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CRASHWORTHY TROOP SEAT INVESTIGATION

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Boeing Vertol Company

Prepared for:

Army Air Mobility Research and Development Laboratory

December 1974

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EUSTIS DIRECTORATE POSITION STATEMENT

The conclusions submitted by the contractor are considered to be valid. Before the recommended changes to the proposed draft General Military Specification can be accepted, a troop seat design must be tested to demonstrate compliance with the proposed draft General Military Specification. Such testing will be performed under the terms of Eustis Directorate Contract DAAJ02-74-C-0036. Following verification of the proposed specification, it will be coordinated, finalized, and published. Once published, the crashworthy troop seat Military Specification will ensure that passengers of future Army troop transport helicopters will be afforded a higher probability of survival during crash impact.

This report has been reviewed by this Directorate and is considered to be technically sound. The technical monitor for this contract was Mr. George T. Singley III of the Technology Applications Division.

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

The purpose of this investigation was to perform a research program for the development, analytical verification, mockup evaluation, and comparison of designs for practical crashworthy forward-, aft-, and side-facing troop seating systems for U. S. Army helicopters. Recommendations for modifications to the proposed Crashworthy Troop Seat Draft Military Specification and USAAMRDL TR 71-22 were also required. Tasks performed during

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the program included a literature survey, military organization survey, and questionnaire distribution to obtain data on existing seats, restraint systems, accommodation and human factors requirements, mathematical simulation of crash force attenuation, and energy attenuator development. These data were used in developing 19 crashworthy troop seat concepts and several restraint systems applicable to troop use. An attenuator was optimized through the use of a computer program. Seat concepts were evaluated and one was selected for detail design. Eight seats were fabricated and installed in a utility aircraft mockup. Human factors and functional evaluations were performed on the seat system using troops with various combinations of clothing and equipment. These evaluations resulted in the recommendation of changes to the Draft Military Specification for Crashworthy Helicopter Troop Seats and USAAMRDL TR 71-22. When this draft military specification is coordinated, finalized, and published, all future Army helicopters will be required to have crashworthy troop seats.

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INTRODUCTION

The poor crash impact performance of helicopter troops seats designed to current military specifications was revealed by the U.S. Army in the early 1960's through accident investigations, full-scale crash tests and critical review of the applicable specifications. It was discovered that numerous troop seat occupants were being injured during moderate impacts because of inadequate upper torso restraint, inadequate seat strength, the absence of any significant means of vertical crash-force attenuation, and inadequate testing criteria and methods. Crashworthiness design criteria for improved troop seat design were developed and published in TCREC Technical Report 62-79,[1] "Military Troop Seat Design Criteria". Several experimental troop seat concepts designed in accordance with these criteria were subsequently developed and tested as described in TRECOM Technical Reports 63-62[2] and 65-6.[3] These efforts (1) demonstrated that the TCREC TR 62-79 crashworthiness design criteria are technically attainable and (2) led to the inclusion of these criteria in USAAVLABS TR 67-22,[4] "Crash Survival Design Guide".

Crashworthy troop seat development has continued with a limited degree of success. The principal problems are the requirements for low cost and weight, high strength, stowability in a small space, rapid removal and folding, adjustability for troops with and without field equipment, attentuation

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[1] Turnbow, J. W., et al, CRASH INJURY EVALUATION, Aviation Crash Injury Research, Phoenix, Arizona, TCREC Technical Report 62-79, U.S. Army Transportation Research Command, Fort Eustis, Virginia, November 1962.

[2] Turnbow, J. W., et al, CRASH INJURY EVALUATION, DYNAMIC TEST OF AN EXPERIMENTAL TROOP SEAT INSTALLATION IN AN H-21 HELICOPTER, Aviation Safety Engineering and Research, Phoenix, Arizona, TRECOM Technical Report 63-62, U.S. Army Transportation Research Command, Fort Eustis, Virginia, November 1963.

[3] Weinberg, L.W.T., CRASHWORTHINESS EVALUATION OF AN ENERGY-ABSORPTION EXPERIMENTAL TROOP SEAT CONCEPT, Aviation Safety Engineering and Research, Phoenix, Arizona, USATRECOM Technical Report 65-6, U.S. Army Transportation Research Command, Fort Eustis, Virginia, February 1965.

[4] Turnbow, J. W., et al, CRASH SURVIVAL DESIGN GUIDE, Aviation Safety Engineering and Research, Phoenix, Arizona, USAAVLABS Technical Report 67-22, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, December 1967.

systems adaptable to the wide range of troop and equipment weights, stability during and after impact, adequate support for shoulder restraint, operational simplicity for troops unfamiliar with restraint devices, clear seat area for rapid ingress and egress, and the normal environmental requirements. With such a formidable list of requirements, development has been slow.

The principal purpose of this investigation was to refine the list of requirements into a practical military specification. Trade-offs were conducted to balance the operational simplicity requirements with the requirements for crash survival. A thorough understanding of the requirements was attained through literature surveys and visits to the Government technical and operational agencies. A number of restraint system and seat concept designs were developed and evaluated. Selections were made and seats designed and built for human factors evaluations using troops with various clothing and equipments. The final product is a practical military specification for crashworthy troop seating systems.

CRASHWORTHY TROOP SEAT SYSTEM INVESTIGATION PROGRAM

The Crashworthy Troop Seat System Investigation Program was divided into three phases. At the completion of each phase, a report was prepared and a briefing given on the work accomplished. The required tasks to be performed for each of the phases were as follows:

Phase I - State-of-the-Art Establishment

1. Literature survey
2. Organization survey
3. Evaluation and analysis of attenuating techniques and devices
   - (a) Evaluation of attenuators
   - (b) Analysis using mathematical simulation
4. Restraint analysis and evaluation
   - (a) System analysis
   - (b) Comparative evaluation
   - (c) System selection

Phase II - Design Development

1. Design a minimum of fourteen troop seat concepts for various orientations and mounting arrangements.

Phase III - Design Selection and Refinement

1. Trade-off studies and concept selection
2. Design refinements
3. Fabrication and human factors evaluation of mockup seat
4. Recommend modifications to the Draft Military Specification for Crashworthy Troop Seats

The report discusses each of these areas and is arranged in the above order.

LITERATURE SURVEY

Literature surveyed during Phase I is listed under references. Data obtained has been classified into three categories, and a discussion of each is contained in the following paragraphs:

- Troop Seat Design and Test
- Restraint Systems Design and Test
- Math Simulation of Human Response to Crash Impulse

TROOP SEAT DESIGN AND TEST

The following is a list of troop seat design programs reviewed. These programs cover a ten-year span and have produced varying degrees of success under dynamic test conditions.

Ref. No.	Program	Performed By	Date	For	Contract
5	Troop Seat Test	AVSER	Nov 63	USATRECOM	DA 44-177-AMC-888(T)
6	Troop Seat Test	AVSER	Feb 65	USATRECOM	DA 44-177-AMC-116(T)
7	Troop Seat Test	Boeing	Mar 71	NADC	NADC-73121-40
8	Troop Seat Development	USAAAVS	Dec 71	USAAAVS	-

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[5] Turnbow, J.W., et al, CRASH INJURY EVALUATION, DYNAMIC TEST OF AN EXPERIMENTAL TROOP SEAT INSTALLATION IN AN H-21 HELICOPTER, Aviation Safety Engineering and Research, Phoenix, Arizona, TRECOM Technical Report 63-62, U.S. Army Transportation Research Command, Ft. Eustis, Va., November 1963.

[6] Weinberg, L.W.T., CRASHWORTHINESS EVALUATION OF AN ENERGY-ABSORPTION EXPERIMENTAL TROOP SEAT CONCEPT, Aviation Safety Engineering and Research, Phoenix, Arizona, USATRECOM Technical Report 65-6, U.S. Army Transportation Research Command, Ft. Eustis, Va., February 1965.

[7] Reilly, M.J., ENERGY ATTENUATING TROOP SEAT DEVELOPMENT, The Boeing Company, Vertol Division, Report NADC-AC-7105 with Addendum NADC-73121-40, U.S. Naval Air Development Center, Aerospace Crew Equipment Department, Johnsville, Warminster, Pa., May 1971.

[8] PROPOSAL FOR A FORWARD OR REARWARD-FACED CABLE-SUPPORTED, "LOAD-LIMITED" TROOP SEAT FOR UTTAS, USABAAR Technical Report 72-5, Applied Research Division, Technical Research and Application Department, U.S. Army Board for Aviation Accident Research, Ft. Rucker, Ala., December 1971.

Test Program, Reference 5

One seat tested consisted of a tubular seat pan frame supported from the ceiling by straps or cables. Reel type energy attenuators attached the straps to the ceiling. The seat pan was stabilized by a linkage system attached to the side of the aircraft. Tests were conducted in a vertical direction only. Drop heights were limited due to the 5-inch stroke capability of the energy attenuators. The maximum deck acceleration recorded, 38.9G, was reduced to a 23.3G pelvic reading.

Crash test in an H-21 helicopter at 40 fps vertical velocity resulted in the 18-inch-high seat just touching the floor. The seat stroked only 5-1/2 inches; the remaining 10 inches were due to structural deformation between the floor and ceiling supports. The maximum acceleration on the dummy was 25G.

Test Program, Reference 6

A second troop seat development consisted of a tubular frame seat pan supported at the front by a single energy attenuating strut and at the back by the side frames of the aircraft. Straps from energy attenuators at the ceiling attached to the seat pan. The attenuator consisted of nylon strap threaded back and forth through slots in a plate.

The seat was mounted in a damaged H-21 fuselage and drop tested with an impact velocity of 40 fps. Partial stroking occurred on the attenuator attached to the floor. The attenuators at the ceiling did not stroke due to their being torn from the ceiling along with their support beam.

A modified version of the seat was installed in another H-21 drone helicopter. Wire threaded in and out of holes in a plate was used for the attenuators at the ceiling. The aircraft impacted at an excessive velocity of 52.5 fps, and the occupied area of the fuselage was reduced to 65 percent of its original height. All attenuators functioned properly, but the seat pan was torn from the side frames of the aircraft. A 30G vertical acceleration was recorded on the dummy, while 175G was recorded on the floor.

A subsequent test using a damaged H-21 fuselage with the same seat configuration resulted in all attenuators functioning properly and the wall attachment remaining intact. Acceleration of the dummy was recorded at 30G, for a vertical impact velocity of 36.8 fps.

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Further sled tests with this seat configuration failed to pass the longitudinal acceleration requirements.

Test Program, Reference 7

A lightweight, hammock type troop seat was developed consisting of a fabric and webbing bucket supported by straps attached to the ceiling with wire bending attenuators. A spreader tube supports the front of the seat pan, and diagonal legs attached to the floor stabilize the seat pan. Ball joints allow the seat pan to move in three axes. Diagonal straps are attached to the sides of the seat for lateral seat loads. In vertical drop tests, acceleration on the dummy was reduced to 17G with a 42-fps impact velocity. Sled tests for 95th percentile longitudinal impacts (lateral seat loading) did not pass due to lateral tie-down strap or attachment fitting failures. Further refinements of this concept are anticipated using an energy attenuator in the diagonal floor strap.

Development Program, Reference 8

An energy attenuating troop seat was constructed by USAAAVS and consists of a tubular seat pan frame covered with wire-reinforced fabric and a similar seat back with energy attenuators attached to the ceiling. Vertical legs at the front of the seat and a diagonal leg from the front of the seat to the floor are inverting tube energy attenuators. Tests are planned for this configuration.

RESTRAINT SYSTEMS DESIGN AND TEST

Significant excerpts from the literature surveyed are included in the following paragraphs. Items 1 through 7 are from Reference 9; items 8 through 10 are from Reference 10.

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[9] Haley, J. L., Jr., PERSONNEL RESTRAINT SYSTEMS STUDY BASIC CONCEPTS, Aviation Crash Injury Research, Phoenix, Arizona, TCREC Technical Report 62-94, U.S. Army Transportation Research Command, Fort Eustis, Virginia, 23604, December 1962.

[10] Kourouklis, G., et al, THE DESIGN, DEVELOPMENT, AND TESTING OF AN AIRCREW RESTRAINT SYSTEM FOR ARMY AIRCRAFT, by Dynamic Science, USAAMRDL Technical Report 72-26 for U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, 23604, June 1972.

1. Forward-facing personnel, restrained by lap belt and shoulder straps only, tend to "submarine" under the lap belt during deceleration; the "submarining" can cause serious injuries. The addition of a lap belt tiedown (a vertical attachment to prevent upward movement of the lap belt) will reduce the "submarining" and improve the restraint provided by the existing lap belt and shoulder straps.

2. The optimum width of a lap belt is considered to be 2.5 - 3.0 inches for all aircraft passengers; this width insures minimum webbing pressure consistent with comfort.

3. The standard double-strap shoulder harness should be increased in width from the existing 1.72 inches to 2.0 inches. This width insures minimum webbing pressure consistent with comfort.

4. The optimum angle of the lap belt, measured in respect to the seat cushion, is 45-55 degrees.

5. The diagonal shoulder strap, which is placed on the forward side of the neck, offers much more restraint (in side-facing seats) to expected forward impact loads than the standard, two-strap harness used by forward-facing personnel. It also requires only one point of release with the lap belt.

6. Experimental tests conducted by the Navy indicated that a single diagonal shoulder strap with a shoulder band attached was adequate for transverse deceleration, but it did not prevent the subsequent rebound out of the harness. Fit for the 5th through the 95th percentile troop range is also a problem.

7. Maximum benefit from shoulder straps, for side-facing personnel, is obtained when the straps are mounted level with or only slightly above the shoulder. Shoulder harnesses in some aircraft have been mounted above head level, which minimizes their effectiveness; the angle of the shoulder strap should not exceed 30 degrees to the horizontal.

8. Protected only by a lap-belt restraint, human subjects have been voluntarily tested to 26G forward acceleration.

   For the forward-facing position with lap-belt restraint only, Stapp concluded that "rates of onset between 250 and 1600G/sec and 11.4 to 32.0 peak G can be sustained against a lap belt restraint up to approximately 90 psi average pressure load, with no significant injuries resulting". Effects of higher loads have been investigated with animal subjects. In tests where the lap belt was purposely positioned high and loose, a 30G peak impact value (74.2 ft/sec entrance velocity, 3000G/sec onset rate, 20-deg seat pan pitch, 0.055-sec plateau time, and 0.094-sec total impact duration) produced no significant injury. It has been found that seated human occupants restrained only by a 3-inch-wide lap belt can survive a peak deceleration of 30G at rates of onset below 1500G/sec with only minor reversible injurious effects.

9. Use of upper torso restraint increases whole-body human tolerance limits to approximately 50G peak (at 500G/sec rate of onset for 0.25 sec duration). Air Force design recommendations are 45G for a duration of 0.1 sec or 25G for a duration of 0.2 sec. Restraint in the experiments establishing these limits was provided by a 3-inch-wide double shoulder harness, a seat belt with thigh straps, and a chest belt.

10. Knowledge of human response to lateral deceleration forces is very limited, but tests to date strongly indicate that tolerances are lower for this position than for either forward- or rearward-facing body orientations. Human subjects have found the subjective pain threshold to be 9G (average) for a duration of approximately 0.1 sec. Even when body restraint consisting of both lap belt and upper torso harness is worn, Sonntag found the maximum voluntary subjective tolerance to be 14.1 peak sled G at 600G/sec rate of onset for 0.122 sec duration.

    More recent tests with the F-111 restraint system (General Dynamics' version) resulted in subjective tolerance levels of 12 to 14G measured on the chest.

MATH SIMULATION OF HUMAN RESPONSE TO CRASH IMPULSE

Significant excerpts from literature surveyed are included in the following paragraphs. Excerpts are from Reference 11.

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[11] Phillips, N. S., et al, A STATISTICAL EVALUATION OF THE INJURY POTENTIAL OF A "SQUARE WAVE" ENERGY ABSORBER, Beta Industries, Inc., Dayton, Ohio, USAAMRDL Technical Report 72-9, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, 23604, June 1972.

"The Dynamic Response Index (DRI) program consists of nonlinear ordinary differential equations which relate the forces and displacements of a seated subject, structural seat, and energy absorber. Hence, for any given vertical impulse input, it is possible to calculate the response of the seat and the man. Since there exists a means of relating seat vertical acceleration to injury, an additional degree of freedom is added to the 'force' model of the man to calculate the DRI."

"The human response is calculated in two ways in order to evaluate the injury level (DRI). The equations of motion are written for a 10-Hz system to duplicate man's force response. This yields the correct seat acceleration that would exist if a human were subjected to the attenuated acceleration pulse. The seat acceleration is then used as the input acceleration to the DRI model, an 8-Hz system. The output of the latter model is then the desired DRI magnitude which is directly related to probability of injury."

"Seat stroke is critical and bottoming of the seat on floor structure serious. Since the DRI is linearly related to the velocity change in feet per second, nearly one to one, a small velocity residue of 1 foot per second increases the DRI by one unit. A one-unit change does not create a small change in probability because of the statistical relation of DRI to probability. Hence, even for a small velocity residue at the instant of 'bottoming', the probability of injury approaches unity."

ORGANIZATION SURVEY

DATA FROM MILITARY AGENCY AND COMMERCIAL FIRM VISITS

Visits were made to various military agencies and commercial firms to obtain data useful to the design of crashworthy troop seats. The data reported in this chapter was obtained from the following agencies and firms surveyed as noted:

Military Agency or Commercial Firm	Contact by Boeing Project Engineer		Contact by Boeing Rep by Visit	Questionnaire Distributed or Data Supplied for Following Paragraphs
	by Visit	by Phone		
U.S. Army Combat Developments Command Infantry Agency (CDC)	Yes	Yes	-	1, 2, 3 and Questionnaires
U.S. Army Combat Developments Command Aviation Agency (CDC)	Yes	Yes	-	4, 5
U.S. Army Human Engineering Laboratory (HEL)	Yes	Yes	-	6, 7
U.S. Army Aero-medical Research Laboratory (USAARL)	Yes	Yes	-	8, 9, 10, 11, 12
U.S. Army Air Mobility Research and Development Laboratory	Yes	Yes	-	Questionnaires
U.S. Army Agency for Aviation Safety (USAAAVS)	Yes	Yes	-	-
U.S. Naval Air Development Center (NADC)	-	Yes	-	-
U.S. Army Commands (RVN)	-	-	Yes	Questionnaires
U.S. Marine Corps Commands (RVN)	-	-	Yes	Questionnaires
ORO Mfg	-	Yes	-	-
C. R. Daniels	Yes	Yes	-	-
Pacific Scientific	Yes	-	-	-
American Safety	Yes	-	-	-

1. Field Pack and Troop Equipment Weight Considerations for Troop Seat Design

Seat occupant weight can range from a lightly equipped 5th percentile troop to a heavily equipped 95th percentile troop and is critical in the design of energy attenuating troop seats. Information was requested on troop equipment combinations, equipment weight and the probabilities of various equipment being carried at any one time.

