall be of the following types as specified (see 6.2):

Type I	Unarmored seat
Type II	Seat with integral armor bucket
Type III	Seat with modular armor
Class A	Fixed seat
Class B	Swivel seat

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of the invitation for bids or request for proposal form a part of the specification to the extent specified herein.

SPECIFICATION

Federal

V-T-295	Thread, Nylon
QQ-P-416	Plating, Cadmium (Electrodeposited)
QQ-Z-235	Zinc Coating, Electrodeposited, Requirements for
PPP-B-601	Boxes, Wood, Cleated-Plywood
PPP-B-621	Boxes, Wood, Nailed and Lock-Corner
PPP-B-636	Boxes, Fibergoard

Military

MIL-P-116	Preservation, Methods of
MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-R-8235	Reel, Shoulder Harness, Inertia Lock
MIL-W-8604	Welding of Aluminum Alloys: Process for
MIL-F-8905	Adapter, Tie Down, Aircraft Floor
MIL-W-25361	Webbing, Textile, Polyester, Low Elongation

MIL-W-5205 Welding, Gas Metal-Arc & Gas Tungsten-Arc,  
Aluminum Alloys, Readily Weldable for  
Structures, Excluding Armor

#### STANDARDS

##### Federal

FED-STD-505 Colors  
FED-STD-751 Stitches, Seams, and Stitchings

##### Military

MIL-STD-22 Weld-Joint Designs  
MIL-STD-129 Marking for Shipment and Storage  
MIL-STD-130 Identification Marking of US Military  
Property  
MIL-STD-143 Specifications and Standards, Order of  
Precedence for the Selection of  
MIL-STD-471 Maintainability Demonstration  
MIL-STD-785 Reliability Program for Systems and  
Equipment Development and Production  
MIL-STD-810 Environmental Test Methods  
MIL-STD-831 Test Reports, Preparation of  
MIL-STD-889 Dissimilar Metals  
MIL-STD-1186 Cushioning, Anchoring, Bracing, Blocking,  
and Waterproofing; with Appropriate Test  
Methods  
MIL-STD-1261 Welding Procedures for Constructional  
Sheets  
MIL-STD-1290 Light Fixed- and Rotary-Wing Aircraft  
Crashworthiness  
MIL-STD-1472 Human Engineering Design Criteria for  
Military Systems, Equipment, and Facilities  
MS26504 Plate-Anchor, Aircraft Troop Seat

#### PUBLICATION

##### Military Handbook

MIL-HDBK-5 Metallic Materials and Elements for Aero-  
space Vehicle Structures

#### REPORTS

USAAMRDL TR 71-22 Crash Survival Design Guide  
USAAMRDL TR 71-41A, Survivability Design Guide for US  
-41B Army Aircraft  
USANLABS TR 72-51-CE Body Size of Soldiers-US Army-  
Anthropometry 1966

(Copies of specifications, standards, publications, and reports required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

### 3. REQUIREMENTS

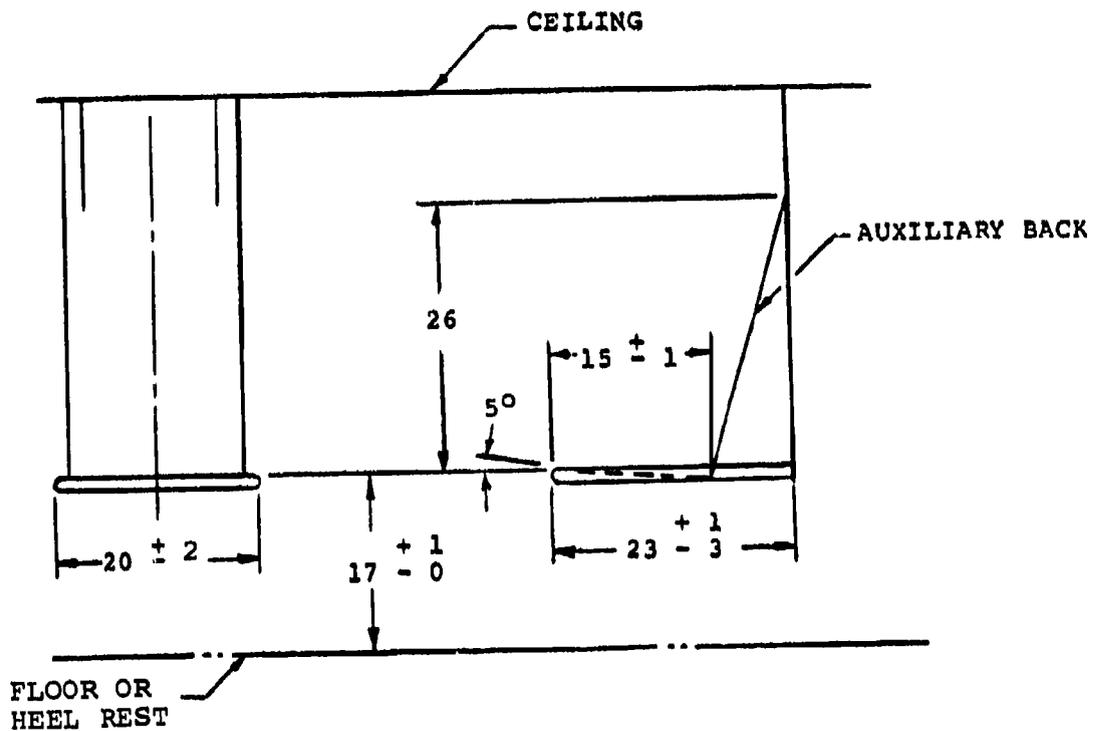
3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern.

3.2 First article. Unless otherwise specified, the seat furnished under this specification shall be a product which has been inspected and has passed the first article inspection of 4.4.

3.3 Design characteristics of seat system. Occupant protection and survival in aircraft accidents shall be a primary consideration in seat system design. Such protection requires that both the seat system and the occupant be retained in the same relative position within the aircraft throughout the 95th percentile potentially survivable accident (see USAAMRDL TR 71-22) without the occupant being subjected to conditions in excess of human tolerance (see 3.3.2). The seat system shall also provide maximum comfort and ease of removal. The occupant restraint subsystem, the means of attaching the seat to the basic aircraft structure, any seat cushions required and any armor required are parts of the seat system. Another primary design consideration is that the seat system permit the occupant to perform his gunner tasks unencumbered while restrained to the seat.

3.3.1 Seating surface. The seat bottom and back shall be designed for comfort and durability. Seat bottoms made of fabric shall be provided with means of tightening to compensate for sagging due to use. Sufficient clearance between fabric backs and bottoms shall be provided to preclude body contact with seat structure when subjected to the specified loads (see 3.6). Headrests may be provided to prevent contact between occupant's head and seat structure. Backs of Type I seats shall be convertible without tools, to provide the recess shown in Figure 1 to accommodate combat packs, that troops may be wearing. Maximum time to convert either way shall not exceed 10 seconds, and both back supports shall meet the strength requirements.

3.3.2 Crash resistance. The seat shall prevent the 5th through 95th percentile occupants (see 6.3.1) from experiencing vertical decelerations in excess of human tolerance (see Figure 2) during crash pulses of the severity shown in



Notes:

Seats with sides must have a minimum inside width of 20 in. Auxiliary back shall be capable of being adjusted to accommodate occupant wearing Butt-pack or medium Rucksack without Frame. This figure presents max-min dimensional restrictions and is not intended to represent design.

Figure 1. Seat dimensional limits.

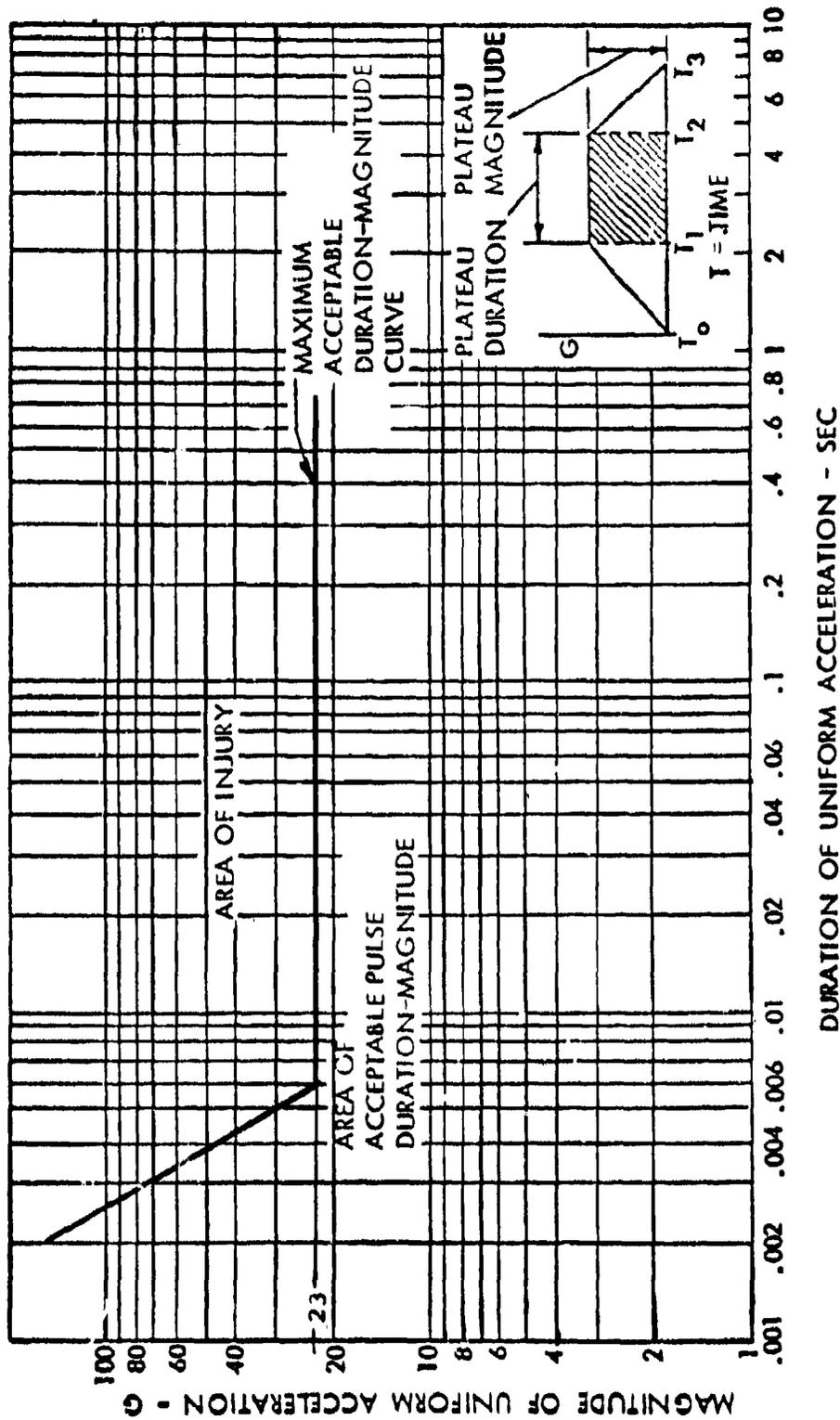


Figure 2. Maximum acceptable vertical pulse acceleration and duration values.

Figure 3 and not experience structural failure. Energy shall be absorbed in the vertical axis, and longitudinal axis of fixed side-facing seats, by load-limiting devices. The energy-absorption stroke shall be the maximum attainable in the space between the seat bottom and the aircraft floor. In any case, not less than 14 inches of vertical stroking distance shall be provided when measured at the occupant's center of gravity. The seat and restraint shall minimize occupant submarining (see 6.3.5) and dynamic overshoot (see 6.3.6).

**3.3.3 Seat attachment.** Acceptable means of attaching seats to the cabin interior are ranked below in order of desirability:

1. Suspended from the ceiling with attenuators, and wall stabilized.
2. Suspended from the ceiling with attenuators, and floor stabilized.
3. Wall mounted with attenuators.
4. Floor mounted with attenuators.
5. Ceiling and floor mounted (vertical energy attenuators above and below seat).

The seat pan should be stabilized in a manner that does not require the use of energy attenuators in series (i.e., attenuators above and below seat) for vertical loading.

**3.3.3.1 Attachment distortion.** Seat attachments shall be capable of accommodating crash induced cabin distortion consisting of a 4-inch vertical displacement and a 10 degree misalignment of any attachment.

**3.3.4 Ballistic protection.** Type II and Type III seats shall provide the occupant with the following ballistic protection:

V20, 7.62mm AP (Armor Piercing), 100 yards 2550  $\pm$ 50 FPS, at 0° Obliquity.

Type II seats shall provide the specified level of ballistic protection with an integrally armored seat bucket, i.e., a seat bucket structure fabricated of armor. Type III seats shall provide the specified level of ballistic protection using a modular armor concept, i.e., armor panels secured to the seat bucket structure. Type III seats shall be designed to be convertible for use either as an armored or unarmored seat. Seat strength (see 3.6) shall be based on the armored configuration. USAAMRDL TR 71-41, Survivability Design Guide

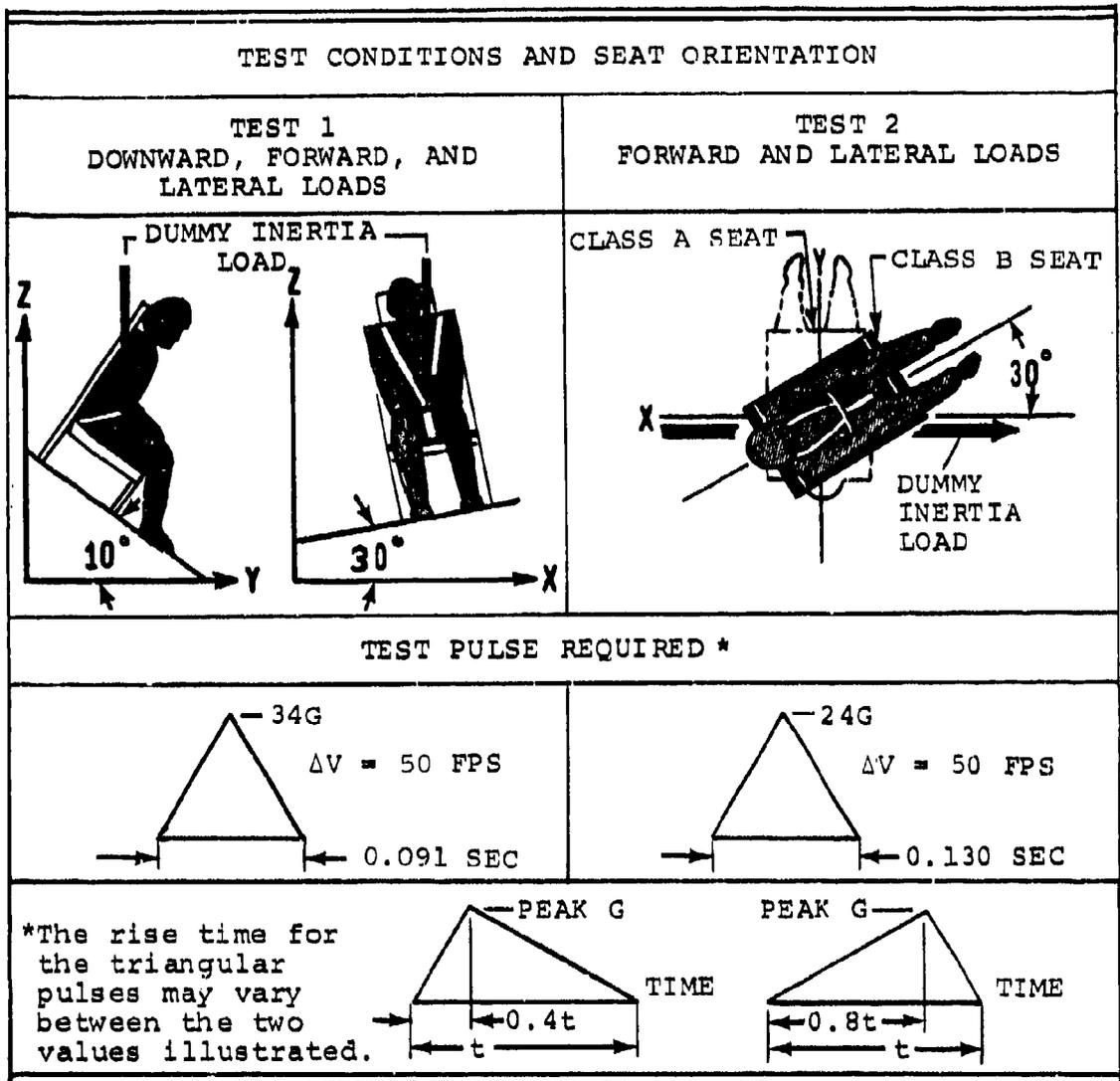


Figure 3. Dynamic test requirements.

for U.S. Army Aircraft, shall be used as a guide during the design of occupant ballistic protection.

3.3.5 Orientation. Class B swivel seats shall be designed to face sideward and to permit rapid rotation to a forward-facing position. Locks shall be provided to maintain the seat in a side-facing and forward-facing direction. Lock controls shall be provided to permit releasing the lock so the seat can be swiveled 90 degrees.

Class A fixed seats shall be designed to face toward the side of the aircraft. Energy attenuating devices shall be oriented to stroke under vertical or forward impact conditions or a combination of both conditions.

3.3.6 Seat folding and stowing. Seats shall be so designed that they may be quickly removed or folded and secured. Tools shall not be required.

3.3.6.1 Seat disconnect time. The time for disconnecting each Type I seat by one man shall not exceed 20 seconds. The time for disconnecting Type II or III seats by two men shall not exceed 10 minutes.

3.3.6.2 Folding and stowage. Each Type I or Type II seat without armor shall be capable of being folded, stowed, and secured or unstowed quickly and easily by one man in a period not to exceed 20 seconds.

3.3.7 Obstructions. Seat suspension or mounting shall not interfere with rapid ingress or egress. Braces, legs, cables, straps, and other structures shall be designed to prevent snagging or tripping. Loops shall not be formed when the restraint system is in the unbuckled position.

3.3.8 Occupant restraint. The seats shall have an integral restraint system with self-retracting and self-locking shoulder harness and lapbelt. The restraint shall be comfortable, light in weight, and easy for the occupant to put on and remove. Reduction in support of the occupant shall not occur due to stroking of the energy absorbers or deformation of the seat. The restraint system shall provide retention of the occupant in all directions while seated, yet allow the occupant to stand to perform gunner duties without having to detach or without riding up or displacing laterally.

3.3.8.1 Lapbelt. The lapbelt anchorage geometry shall be as shown in Figure 4. The lapbelt anchor fittings shall be attached to the stroking portion of the seat and shall be capable of displacing plus or minus 30 degrees vertically. These fittings shall also be capable of withstanding lateral

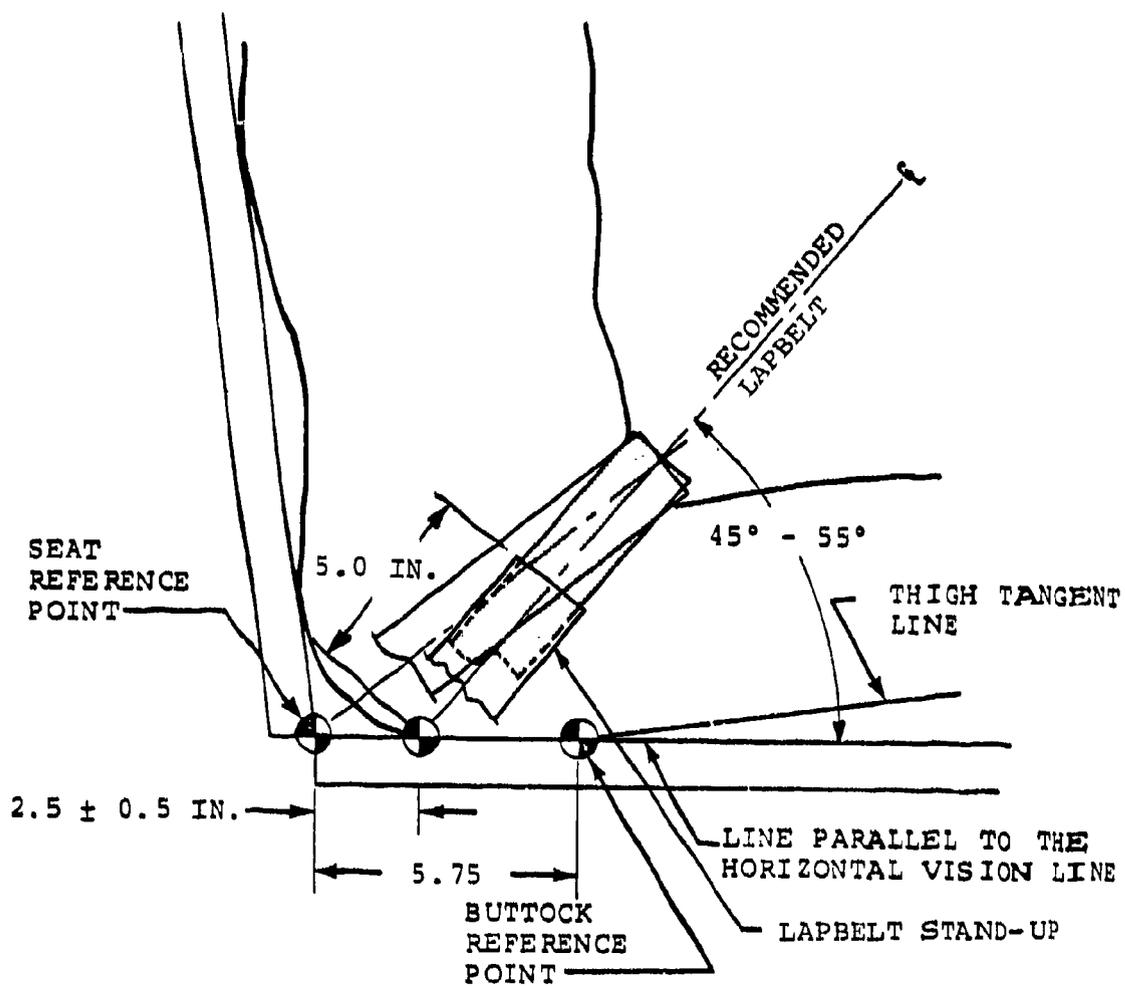


Figure 4. Lapbelt anchorage geometry.

loads when the webbing is pulling at an angle of plus or minus 60 degrees to the normal plane of the fitting. Lapbelt inertia reels shall be used. They shall not be located over hard points of the occupant's skeletal structure. Retractors shall not pull with more than 3 pounds force, and shall ratchet in increments not to exceed 0.5 inch.

3.3.8.2 Shoulder straps. A double strap shoulder harness shall be used as shown in Figure 5. The anchorage or guide at the top of the seat shall not permit more than 0.5 inch lateral movement of the strap at this point. The guide height shall be as shown in Figure 6. The shoulder straps shall form an inverted Y at the seat back. An adjuster shall be provided in each strap.

3.3.8.3 Inertia reel. Shoulder strap and lapbelt inertia reels shall be provided which pull with not more than 3 pounds force and will fully retract the lapbelts and retract the shoulder straps to the Y intersection. The reels shall be of a type which remains locked after it locks up initially, as per the locking requirements stated in MIL-R-8236 and must be manually reset by a device on the reel. The shoulder strap reel shall be located close to the shoulder strap guide point at the back of the seat to minimize strap elongation. Sufficient strap shall be stored on the reels to permit the occupant full gun envelope operation and tail rotor observation.

3.3.8.4 Restraint buckle. The restraint harness buckle shall be of the quick-release type and require intentional motion by the occupant to activate it. The buckle shall be capable of being operated with a gloved hand as well as with one finger of either hand while tension equal to the occupant's weight is supported by the harness. The force required to release it normally, as well as post crash and under the previous condition, shall not be less than 15 pounds nor more than 25 pounds. The buckle shall be of a lift lever release configuration. Lapbelt and shoulder strap fittings shall be ejected simultaneously when the lever is lifted, even when there is no load on the restraint straps. The lapbelt shall be capable of connection without connecting the shoulder straps. The release buckle shall be guarded to prevent jamming of the mechanism by clothing or equipment worn by the seat occupant causing inadvertent release.