The amount of combat equipment carried depends on the type of combat operation. Combat operations can be divided into three general categories: combat assault, sustained combat with subsistence load, and command and control. For command and control operations, little or no equipment is carried. Seventy-five percent of operations are combat assault, and minimum equipment is carried. Maximum equipment is carried on a sustained operation, which includes a subsistence load.

On combat assault operations, the combat or butt pack has usually been used, but a medium rucksack without carrying frame will be used in the future. Typical equipment carried on an assault operation is as follows:

Item	Weight - lb
Clothing	3.5
Boots	4.0
M-16 Rifle	13.5
Field Equipment (which includes)	16.8
Helmet	
Pistol Belt	
Canteen and Water	
Trenching Tool	
Hand Grenades	
Claymore Mines	
Butt Pack and Suspenders	
Poncho and Other Personal Equipment	10.0
Total	47.8 lb

A fragmentation vest was not included in the list because it is not usually worn on combat assault operations. It is ineffective against small-arms fire and is heavy, cumbersome and hot. Of the 47 pounds, only 36.8 pounds of equipment is effective on the seat in the vertical direction as compared to the total weight of 58.5 pounds listed in TR 71-22. For a sustained operation, the total load carried consists of the subsistence load plus the weight of equipment used in the assault operation. A rucksack is used to carry most of the equipment. Several types are used but are basically the same dimensionally. The tropical rucksack has an integral frame and is approximately 14 inches deep. The large rucksack fully packed with the external "Lincloe" frame is approximately 17 inches deep. The medium rucksack without carrying frame is 8 inches deep. Troops cannot sit on existing troop seats while wearing the large rucksack due to its extreme depth. Seats are folded up or removed under these conditions, and troops sit on the floor. The other alternative is to remove the rucksacks and place them on the floor while sitting on the seats. Weights for the subsistance load are as follows:

Item	Weight - lb
Combat Assault Equipment	47.8
Subsistence Load (which includes)	29.0
Extra Clothing	
Sleeping Bag	
Shelter Half	
Poncho Liner	
Air Mattress	
Mess Kit	
"C" Rations	
Fragmentation Vest	8.5
Starlit Scope or equal load	6.0
Total	91.3 lb

Of these items the effective vertical weight is: 80.3 lb

Recommendation - Energy attenuating troop seats should not be designed for large rucksacks with the subsistence load or for fragmentation vests. Vests are infrequently used on combat assault operations, and cabin space will not permit the design of troop seats to accommodate the deep packs. Fast ingress or egress should not be considered while the troops are wearing rucksacks with subsistence load because troops usually require assistance in getting into or out of the aircraft with the heavy load, and operations are generally from and to relatively safe areas. Troops should not wear rucksacks while in an aircraft due to spinal injury considerations. Rucksacks are worn high on the back with a gap of 5 to 12 inches under the pack to the seat. Crash loads on the pack would be transferred through the troop's spine rather than directly into the seat as in the case of the butt pack.

2. Restraint System

One-hand connection of the restraint system and various types of buckles were discussed. Advantages for a one-hand operation were seen for operations where troops are carrying weapons. Holding onto their weapon is instilled in them, and they are reluctant to lay their weapon down to fasten their seat belt with two hands although the weapon can be held by the knees. Disadvantages of one-hand operation are: (1) use of double shoulder straps would be prohibited because one-hand operation requires a fixed lap belt socket on the side of the seat, (2) side buckles are harder to reach when wearing combat equipment, and (3) in emergency egress the tendency is to go to the center to release the restraint system.

The opinion was that restraint system release should be operable with a troop hanging upside down while wearing heavy gloves and should not require fingers to operate.

> Recommendation - A trade-off should be made between one-hand restraint connection using a single diagonal strap and two-hand restraint connection using double shoulder strap.

3. Selective Seating of Troops

Multi-unit crashworthy seats will not function properly in a crash unless fully occupied, and this problem was discussed. To use multi-unit seats, some single-unit seats would be required to accommodate the troops left over in the multi-unit seat not fully occupied. Two single-unit seats would be required if three-man seats were used. In addition, the crew chief would have to direct the seating of troops to assure full occupancy of all multi-unit seats.

> Recommendation - Selective seating was not considered a problem, as crew chiefs presently direct the seat loading for weight and balance, seat damage and other considerations. It is recommended that if multi-unit seats are used, sufficient single seats be provided to permit normal functioning of all seats. The seats must be stenciled to indicate that multi-unit seats must be fully occupied to be crashworthy.

4. The Effect That Retrofitting Existing Helicopters With Crashworthy Troop Seats Will Have on MIL-Spec Requirements and Seat Design

Seat weight and cost will be the prime concern for retrofitting existing aircraft with crashworthy troop seats. The extent of structural modifications to support the ceiling-mounted type seat is another area of concern. Present helicopter ceilings are not designed to support the seats under crash loads. Assuming 15 to 20 pounds per seat increase in weight for seat and structural modifications, an aircraft such as the 10-man UH-1 would increase in weight by up to 200 pounds. An increase of this nature would reduce the payload-carrying capability by one man. Limitations of this sort may not be acceptable for existing aircraft, and the probability of retrofitting existing aircraft with energy-attenuating troop seats is small.

There is a considerable difference between the degree that existing and future helicopter structures and landing gear attenuate crash pulses. A negligible contribution is made by existing helicopter structure and landing gear. Newly designed helicopters will have landing gear designed to withstand high sink rates and structure which provides controlled deformation. With these features, a troop seat can be developed with less attenuation provisions than for an existing helicopter, assuming the same crash impact design velocity.

> Recommendation - Seats should not be developed for the attenuation capability of existing aircraft but for the attenuation capability of new helicopters such as the Utility Tactical Transport Aircraft System and Heavy Lift Helicopter (HLH). A reduced impact protection will have to be accepted for existing helicopters when using seats developed for the new helicopters.

5. The Prime Considerations in Crashworthy Troop Seat Design

It was the opinion of CDC Aviation Agency personnel interviewed that seats, soundproofing and interior trim are the first things thrown out of helicopters when they get to a combat zone. Few troop seats were seen in UH-1's in Vietnam.

The operational considerations should be paramount in the design of energy-attenuating troop seats even if some attenuation features have to be compromised. Complex restraint systems must be avoided. It is difficult to get troops to use existing lap belts, and they will be reluctant to use shoulder straps.

Simplicity and ease of seat disconnect, folding, and stowage are important considerations. If they must be removed for cargo, they may never find their way back into the aircraft again.

> Recommendation - Seats and restraint systems should be designed so as to be conducive to use. Restraint should be simple. Seats should be easy to disconnect and fold up. The seat weight should be as light as possible.

6. Seat and Cabin Dimensional Limitations

Minimum height from top of seat pan to ceiling and maximum height of troop seat pan were discussed, taking into consideration the increased seat height required for seat stroke and the effect that higher seats would have on head clearance in low-ceiling helicopters. Seat width and depth were also discussed.

Recommendation - Although present troop seat specifications use 15 inches for the floor to seat pan height, a height of 19 inches could be used if necessary. This would accommodate the leg height of a 5th percentile troop with a 1.5-inch boot heel height. The height from the top of the seat to the ceiling can be as little as 37.56 inches. This allows for a 95th percentile troop (38.06 in.) plus 1.5 inches for helmet and minus 2 inches for crouching. Using the crouched height with an 18-inch-high seat would make the minimum ceiling height 55.56 inches. Minimum seat width should be limited to 20 inches, with 21 or 22 inches being more desirable. Seat depth should be 20 to 23 inches to accommodate a man with a butt pack or medium rucksack without frame (14 inches minimum for man and 6 to 8 inches for pack).

7. Restraint System

The advantages and disadvantages of a one-hand-operated single-piece lap belt/shoulder strap system were discussed with Human Engineering Laboratory personnel. A single-piece lap belt/shoulder strap system allows troops with a weapon to make the connection while holding onto their weapon. A disadvantage is the difficulty in reaching the socket on the left side with the right hand while wearing bulky combat equipment. It would also be more difficult to connect by left-handed troops. Another disadvantage is that in an emergency, the tendency is to reach for the release in the center rather than the side. With the shoulder harness attached, it would form a loop which would snag on hand grenades and other articles hooked on the pistol belt during egress.

Recommendation - It was the laboratory personnel's opinion that a one-hand connection restraint system would present more problems than are being resolved. They recommended that a one-hand-connection system not be considered. Their concern was fastening the lap belt over soft equipment such as a gas mask which can cause submarining during crash impact. They recommended that the problem be investigated.

8. Dynamic Response Index (DRI) Effectiveness in Troop Seat Design

Aeromedical Laboratory personnel stated that the DRI was developed primarily for ejection seat vertical acceleration loads. It is effective only if the occupant is fully restrained and sitting erect and if the acceleration is parallel to the spine. It is not ideally suited for the crashworthy troop seat design, but for want of a better method, it is a reasonable tool to use to evaluate vertical attenuator selection. Consideration must be given to the effect of the moment arm of equipment hanging on the upper torso such as body armor, field pack, hand grenades and other equipment hung on the suspender straps. The moment arm of the ejection seat occupant's arms pulling on a face curtain during ejection can have a serious effect on DRI. Therefore, a troop's equipment can have a much more serious effect on DRI. Other programs are under development which will be more suited to crashworthy seat design. Work has been started at the Air Force Institute of Pathology to develop the "Predictive Index" which will take into account various attitudes of the body, impact attitudes and force vectors. Pathological data from actual accidents will be used to develop the program.

9. The Need for Shoulder Harness on Troop Seat

The evolution of restraint for pilots started with the lap belt. The need for a shoulder harness was realized as a result of fatalities in accidents where the pilot struck the instrument panel or was impaled by the stick or control column. A shoulder harness was added but was found to be causing additional problems in accidents by pulling the lap belt into the soft viscera, causing internal injury and also allowing the pilot to submarine under the lap belt and sustain spinal injury. A tie-down strap was added to alleviate this condition. Shoulder straps provided minimal lateral restraint, so bias straps were added over pulleys in a system, such as is used in the F-111 aircraft, to improve lateral restraint.

It was pointed out that human subjects have been tested with lap belts alone without injury for accelerations up to 26G at onset rates of 850G/sec for .02 second in a forward direction. This impulse would be greater than that experienced with energy attenuation provisions. The need of shoulder straps for troops was questioned, as they would provide minimal lateral restraint, would subject the troops to submarining by not having tiedown straps, and would not be needed to prevent the troops from striking objects such as instrument panels or control sticks in front of them. The principal advantage of shoulder straps is that they hold the occupant erect during vertical impact.

The need for some form of shoulder restraint was felt by USSARL personnel interviewed to be necessary. The problems and limitations of a simple shoulder harness were recognized and would be further compounded by the fact that if the field commands accepted a shoulder harness at all, it would probably be only a single diagonal strap. It was stated that a single strap is a "reasonable compromise", not that a single strap would be fully effective but that it would be a foot in the door for more effective restraint systems in the future. It was also stated that an insufficient shoulder restraint could be worse than none at all. High elongation of a shoulder strap, such as could occur if the strap were tied to the ceiling or soft-back troop seats, could permit the upper torso to accelerate and cause the head to snap forward as the strap bottomed out. This could result in severance of the brain stem, which controls breathing and heart beat. Incidents such as this have occurred at low accelerations. A case was described regarding a prize fighter who died as a result of brain stem severance just by falling backward on the ropes of the ring, which caught him at the neck and caused his head to snap back.

> Recommendation - The concern that the field commands have about introducing a complex restraint system for troops is understood. Care must be exercised in the selection of a restraint system that is simplified to insure a high probability of use, yet is not simplified to the point where the system will do more harm than good.

10. The Principal Design Objectives of a Restraint System for Troops

Objectives for existing aircraft and future aircraft may be different. As an example, the present objective for UH-1 restraint is to keep the men in the aircraft after impact. Although they may survive the first impact, troops may be thrown out on subsequent impacts and the aircraft may roll over on them. Disintegration of the aircraft on the subsequent impacts also contributes to throwing out troops. To meet the objective of keeping the troops tied to the aircraft, work is being initiated by the Army to change the lap belt attachment point from the seat to the more durable floor structure of the UH-1.

The restraint system including shoulder straps will be more important for the UTTAS than for existing aircraft due to the higher potential for survival because of the UTTAS roll-over capability and structural integrity criteria. The new objectives should be to keep the man on the seat and the seat in the aircraft. Also, the restraint system must be designed so as to be conducive to its use.

> Recommendation - Design the restraint system for non-energy-attenuating troop seats to keep the men tied to the aircraft even if the seat fails. The restraint system, to be conducive to use, must be designed to be easily reached, must not fall between seats, and must not become entangled with the restraint system of the adjacent seat.

11. Parts of the Human Body Most Critical to Injury for Various Restraint Conditions and Impact Directions

The spine is the most critical part of the human body to injury in vertical impacts. High thoracic failure occurs if the head is forward of the spine or the body is in a crouched position during vertical impact with Gs in the upper twenties or greater. Lower lumbar failure occurs first if the torso is erect during vertical impact. The next critical areas of the body are the aortic vessels which shear and internal organs which are damaged at accelerations above 30G vertical with onset rates of 350G/sec. No data is available on the effects on human tolerance to vertical acceleration that armor vests, field packs or other equipment suspended from the body have. Rigid armor vests have caused jaw injury in vertical impacts.

Injury resulting from longitudinal acceleration depends upon the type of restraint system used. Human subjects restrained by only a lap belt have been tested to 26G without injury. Accelerations of 30G have been tolerated while wearing only a lap belt; and when injuries result, they are usually minor and reversible. More serious injuries occur at some point above 30G, with thoracic spinal injury occurring first.

Occupants with restraint systems which have shoulder straps can withstand higher forward acceleration than with only a lap belt. However, if an improper shoulder restraint is used, the resulting injuries can be more serious than had a lap belt only been worn. Severance of the brain stem can result due to whiplash if a loose or elastic shoulder restraint is used. This area is not critical when only a lap belt is worn.

> Recommendation - To minimize injury from vertical acceleration, soft seat cushions should be avoided. It is best not to use a cushion. A thin cushion without memory is better than a thicker cushion or one that is elastic. "Bean bag" cushions using polystyrene beans are being investigated.
>
> Injury from longitudinal acceleration can be minimized in the following manner: if shoulder straps are used, they must be anchored to solid structure and be of low-elongation material; otherwise head whiplash and brain stem severance are possible. If just a lap belt is used, the jackknife envelope of the occupant must be free of rigid objects. Lap belts must be tied directly or indirectly to rigid aircraft structure and must hold if the seat fails. It is better to sit on the floor and maintain restraint integrity than to be thrown out.

12. Other Areas Which Should be Considered To Prevent Impact Injuries

Troops are subject to critical injury in impacts due to flying equipment. Loose equipment is usually carried by troops and is handheld. Weapons, radios, medical kits, etc., become lethal flying objects, especially in impacts involving forward velocity.

Recommendation - Consideration must be given in restraining loose equipment or in orienting parallel rows of seats such that the backs of seats form a barrier to the flying equipment.

QUESTIONNAIRE DATA

A questionnaire was prepared to determine troop seat operational usage practices, restraint system perference and maintenance factors. Eight questions were directed at opinion sampling with regard to these areas. Approximately 600 questionnaires were distributed to Army personnel with field experience by Boeing field service representatives, USACDC infantry agency and USAAMRDL. Approximately 300 completed questionnaires were returned to Boeing for correlation. These were separated into three classes of helicopters:

- Utility (Primarily UH-1)
- Medium Cargo (CH-46 and CH-47)
- Observation and Others

Those responding for each class of helicopters were also separated into three types:

- Pilots and Maintenance Officers
- Crew Chiefs and Flight Engineers
- Mechanics and Technical Inspectors

In general the questionnaire results showed that most questions were answered with the same trends, regardless of helicopter type or the classification of the person reporting. There were a few exceptions due to the configuration of the aircraft, type of seat being reported on, or specialty of the person reporting. Where discrepancies occurred, more weight was given to the person reporting in his specialty area. A detail tabulation of the questionnaire results, using the questionnaire format, follows, and a summary of the four general areas of the questionnaire (Operational Usage, Restraint System Usage, Maintenance, and Opinions) follows the tabulation.

SUMMARY OF TROOP SEAT QUESTIONNAIRE RESULTS BY CLASS OF AIRCRAFT AND PERSONNEL TYPES

THE BOEING COMPANY
VERTOL DIVISION

TROOP SEAT INVESTIGATION QUESTIONNAIRE
FOR ARMY CONTRACT DAAJ02-72-C-0077

EVALUATORS BACKGROUND DATA

NAME (OPTIONAL) ________________________________

LOCATION ________________________________

POSITION (CHECK ONE)

- 127 PILOT
- 18 MECHANIC
- 17 FLIGHT ENGINEER
- 31 OTHER ____________________
- 73 CREW CHIEF
- 34 MAINTENANCE OFFICER
- 30 TECH INSPECTOR

AVIATION EXPERIENCE

_____ YEARS _____ MONTHS

PRIMARY ☐ HELICOPTER ☐ FIXED WING

MODEL AIRCRAFT EXPERIENCE WITH

____

TOTAL RETURNS ALL AIRCRAFT

NEXT TWO SHEETS

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft. Check NO OPINION column if you have had no experience with question.

1. Aircraft on which answers based ________________ 2. Theater aircraft was used in ____________

3. Answers are based on following aircraft usage (insert % utilization in each box)

☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION

☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS

4. Were aircraft configured for specific mission ☐

Or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE

		NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1.	Are all seats normally folded down ready for use	32	68	65	77	50	8
2.	Are some seats folded up and some down - why	73	90	36	57	14	26
3.	Are seats unfolded by other than aircraft crew	178	76	7	12	9	13
4.	Are seats removed other than for maintenance - why	154	67	22	26	14	16
5.	Do troops sit on seats while wearing rucksacks	72	76	29	48	38	26
6.	Are rucksacks taken off and placed on floor	81	86	23	36	22	37
7.	Are seat backs adjusted for field packs or no field packs - who adjusts	156	30	8	6	11	63
8.	Are fragmentation protection vests worn with combat packs ("butt" packs)	88	60	22	39	19	69
9.	Do troops sit on floor with seats available - why	180	51	11	28	13	19
10.	Are orders given which seats to sit in or not to sit in - why - by whom	82	81	23	41	42	30
11.	Do troops sit on floor with all seats full	145	81	8	21	22	22
12.	Are seats used to lie on in flight	129	11	12	16	1	23
13.	Do troops slide along seats for ingress or egress	115	92	27	23	4	36
14.	Does personal equipment become snagged in seat appendages - where	67	116	26	39	4	41
15.	Are instructions given to troops on ingress and egress - by whom	36	56	35	68	64	35
16.	Is ingress or egress encumbered by seat spacing	124	76	26	20	9	43

TOTAL FOR ALL GROUPS

AND ALL AIRCRAFT

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	6	1	5	31	241	5	
2. Are shoulder straps made available for troops in the field	212	15	1	5	19	33	
3. Are seat belts used	5	26	27	64	166	6	TOTAL FOR ALL GROUPS
4. Are seat belts snugged up	7	34	24	77	117	8	
5. Are orders given to use seat belts - by whom	13	24	14	51	171	14	AND ALL AIRCRAFT
6. Are instructions given in use of seat belts - by whom	26	61	22	55	98	22	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	37	64	35	73	39	42	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	34	54	29	61	55	58	
9. Are seat belts readily accessible for fastening	11	37	43	66	119	8	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	50	135	37	26	8	31	
2. Does seat structure require repair	45	153	34	23	7	26	
3. Do seat belts require replacement	42	151	27	11	22	25	
4. Do seat quick disconnect fittings require replacement	82	134	12	7	6	38	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity Yes (115) No (154)
   Percentage of time needed 50% Less (68) - 50% More (62)
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment Yes (165) No (102) for release Yes (152) No (94)
3. Do you foresee any problems with the use of shoulder harness restraint system by troops Yes (202) No (80)
   What ______
4. Do you think shoulder harness for troops is necessary Yes (45) No (158) desirable Yes (107) No (48) practical Yes (37) No (79)
   Why ______
5. What are your personal complaints about troop seats ______
6. What are your personal complaints about troop restraint systems ______
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known Assult Pack (45) Ruck Sack (65)

(Weight)

30 lb	40 lb	50 lb	Over	Armored Vest
(9)	(11)	(26)	(77)	(18)

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft. Check NO OPINION column if you have had no experience with question.

1. Aircraft on which answers based ________________ 2. Theater aircraft was used in ________________
3. Answers are based on following aircraft usage (insert % utilization in each box)
☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION
☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS
4. Were aircraft configured for specific mission ☐
Or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE

	QUESTIONS ON TROOP SEAT USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1.	Are all seats normally folded down ready for use	6	8	13	25	15	3
2.	Are some seats folded up and some down - why	26	22	10	6		6
3.	Are seats unfolded by other than aircraft crew	37	18	1	4	4	8
4.	Are seats removed other than for maintenance - why	17	23	10	9	4	8
5.	Do troops sit on seats while wearing rucksacks	17	22	5	11	6	10
6.	Are rucksacks taken off and placed on floor	11	24	4	12	5	14
7.	Are seat backs adjusted for field packs or no field packs - who adjusts	41	8	3		1	16
8.	Are fragmentation protection vests worn with combat packs ("butt" packs)	22	11	6	8	3	21
9.	Do troops sit on floor with seats available - why	34	18	4	7	4	6
10.	Are orders given which seats to sit in or not to sit in - why - by whom	14	20	9	9	4	13
11.	Do troops sit on floor with all seats full	29	20	3	5	1	10
12.	Are seats used to lie on in flight	38	13	1	2		13
13.	Do troops slide along seats for ingress or egress	19	22	6	6	2	12
14.	Does personal equipment become snagged in seat appendages - where	10	27	8	9	1	13
15.	Are instructions given to troops on ingress and egress - by whom	7	16	7	13	8	17
16.	Is ingress or egress encumbered by seat spacing	13	25	11	3	3	15

GROUP 1

UH-1
UTILITY HELICOPTER
PILOTS AND MAINTENANCE OFFICERS

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	2		3	5	55	2	
2. Are shoulder straps made available for troops in the field	51	2		1	2	10	GROUP 1
3. Are seat belts used	2		5	15	41	4	
4. Are seat belts snugged up	3	4	7	17	31	5	
5. Are orders given to use seat belts - by whom	3	4	1	13	39	6	UH-1 UTILITY HELICOPTERS PILOTS AND MAINTENANCE OFFICERS
6. Are instructions given in use of seat belts - by whom	6	8	3	16	21	9	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	3	16	9	12	13	13	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	6	9	7	19	10	16	
9. Are seat belts readily accessible for fastening	2	12	13	12	21	4	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	7	36	7	2	3	10	
2. Does seat structure require repair	13	34	5	2	3	9	
3. Do seat belts require replacement	9	33	5	3	6	9	
4. Do seat quick disconnect fittings require replacement	14	33	3	2	2	11	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity ____________
   Percentage of time needed ____________
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment ____________ for release ________
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ________
   What ____
4. Do you think shoulder harness for troops is necessary ______ desirable ______ practical ______
   Why ____
5. What are your personal complaints about troop seats ________________________
6. What are your personal complaints about troop restraint systems ________________________
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ____

____

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft. Check NO OPINION column if you have had no experience with question.

1. Aircraft on which answers based ________________ 2. Theater aircraft was used in ________________

3. Answers are based on following aircraft usage (insert % utilization in each box)

☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION

☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS

4. Were aircraft configured for specific mission ☐

Or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE

	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1. Are all seats normally folded down ready for use	1	7	5	5	4	-
2. Are some seats folded up and some down - why	6	5	4	3	2	1
3. Are seats unfolded by other than aircraft crew	10	7	2	3		-
4. Are seats removed other than for maintenance - why	6	6	4	5	1	-
5. Do troops sit on seats while wearing rucksacks	8	8	2	1	1	2
6. Are rucksacks taken off and placed on floor	10	5	1	2		4
7. Are seat backs adjusted for field packs or no field packs - who adjusts	17	1	-	1	-	3
8. Are fragmentation protection vests worn with combat packs ("butt" packs)	10	6	-	1	1	4
9. Do troops sit on floor with seats available - why	9	2	1	7	2	1
10. Are orders given which seats to sit in or not to sit in - why - by whom	8	5	1	3	6	-
11. Do troops sit on floor with all seats full	10	6	1	1	3	2
12. Are seats used to lie on in flight	15	7	-	1	-	-
13. Do troops slide along seats for ingress or egress	8	7	-	6	-	1
14. Does personal equipment become snagged in seat appendages - where	8	7	3	4	-	-
15. Are instructions given to troops on ingress and egress - by whom	7	4	4	5	2	-
16. Is ingress or egress encumbered by seat spacing	13	3	2	2	1	1

GROUP 2

UH-1
UTILITY HELICOPTERS
CREW CHIFFS AND FLIGHT
ENGINEERS

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	1	-	1	3	17	-	
2. Are shoulder straps made available for troops in the field	18	1	-	-	-	3	GROUP 2
3. Are seat belts used	-	4	2	2	13	1	
4. Are seat belts snugged up	-	4	2	1	15	-	
5. Are orders given to use seat belts - by whom	1	1	-	1	16	3	UH-1 UTILITY HELICOPTERS CREW CHIEFS AND FLIGHT ENGINEERS
6. Are instructions given in use of seat belts - by whom	1	7	-	4	8	2	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	5	2	5	6	3	1	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	4	1	2	3	9	3	
9. Are seat belts readily accessible for fastening	3	1	3	3	12	-	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	7	13	1	1	-	-	
2. Does seat structure require repair	5	14	3	-	-	-	
3. Do seat belts require replacement	6	10	3	1	2	-	
4. Do seat quick disconnect fittings require replacement	10	6	2	1	1	1	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity ____________
   Percentage of time needed ____________
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment ____________ for release ________
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ________
   What ____
4. Do you think shoulder harness for troops is necessary ______ desirable ______ practical ______
   Why ____
5. What are your personal complaints about troop seats ________________________________
6. What are your personal complaints about troop restraint systems ________________________
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ____

____

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft. Check NO OPINION column if you have had no experience with question.

1. Aircraft on which answers based ______________ 2. Theater aircraft was used in ______________

3. Answers are based on following aircraft usage (insert % utilization in each box)

☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION
☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS

4. Were aircraft configured for specific mission ☐
Or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE	NEVER OR 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1. Are all seats normally folded down ready for use	4	5	5	6	5	-
2. Are some seats folded up and some down - why	10	3	1	6	1	5
3. Are seats unfolded by other than aircraft crew	11	8	1	2	1	1
4. Are seats removed other than for maintenance - why	9	7	1	7	-	2
5. Do troops sit on seats while wearing rucksacks	13	4	-	5	-	4
6. Are rucksacks taken off and placed on floor	4	7	1	5	4	4
7. Are seat backs adjusted for field packs or no field packs - who adjusts	15	1	-	3	-	5
8. Are fragmentation protection vests worn with combat packs ("butt" packs)	4	4	2	6	3	5
9. Do troops sit on floor with seats available - why	9	4	2	3	3	4
10. Are orders given which seats to sit in or not to sit in - why - by whom	6	5	1	6	2	5
11. Do troops sit on floor with all seats full	9	5	1	5	3	3
12. Are seats used to lie on in flight	11	7	-	4	-	2
13. Do troops slide along seats for ingress or egress	8	10	2	3	-	3
14. Does personal equipment become snagged in seat appendages - where	6	10	2	4	-	3
15. Are instructions given to troops on ingress and egress - by whom	1	5	1	4	12	2
16. Is ingress or egress encumbered by seat spacing	9	5	2	3	-	5

GROUP 3

UH-1
UTILITY HELICOPTERS
MECHANICS AND TECH INSPECTORS

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	-	1	-	4	18	1	
2. Are shoulder straps made available for troops in the field	12	5	-	3	2	3	GROUP 3
3. Are seat belts used	1	2	3	7	11	-	
4. Are seat belts snugged up	-	3	3	7	9	-	
5. Are orders given to use seat belts - by whom	1	3	3	5	11	1	UH-1 UTILITY HELICOPTERS MECHANICS AND TECH INSPECTOR
6. Are instructions given in use of seat belts - by whom	4	5	3	6	4	2	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	7	4	2	5	1	4	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	5	1	4	5	5	5	
9. Are seat belts readily accessible for fastening	-	1	5	7	9	1	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	5	10	2	4	1	3	
2. Does seat structure require repair	4	9	4	3	1	4	
3. Do seat belts require replacement	2	10	1	2	4	3	
4. Do seat quick disconnect fittings require replacement	6	10	1	2	-	4	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity ____________
   Percentage of time needed ____________
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment ____________ for release ________
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ________
   What ____
4. Do you think shoulder harness for troops is necessary ______ desirable ______ practical ______
   Why ____
5. What are your personal complaints about troop seats ____
6. What are your personal complaints about troop restraint systems ____
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ____

____

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	1	-	-	11	69	-	
2. Are shoulder straps made available for troops in the field	72	3	-	1	2	4	GROUP 4
3. Are seat belts used	-	14	10	19	32	-	
4. Are seat belts snugged up	-	16	18	29	16	2	CH-46 AND CH-47
5. Are orders given to use seat belts - by whom	2	11	7	19	41	1	MEDIUM LIFT HELICOPTERS PILOTS AND MAINTENANCE
6. Are instructions given in use of seat belts - by whom	6	27	10	17	17	4	OFFICERS
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	7	21	8	24	14	9	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	7	20	7	16	15	16	
9. Are seat belts readily accessible for fastening	1	11	11	28	29	-	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	13	39	12	7	1	9	
2. Does seat structure require repair	6	50	11	5	-	8	
3. Do seat belts require replacement	11	51	8	1	2	7	
4. Do seat quick disconnect fittings require replacement	19	44	3	1	-	13	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity __________
   Percentage of time needed __________
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment __________ for release ________
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ________
   What ____
4. Do you think shoulder harness for troops is necessary ______ desirable ______ practical ______
   Why ____
5. What are your personal complaints about troop seats ______________________________
6. What are your personal complaints about troop restraint systems ________________________
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ____

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft.
Check **NO OPINION** column if you have had no experience with question.

1. Aircraft on which answers based ______________ 2. Theater aircraft was used in __________
3. Answers are based on following aircraft usage (insert % utilization in each box)
☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION
☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS
4. Were aircraft configured for specific mission ☐
Or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1. Are all seats normally folded down ready for use	5	14	19	11	9	-
2. Are some seats folded up and some down - why	9	20	6	11	3	6
3. Are seats unfolded by other than aircraft crew	30	21	3	2	1	1
4. Are seats removed other than for maintenance - why	40	9	3	1	4	1
5. Do troops sit on seats while wearing rucksacks	8	11	6	12	3	2
6. Are rucksacks taken off and placed on floor	26	15	3	3	1	4
7. Are seat backs adjusted for field packs or no field packs - who adjusts	20	5	4	1	5	12
8. Are fragmentation protection vests worn with combat packs ("butt" packs)	19	13	4	9	2	10
9. Do troops sit on floor with seats available - why	39	13	1	2	1	4
10. Are orders given which seats to sit in or not to sit in - why - by whom	16	14	3	8	15	2
11. Do troops sit on floor with all seats full	33	15	1	4	5	1
12. Are seats used to lie on in flight	21	25	5	4	-	3
13. Do troops slide along seats for ingress or egress	21	20	5	4	-	5
14. Does personal equipment become snagged in seat appendages - where	10	23	5	13	2	4
15. Are instructions given to troops on ingress and egress - by whom	8	12	2	12	21	3
16. Is ingress or egress encumbered by seat spacing	21	16	5	6	4	6

GROUP 5

CH-46 AND CH-47
MEDIUM LIFT HELICOPTERS
CREW CHIEFS AND FLIGHT
ENGINEERS

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	1	-	1	6	47	1	
2. Are shoulder straps made available for troops in the field	39	3	1	-	1	7	GROUP 5
3. Are seat belts used	2	4	5	16	30	-	
4. Are seat belts snugged up	3	6	6	15	25	1	CH-46 AND CH-47 MEDIUM LIFT HELICOPTERS CREW CHIEFS AND FLIGHT ENGINEERS
5. Are orders given to use seat belts - by whom	4	2	1	9	39	1	
6. Are instructions given in use of seat belts - by whom	6	6	4	6	31	2	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	8	11	8	17	6	6	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	6	13	7	11	13	6	
9. Are seat belts readily accessible for fastening	3	7	7	12	25	2	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	10	19	11	11	1	3	
2. Does seat structure require repair	7	24	10	12	2	1	
3. Do seat belts require replacement	7	34	4	2	4	2	
4. Do seat quick disconnect fittings require replacement	18	29	1	1	2	3	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity __________ Percentage of time needed __________
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment __________ for release ________
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ________ What ____________________
4. Do you think shoulder harness for troops is necessary ______ desirable ______ practical ______ Why ____________________
5. What are your personal complaints about troop seats ____________________
6. What are your personal complaints about troop restraint systems ____________________
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ____________________

(SEE FIRST SHEET FOR OPINION TOTALS)

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft. Check **NO OPINION** column if you have had no experience with question.

1. Aircraft on which answers based ________________ 2. Theater aircraft was used in ________________

3. Answers are based on following aircraft usage (insert % utilization in each box)

☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION

☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS

4. Were aircraft configured for specific mission ☐ or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1. Are all seats normally folded down ready for use	-	4	5	4	2	-
2. Are some seats folded up and some down - why	1	4	4	5	1	-
3. Are seats unfolded by other than aircraft crew	12	2	-	-	1	-
4. Are seats removed other than for maintenance - why	13	1	-	-	-	-
5. Do troops sit on seats while wearing rucksacks	2	3	2	3	3	2
6. Are rucksacks taken off and placed on floor	3	5	1	3	-	2
7. Are seat backs adjusted for field packs or no field packs - who adjusts	5	1	-	-	2	6
8. Are fragmentation protection vests worn with combat packs ("butt" packs)	4	2	-	2	2	4
9. Do troops sit on floor with seats available - why	12	3	-	-	-	-
10. Are orders given which seats to sit in or not to sit in - why - by whom	2	3	-	2	5	2
11. Do troops sit on floor with all seats full	7	2	1	1	1	3
12. Are seats used to lie on in flight	5	5	1	1	1	2
13. Do troops slide along seats for ingress or egress	8	3	-	1	-	3
14. Does personal equipment become snagged in seat appendages - where	3	6	1	2	1	2
15. Are instructions given to troops on ingress and egress - by whom	-	2	2	4	5	2
16. Is ingress or egress encumbered by seat spacing	8	1	1	2	-	3

GROUP 6

CH-46 AND CH-47
MEDIUM LIFT HELICOPTERS
<u>MECHANICS AND</u> TECH INSPECTORS

THE BOEING COMPANY, VERTOL DIVISION
TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	-	-	-	1	14	-	GROUP 6 CH-46 AND CH-47 MEDIUM LIFT HELICOPTERS MECHANICS AND TECH INSPECTORS
2. Are shoulder straps made available for troops in the field	12	-	-	-	-	3	
3. Are seat belts used	-	2	2	4	7	-	
4. Are seat belts snugged up	1	1	3	6	3	1	
5. Are orders given to use seat belts - by whom	-	2	2	2	9	-	
6. Are instructions given in use of seat belts - by whom	2	4	1	3	4	1	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	4	4	1	4	2	1	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	4	2	2	2	3	2	
9. Are seat belts readily accessible for fastening	1	2	2	1	9	-	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	3	8	2	-	2	-	
2. Does seat structure require repair	2	10	1	-	1	-	
3. Do seat belts require replacement	3	4	4	-	1	-	
4. Do seat quick disconnect fittings require replacement	5	6	2	-	-	-	

OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity __________
   Percentage of time needed __________
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment __________ for release ________
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ________
   What ______________________________
4. Do you think shoulder harness for troops is necessary _____ desirable _____ practical _____
   Why ______________________________
5. What are your personal complaints about troop seats ______________________________
6. What are your personal complaints about troop restraint systems ______________________________
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ______________________________

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE

Answer questions for a specific aircraft. Use additional forms for other aircraft. Check NO OPINION column if you have had no experience with question.