#### 3.4 Construction.

3.4.1 Critical members. All critical compressive structural members shall be fabricated from ductile materials having a characteristic value of not less than 5 percent elongation. All critical tensile and bending members shall be capable of elongating a minimum of 10 percent prior to failure.

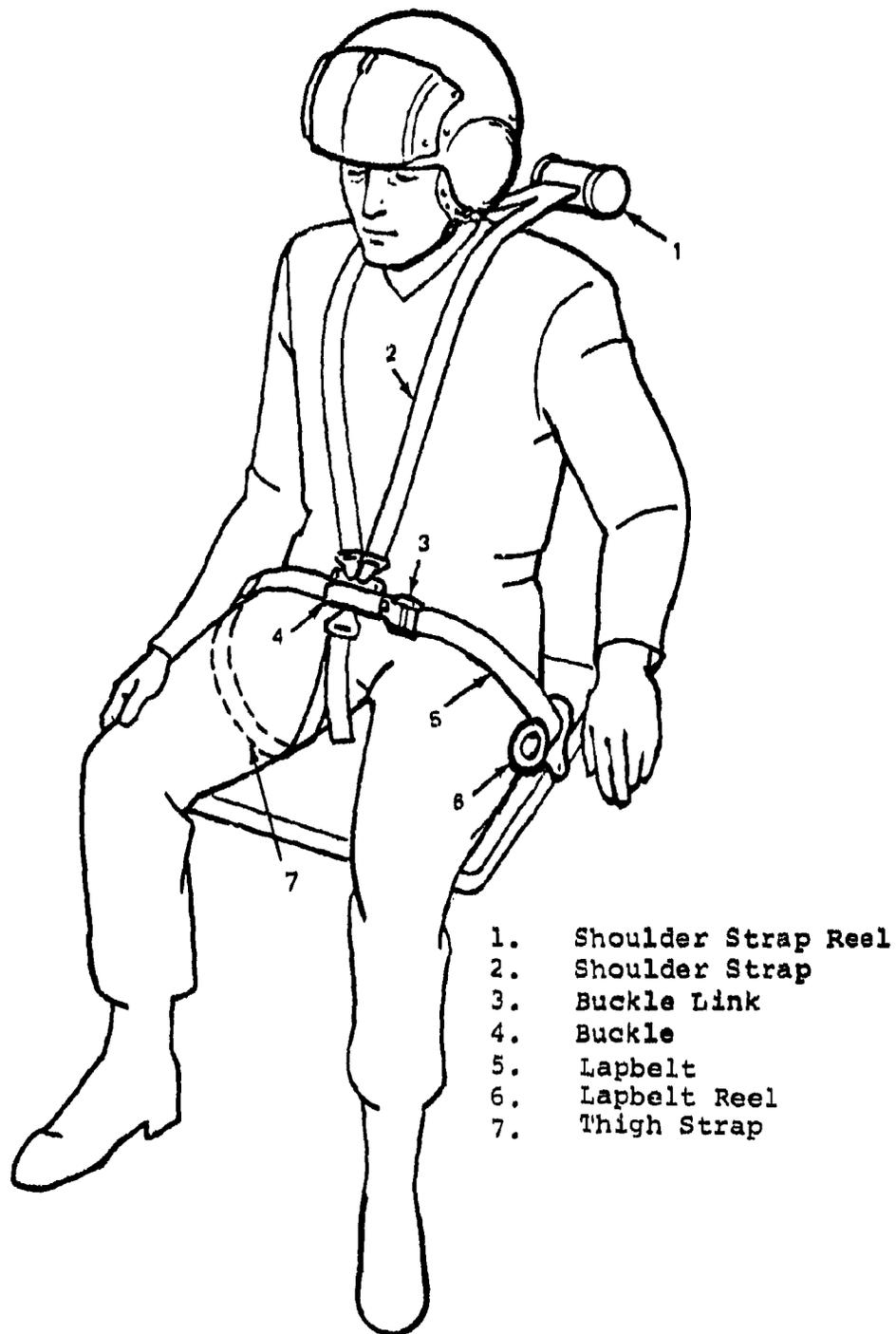


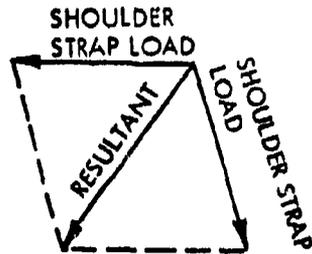
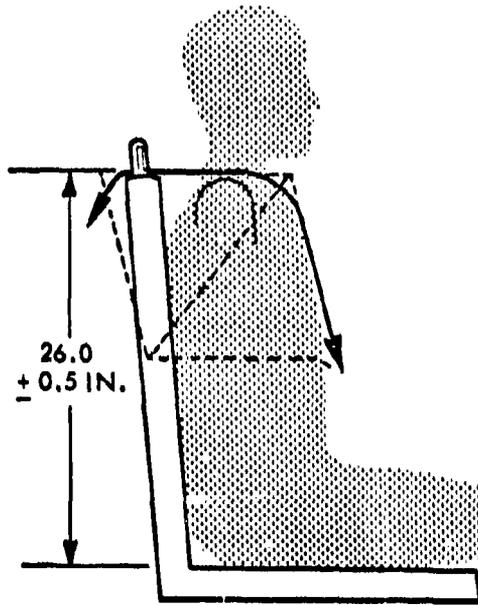
Figure 5. Gunner restraint system configuration.

SIDE VIEW

FORCE DIAGRAM

RIGHT

(TORSO CARRIES ONLY A PORTION OF SHOULDER STRAP LOAD)



WRONG

(TORSO CARRIES NEARLY ALL OF SHOULDER STRAP LOAD)

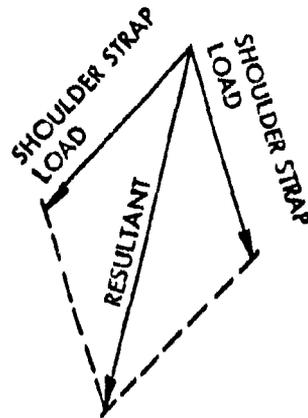
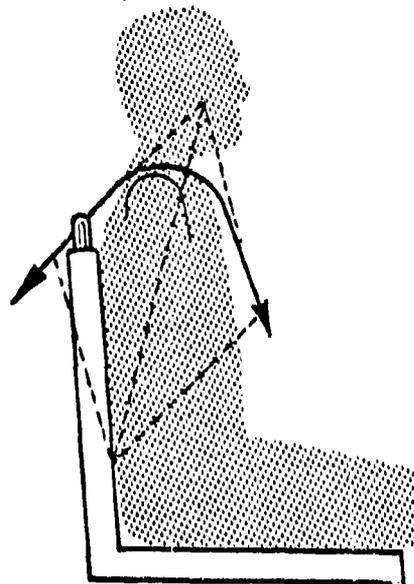


Figure 6. Shoulder harness anchorage geometry.

3.4.2 Dissimilar metals. Unless components are suitably protected against electrolytic corrosion, contact between dissimilar metals shall not be used where it is feasible to avoid it. Dissimilar metals are defined in MIL-STD-889.

3.4.3 Castings. Castings used in the seat shall conform to MIL-C-6021.

3.4.4 Heat treatment. Heat treatment of aluminum and steel parts shall conform to MIL-H-6088 and MIL-H-6875, respectively.

3.4.5 Structural connections. Safety factors shall be 5 percent and 10 percent for shear and tensile bolts, respectively. Bolts less than 0.25 inch in diameter shall not be used in tensile applications. Riveted joints shall be designed in accordance with MIL-HDBK-5. Welding shall be in accordance with MIL-W-6873, MIL-W-8604, MIL-W-45204, MIL-STD-22, and MIL-STD-1261.

3.4.6 Joining and fastening. Fittings and joints requiring disassembly for maintenance shall be bolted. All thread and stitches used for sewing seat back and seat bottom shall be in accordance with V-T-295 and FED-STD-751, Type 301, respectively.

3.4.7 Standard parts. MS or AN standard parts shall be used wherever they are suitable for the purpose.

3.4.8 Restraint construction.

3.4.8.1 Stitch pattern and cord size. Stitch pattern and cord size shall sustain a minimum of 100 pounds per inch of stitch length, and shall comply with Figure 7.

3.4.8.2 Wrap radius. The wrap radius shall be the radius of the fitting over which the strap is wrapped at buckles and anchorages, as shown in Figure 8. The strap wrap radius shall be not less than 0.062 inch.

3.4.8.3 Hardware-to-strap folds. Figure 9 illustrates a recommended method to reduce the weight and size of attachment fittings by folding the strap at anchorage buckle fittings.

3.4.8.4. Surface roughness of fittings. Fittings in contact with the straps shall have a maximum surface roughness of RMS-32.

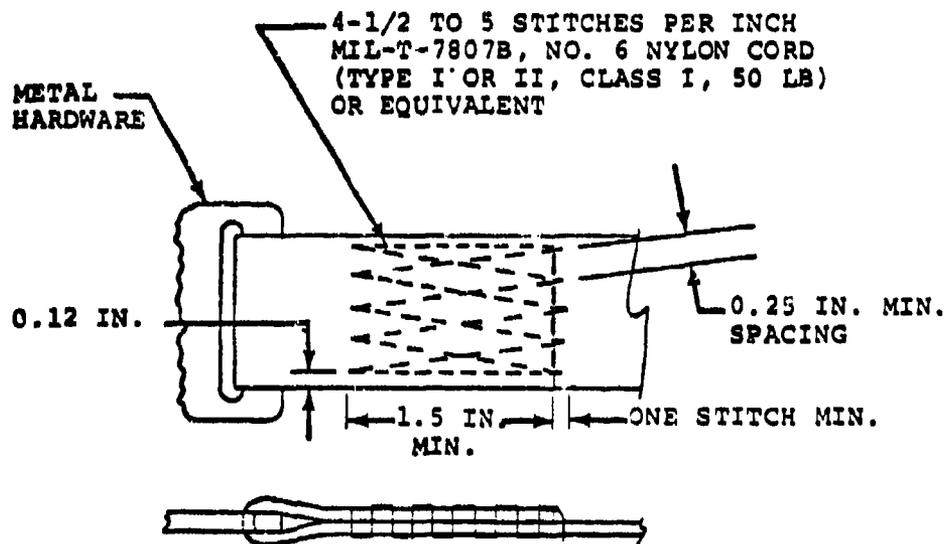


Figure 7. Stitch pattern and cord size.

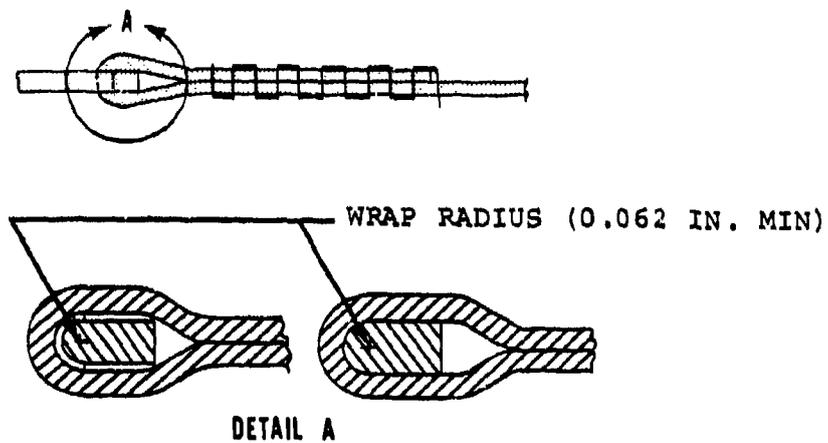


Figure 8. Wrap radius for webbing joints.