1. Aircraft on which answers based ______________ 2. Theater aircraft was used in ______________
3. Answers are based on following aircraft usage (insert % utilization in each box)
   ☐ TROOP ASSAULT ☐ MED EVAC ☐ TROOP ADMINISTRATION
   ☐ TROOP RESUPPLY ☐ ALL CARGO ☐ MIXED CARGO/TROOPS
4. Were aircraft configured for specific mission ☐
   Or were they changed to perform new missions ☐

QUESTIONS ON TROOP SEAT USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION
1. Are all seats normally folded down ready for use	8	3		2	10	4
2. Are some seats folded up and some down - why	15	2	1		2	5
3. Are seats unfolded by other than aircraft crew	20	1			2	2
4. Are seats removed other than for maintenance - why	9	9	2		3	3
5. Do troops sit on seats while wearing rucksacks	11	10		1	2	2
6. Are rucksacks taken off and placed on floor	7	8	1	2	6	4
7. Are seat backs adjusted for field packs or no field packs - who adjusts	17	3				6
8. Are fragmentation protection vests worn with combat packs ("butt" packs)	12	6	1		2	5
9. Do troops sit on floor with seats available - why	19			4	1	2
10. Are orders given which seats to sit in or not to sit in - why - by whom	12	6	2	1		4
11. Do troops sit on floor with all seats full	21	4				1
12. Are seats used to lie on in flight	18	3	1			1
13. Do troops slide along seats for ingress or egress	15	3	1	1		4
14. Does personal equipment become snagged in seat appendages - where	15	5				4
15. Are instructions given to troops on ingress and egress - by whom	7	4	2	1	4	6
16. Is ingress or egress encumbered by seat spacing	16	1			1	6

GROUP 7

OTHER HELICOPTERS

PILOTS AND MAINTENANCE OFFICERS

CREW CHIEFS AND FLIGHT ENGINEERS

MECHANICS AND TECH INSPECTORS

THE BOEING COMPANY, VERTOL DIVISION

TROOP SEAT QUESTIONNAIRE (CONT'D)

QUESTIONS ON RESTRAINT SYSTEM USAGE	NEVER OR NO 0%	OCCASIONALLY 25%	AVERAGE 50%	FREQUENTLY 75%	ALWAYS 100%	NO OPINION	COMMENTS
1. Are seat belts available for all troop seats	1			1	21	1	GROUP 7 OTHER HELICOPTERS PILOTS AND MAINTENANCE OFFICERS CREW CHIEFS AND FLIGHT ENGINEERS MECHANICS AND TECH INSPECTORS
2. Are shoulder straps made available for troops in the field	8	1			12	3	
3. Are seat belts used				1	22	1	
4. Are seat belts snugged up			3	2	18	1	
5. Are orders given to use seat belts - by whom	2	1		2	16	2	
6. Are instructions given in use of seat belts - by whom	1	4	1	3	13	2	
7. Is difficulty experienced in holding weapon or other equipment while fastening seat belt	3	6	2	5		8	
8. Are seat belts difficult to connect while wearing combat equipment - what type equipment	2	8		5		10	
9. Are seat belts readily accessible for fastening	1	3	2	3	14	1	
QUESTIONS ON MAINTENANCE							
1. Does seat fabric require repair	5	10	2	1		6	
2. Does seat structure require repair	8	12		1		4	
3. Do seat belts require replacement	4	9	2	2	3	4	
4. Do seat quick disconnect fittings require replacement	10	6			1	6	

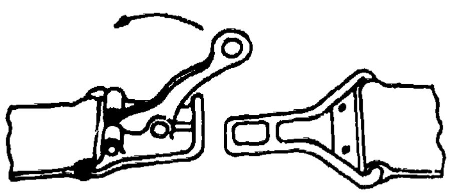
OPINIONS

1. Do you feel that providing for a one-hand hookup of seat belt is a necessity ______
   Percentage of time needed ______
2. Do you feel that a one-hand operation seat belt buckle located toward the side would be more difficult to reach than center buckle, for attachment ______ for release ______
3. Do you foresee any problems with the use of shoulder harness restraint system by troops ______
   What ______
4. Do you think shoulder harness for troops is necessary ______ desirable ______ practical ______
   Why ______
5. What are your personal complaints about troop seats ______
6. What are your personal complaints about troop restraint systems ______
7. What equipment is carried on person, and type of pack used, on combat assault operations - total weight if known ______

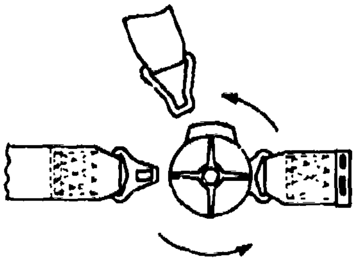
See Tables 1 and 2 for results pertaining to this sheet.

OPINIONS (continued)

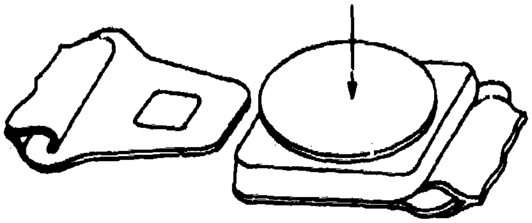
8. SHOW PREFERENCE ORDER OF SEAT BELT LATCH BY PLACING NUMBERS IN BLOCKS (1 THROUGH 6)



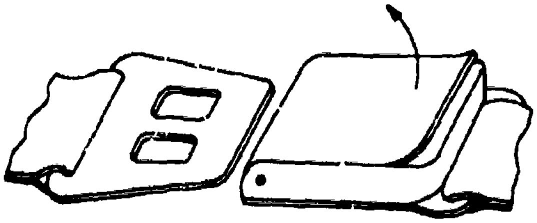
TOGGLE



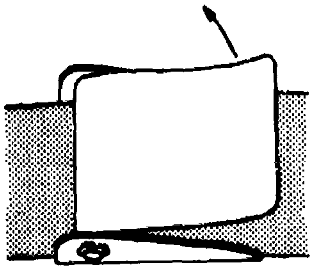
ROTARY



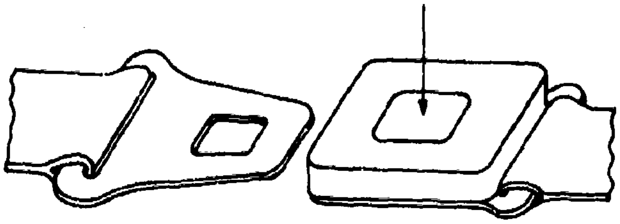
PRESSURE PLATE



METAL-TO-METAL CAM



METAL-TO-WEBBING CAM



PUSH BUTTON

☐ **METAL TO WEBBING CAM**

☐ **PUSH BUTTON**

☐ **OTHER** ______________________________

LIST REQUIREMENTS A SEAT BELT LATCH SHOULD HAVE ________________________

Operational Usage

The questions on operational usage and the general responses to them are as follows:

1, 2, and 3 (seat folding)

Seats are nearly always folded by aircraft crew, and no definite pattern was evident in whether seats were left up or down.

4 (seat removal other than for maintenance)

Troop seats, in the UH-1, were removed during combat operations almost half of the time; while on the medium cargo and other helicopters, they were rarely removed.

5, 6, and 7 (field packs)

Rucksacks were almost never worn while troops were sitting in the UH-1 seats. Rucksacks were put on the floor a high percentage of the time. Seat backs were not adjusted in the UH-1 probably due to the small adjustment available.

A higher percentage of troops were reported as wearing rucksacks on the medium cargo helicopter seats; however, most of these reports were on marine CH-46's, and marines do not have rucksacks but reported their lighter combat field packs as rucksacks. Regardless of the type of field pack, a high percentage reported that the packs were taken off and placed on the floor. The CH-46 does not have seat backs; therefore, there is no adjustment.

8 (wearing of fragmentation vests)

Wearing of fragmentation vests was reported as "almost never" by pilots, crew chiefs, and flight engineers for all aircraft. The exceptions were the mechanics and the CH-46 marine pilots, who reported a higher percentage of fragmentation vest users.

9 (sitting on floor with seats available)

Troops sit on the floor a high percentage of the time when seats are available in the UH-1 helicopters but rarely in medium cargo and other helicopters.

10 (directing which seat to sit in)

A very high percentage reported that direction is given as to which seat to sit in.

11 (sitting on floor with all seats full)

Troops "occasionally" sit on the floor when all seats are full in all aircraft.

12 (lying on seats in flight)

Lying on seats in flight is rare in the UH-1 but occurs "occasionally" in the medium cargo helicopters.

13 and 14 (sliding along seats and snagging equipment)

Sliding along seats and snagging equipment on seats occur "occasionally" to "never" in all aircraft.

15 and 16 (ingress and egress)

Instructions on ingress and egress are given on an "average", and encumbrances are not considered a problem.

Restraint System Usage

The questions on restraint system usage and the general responses to them are as follows:

1 and 2 (availability of lap belts and shoulder harnesses)

Questions on the availability of lap belts and shoulder harnesses for troop seats were answered "almost always", for the lap belt and "never" for the shoulder straps, with the exception of the observation helicopters which have shoulder straps.

3, 4, 5, and 6 (seat belt use)

Questions regarding seat belt use, tightening, orders for use, and instructions in use received "almost always" as the reply for all helicopters.

7 and 8 (seat belt fastening while holding a weapon)

Replies to questions on the difficulty in fastening a seat belt while holding a weapon or wearing combat equipment were an even distribution of answers from "never" to "always" for all aircraft and all types of personnel responding.

9 (accessibility of seat belts)

Seat belts are "almost always" accessible for fastening.

Maintenance

The four questions on maintenance pertained to the need for repair or replacement of fabric, structure, seat belts, and quick-disconnect fittings. The responses indicated that each of the four areas required "occasional" repair or replacement for all helicopter types.

Opinions

Eight questions were asked with a request for opinions. The questions and general responses to them are as follows:

1 (the provision for one-hand restraint system hookup)

More were opposed to one-hand hookup (154) than were for it (115), and opinion on the frequency of need was about "50 percent" of the time.

2 (side or center buckle more difficult to operate)

A lap belt buckle located toward the side was felt to be more difficult to fasten - (165) to (102) - and more difficult to release - (152) to (94).

3 (problems foreseen for troops using shoulder harnesses)

The number who foresaw problems in providing shoulder harness restraint for troops was substantial: (202) to (80).

4 (necessity of shoulder harness for troops)

An overwhelming number - (158) to (45) - felt that shoulder harnesses for troops were unnecessary, although 107 out of 155 thought they were desirable. As for being practical, 79 reported "no" and 37 "yes".

5 (complaints about troop seats)

The chief complaint about troop seats was that they were uncomfortable and flimsy.

6 (complaints about restraint systems)

Relatively few commented on the restraint question; those who did, complained of getting the strap from an adjacent seat mixed up with theirs.

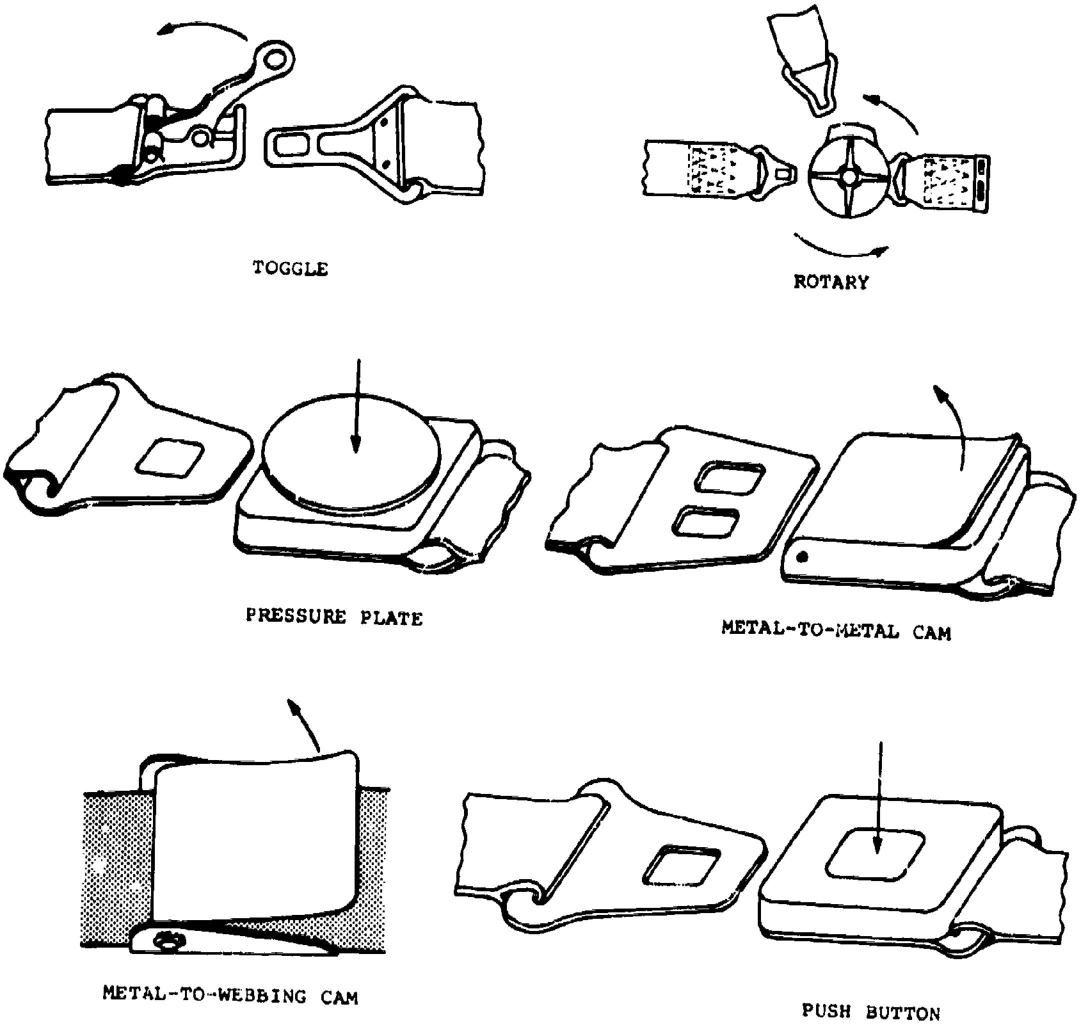
7 (troop equipment carried and type of pack used)

Meaningful data was not obtained for the question on type of equipment and pack used on combat assault operations due to the lack of standard nomenclature for field packs, the lack of complete equipment reported, and the few who responded to the question.

8 (preference for seat belt latches)

The voting preference of six seat belt latches shown in Figure 1 is tabulated in Table 1. A weighted analysis was performed on the numbers to take into account the value that votes in a lower order had on a higher order selection. For example, the number of votes a particular latch had for second choice was weighted to influence the first choice. Ranking was done by weighted latin squares, the weight mean being 3.5, weight $\alpha^2 = 1$. The order of preference was as follows (see Table 2):

a. Metal-to-metal cam
b. Toggle
c. Push button
d. Pressure plate
e. Metal-to-webbing cam
f. Rotary



TOGGLE

ROTARY

PRESSURE PLATE

METAL-TO-METAL CAM

METAL-TO-WEBBING CAM

PUSH BUTTON

Figure 1. Types of Seat Belt Latches Reviewed.

Total votes in preference order were as follows:

TABLE 1. SEAT BELT LATCH OPINIONS

Place	Toggle	Rotary	Pressure Plate	Metal-to-Metal Cam	Metal-to-Web Cam	Push Button	Other or Non-vote
1st	107	8	52	65	15	39	8
2nd	38	8	24	96	24	60	44
3rd	32	22	34	53	39	58	56
4th	41	39	53	26	37	52	46
5th	32	60	48	11	57	37	49
6th	15	104	37	1	70	9	58

TABLE 2. SEAT BELT LATCH OPINIONS WEIGHTED FOR ALTERNATE CHOICES

Place	Toggle	Rotary	Pres-sure Plate	Metal-to-Metal Cam	Metal-to-Web Cam	Push Button	Other or Non-Vote
-3 1st	107 (-321)	8 (-24)	52 (-156)	65 (-195)	15 (-45)	39 (-117)	8 (-24)
-3 2nd	38 (- 76)	8 (-16)	24 (-48)	96 (-192)	24 (-48)	60 (-120)	44 (-88)
-1 3rd	32 (-)	22 (-)	34 (-)	53 (-)	39 (-)	58 (-)	56 (-)
+1 4th	41 (+)	39 (+)	53 (+)	26 (+)	37 (+)	52 (+)	46 (+)
+2 5th	32 (64)	60 (120)	48 (96)	11 (22)	57 (114)	37 (74)	49 (98)
+3 6th	15 (45)	104 (312)	37 (111)	1 (3)	70 (210)	9 (27)	58 (174)
Total	-279	+409	+12	-389	+229	-142	+150
Ranking	2	7	4	1	6	3	5

EVALUATION AND ANALYSIS OF CRASH FORCE ATTENUATION TECHNIQUES AND DEVICES

EVALUATION

The following factors were considered in the evaluation:

- Adaptability to troop seat configurations
- Weight
- Compactness
- Stroke for given length
- Environmental tolerance
- Dynamic Response Index (DRI) for a given length of seat stroke

Energy attenuators adaptable to troop seat configurations were found to fall within two basic groups: tension type and compression type.

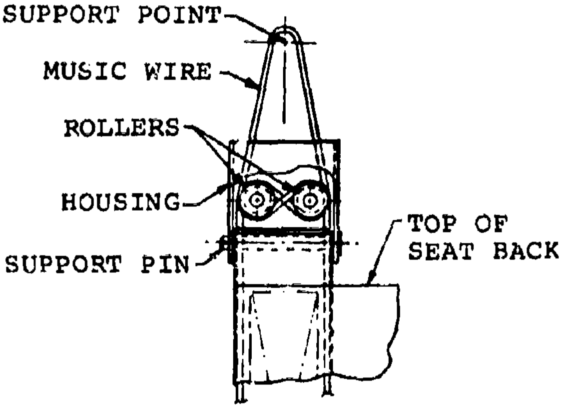
Tension Energy Attenuators

Tension types consist of those that use flexible or high elongation materials as the stroking member. Wire, strap, or cable is used as flexible material; and annealed tubes, rod, or wire is used as high-elongation material. Typical examples of these attenuators are shown in Figure 2. They are well adapted for suspending troop seats from ceiling structure.

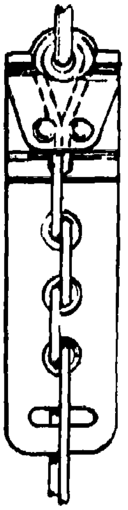
The advantages of the tension type energy attenuators is that they are usually lightest in weight. Flexible material types which employ bending rather than tensile yielding are compact and provide the maximum stroke for a minimum length. The stroke of units a, b, and c in Figure 2 is limited only by the length of wire used, whereas the stroke of unit d is limited by the pully diameter. These units more easily meet the environmental requirements than the compression type energy attenuators. The wire bending type attenuators have been tested using heavily corroded wire and rollers and were found to function just as effectively as new units or those with corrosion prevention treatment.

The disadvantage of the tension type attenuators is that they do not have the ability to prevent rebound.

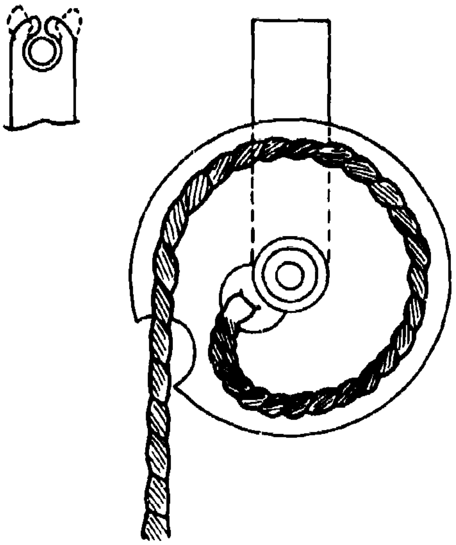
a. SERIES ROLLERS WIRE BENDING ENERGY ATTENUATOR



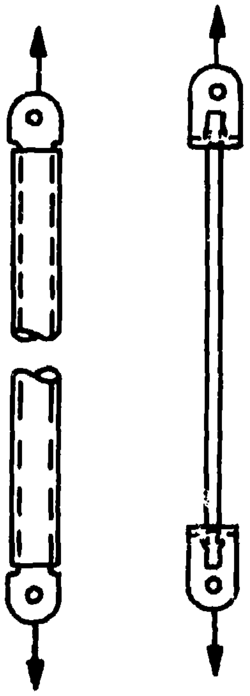
b. SERIES PARALLEL ROLLER COMPACT WIRE BENDING ENERGY ATTENUATOR



c. PLATE-SERIES HOLES WIRE BENDING ENERGY ATTENUATOR



d. CABLE/PULLEY FLANGE BENDING ENERGY ATTENUATOR



e. TENSILE YIELDING TUBE AND WIRE ENERGY ATTENUATORS

Compression Energy Attenuators

The compressive type energy attenuators most adaptable to troop seat designs are generally constructed of tubular material. Some of these attenuators have the capability of being used as tension or compression attenuators. Typical examples of these attenuators are shown in Figure 3. Unit a, the torus wire type, consists of telescoping tubes with wire wrapped between the tubes. This unit is capable of stroking in tension or compression and is inherently capable of preventing rebound.