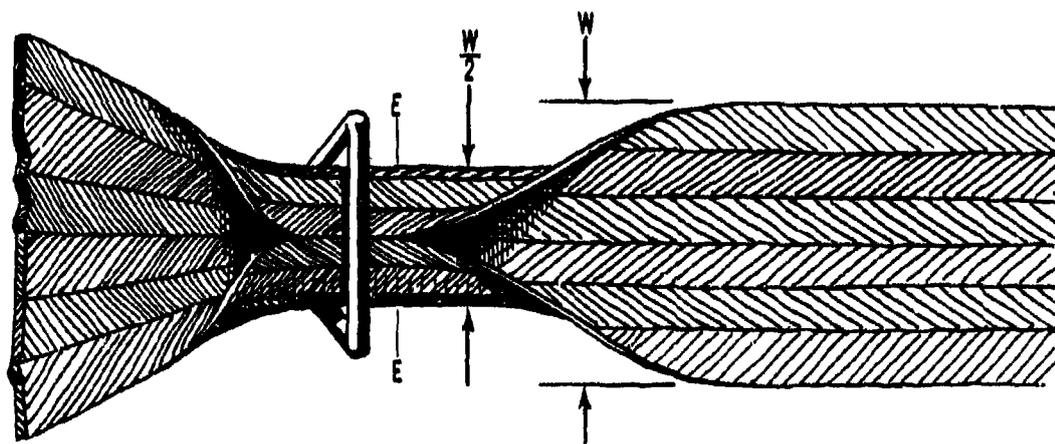


Figure 9. Webbing fold at metal hardware attachment.

3.5 Weight. The complete seat of each type, including the restraint, shall not exceed the weights tabulated below:

<u>Class A seat</u>	<u>Weight-lb</u>	<u>Class B seat</u>	<u>Weight-lb</u>
Type I	15	Type I	25
Type II	90	Type II	100
Type III	40	Type III	50

3.6 Structural strength and deformation. Longitudinal, lateral, and upward seat structural strength and deformation requirements are based on the 95th percentile clothed and equipped occupant weight of 242.2 pounds (see Table 1), plus the stroking portion of the seat weight. Downward seat structural strength and deformation requirements are based on the 160.7-pound effective weight of the 50th percentile clothed and equipped occupant, plus the weight of that portion of the seat which must stroke during vertical crash force attenuation. Table 1 lists the applicable weights.

TABLE 1. SEAT DESIGN AND STATIC TEST REQUIREMENTS				
Test no.	Loading direction with respect to aircraft axes	Load factor	Seat occupant weight-lb	Deformation
1	Forward, a	See Fig. 10	245.2	See Fig. 10
2	Aftward	12g minimum	245.2	No reqmt.
3	Lateral, b	See Fig. 11	245.2	See Fig. 11
4	Downward	14.5+1 G	160.7	See Fig. 12
5	Upward	8g minimum	245.2	No reqmt.
6	Combined forward, downward, and lateral, c (See Fig. 3, test 1)	14.5+1 G	160.7	Vertical reqmt. same as Test 4.

Notes:

a. Forward loading shall be applied toward the side of the Class A seats and toward the front of the Class B seats.

b. The lateral loads shall be applied toward the front or rear of the Class A seats and toward the side of the Class B seats.

c. The forward and lateral loads shall be applied prior to the downward load application if distortions could impede vertical stroking.

3.6.1 Forward load. The seat shall have a static forward load deflection curve measured along the longitudinal (roll) axis of the aircraft which rises to the left and above the base area and extends into the acceptable seat failure area shown in Figure 10. Class A seats shall have energy attenuation in the forward aircraft direction and loading shall not exceed 20g.

3.6.2 Aftward load. The seat strength shall be not less than 12g (see 6.3.4) for aftward loads measured along the longitudinal (roll) axis of the aircraft.

3.6.3 Lateral load. The seat shall have a static lateral load deflection curve measured along the lateral (pitch) axis of the aircraft which rises to the left and above the base curve and extends into the acceptable seat failure area shown in Figure 11.

3.6.4 Downward load. Human tolerance to vertical impact limits the allowable forces along the vertical axis of the aircraft and necessitates energy attenuation. The seat shall have a downward load-deflection curve measured along the vertical (yaw) axis which falls within the acceptable area in Figure 12.

After the seat has stroked through the available stroking distance, the seat bottom shall be supported on the floor.

3.6.5 Upward load. The seat strength upwards shall not be less than 8g parallel to the vertical axis.

3.6.6 Restraint design loads. Strength and elongation properties of the restraint shall conform to Table 2.

TABLE 2. RESTRAINT LOAD - ELONGATION REQUIREMENTS					
Use	Minimum strap width -in+0.10	Minimum thickness	Maximum elongation at design load -percent	Design load -lb	Minimum breaking strength -lb
Lapbelt	2.25	.065	7.5	4,000	6,000
Shoulder Straps	2.00	.045	7.5	4,000	6,000

NOTE: All loads are applied in straight tension.

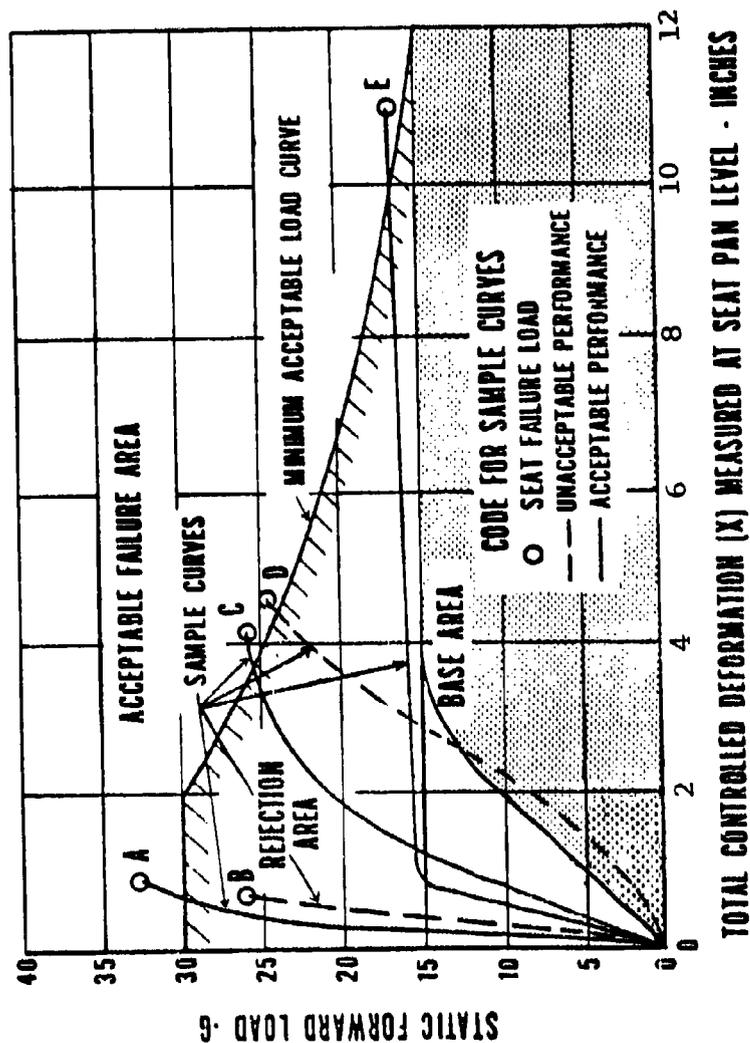


Figure 10. Forward crash load and deflection requirements.

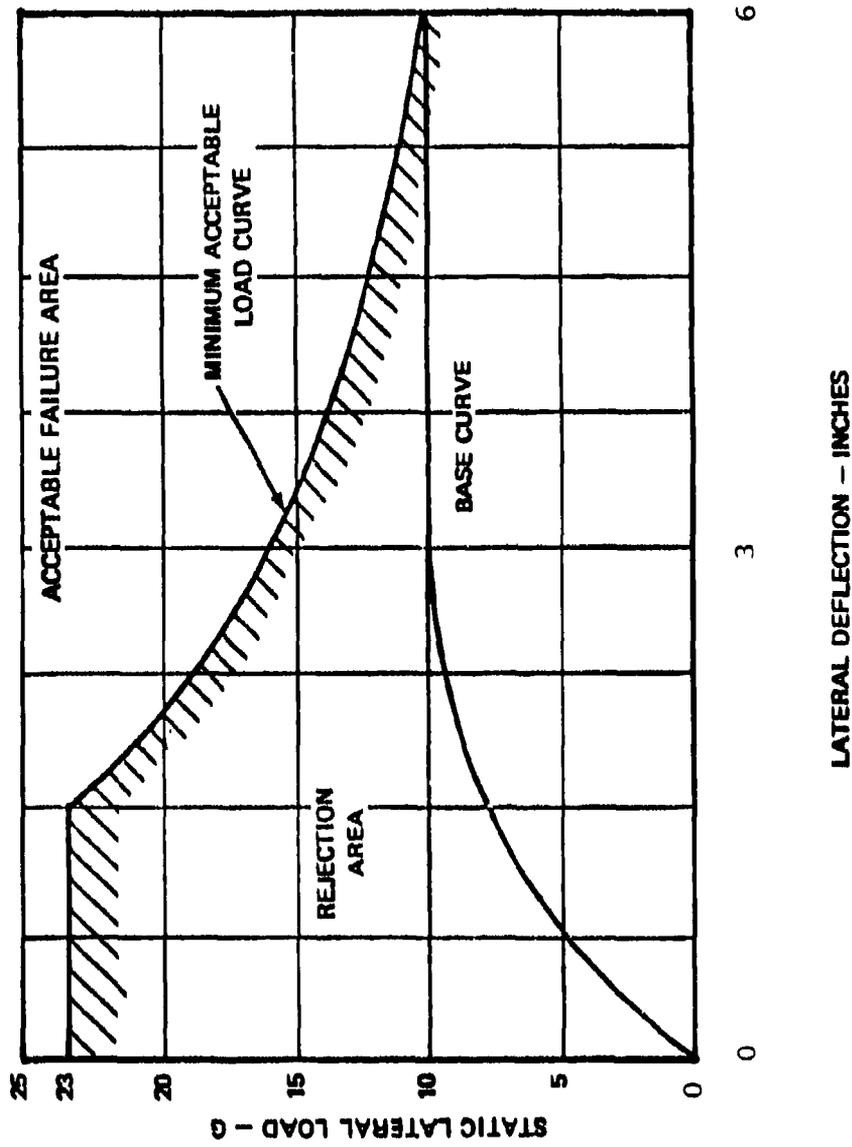


Figure 11. Lateral crash load and deflection requirements.

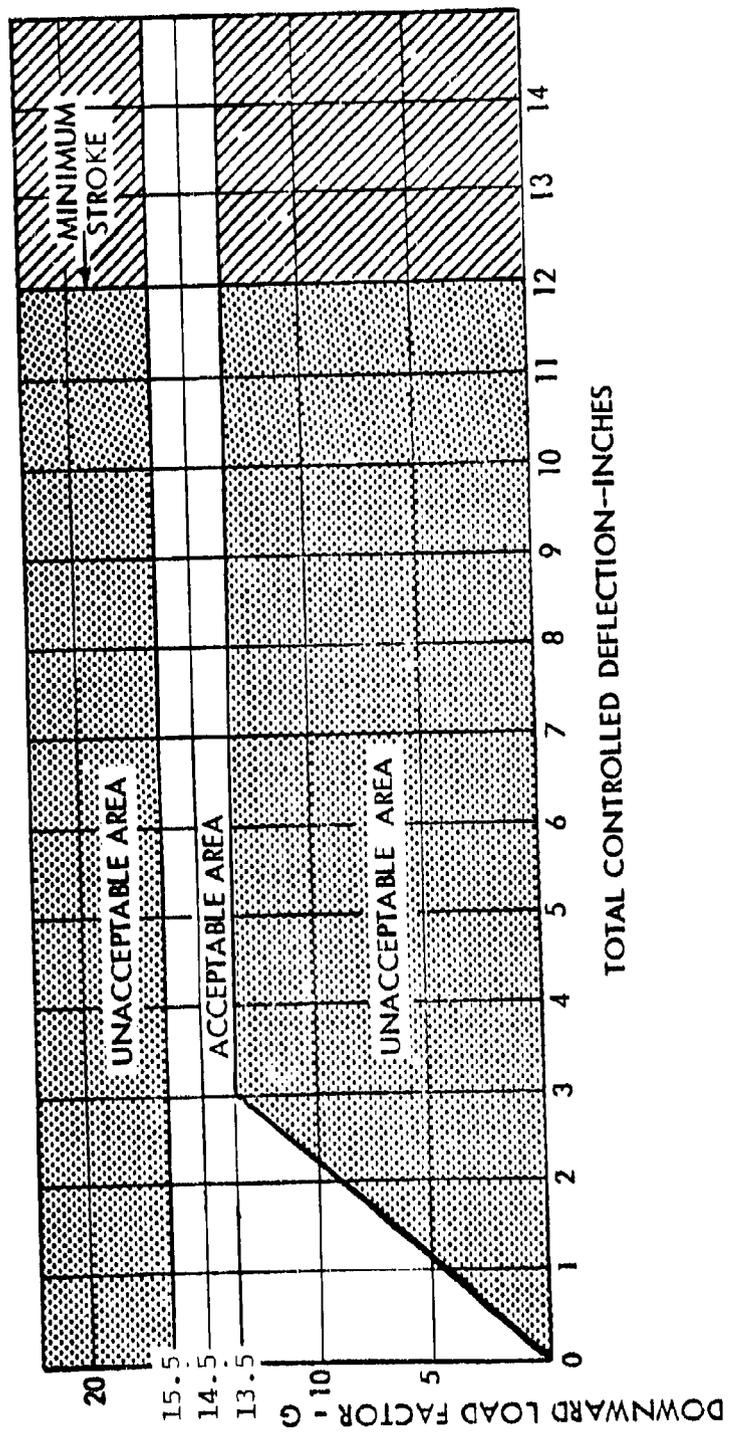


Figure 12. Downward crash load and deflection requirements.

3.7 Materials. When specifications and standards are not specifically designated, selection of materials and processes shall be in accordance with MIL-STD-143. Materials that are nutrients for fungi shall not be used when it is feasible to avoid them; where used and not hermetically sealed, they shall be treated with a fungicidal agent.

3.7.1 Flammability and toxicity. Materials that support a self-sustained combustion and materials which, when burned or exposed to high temperatures, give off toxic fumes shall not be used.

3.8 Reliability. Except for fabric parts, the minimum life of all seat components subjected to normal wear and tear shall be 5,000 hours of aircraft operation and 5,000 hours for adjustments. Deterioration and wear of fabric parts shall be limited so as to meet minimum strength requirements after five years of use, and possess unlimited shelf life.

3.9 Maintainability. The seat shall require no scheduled maintenance other than for replacement of fabric components. The mean time to repair for both scheduled and unscheduled maintenance shall be less than 0.2 manhour.

3.9.1 Interchangeability and replaceability. Parts and assemblies of the seat shall be interchangeable or replaceable in accordance with MIL-I-8500.

3.9.2 Tools. Maintenance operations shall not require uncommon tools or special equipment.

3.10 Environmental resistance. The seat with restraint system shall be capable of operating and of meeting the structural requirements of 4.6.2 after exposure to the following conditions.

3.10.1 Temperature. The seat shall deliver the specified operational and crashworthiness performance when subjected to the 4.6.4.1 and 4.6.4.2 temperature tests.

3.10.2 Sunshine. All nonfabric materials shall show no evidence of any degrading effect when subjected to the 4.6.4.3 sunshine test.

3.10.3 Humidity. The seat shall withstand the humidity test specified in 4.6.4.4.

3.10.4 Fungus. If any material utilized in the construction of the seat is suspected to be a nutrient to fungi, the material shall show no deterioration when subjected to fungus tests in accordance with 4.6.4.5.

3.10.5 Salt fog. All materials used in the construction of the seat shall withstand the salt fog test of 4.6.4.6.

3.10.6 Dust. The seat shall be capable of satisfactory operation after exposure to the dust test specified in 4.6.4.7.

3.10.7 Vibration. The seat shall be capable of satisfactory operation after being subjected to the vibration tests of 4.6.4.8. The occupied and unoccupied seat shall be free of resonance within the frequency range of the aircraft in which it will be used and no amplification shall occur.

3.11 System safety. Maximum effectiveness and conservation of Army resources dictate a need for early identification, evaluation, and correction of system hazards. A system safety program shall be established by the contractor in accordance with MIL-STD-882 and implemented as directed by the procuring activity. The goal of the program shall be to insure that the optimum degree of freedom from hazard is effectively designed into the seat system.

3.12 Dimensions. Seats shall comply with the dimensions shown in Figure 1. Unless otherwise specified, a tolerance of  $\pm 1/16$  inch will be allowed for seat overall dimensions. Restraint system webbing dimensions shall comply with Table 2, and Figures 5 and 6. Seats required to fold for stowage shall, when in the stowed position, be held to a minimum size, not to exceed a thickness of six inches.

3.13 Finish.

3.13.1 Surface roughness. All exterior surfaces of the seat and restraint shall be free from both sharp edges and corners, or any other projections that could scratch the hands or clothing of the occupant.

3.13.2 Finishes. Aluminum alloy parts shall be anodized with MIL-A-8625, Type II. Magnesium alloy parts shall be treated in accordance with MIL-M-3171. Corrosive steel parts shall be either cadmium-plated in accordance with QQ-P-416, zinc-plated in accordance with QQ-Z-325, or chrome-plated in accordance with QQ-C-320.

3.13.3 Paint. The paint finish shall consist of one coat of zinc-chromate primer conforming to MIL-P-8585, followed by two coats of enamel conforming to TT-E-489.

3.13.4 Color. The seat and restraint color shall be in accordance with the cabin color scheme specified for the aircraft in which the seat will be used.

### 3.14 Identification of product.

3.14.1 Seat identification. A nameplate, permanently and legibly filled in with the following information, shall be securely attached to a permanent portion of the seat in a position capable of being read after the seat is installed. Marking shall be in accordance with MIL-STD-130 in 1/8 inch letters.

Seat, Helicopter, Gunner  
Type (I, II or III, as applicable)  
Class (A or B, as applicable)  
Specification MIL-S-XXXX/X(AV)  
National Stock No. \_\_\_\_\_  
Manufacturer and Code \_\_\_\_\_  
Contract or Order No. \_\_\_\_\_  
Serial No. \_\_\_\_\_  
U. S. Property

3.14.2 Restraint identification. Each individually replaceable strap shall have a permanent label attached. Each label shall contain the following information:

National Stock No. \_\_\_\_\_  
Manufacturer and Code \_\_\_\_\_  
Part No. \_\_\_\_\_  
Date of Manufacture \_\_\_\_\_  
Retirement Date \_\_\_\_\_  
Serial No. \_\_\_\_\_

3.14.3 Warning marking. The following warning shall be stenciled in 1/2 inch letters on the front of the seat back.

W A R N I N G  
DO NOT STOW  
EQUIPMENT  
UNDER SEAT

3.15 Workmanship. The seat, including all parts, shall be constructed and finished in a thoroughly workmanlike manner. Particular attention shall be given to neatness and thoroughness of welding, riveting, machine-screw assemblies, and painting; freedom of parts from burrs and sharp edges; avoidance of unraveled edges of cloth; and straightness of stitched seams.

#### 4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

1. First article inspection (see 4.4)
2. Quality conformance inspection (see 4.5)

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed under ambient environmental conditions.

4.4 First article inspection. The first article inspection tests shall consist of all the tests specified under 4.6. Four seats of each type, class, and size are required for these tests, as a minimum.

4.5 Quality conformance inspections. Quality conformance tests shall consist of the following:

1. Visual examination
2. Functional test

4.5.1 Visual examination. Sampling shall be in accordance with MIL-STD-105, Inspection Level II, for the critical defects listed in Table 3, and Inspection Level I, for the minor defects. The acceptable quality levels are 1.5 and 2.5, respectively.

TABLE 2. CLASSIFICATION OF DEFECTS FOR VISUAL EXAMINATION OF THE SEAT

CRITICAL	MINOR
<ol style="list-style-type: none"> <li>1. Dimensions not within specified tolerances</li> <li>2. Material imperfections</li> <li>3. Surfaces--misaligned or containing cracks, nicks, or other flaws</li> <li>4. Any component missing, malformed, fractured, or otherwise damaged</li> <li>5. Incorrect assembling or improper positioning of components</li> <li>6. Any component loose or otherwise not securely retained</li> <li>7. Any functioning part that works with difficulty</li> <li>8. Faulty workmanship or other irregularities</li> </ol>	<ol style="list-style-type: none"> <li>1. Seat marking - missing, insufficient, incorrect, illegible, or not permanent</li> <li>2. Seat color not as specified</li> <li>3. Defective exterior and interior markings on packaging</li> <li>4. Nonconforming packaging materials</li> <li>5. Inadequate packaging workmanship</li> </ol>

4.5.2 Functional tests. Seats, in the quantities specified below, shall be subjected to the dynamic tests of 4.6.2.2.

- (a) Two seat systems from each lot of 200, or fraction thereof, of each type and class.
- (b) Three seat systems from each lot of 500, or fraction thereof above 500, of each type and class.
- (c) One seat system from each additional lot of 500, or fraction thereof above 500, of each type and class.

4.5.3 Lot. An inspection lot shall consist of seats manufactured under essentially the same conditions and from essentially the same materials and components.

#### 4.6 Methods of examination and test.

4.6.1 Fit, function, and design conformance examination. Representative seats of the required type(s) and class(es) shall be furnished and installed in the applicable aircraft. The seats shall then be inspected for conformance to 3.3, 3.4, 3.5, 3.7, 3.9, 3.11, 3.12, 3.13, and 3.14. Occupants representing 5th and 95th percentile gunners and troops, as applicable with and without combat assault equipment, shall be used to demonstrate satisfactory restraint system use, seat accommodations, and lack of encumbrances during gunnery operations and ingress and egress. Occupants shall wear warm-weather, intermediate-weather, and cold-weather clothing and body armor for each of the demonstrations. For troops, the wearing of medium rucksacks and butt packs, with combat assault loads, shall be demonstrated. Ingress, hookup, and egress shall be timed for each combination of clothing, equipment, and personnel percentile. Times for seat installation, disconnect, folding, and stowage shall also be measured when applicable.

4.6.2 Structural tests. Each seat of the required type and class shall be tested as a complete unit and shall be mounted in a suitable fixture by using the normal seat system to aircraft structure tiedowns. The fixture shall be representative of the aircraft's surrounding structure and spring rates. The seat shall be subjected to, and satisfactorily withstand the loads specified in 4.6.2.1 and 4.6.2.2.

4.6.2.1 Static tests. The occupant restraint shall be tested with the rest of the seat during the static tests specified in Table 1. In addition, the lapbelt and shoulder harness shall be statically tested separately to determine compliance with Table 2, thereby insuring that all components possess the required elongation and strength margin. The static test loads shall be applied where shown on Figure 13 through a body block which is contoured as shown. The body block shall include representations of the neck, the shoulders, and the upper legs.

The load shall be applied while the load-deformation performance of the seat is recorded. Deflection shall be measured from the seat pan for horizontal and from the occupant CG for vertical. Total static test load to be applied, for all directions, shall be determined by multiplying the required design load factor (G) specified in Table 1 by the sum of the occupant and equipment effective weight plus the weight of the stroking portion of the seat.

NOTE: ALL DIMENSIONS ARE  
IN INCHES.