The disadvantage of this unit is that it is capable only of approximately a 4.5-inch stroke for a 12-inch initial length.

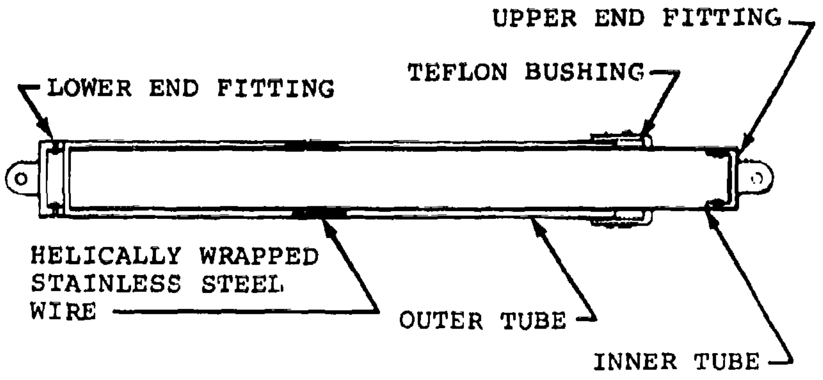
Unit b, the inverted tube, consists of a single tube with a larger diameter on one end then on the other. At the center, the tube reverses direction twice in the transition from the larger to the smaller diameter. This type of attenuator is also inherently capable of preventing rebound and can be used for tensile or compressive stroking. The inverting tube has a higher stroke capability than the torus wire type but only approximately 6.8 inches for a 12-inch-long unit.

Unit c, the curl tube, consists of a plain tube with a number of notches in the end depending upon the number of curls desired. The tube is fitted over a flaring die which causes the end of the tube to curl as a load is applied to the tube. This unit is capable of compression stroking only, and a gripper device must be added to prevent rebound. The principal advantage of the curl tube energy attenuator is its long stroke capability. An initial 12-inch-length tube is capable of stroking up to 10 inches.

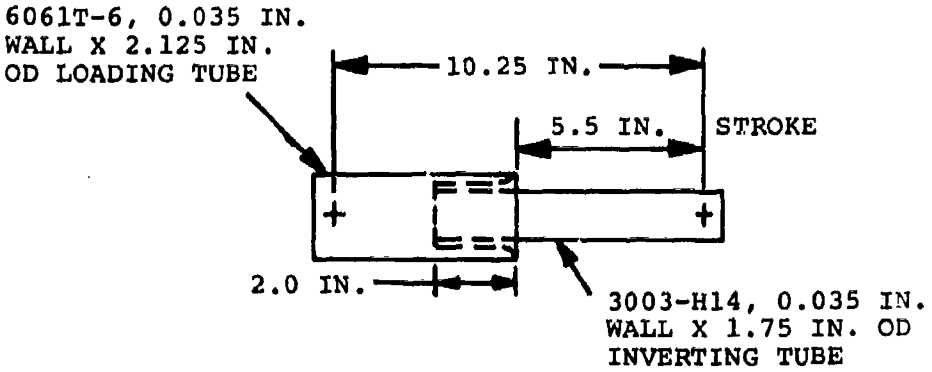
The compression type attenuators are heavier and less compact than the tension-alone type. They are more adaptable to troop seats which are floor mounted and require compression attenuators. Meeting the environmental requirements is more difficult due to the close fit of sliding tubes. Corrosion must be prevented on the inside of the tubes and especially on the small-diameter torus wires. Foreign particle deposits must be prevented in telescoping types; otherwise, their effectiveness would be degraded.

ANALYSIS

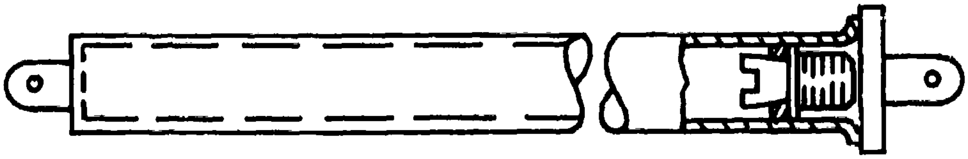
Review of mathematical simulation techniques available to evaluate injury potential led to the conclusion that those techniques based on the Air Force developed Dynamic Response Index (DRI) would be the most applicable.



a. TELESCOPING TUBE ROLLING TORUS ENERGY ATTENUATOR



b. INVERTING TUBE ENERGY ATTENUATOR

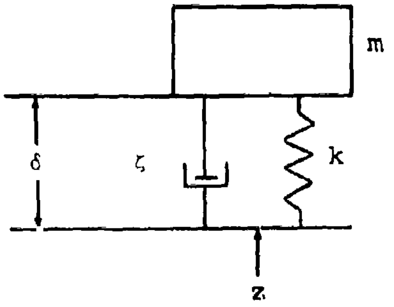


c. TUBE AND DIE CURLING TUBE ENERGY ATTENUATOR

Figure 3. Compression Type Energy Attenuators.

Dynamic Response Index (DRI)

The human response to short-duration accelerations applied in the upward vertical direction parallel to the spine ($+G_Z$) has been modeled by a single lumped-mass, damped-spring system as follows:[12]



m = mass ($\mathrm{lb\text{-}sec^2/in.}$)
δ = deflection (in.)
ζ = damping ratio
k = stiffness (lb/in.)
z = acceleration input ($\mathrm{in./sec^2}$)

$$\mathrm{DRI} = \omega^2 \frac{n\ \delta_{max}}{g}$$

ω_n = natural frequency of the analog = $\sqrt{k/m}$
g = 386 $\mathrm{in./sec^2}$

In this model it has been assumed that the total body mass that acts upon the vertebrae to cause deformation is represented by the single mass. In use, the relationship

$$\frac{d^2\delta}{dt^2} + 2\ \zeta\omega_n \frac{d\delta}{dt} + \omega_n{}^2\delta = z$$

is solved through the use of a computer. The third term is representative of the deformation of the spine and when divided by g is referred to as the Dynamic Response Index (DRI). The model is used to predict the maximum deformation of the spine and associated force within the vertebral column for various short-duration acceleration inputs. The properties used in the model were derived from human samples or tests. The spring stiffness was determined from tests of cadaver vertebral segments; damping ratios were determined from measurements of mechanical impedance of human subjects during vibration and impact. A plot[13,14] of the spinal injury rate vs DRI is shown

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[12] Brinkley, J.W., DEVELOPMENT OF AEROSPACE ESCAPE SYSTEMS, Air University Review, Vol XIX (5), 34-49, July-August 1968.

[13] Weinberg, C.J., LtC., U.S. AIR FORCE EXPLORATORY DEVELOPMENT IN IMPACT INJURY PREDICTION AND PROTECTION, Proceedings of the 8th Annual Survival and Flight Equipment Association Symposium, 28 September 1970.

[14] De Stefano, L.A., DYNAMIC RESPONSE INDEX MODULATION FOR PERSONNEL ESCAPE SYSTEMS, Memorandum Report No. M71-23-1, for Munitions Development and Engineering Directorate, Frankford Arsenal, Philadelphia, Pennsylvania, November 1971.

in Figure 4. The plot is representative of the tolerance for the average or 50th percentile Air Force aviator to ejection seat impulses. Spring stiffness varies from the 5th through the 95th percentile man. Allowances are made in the plot for higher and lower DRIs that would be experienced by other percentiles. Inaccuracies will also occur when using the program for other than 50th percentile due to the varying spring stiffness factor. Another consideration that should be taken into account when using the program for other than ejection seats is that allowances were also made in DRI tolerance for catapult powder grain variance and temperature differential effects.

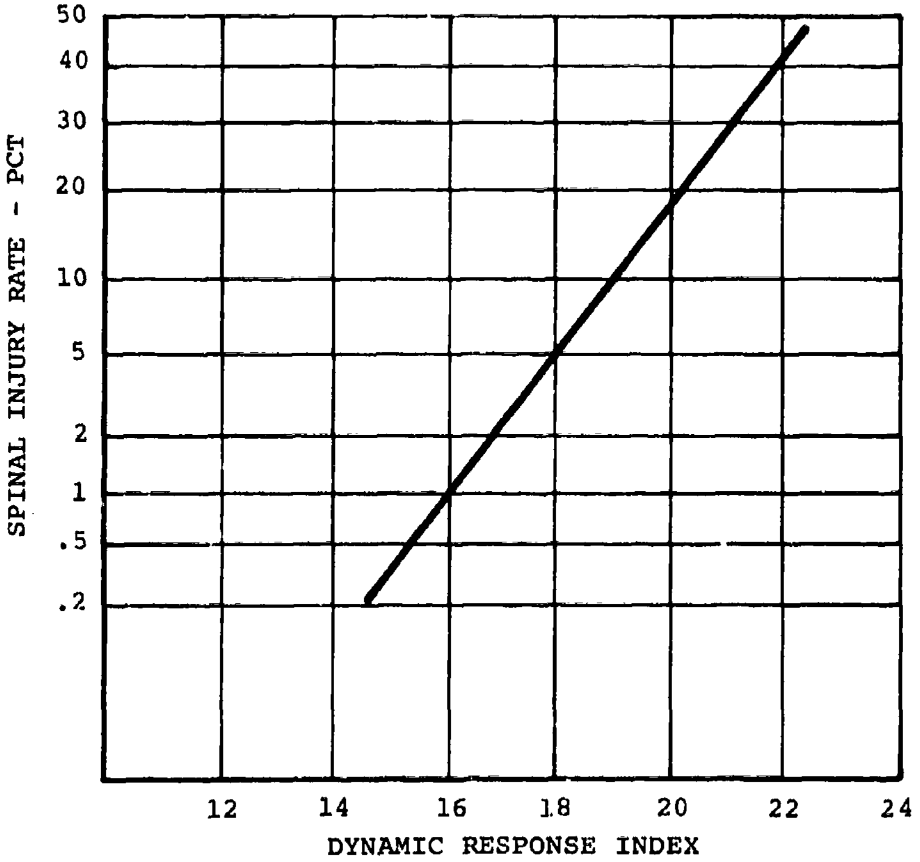


Figure 4. Operational Spinal Injury Rate vs DRI

Mathematical Simulation

In order to evaluate the capability of various energy attenuators to reduce the dynamic response of troops in vertical impact to within human tolerance limits, a computer program was developed based on the DRI methodology. The CSMP (Continuous System Modeling Program) was used for input into the IBM 360-75 equipment.

S/360 CSMP Computer Program User's Guide

The S/360 Continuous System Modeling Program is problem-oriented designed to facilitate the digital simulation of continuous processes on large-scale digital machines. The program provides an application-oriented language that allows these problems to be prepared directly and simply from either a block-diagram representation or a set of ordinary differential equations. The program includes a basic set of functional blocks with which the components of a continuous system may be represented, and accepts application-oriented statements for defining the connections between these functional blocks. S/360 CSMP also accepts FORTRAN statements, thereby allowing the user to readily handle nonlinear and time-variant problems of considerable complexity. Input and output are simplified by means of user-oriented control statements. A fixed format is provided for printing (tabular format) and print-plotting (graphic format) at selected increments of the independent variable as shown in Figure 5. Through these features, S/360 CSMP permits the user to concentrate upon the phenomenon being simulated, rather than the mechanism for implementing the simulation.

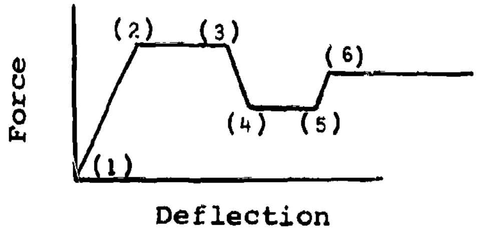
The program is discussed in the following paragraphs:

Card 1 is a timer card. It sets the final time Δt, plotted output Δt, and printed Δt.

Card 2, method RKSFX, fixes the integration time to Δt. Removal of this card allows the computer to pick an optimum time for integration.

Card 3 allows the user to put in any variation in subject weight and seat weight. Card 4 is an input reduction ratio.

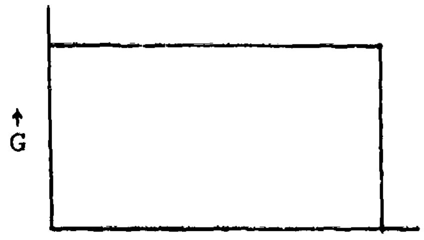
The next set of cards, 5a and on, describes the energy absorber force deflection characteristics. The first number in each set of parantheses is the deflection, and the second number is the force. The force is retained constant at the last set of inputs.



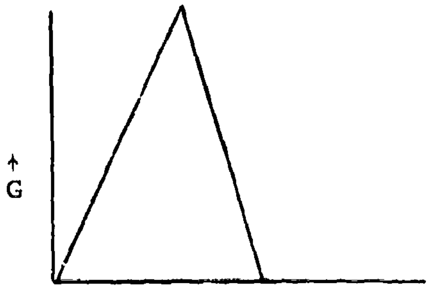
```
(1)     TIMER FINTIM=0.2,DELT=.001,OUTDEL=.005,PRDEL=0.5
(2)     METHOD PKSFX
(3)     PARAM W1=200.7,W2=10.0
(4)     PARAM RA=1.0
(5)a    FUNCTION FORCE=(0.0,0.0),(0.5,2600.0),(2.5,2600.0),
          (2.6,1600.0),... (6.75,1600.0),(7.0,3400.0)
(6)     PARAM ON=1.0,STP=0.0,SPIKE=1.0,ICVP=-33.0
(7)     FUNCTION GS=(0.0,0.0),(0.0214,48.0),(0.0428,0.0)
(8)     PARAM G=386.0
(9)     INIT
 9-01     M1=W1/G
 9-02     M2=W2/G
 9-03     M3=M1
 9-04     OMFG8=16.0*3.14159
 9-05     C3=.44*OMEG8*M3
 9-06     K3=M3*OMEG8**2
 9-07     OMEG10=20.0*3.14159
 9-08     K1=M1*ON*OMEG10**2
 9-09     C1=.60*ON*OMEG10*M1
 9-10     ICV=12.0*ICVP*RA
 9-11     SGNV1=1.0
 9-12     CHANGE=1.0
(10)    DYNAM
 10-01    STEP2=STEP(0.054)
 10-02    STEP1=STEP(0.0)
 10-03    X1DDP=(K1*(X2-X1)+C1*(X2D-X1D)-W1)/M1
 10-04    X1DD=X1DDP*ON
 10-05    GMAN=X1DD/G
 10-06    X2DD=(FSEEN+FEA-W2)/M2
 10-07    X3DD=(C3*(X2D-X3D)+K3*(X2-X3)-W1)/M3
 10-08    X2D=INTGRL(ICV,X2DD)
 10-09    X2+INTGRL(0.0,X2D)
 10-10    X1D=INTGRL(ICV,X1DD)
 10-11    X1=INTGRL(0.0,X1D)
 10-12    FSEEN=K1*(X1-X2)+C1*(X1D-X2D)
 10-13    AX2=ABS(X2)
 10-14    FEA=AFGEN(FORCE,XEA)
 10-15    X3D=INTGRL(ICV,X3DD)
 10-16    X3=INTGRL(0.0,X3D)
 10-17    DRI=K3*(X3-X2)/(M3*G)
 10-18    XA2DP=AFGEN(GS,TIME)
 10-19    XA2D=G*(XA2DP*SPIKE+STEP3*STP)*RA
 10-20    STEP3=24.0*(STEP1-STEP2)
 10-21    XA1DP=INTGRL(ICV,XA2D)
 10-22    XAID=LIMIT(-10000.0,0.0,XA1DP)
 10-23    XA=INTGRL(0.0,XA1D)
 10-24    XEA=(XA-X2)*CHANGE
 10-25    XEAD=XAID-X2D
(11)    PRTPLT GMAN,X1DD,X2DD,X1D,X2D,X1,X2,FEA,DRI,FSEEN,XEA,XA1D,XA
(12)    PRINT RA,ICVP,W1,W2
(13)    END
```

Figure 5. Input Statements for the CSMP Program.

Card 6 describes the parameters for the type of input function, whether it's a step or a spike, along with the impact velocity. When ON = 1.0, there is a spring and damping between the man and the seat. When either STP or SPIKE = 1.0, that is function in use.



Step Function



Spike Function

Card 7 describes the input function. It is inputted similarly to the energy absorber except that the numbers represent time and Gs respectively.

Card 8 is the acceleration due to gravity.

The next series of cards, 9-01 through 9-12, merely evaluates the damping and stiffness coefficient for the man. The coefficients for the man models are 10 Hz and $\zeta = 0.3$ for the force model and 8 Hz and $\zeta = 0.22$ for the injury model and are calculated by using the given body weight.

The dynamic portion of the program is basically the coding of the differential equations of motion, cards 10-01 through 10-25. If a step input function is used, cards 10-01 and 10-02 describe the time limits.

The remaining equations are for computation of the acceleration of the force model mass ($\ddot{X}1$) G of the force model mass, acceleration of the seat ($\ddot{X}2$), the dynamic response index (DRI) and the seat displacement (XEA).

Card 11 provides for print-plotting (graphic format) at selected increments of time, while card 12 provides for printing (tabular form) of RA, YCVP, W1 and W2.

Card 13 ends the program.

Force Deflection Curve Evaluations

The shape of the force deflection curve for an energy attenuator depends upon the type of attenuator that is used. A curvilinear shape is formed by tensile yielding of high-elongation materials such as annealed tubes, wire, rod, cable, etc., as shown in Figure 6. Attenuators that do work through bending, shearing or torsion have a characteristic curve which is generally trapezoidal and in most cases has an initial starting peak force approximately 20 percent higher than the running force level as shown in Figure 7.

A notched force deflection curve was determined in report NADC-AC-7007 to be the optimum force deflection curve for crew seat attenuators producing lowest Dynamic Response Index (DRI) rating for vertical acceleration on the human spine. The curve has an initial short, high plateau followed by a valley and then a long mid-height plateau as shown in Figure 8.