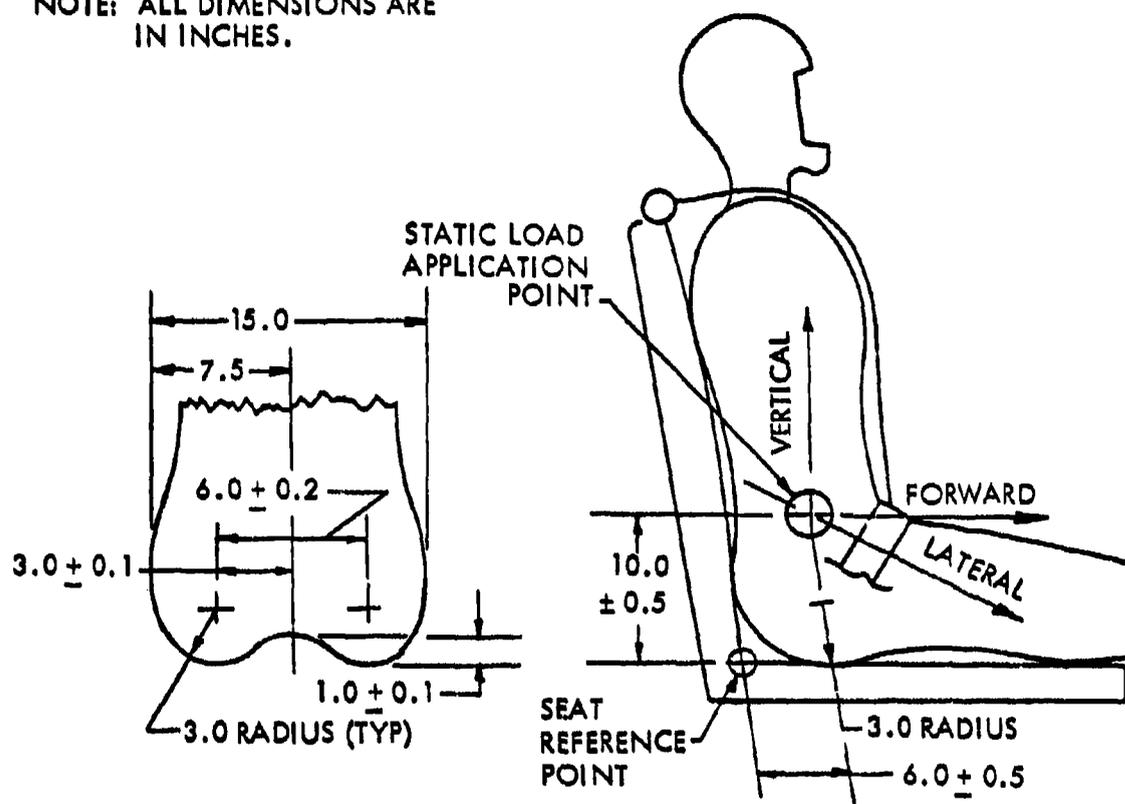


Figure 13. Static load application point and critical dummy pelvis geometry.

4.6.2.2 Dynamic tests. Dynamic first article tests of the seat shall be conducted to the conditions specified in Figure 3, and the seat shall evidence no loss of structural integrity. Dynamic sampling (quality conformance) tests of the seat shall be conducted in accordance with Test I only. The energy absorption mechanism shall limit the acceleration measured on the seat pan to a value which stays within the acceptable pulse duration of Figure 12. Excursions above the 15.5 G plateau level for short durations not to exceed 10 milliseconds and accelerations not to exceed 10 G are permissible as long as the ejection seat design limits in USAAMRDL TR 71-22 Eiband curve are not exceeded. A 95th percentile clothed and equipped anthropomorphic dummy occupant of 242 pounds shall be used to simulate seat occupant for Test 2 of Figure 3 and a 50th percentile clothed and equipped anthropomorphic dummy occupant of 197 pounds shall be used for Test 1 of Figure 3. The 50th percentile dummy shall be in accordance with U. S. Department of Transportation Part 572.

4.6.3 Reliability tests. Components subject to motion, such as fold hinges and belt buckles shall be subjected to cycling tests to demonstrate conformance to 3.8.

4.6.4 Environmental tests. At least one seat shall be subjected to each of the following environmental tests in the order listed. Upon completion of environmental tests, the seat shall be examined for operational capability and subjected to and pass Test I of Figure 3. One additional energy attenuating device of each type used on the seat shall be environmentally tested and stroked after testing to verify function and force-deflection values.

4.6.4.1 High temperature. High temperature tests shall be conducted in accordance with method 502 of MIL-STD-810. The test temperature shall be -65°F.

4.6.4.2 Low temperature. Low temperature tests shall be conducted in accordance with method 502 of MIL-STD-810. The test temperature shall be -65°F.

4.6.4.3 Sunshine. Sunshine tests shall be conducted in accordance with procedure 1 of method 505 of MIL-STD-810.

4.6.4.4 Humidity. Humidity tests shall be conducted in accordance with method 507 of MIL-STD-810.

4.6.4.5 Fungus. If any material utilized in the construction of the seat system is suspected to be a nutrient to fungi, the material shall be tested in accordance with method 508 of MIL-STD-810.

4.6.4.6 Salt fog. Salt fog tests shall be conducted in accordance with method 509 of MIL-STD-810.

4.6.4.7 Dust. The seat system shall be subjected to the dust test specified in MIL-STD-810.

4.6.4.8 Vibration. Vibration tests shall be conducted in accordance with method 514, procedure I (parts 1, 2, and 3) of MIL-STD-810.

4.6.4.9 Mud. All mechanical joints and energy attenuators shall be coated with mud and the seat must operate before and after it has dried.

## 5. PACKAGING

5.1 Preservation and packaging. Preservation and packaging shall be level A or C, as specified (see 6.2).

5.1.1 Level A. Each seat shall be preserved and packaged in accordance with MIL-P-116, method III, in a weather-resistant container conforming to PPP-B-636.

5.1.2 Level C. Each seat shall be preserved and packaged in a manner that will afford adequate protection against corrosion, deterioration, and physical damage during shipment from the supply source to the first receiving activity for immediate use. This level may conform to the supplier's commercial practice, provided the latter meets the requirements of this level.

5.2 Packing. Packing shall be level A, B, or C, as specified.

5.2.1 Level A. Seats preserved and packaged as specified in 5.1.1 shall be packed in overseas-type shipping containers conforming to PPP-B-601 or PPP-B-621. As far as practicable, shipping containers shall be of uniform shape, size, and minimum cube and tare consistent with the protection required, and contain identical quantities. The gross weight of each shipping container shall not exceed the weight limitation of the specification. Containers shall be closed and strapped in accordance with the above specifications and appendices thereto.

5.2.2 Level B. Seats preserved and packaged as specified in 5.1.1 shall not be overboxed for domestic shipments. The container, closed and strapped in accordance with the applicable appendix of the container specification, shall be the shipping container.

5.2.3 Level C. Seats shall be packed in a manner that will afford adequate protection at the lowest rate against damage during direct domestic shipment from the supply source to the first receiving activity and are destined for immediate use at that activity. This level shall conform to applicable carrier rules and regulations and may be the supplier's commercial practice, provided the latter meets the requirements of this level.

5.3 Physical protection. Cushioning, blocking, and bracing shall be in accordance with MIL-STD-1186, except for domestic shipments. Waterproofing requirements for cushioning materials and containers shall be waived when preservation, packaging, and packing designed for immediate use of the item, or when drop tests of MIL-P-116 are applicable.

5.4 Marking. Interior packages and exterior shipping containers shall be marked in accordance with MIL-STD-129.

## 6. NOTES

6.1 Intended use. The seats covered by this specification are intended for use by crewchief/gunners and troops in helicopters, and to provide crash survival for most of these occupants in the majority of crashes.

6.2 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification
- (b) Type and class of seat required (see 1.2)

6.3 Definitions. For the purpose of this specification, the following definitions apply.

6.3.1 Anthropometric data. U. S. Army Natick Labs Report 72-51-CE shall be referred to as a source document for anthropometric data on gunner/troops.

6.3.2 Occupant weights and equipment. Unless otherwise specified, the occupant and equipment weights in Table 4 are applicable for design and test considerations.

TABLE 4. OCCUPANT WEIGHTS			
Item	95th percentile wt-lb	50th percentile wt-lb	5th percentile wt-lb
Troop weight	201.9	156.3	126.3
Clothing*	7.0	7.0	7.0
Equipment	33.3	33.3	33.3
Total weight	242.2	196.6	166.6
Vertical effective weight clothed	163.9	127.4	103.4
Vertical effective weight equipped	197.2	160.7	136.7

\*Includes 4.0 pounds for boots.

6.3.3 Effective weight of occupant. The effective weight of a seated occupant in the vertical direction is the sum of the following quantities: 80 percent of the occupant's body weight, 80 percent of the weight of the occupant's clothing less boots, and 100 percent of the weight of any equipment carried totally on the occupant's body above knee level.

6.3.4 G. The term g is the ratio of a particular acceleration to the acceleration due to gravitational attraction at sea level; therefore, 10g represents an acceleration of 321.7 feet/second/second.

6.3.5 Occupant submarining. In a crash with high vertical and longitudinal forces (measured along the seat longitudinal axis) present, the restrained body will tend to sink down into the seat first and then almost simultaneously be forced forward. If the seat is provided with an improperly designed

restraint or seat cushion, the inertia load of the hips and thighs will pull the lower torso under the lapbelt during the crash sequence. This phenomenon is referred to as occupant submarining.

6.3.6 Dynamic overshoot. Dynamic overshoot exists when the seated occupant received an amplification of the accelerative force applied to the seat. A loose or highly elastic system, or highly elastic cushion, can facilitate dynamic overshoot.

CRASH SURVIVAL DESIGN GUIDE (TR 71-22)

Modifications to USAAMRDL TR71-22, Crash Survival Design Guide, are recommended.

The affected paragraphs of TR 71-22 have been reproduced, and the recommended changes are noted by crosshatching (////) portions deleted and underlining (\_\_\_\_) added portions.

3.3.1 The same percentile range of occupant sizes should be considered for troop and gunner seat design. ~~Since more flexibility is available in the design of troop seats, the typically large clothing and equipment variations for troops should be considered.~~ Since a greater range of clothing and equipment is used by troops than by aviators, troop and troop/gunner seats should be designed to accommodate these variations. The 95th percentile occupant should be considered heavily clothed and equipped, while the 5th percentile occupant should be considered lightly clothed and equipped. ~~Based on data contained in references 22 and 23/~~ It is not reasonable, however, to design a crashworthy troop or gunner seat to accommodate the full range of equipment which can be carried by troops. A subsistence load weight over 90 pounds would be carried in a large rucksack with a hincloe carrying frame. The depth of such equipment is 17 inches and cannot be accommodated within a reasonable seat depth. Seat design should be limited to accommodations for the size and weight range of troops without equipment, to troops with combat assault equipment. Gunner seats which will also be used by troops will be designed by troop weights. The typical weights of seated troops in aircraft are:

	<u>95th Percentile (lb)</u>	
Soldier	<del>192/0</del>	<u>201.9</u>
Clothing	<del>1/2</del>	<u>3.0</u>
Boots	4.0	
<del>Protective/Vest</del>	<del>8/3</del>	
Helmet	3.0	
<del>Equipment</del>	<del>27/3</del>	
<del>FLYA PACK WITH SLEEPING BAG</del>	<del>17/2</del>	
<u>Combat Assault Pack and Equipment</u> <u>not including Rifle</u>		<u>33.3</u>
Total	<u>255/2</u>	245.2

	<u>5th Percentile (1b)</u>	
Man	<del>124.0</del>	<u>126.3</u>
Clothing	<del>7.9</del>	3.0
Boots	4.0	
Helmet	<u>3.0</u>	
	<del>138.8</del>	<u>136.3</u>

(Revise) Figure 3-23A. Seat Forward Load and Deflection Requirements for Forward- or Aft-Facing Crew Seats in ~~70%~~ all Types of Army Aircraft (95th Percentile Accidents). (3)

(Place this Title under Cockpit Seats)

(Revise) Figure 3-23B. Seat Forward Load and Deflection Requirements for Forward-, Aft-, or Side-Facing Troop or Gunner Seats in all Types of Army Aircraft (95th Percentile Accidents). (3)

(Revise Figure, Extending Controlled Deformations from 6 to 12 inches and revise base curve from a straight line to a curve, starting at 0 and tangent at 4 inch deflection.)