Three types of force deflection curves were developed for input into the CSMP program to determine relative DRI values. A force level of 2630 pounds was used for the sustained plateau level in each of the three curves. This figure was computed by assuming the maximum tolerable vertical acceleration level of 23G on a 5th percentile troop without any equipment to obtain the lowest weight. A vertical effective occupant weight of 104.3 pounds was used and was determined as follows:

5th Percentile Troop Weight (ADS-3) - 126 lb

Item	Actual Wt-lb	Vertical Effective Wt-lb
Man	126.0 x 80%	101.0
Boots	3.6	-
Shirt	1.1	1.1
Socks	0.2	-
Trousers	1.2	1.2
Underwear	0.5	0.5
Personal Eq.	0.5	0.5
Total	133.1 lb	104.3 lb

Weights for the 50th and 95th percentile troops with equipment were used to obtain higher weights. The effective weight of 197 pounds for the 95th percentile and 163 pounds for the 50th percentile for vertical acceleration were used and were computed as follows:

Item	Actual Wt-lb	95th Percentile Vertical Effective Wt-lb	50th Percentile Vertical Effective Wt-lb
95th percentile troop	202.0 x 80% =	161.0	
50th percentile troop	159.0 x 80% =		127.2
Boots	4.0	-	-
Shirt	1.1	1.1	1.1
Socks	0.2	-	-
Trousers	1.2	1..	1.2
Underwear	0.5	0.5	0.5
Clothing	7.0	2.8	2.8
M-16 Rifle & Ammunition	13.5	Less Rifle 6.5	6.5
Canteen w/water & cup			
Pistol belt			
First aid pouch			
Suspenders			
Butt pack or med. rucksack			
Bayonet w/scabbard			
Poncho			
Helmet			
Trenching tool w/ cover, etc.			
Total Field Equipment	16.8	16.8	16.8
Fragmentation grenade (2)			
Claymore mine (1)			
Personal equipment			
"C" rations			
Total Additional Equipment	10.0	10.0	10.0
Total Weight-Lb	249.3		
Total Vertical Effective Wt-lb		197.0	163.3

In order to determine the force level of the attenuator, the vertical effective weight of the 5tn percentile was added to the seat weight and then multiplied by the limit acceleration as follows:

(104.3 lb + 10 lb) 23G = 2630 lb

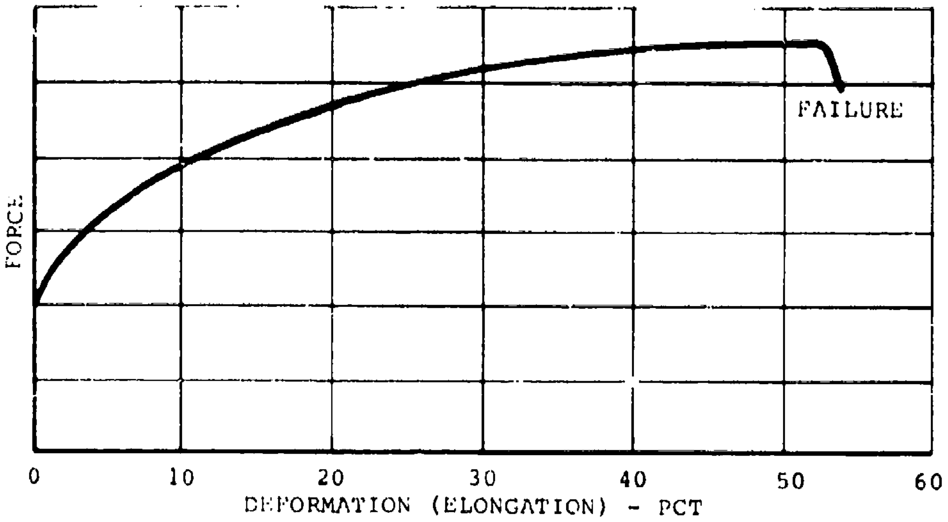


Figure 6. Curvilinear Force Deflection Curve Characteristic of Tensile Yielding Energy Attenuators.

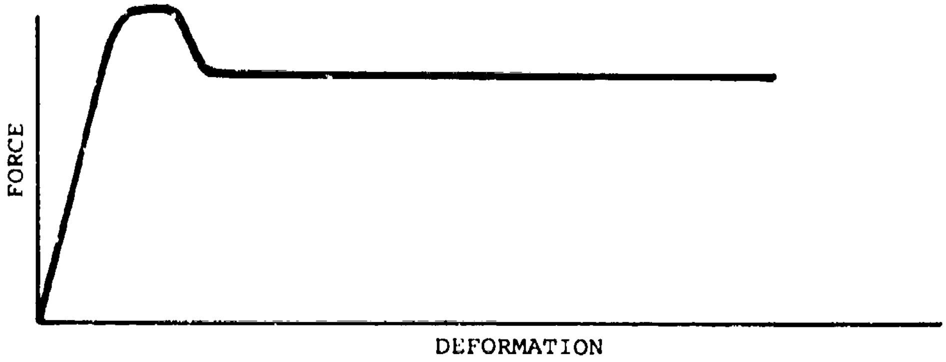


Figure 7. Trapezoidal Force Deflection Curve Characteristic of Bending, Shearing, or Torsion Type Energy Attenuators.

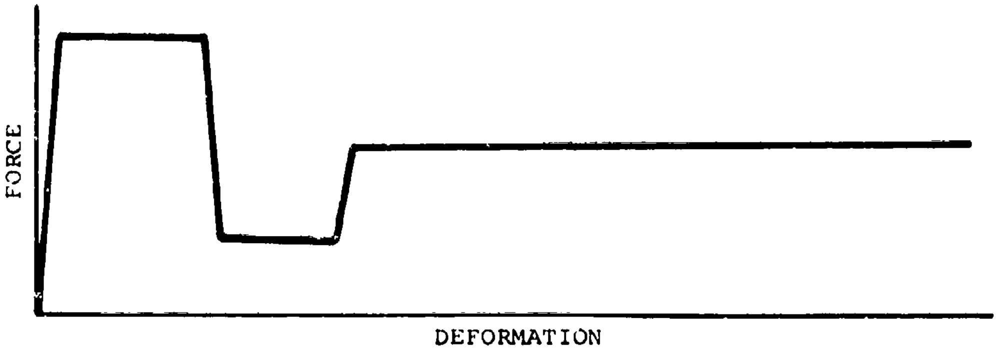


Figure 8. Theoretical Optimum Notched Force Deflection Curve From NADC-AC-7007.

This force was used as an initial basis in the development of an optimum force deflection curve. Three curves - curvilinear, trapezoidal, and notched - were developed, with 2630 lb used as the sustained plateau level as shown in Figures 9, 10, and 11 respectively. Curve 1 in Figure 9 was approximated by using straight line elements. This curve is typical of attenuators using high-elongation materials in tensile yielding.

The second force deflection curve (Figure 10) was an approximation of a theoretical optimum notched curve developed in NADC report NADC-AC-7007.[13] An existing Boeing-Vertol developed wire bending energy attenuator was employed as a model to develop the curve. The steps are produced by the variable diameter wire bending or straightening as it passes over the rollers (Figure 13).

A third force deflection curve (Figure 11) is a typical curve produced by energy attenuators which employ bending, torsion or shearing during the stroking operation. An initial starting peak with 20 percent higher force than the running force was used based on test data.

Each of these three force deflection curves was programmed into the CSMP model to obtain a comparative stroke and DRI. The input included an impact pulse of 48G triangular peak with a base time of 0.054 second. This represents an impact velocity of 42 fps. The results are tabulated in Table 3. Runs 1 to 8 show that the DRI and stroke were similar for all three curves. The critical stroke for the 95th percentile troop was in excess of 20 inches, and the critical DRI for the 5th percentile troop was in the high twenties. The limit was set for the stroke not to exceed 15 inches for a 95th percentile troop and for the DRI not to exceed 20 for a 50th percentile troop.

Curve 4 (Figure 12) was developed maintaining the notch floor at 2630 lb, which represents the 5th percentile force requirement; while the upper plateau was raised to the force requirement for a 95th percentile troop with full equipment--3850 lb. This force was determined by using 17.5G as a reasonable acceleration and multiplying by the sum of the troop, equipment and seat weights as follows:

$$(197 \text{ lb} + 10 \text{ lb}) \; 17.5\text{G} = 3580 \text{ lb}$$

The effect of reducing the impact velocity was investigated. Runs 9 through 16 were made using curve 4 (Figure 13) with varying impact velocities of 36, 35, 33, and 31.5 fps, which represent 90, 88, 84, and 80 percentile impacts respectively. The impact pulse of 48G triangular peak was held constant but the time base was varied accordingly. The results showed that DRI remained constant on the 95th percentile regardless of

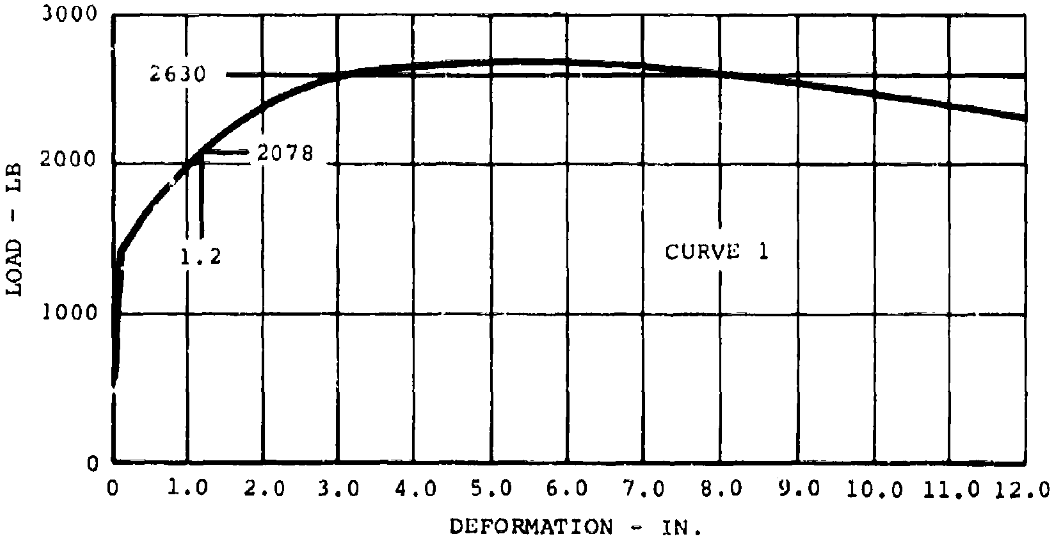


Figure 9. Curvilinear Curve Characteristic of Tensile Type Energy Attenuators.

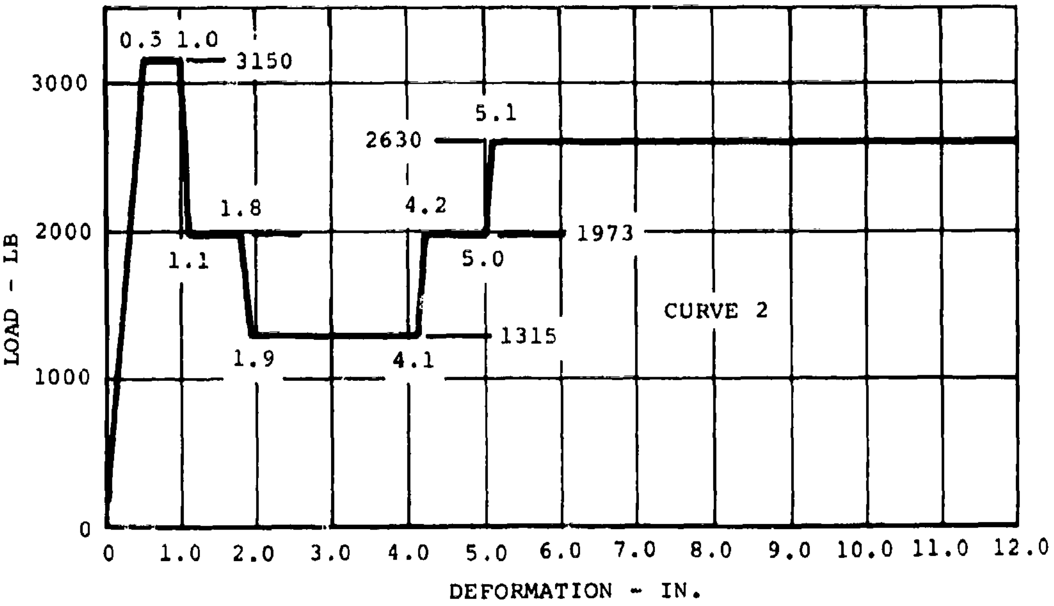


Figure 10. Notch Curve Produced by Variable-Diameter Wire Bending Attenuator.

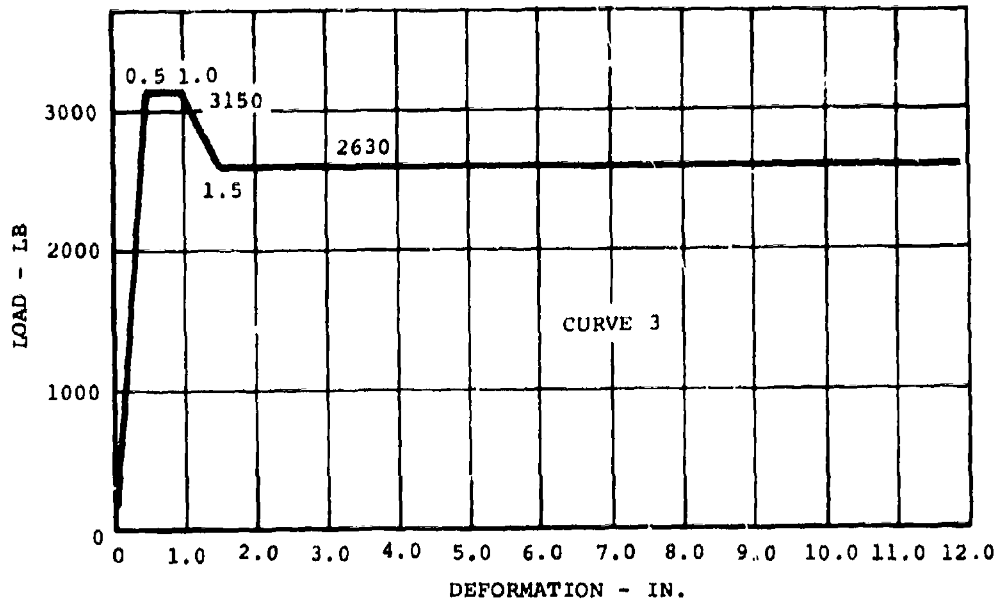


Figure 11. Trapezodial Curve Characteristics of Bending and Shearing Energy Attenuators.

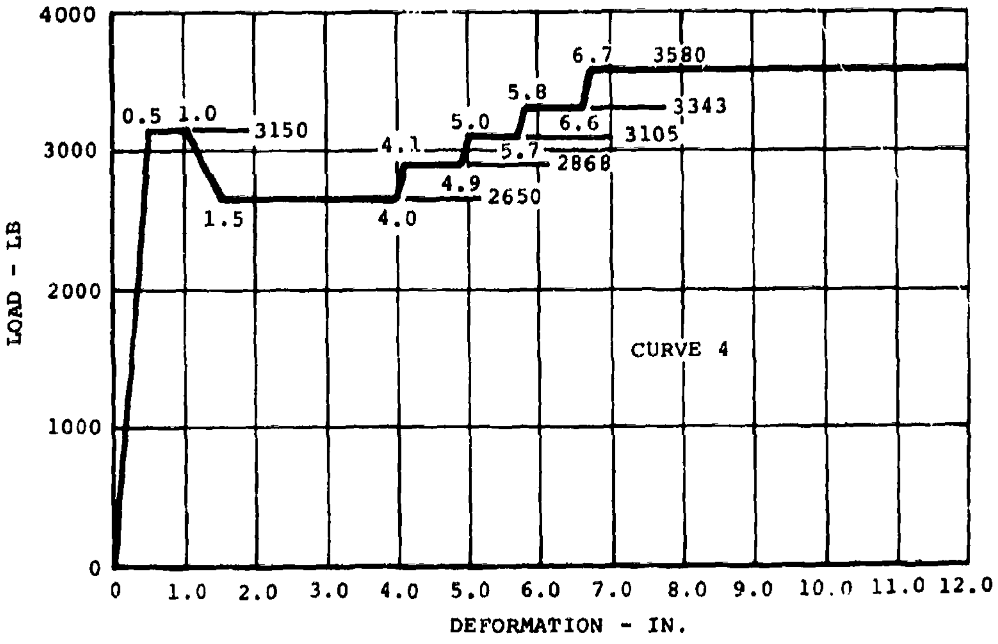
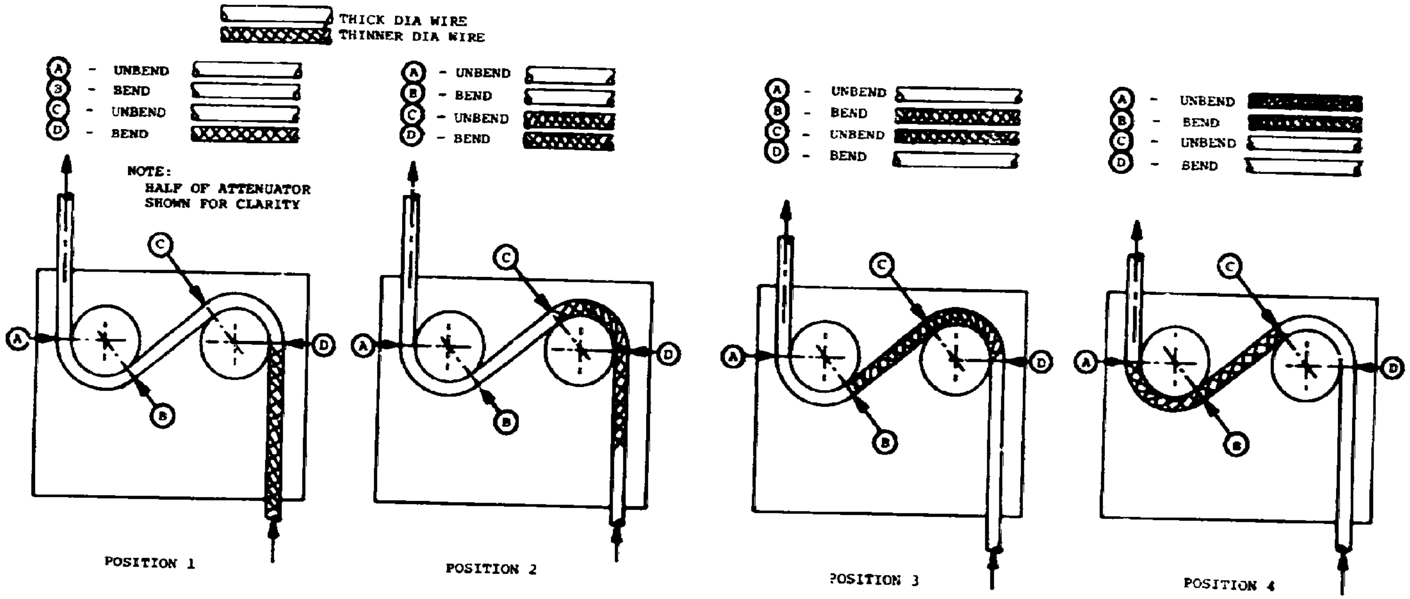


Figure 12. Notched Force Deflection Curve With Low Initial Force.