### 3.3.4 LATERAL STRENGTH AND DEFORMATION REQUIREMENTS

The lateral load and deformation requirements for cabin seats are presented in Figure 3-24 for the 95th percentile accident. (see Table 1-II in Chapter 1). Two curves are presented. One is for rotary-wing aircraft and the cockpits of large fixed-wing aircraft. The other is for light fixed-wing aircraft and cabins of large fixed-wing aircraft. The deflections are to be measured at the neutral seat reference point. Occupant weight should be as stated in paragraph 3.3.1. Lateral load and deformation requirements for cabin seats are presented in Figure 3-24A. (3)

(Add) Figure 3-25A Lateral Seat Load and Deformation Requirements for Cabin Seats in all Types of Army Aircraft (95th Percentile Accident). (3)

(Figure 3.-24A to be similar to Figure 3-24 except base curve to be curvilinear shape starting at 0 and tangent at 3 inch deflection.) (Controlled deformation to be 6 inches instead of 4.) (4)

### 3.5.2 SEAT COMPONENT ATTACHMENT

Since components that break free during a crash can become lethal weapons, it is recommended that attachment strengths be consistent with those specified for ancillary equipment. Static attachment strengths for components, e.g., armored panels, should therefore be as follows:

Downward:	35G
Upward:	15G
Forward:	35G
Aftward:	15G
Lateral:	20G

These criteria may be somewhat conservative for load-limited seats. ~~However~~ Load limiting is mandatory in the vertical direction only ~~in light of the potential hazard, the strength requirements are felt to be justified~~. therefore, these loads shall apply only to the seats that are not load limited. The loads will apply, however, to load-limited seats in the directions that have no load-limiting provisions.

(Rev' ) Table 3-III to change pulse from 48g and 0.065 second to 34g and 0.091 second.

TABLE 3-II. SEAT DESIGN AND STATIC TEST REQUIREMENTS

Test ref. no.	Loading direction with respect to aircraft	Load required	Deformation requirements <sup>a</sup>
1	Forward	See Figure 3-23	See Figure 3-23
2	Aftward	12G Minimum	NO Requirement
3	Lateral <sup>b</sup>	See Figure 3-24	See Figure 3-24
4	Downward/ Crew Seat Troop and gunner Seat	14.5 +1.0G <sup>d,e</sup> 14.5 <u>±</u> 1.0G <sup>d</sup>	See Paragraph 3.3.3.1
5	Upward	8G Minimum	No Requirement
6	Forward <sup>c,f</sup> Downward/ Crew Seat Troop and gunner Seat Lateral <sup>f</sup>	See Figure 3-23 <sup>c</sup> 14.5 +2.0G 14.5 <u>±</u> 2.0G 9G Minimum	See Figure 3-23 Same as Test 4 No Requirements

- a. The aircraft floor or sidewall should be deformed in the xz and yz planes, as detailed in paragraph 3.2.4.4 and in Figure 3-27, simultaneously with the "G" loads specified.
- b. The lateral loads should be applied in the direction which is most critical. In the case of symmetrical seats, the loading direction is optional.
- c. In the event that no load-limiting device is used in the forward direction, a 20G load for cabin seats and a 25G load for crew seats may be used for this combined loading.
- d. If more than one load-limiter setting is provided, each should be tested.
- e. Subsequent to the stroking of the vertical energy-absorber device, the seat should carry a vertical static load of 25G, based on the effective weight of the 95th percentile occupant plus seat and equipment, without loss of attachment to the basic structure/ except when the seat pan is resting on the floor. Plastic deformation is acceptable in this test. ⑦
- f. The forward and lateral loads should be applied prior to the downward load application/ if distortions could impede vertical stroking. ⑧

## RATIONALE FOR CHANGES TO TR 71-22

1. To limit the range of equipment for which troop and gunner seats should be designed. The large rucksack with Lindloe frame is 17 inches deep, which is excessive for the seat depth limitations and cabin space specified by the using agencies.
2. Weight of 95th percentile troop increased 10 pounds per Natick Labs Report 72-51-CE. Troop equipment weight for combat assault operation is reduced 23 pounds, which includes weight of sleeping bag and protective vest (not used on combat assault operations) and rifle which is not effective on seat load.
3. Figure 3-23 curve with short stroke and requiring higher G is not applicable to cabin seats which are of lighter construction, are more flexible, and generally have more room in which to stroke. More stroking is also needed for troop and gunner seats due to the wider range of equipment weight that may be carried. More stroking is also needed for side-facing seats to reduce lateral acceleration to within human tolerance limits.
4. Base curve shown in Figure 3-24 not achievable with light tension yielding energy attenuators suitable to light troop and gunner seats.
5. Design for loads considerably above the load-limited loads on lightweight seats imposes a severe weight penalty.
6. TR 71-22 establishes requirements for the seat to be designed for a 50th percentile occupant who should not exceed an acceleration of  $14.5 \pm 1$  G in a vertical direction under a 42-fps impact, with a peak pulse of 48 G. The criteria also requires the seat to be designed for a predominantly vertical impact with forward and lateral components and impact velocity of 50-fps with a 95th percentile occupant. These requirements are not compatible. Also, a ceiling-suspended seat will align itself along the resultant path and will stroke at the vertical impact setting. Insufficient stroking is available in a 17-inch-high seat to prevent the seat from bottoming on the floor.
7. Vertical static load requirements considerably above the load-limited load on all seats is unnecessarily costly in weight if the seat bottoms out on the floor before the energy attenuator bottoms.
8. Seats not subject to vertical binding due to horizontal distortion should not be subjected to unnecessary test.

## APPENDIX A

### STATIC TEST PLAN CRASHWORTHY GUNNER SEAT

#### INTRODUCTION

Contract DAAJ02-75-C-0032 has been awarded to the Boeing Company to design, build and test swiveling side-facing crashworthy gunner seats. Static tests and dynamic tests will be performed. This document sets forth a test plan to static test the gunner seats under simulated crash loads and to determine energy attenuator function and seat integrity. Four static test setups will be made for downward, forward, lateral and three-axis combined loading. (Directions contained herein refer to helicopter body axes.)

#### STATEMENT OF WORK

Static test of the crashworthy gunner seats shall consist of the following tasks:

1. Design and fabrication of a test fixture
2. Seat installation
3. Loading and instrumentation
4. Static testing
5. Photographic coverage
6. Data of instrumentation recordings.

#### TEST FIXTURE DESIGN AND FABRICATION

A test fixture shall be designed and fabricated which will support the test specimens in the same geometric manner as it would be in the aircraft (Figure A-1). The fixture shall be capable of supporting the seat, without deflecting, while loads are applied as specified in the test section. Structure shall be provided to which the floor and ceiling swivel rings can be securely bolted.

The test fixture shall be designed to permit a minimum seat displacement of 12 inches laterally and 24 inches frontward without contacting the fixture.

The same test fixture shall be adaptable for the four test conditions. A minimum preparation shall be required to convert the fixture from one test condition to another.

### SEAT INSTALLATION

The seat shall be installed in the test fixture as in the aircraft (Figure A-1). The procedure for seat installation is as follows:

1. Loosen several bolts adjacent to ceiling swivel ring split and slide saddle block assembly onto ring.
2. Loosen several bolts adjacent to floor swivel ring split and slide base plate saddle blocks onto ring.
3. Attach turn buckles at top of seat to ceiling saddle blocks and tighten until slack of seat is removed.

### LOADING AND INSTRUMENTATION

The specified load shall be applied to the body block at the C.G. The cable attachment to the body block shall be through a cable yoke and pulley arrangement so that the load is maintained through the C.G. as the seat rotates to align itself in the direction of the applied load. Load direction specified shall not vary more than plus or minus 5 degrees as the seat strokes. A load cell shall be provided in the load applicator and the output shall be capable of being used to produce a curve showing force in pounds versus deflection in inches. Instrumentation shall be installed on the seat in the following manner:

1. Tensionmeters attached to main shoulder harness strap and both shoulder straps.
2. Strain gages attached to both sides of square bar fitting at the end of each diagonal strut energy attenuator.
3. Load cell or strain gaged yoke fittings attached to each side of seat at lapbelt attachment fittings and lapbelt to be attached to instrumentation.
4. String potentiometers attached to seat pan for vertical and horizontal displacement measurement.

This instrumentation shall produce a force output in pounds which can be plotted versus deflection in inches.

### STATIC TESTING

Four static tests shall be performed using a body block (Government furnished). Each static test shall be performed as follows using a new seat:

### Test 1 - Vertical Loading

A load shall be applied to the center of gravity of the body block, in a vertical direction and perpendicular to the floor. Loading direction shall not vary more than plus or minus 5 degrees to the vertical axis of the seat as the seat moves forward during vertical stroking. Loading shall be applied in a continuous manner. The seat shall be photographed from a fixed position at increments during deformation. Loading shall be continued until the seat bottoms-out against the floor. The seat will stroke vertically at an approximate load of 2813 pounds which is 194 pounds (the vertical effective weight of a fully equipped 50th percentile gunner plus seat weight) multiplied by 14.5 G. Force versus deflection shall be recorded during seat stroking.

### Test 2 - Forward Loading

A load shall be applied at the center of gravity of the body block, in a forward direction and parallel to the floor. Loading shall be applied in a continuous manner. The seat shall be photographed from a fixed position at increments during the deformation. Some stroking of the ceiling attenuators at low loads is anticipated due to the "bow string" effect. As the angle of the attenuator with the ceiling decreases the stroking will decrease until a stable position is reached and the lower, diagonal attenuators, under the seat pan, begin stroking. As the lower attenuators begin stroking, loading is to be continued until the seat pan has moved 10 inches in a forward direction. The seat will stroke at approximately 4140 pounds which is 15 G multiplied by 276 pounds, the 95th percentile fully equipped gunner weight plus seat weight. Force versus deflection shall be recorded during seat stroking.

### Test 3 - 3 Axis Loading

The load shall be applied at an angle which is the resultant of the three-axis loading and shall be applied at the center of gravity of the body block. The angle of the resultant load shall be determined by using the following load vectors:

14.5 G Downward	X	194*	=	2813 lb
15 G Forward	X	276**	=	4140 lb
9 G Lateral	X	276**	=	2484 lb

\* 50th percentile fully equipped gunner effective vertical weight plus 12 pounds effective seat weight.

\*\*95th percentile fully equipped gunner weight plus 12 pounds seat effective weight.

Loading shall be applied in a continuous manner. The seat shall be photographed from a fixed position at increments during deformation. The seat will stroke at approximately 4920 pounds (the approximate forward and vertical resultant load) and loading is to be continued until the seat has stroked 10 inches in the forward direction or has contacted the floor. Force versus deflection shall be recorded during seat stroking.

#### Test 4 - Lateral Loading

A load shall be applied at the center of gravity of the body block in a lateral direction and parallel to the floor. Loading shall be applied in a continuous manner. The seat shall be photographed from a fixed position at increments during the deformation. It is anticipated that the ceiling attenuators will stroke first due to the "bow string" effect. Stability is reached as the angle of the attenuator with the ceiling decreases. As the lower attenuators begin stroking, loading is to be continued until the seat pan has moved horizontally 10 inches. The seat will stroke at approximately 4140 pounds which is 15 G multiplied by 276 pounds, the 95th percentile fully equipped gunner weight plus seat weight. Force versus deflection shall be recorded during seat stroking.

#### PHOTOGRAPHIC COVERAGE

Photographs shall be taken before and after each test. Five pre-test photographs shall be taken showing the complete seat in the test fixture. The photographs shall include a frontal, side, rear and 3/4 view, and a view showing the load applicator attachment to the body block. A minimum of 4 post-test photographs shall be taken and shall include front, rear, side and 3/4 view. Additional photographs shall be taken as necessary to show failed components or excessive deformation. Photographs during deformation shall be made.

## DATA

The data output of all instrumentation used shall be provided. The data shall be in the form of graphs showing force versus deflection. Deflection shall be measured from the seat pan. Test data shall be displayed in a form showing the degree of compliance with the static test criteria, paragraph 4.5.3.1 of the draft Military Specification Seat, Crashworthy Helicopter Gunner.