NOTE:
HALF OF ATTENUATOR
SHOWN FOR CLARITY

Figure 13. Positions of Varying Diameter Wire Passing Through Rollers To Produce Notched Force Deflection Curve.

TABLE 3. COMPUTER RUN RESULTS FOR DRI AND STROKE					
Run No.	Impact Velocity (fps)	Troop Percentile	Max Stroke	Max DRI	Curve No.
1	42	95	22.6	14.5	1
2	42	95	22.8	14.2	2
3	42	95	20.3	14.9	3
4	42	95	15.6	19.4	4
5	42	5	9.0	26.8	1
6	42	5	8.65	26.0	2
7	42	5	6.81	27.6	3
8	42	5	5.97	31.1	4
9	36	95	12.10	19.31	4
10	35	95	11.47	19.41	4
11	33	95	10.41	19.38	4
12	31.5	95	9.59	19.30	4
13	36	5	4.74	28.17	4
14	35	5	4.48	26.9	4
15	33	5	4.06	26.38	4
16	31.5	5	3.62	25.2	4
17	36	95	10.1	19.63	5
18	35	95	9.60	19.46	5
19	33	95	8.65	19.55	5
20	31.5	95	7.90	19.49	5
21	36	5	1.50	35.4	5
22	35	5	1.26	34.5	5
23	33	5	1.00	32.1	5
24	31.5	5	.81	32.3	5
25	36	95	6.92	17.2	6
26	36	5	0	31.3	6
27	33	95	5.8	17.1	6
28	33	5	0	31.3	6
29	33	95	11.9	18.54	7
30	33	5	4.98	27.68	7
31	36	5	5.68	29.82	7
32	36	95	13.91	18.53	7
33	33	95	12.26	18.42	8
34	33	5	5.28	23.1	8
35	36	5	5.94	29.1	8
36	36	95	14.17	18.4	8
37	36	95	14.21	18.3	9
38	36	5	6.01	28.7	9
39	33	5	5.48	21.6	9
40	33	95	12.29	18.3	9

TABLE 3. - CONTINUED

Run No.	Impact Velocity (fps)	Troop Percentile	Max Stroke	Max DRI	Curve No.
41	33	95	12.1	18.31	10
42	33	5	5.5	19.93	10
43	36	5	5.97	25.33	10
44	36	95	14.08	18.3	10
45	36	95	13.7	18.3	11
46	36	5	5.68	25.8	11
47	33	5	5.33	20.5	11
48	33	95	11.8	18.3	11
49	33	95	12.23	18.25	12
50	33	5	5.7	22.2	12
51	36	5	6.09	24.45	12
52	36	95	14.14	18.28	12
53	36	95	14.25	18.23	13
54	36	5	6.26	23.48	13
55	33	5	5.94	20.69	13
56	33	95	12.34	18.2	13
57	33	95	12.10	18.30	14
58	33	5	5.50	20.08	14
59	36	5	5.92	25.40	14
60	36	95	14.00	18.34	14
61	36	95	14.17	18.20	15
62	36	5	5.96	29.20	15
63	33	5	5.95	20.70	15
64	33	95	12.27	18.20	15
65	33	95	12.41	18.19	16
66	33	5	6.01	21.03	16
67	36	5	6.29	23.62	16
68	36	95	14.33	17.90	16
69	36	95	14.48	17.90	17
70	36	5	6.35	23.56	17
71	33	5	6.01	21.34	17
72	33	95	12.54	18.08	17
73	33	95	13.1	17.90	18
74	33	5	6.90	18.70	18
75	36	5	7.09	19.20	18
76	36	95	15.04	17.82	18
77	36	95	14.41	19.01	19
78	36	5	7.07	19.29	19
79	33	5	6.09	18.73	19
80	33	95	12.60	18.96	19

TABLE 3. - CONTINUED

Run No.	Impact Velocity (fps)	Troop Percentile	Max Stroke	Max DRI	Curve No.
81	33	65	11.44	19.77	18
82	33	35	8.33	24.88	18
83	36	35	9.44	24.70	18
84	36	65	13.09	20.01	18
85	36	65	12.60	21.16	19
86	36	35	9.12	25.12	19
87	33	35	8.07	23.57	19
88	33	65	11.05	20.86	19
89	33	65	12.01	19.52	20
90	33	35	8.89	22.40	20
91	36	35	9.99	23.86	20
92	36	65	13.65	19.74	20
93	36	65	13.16	20.78	21
94	36	35	9.69	25.01	21
95	33	35	8.69	23.35	21
96	33	65	11.61	20.33	21
97	36.8	50	11.94	22.0	18
98	42	50	14.64	22.0	18
99	36.8	50	14.54	21.3	22
100	42	50	14.41	22.0	22
101	36.8	50	12.1	21.6	23
102	42	50	14.7	21.8	23
103	42	50	14.4	21.8	24
104	36.8	50	11.8	21.6	24
105	36.8	50	11.8	19.8	25
106	42	50	14.6	20.0	25
107	42	50	15.1	19.5	25
108	36.8	50	12.2	19.3	25
109	36.8	5	7.6	18.5	25
110	42	5	8.5	27.2	25
111	42	95	19.6	14.9	25
112	36.8	95	15.8	15.5	25
113	36.8	5	8.0	19.9	26
114	36.8	50	12.8	19.2	26
115	36.8	95	16.4	15.3	26
116	42	5	9.0	27.0	26
117	42	50	15.8	18.2	26
118	42	5	8.9	26.5	27
119	42	50	15.3	20.1	27
120	42	95	19.5	16.2	27

TABLE 3. - CONTINUED

Run No.	Impact Velocity (fps)	Troop Percentile	Max Stroke	Max DRI	Curve No.
121	36.8	95	15.9	16.4	27
122	36.8	50	12.5	20.2	27
123	36.8	5	8.0	21.2	27
124	42	5	8.6	25.0	28
125	42	50	14.6	21.8	28
126	42	95	18.6	18.2	28
127	36.8	95	15.1	18.2	28
128	36.8	50	12.0	21.7	28
129	36.8	5	8.0	21.0	28
130	42	5	9.0	27.5	29
131	42	50	14.8	22.4	29
132	42	95	18.7	18.7	29
133	36.8	95	15.3	18.6	29
134	36.8	50	12.2	22.1	29
135	36.8	5	8.2	22.5	29
136	42	5	8.9	26.8	29
137	42	50	15.1	21.2	29
138	42	95	19.2	17.7	30
139	36.8	95	15.6	17.6	30
140	36.8	50	12.4	21.0	30
141	36.8	5	8.1	20.4	30
142	42	5	8.59	29.01	30
143	42	50	14.38	22.70	30
144	42	95	18.24	18.93	31
145	36.8	95	14.86	18.89	31
146	36.8	50	11.78	22.35	31
147	36.8	5	7.65	24.54	31
148	42	5	8.20	24.22	31
149	42	50	13.26	22.39	31
150	42	95	16.93	19.64	32
151	36.8	95	13.85	19.5	32
152	36.8	50	10.93	22.9	32
153	36.8	5	7.01	22.6	32
154	42	5	8.92	26.8	32
155	42	50	15.23	20.6	32
156	42	95	19.55	17.2	33
157	36.8	95	15.87	17.1	33
158	36.8	50	12.52	20.5	33
159	36.8	5	8.05	20.6	33
160	42	5	9.02	26.3	33

TABLE 3. - CONTINUED

Run No.	Impact Velocity (fps)	Troop Percentile	Max Stroke	Max DRI	Curve No.
161	42	50	15.63	20.0	33
162	42	95	19.99	16.7	34
163	36.8	95	16.20	16.6	34
164	36.8	50	12.73	19.9	34
165	36.8	5	8.06	20.6	34
166	42	50	22.5	13.9	35
167	36.8	50	17.4	13.9	35
168	42	50	20.6	14.6	36
169	36.8	50	16.1	14.6	36
170	36.8	50	16.2	15.0	37
171	42	50	20.6	15.0	37
172	42	50	19.0	15.7	38
173	36.8	50	14.9	15.7	38
174	36.8	50	14.3	16.3	39
175	42	50	18.1	16.3	39
176	42	50	17.2	16.8	40
177	36.8	50	13.5	16.8	40
178	36.8	50	12.7	17.4	41
179	42	50	16.2	17.4	41
180	42	50	14.1	18.7	42
181	36.8	50	11.0	18.7	42
182	36.8	50	10.6	19.2	43
183	42	50	13.6	19.2	43
184	42	50	13.8	19.0	44
185	36.8	50	10.8	19.0	44
186	36.8	50	10.5	19.0	45
187	42	50	13.5	19.0	45

velocity and was in the high twenties for all 5th percentile cases.

A curve plotting DRI with the force deflection curve indicated a need to absorb more energy during the initial portion of the stroke (Figure 15). In Curve 5 (Figure 14), the initial plateau was increased to 20 percent above the running plateau of Curve 4. Runs 17 through 24 were made using the five velocities of the previous series with the unexpected result that DRI for the 5th percentile troop was well above 30 for all cases.

To save time, straight line element curves were used to represent stepped curves achievable by using a wire bending attenuator with variable-diameter wire. Impact velocities were limited to 36 and 33 fps. The high initial plateau recommended in NADC-AC-7007[13] was abandoned in favor of a low initial plateau with more favorable results. Curves 6, 7, 8, 9, and 10 (Figure 16), small variations of each other, were run and some improvement was made (Table 3, runs 25 through 43).

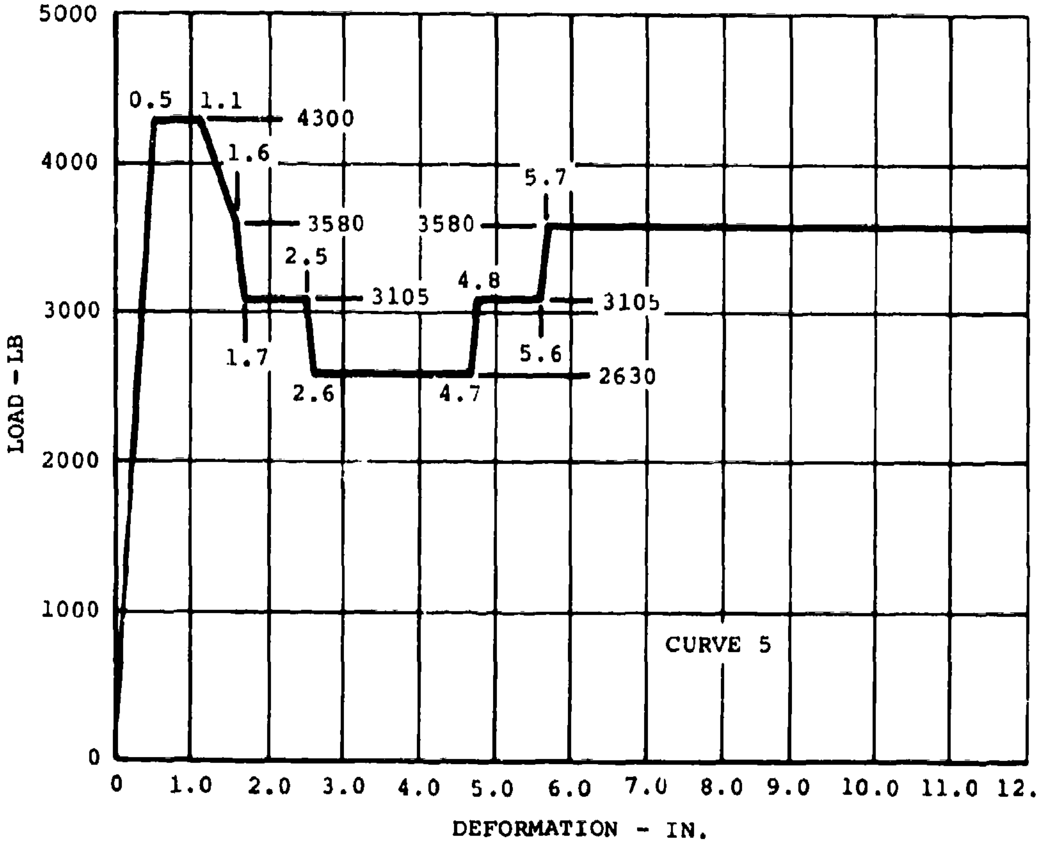


Figure 14. Notched Force Deflection Curve With High Initial Force.

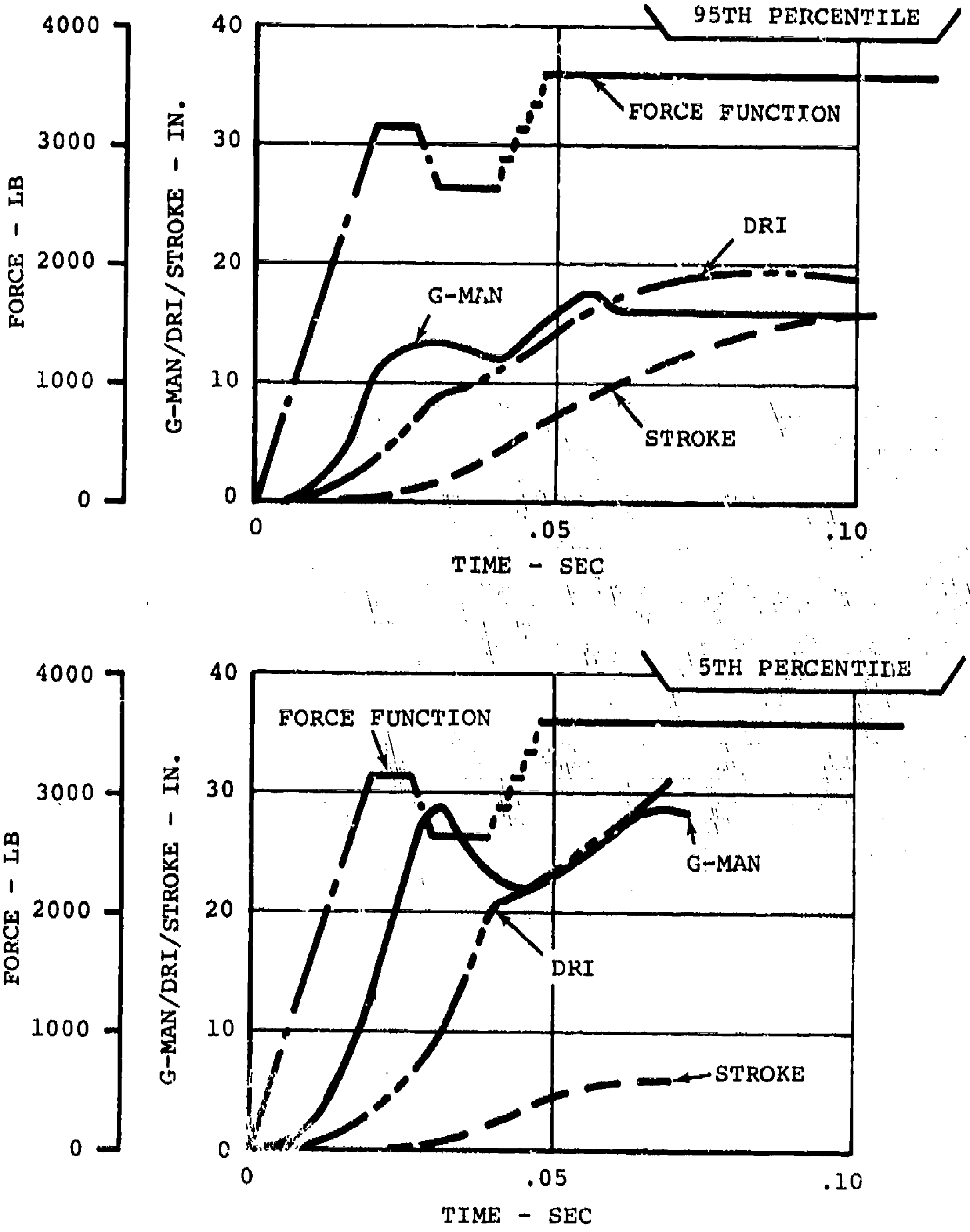
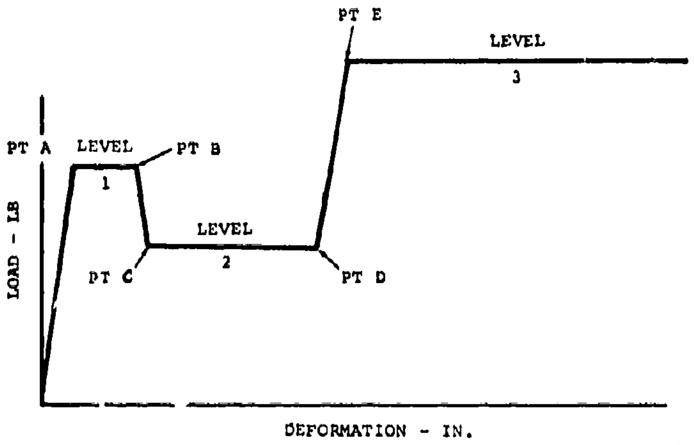


Figure 15. Force Function and DRI for Curve 4.



CURVE	PT A	PT B	PT C	PT D	PT E	LEVEL 1	LEVEL 2	LEVEL 3
6	0	2.0	2.1	4.0	4.5	3000	2000	3400
7	0.5	1.75	1.85	4.0	4.5	2500	1750	3400
8	0.5	2.0	2.1	4.5	5.0	2500	1650	3400
9	0.5	2.75	2.35	5.0	5.25	2500	1750	3400
10	0.5	2.50	2.60	5.25	5.50	2600	1750	3400
11	0.5	2.5	2.60	5.0	5.25	2700	1750	3400
12	0.5	2.75	2.85	5.50	5.75	2600	1750	3400
13	0.5	2.75	2.85	5.75	6.0	2600	1750	3400
14	0.5	2.50	2.60	5.25	5.50	2600	1850	3400
15	0.5	2.75	2.85	5.75	6.0	2600	1850	3400
16	0.5	2.50	2.60	5.75	6.0	2600	1750	3400
17	0.5	2.50	2.60	5.75	6.0	2600	1600	3400
18	0.5	2.5	2.6	6.75	7.0	2600	1600	3400
19	0.5	2.5	2.6	6.75	7.0	2600	1600	3600
20	0.5	2.5	2.6	7.75	9.0	2600	1600	3400
21	0.5	2.5	2.6	[illegible]	[illegible]	2600	1600	3600
22	0.4	2.0	2.4	6.55	6.75	2600	1600	3400
23	0.5	3.5	3.6	7.75	8.0	2600	1600	3400
24	0.5	4.5	4.6	7.75	8.0	2600	1600	3400
25	0.5	4.5	4.6	7.75	8.0	2800	1600	3100
26	0.5	4.5	4.6	7.75	8.0	2600	1600	3100
27	0.5	4.5	4.6	7.75	8.0	2600	1600	3250
28	0.5	4.5	4.6	7.75	8.0	2600	1600	3500
33	.5	4.2	4.3	7.75	8.0	2600	1600	3300
34	.5	4.2	4.3	7.75	8.0	2600	1600	3200

Figure 16. Summary Of Similar Notched Curves.