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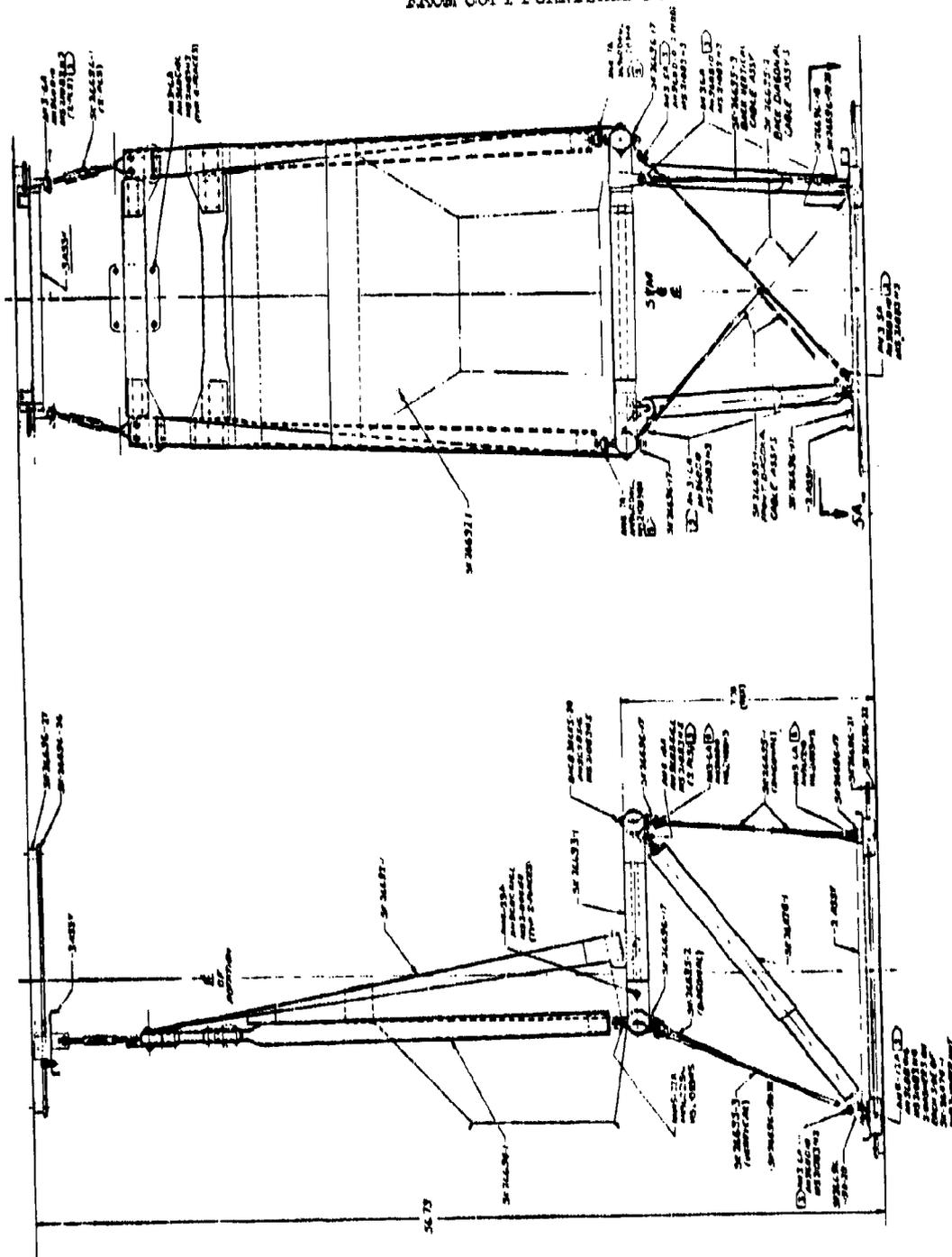


Figure A-1. Seat installation.

## APPENDIX B

### DYNAMIC TEST PLAN CRASHWORTHY GUNNER SEAT

#### INTRODUCTION

Contract DAAJ02-75-C-0032 has been awarded to The Boeing Company to design, build, and test swiveling crashworthy gunner seats. Static tests and dynamic tests will be performed. This document sets forth a test plan to dynamic test the gunner seats under crash impact conditions to determine energy attenuation and seat integrity. Two dynamic test setups will be made, one for horizontal impact and one with combined three-axis loading.

#### STATEMENT OF WORK

Dynamic testing of the crashworthy gunner seats shall consist of the following tasks:

1. Design and fabrication of a dynamic test fixture
2. Seat installation
3. Loading and instrumentation
4. Dynamic testing
5. Photographic coverage
6. Instrumentation data acquisition

#### TEST FIXTURE DESIGN AND FABRICATION

A test fixture shall be designed and fabricated which will support the test specimens in the same geometric manner as it would be in the aircraft (Figure B-1). The fixture shall be capable of supporting the seat, without deforming during dynamic load application as specified in the test section. Plates shall be provided to simulate the floor and ceiling surfaces on which the circular tracks shall be rigidly attached with bolts.

The test fixture shall be designed to permit a minimum seat displacement of 12 inches laterally and 24 inches frontward without contacting the fixture. Adequate clearance for dummy limb flailing shall be provided.

It is desirable that the same test fixture be adaptable for the two test conditions. A minimum preparation shall be required to convert the fixture from one test condition to another.

#### SEAT INSTALLATION

The seat shall be installed in the test fixture as in the aircraft (Figure B-1). The procedure for seat installation is as follows:

1. Loosen several bolts adjacent to ceiling swivel ring split and slide saddle block assembly onto ring.
2. Loosen several bolts adjacent to floor swivel ring split and slide base plate saddle blocks onto ring.
3. Attach turn buckles at top of seat to ceiling saddle blocks and tighten until slack of seat is removed.

#### LOADING AND INSTRUMENTATION

Each seat shall be loaded with a 95th percentile anthropomorphic dummy weighted to a total weight of 202 pounds, including clothing and boots. The dummy shall be wearing gunner combat equipment (supplied by the Government) which will weigh a total of 62 pounds.

The dummy shall be instrumented with a three-axis accelerometer. Strain gages shall be placed on test components and test fixture as specified for each test condition, the output of which shall show force in pounds versus time. Accelerometer output shall show acceleration (G) versus time. Instrumentation shall be installed in the following locations for all tests:

1. Strain gages on the ceiling connection turn buckle barrel (2 places) (2 per seat).
2. Tensiometer attached to both shoulder straps.
3. Strain gages attached to the square block fitting at the end of the diagonal strut energy attenuator (2 places) (2 per seat).
4. Strain gaged lap belt to seat pan adapter fitting (2 per seat). Use same adapter fabricated for troop seat test.
5. Accelerometer (three-axis) attached to the test fixture at floor level (2 required).
6. Accelerometer (three-axis) in chest cavity of dummy and on seat pan.

#### DYNAMIC TESTING

Two dynamic tests shall be performed using anthropomorphic dummies with equipment. Each dynamic test shall be performed as follows:

### Test 1 - Downward, Forward, and Lateral Loads

The seat shall be installed in the vertical drop test fixture and oriented as shown in Figure B-2. A 95th percentile dummy weighted as specified and wearing gunner combat equipment shall be placed in the seat.

The seat shall be impact-tested at a vertical velocity of 50 fps. A triangular impact pulse shall be produced with a duration and peak acceleration as shown in Figure B-2.

### Test 2 - Forward and Lateral Loads

The seat shall be installed in the horizontal accelerator test fixture and oriented as shown in Figure B-3. A 95th percentile dummy weighted as specified and wearing gunner combat equipment shall be placed in the seat.

The seat system shall be impact-tested at a horizontal velocity of 50 fps. A triangular impact pulse shall be produced with a duration and peak acceleration as shown in Figure B-3.

### PHOTOGRAPHIC COVERAGE

Photographs shall be taken before and after each test. Four pre-test photographs shall be taken showing the complete seat in the test fixture. The photographs shall include a frontal, side, rear, and 3/4 view. A minimum of four post-test photographs shall be taken and shall include front, rear, side, and 3/4 view. Additional photographs shall be taken as necessary to show failed components of deformation.

High-speed color motion pictures (400 frames per second) shall be made of each dynamic test. Four cameras shall be used providing full coverage of the back, side, and 3/4 front view of each seat. The side camera shall be redundant.

### DATA

The data output of all instrumentation used shall be provided. The data shall be in the form of graphs showing force versus time or acceleration versus time. Deflection of attenuators shall be measured after each test. Test data shall be displayed in a form showing the degree of compliance with the dynamic test criteria, Paragraph 4.5.3.2 of the draft Military Specification Seat, Helicopter, Gunner (USAAMRDL-TR-74-98).



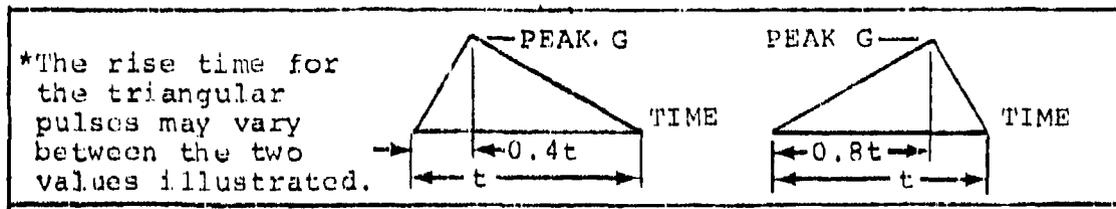
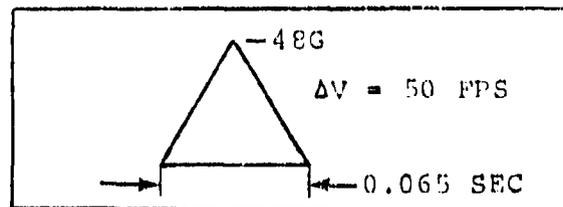
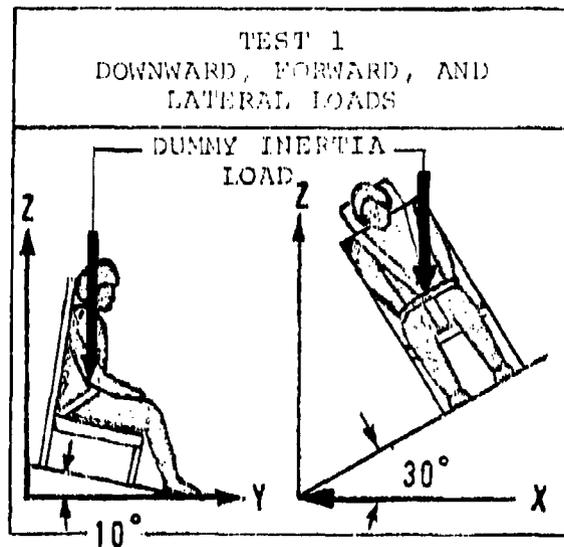


Figure B-2. Impact pulse and seat orientation, test 1.

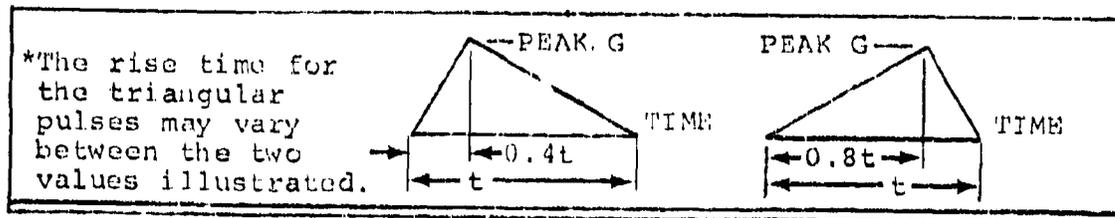
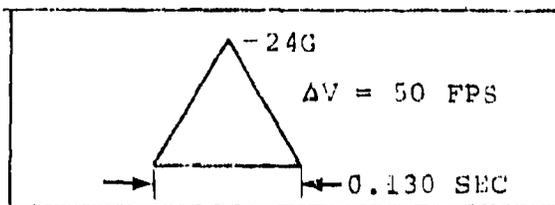
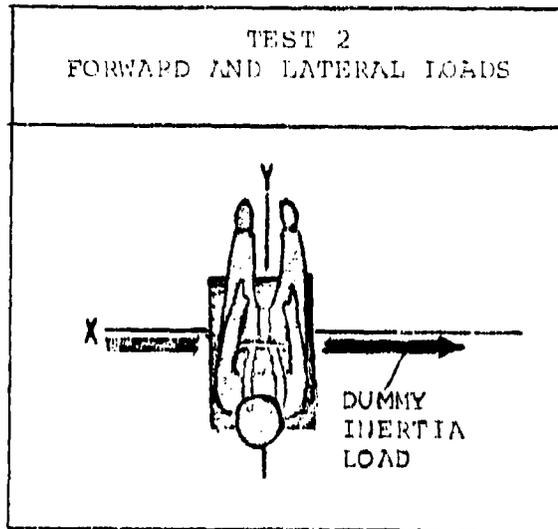


Figure B-3. Impact pulse and seat orientation, test 2.