Plots of DRI on the force deflection curve for Curves 9 and 10 show a tendency for DRI to turn upward near the end of stroke (Figures 17 and 18). Further refinements were made in Curves 11 through 17 (Figure 16) without improvement, as shown by Table 3, runs 45 through 72.

The basic curve was modified by increasing the valley width by 1 inch (Curve 18) and increasing the plateau to 3600 lb (Curve 19 in Figure 16). In doing so, the sharp upward trend of the DRI curve was removed (Figure 19) and the goal of not exceeding a DRI of 20 for the 5th percentile and not exceeding a stroke of 15 for the 95th percentile fully equipped troop was achieved. Using Curve 19, the DRI for the 5th percentile is 19.2 and the stroke for the 95th percentile is 14.4 inches (Table 3, runs 77 and 78).

To achieve the DRI and seat stroke within the limits established, the impact velocity had to be reduced to 36 fps rather than the 42 fps impact velocity specified. So, at this point of the energy attenuator development, other means were investigated to reduce crash impulse on the fuselage for impacts with an initial velocity of 42 fps. Using 42 fps as the fuselage impact velocity does not take into account any attenuation afforded by the landing gear. However, with the advent of crashworthiness requirements for new helicopters, landing gears are being designed with a 20-fps or better impact capability without the fuselage touching the ground. A 20-fps nose gear and main gear when acting together can increase the total capability up to 22 fps. In this case the fuselage impact velocity would be reduced to 35.8 fps in a 95th percentile impact with an initial velocity of 42 fps.

$$V_f = \sqrt{V_i^2 - V_l^2}$$

$$V_f = \sqrt{42^2 - 22^2} = 35.8 \text{ fps}$$

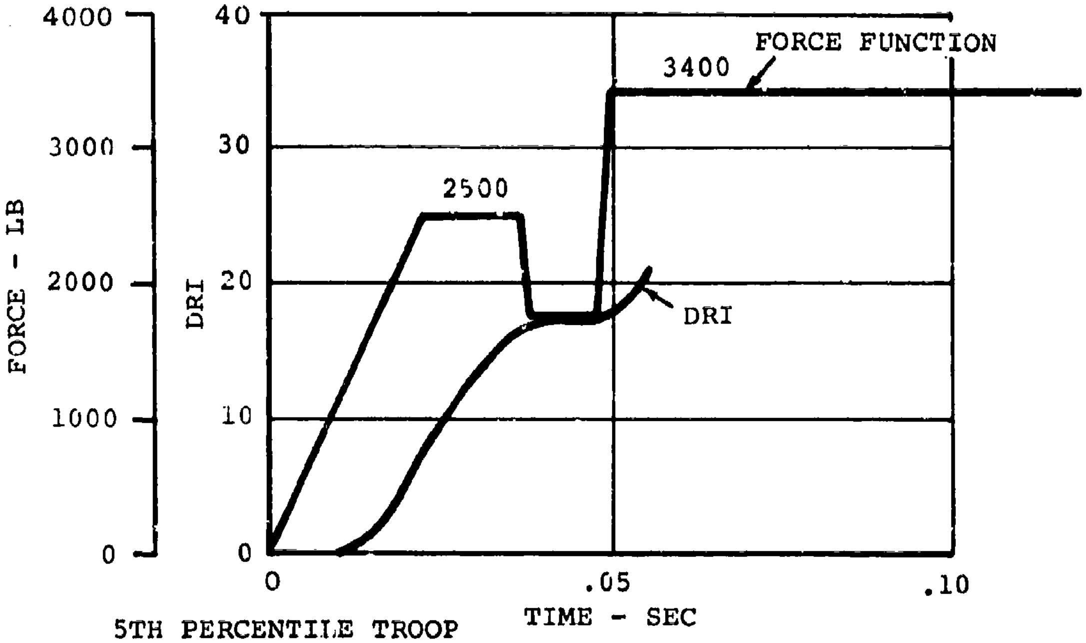
V_f - Fuselage Impact Velocity

V_i - Initial Impact Velocity

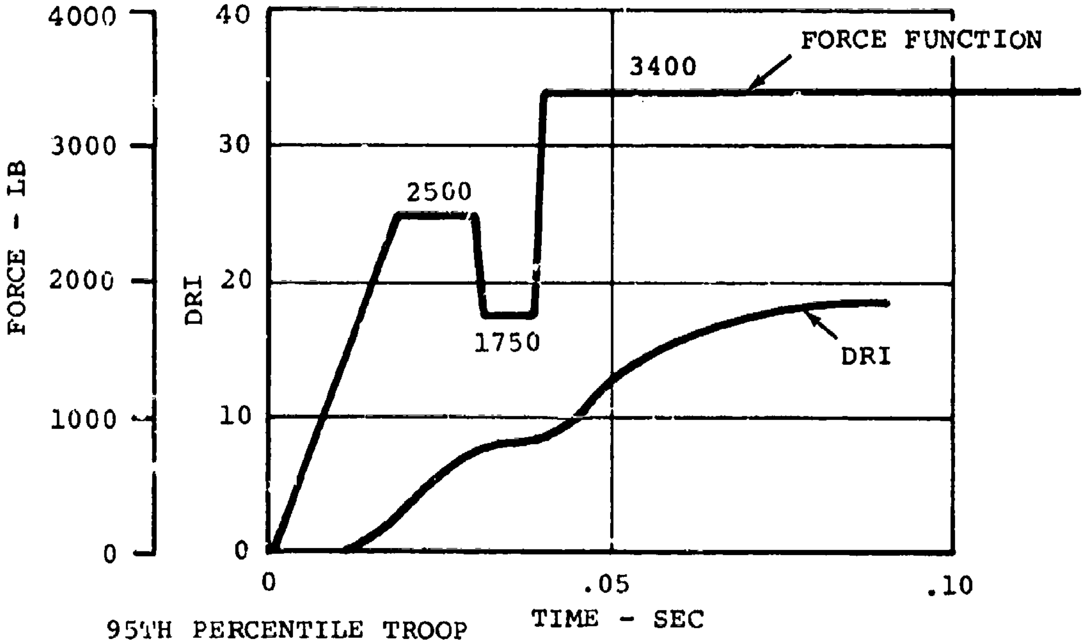
V_l - Landing Gear Capability

Nose-down or tail-down impacts with 20 fps landing gear capability would reduce the fuselage impact velocity to 36.8 fps (Figure 20) for an initial impact velocity of 42 fps or a 95th percentile impact. These velocities are within the tolerable limits for DRI and seat stroke achieved with force deflection curves used in computer runs 77 through 80 (Table 3).

In an attempt to further refine the force deflection curves to produce reasonable DRI levels and stroke lengths for fuselage impacts at 42 fps, Curves 18 through 34 were developed



5TH PERCENTILE TROOP



95TH PERCENTILE TROOP

Figure 17. Force Function and DRI for Curve 9.

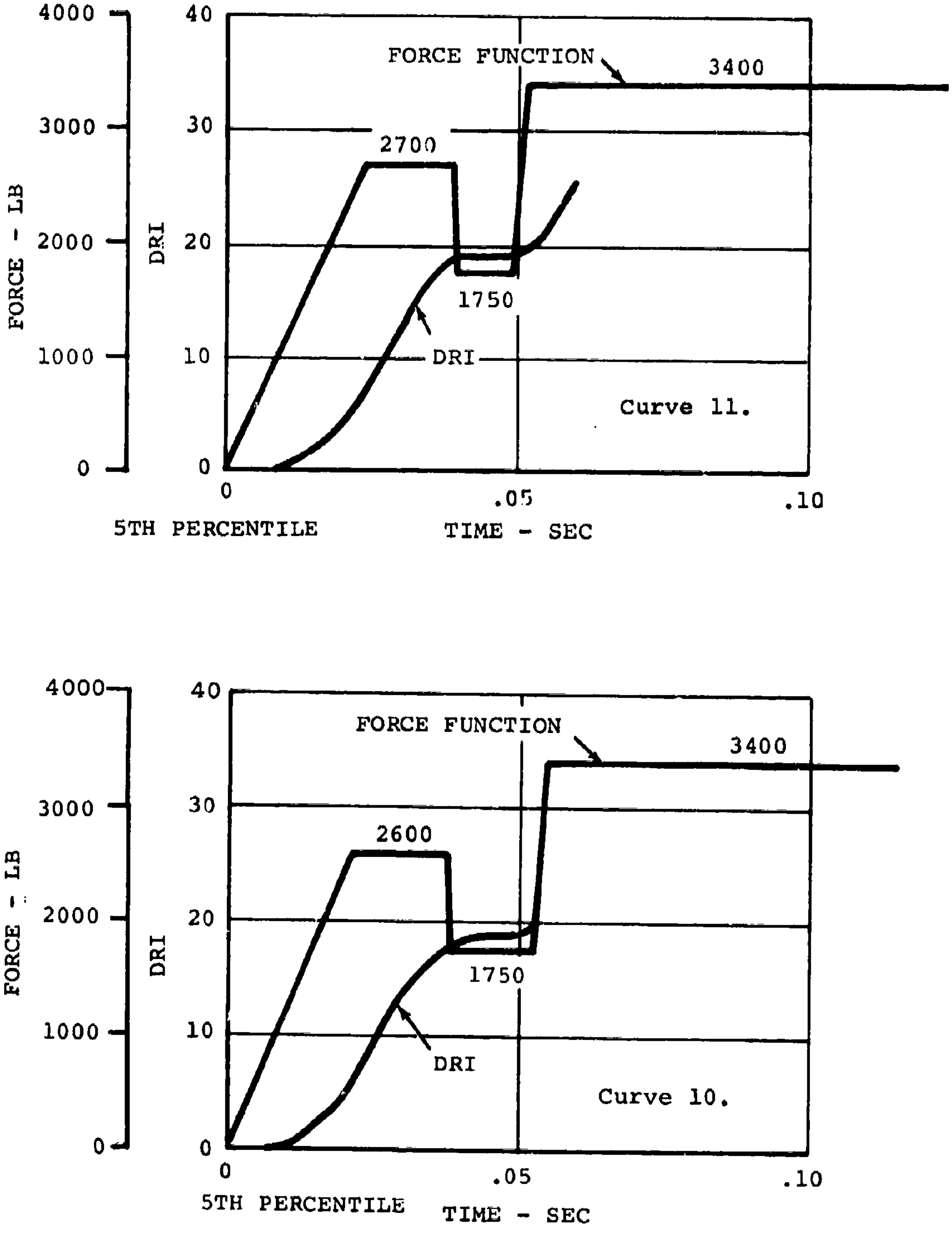


Figure 18. Force Function and DRI.

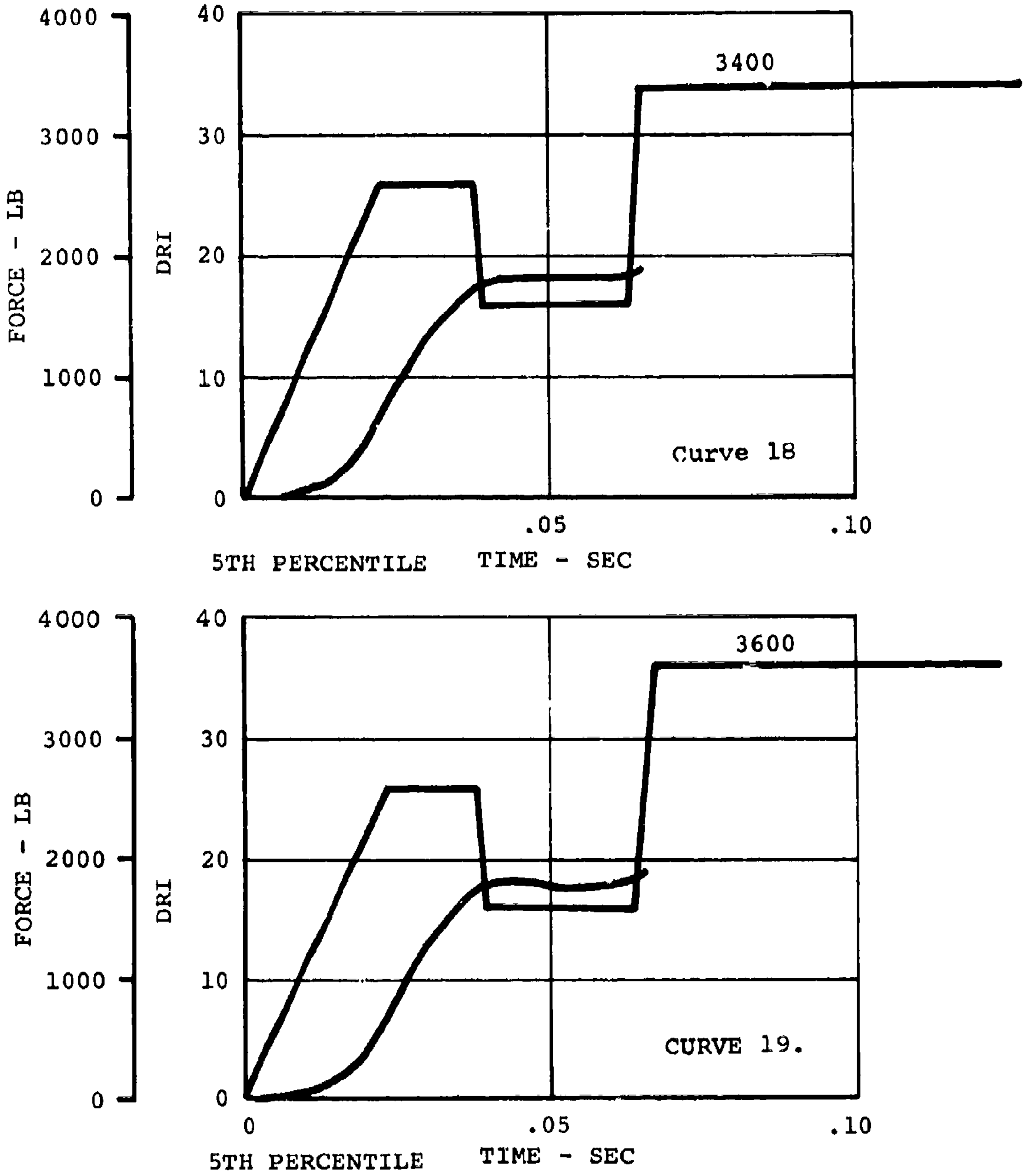


Figure 19. Force Function and DRI.

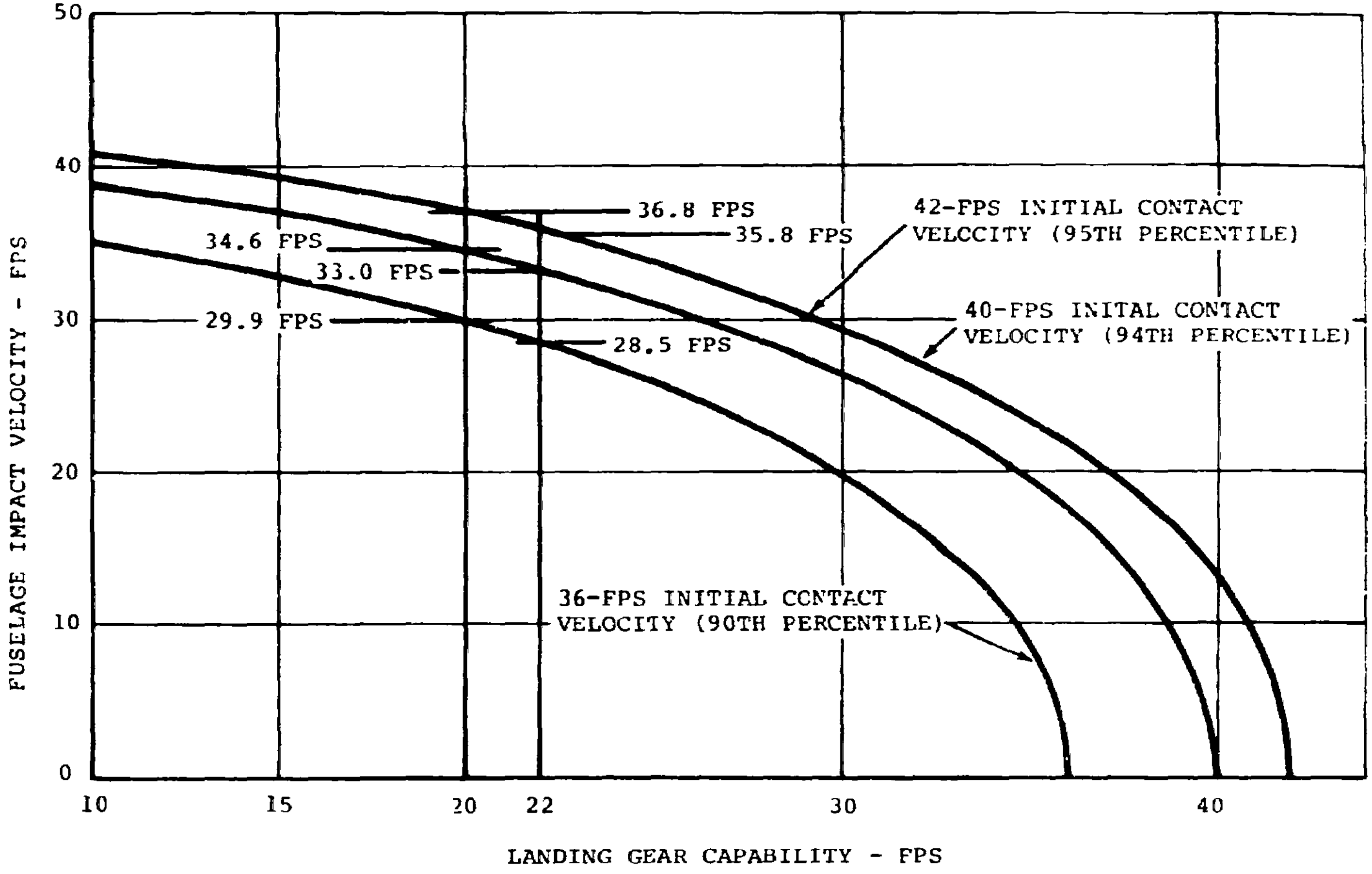


Figure 20. Effect of Landing Gear Impact Capability on Fuselage Impact Velocity.

(Figures 16 and 21). Computer runs 81 through 165 were made, and there was some improvement toward achieving tolerable DRI and stroke levels with impulses at the 42-fps velocity. Function force and DRI curves were ploted for notched Curves 25, 26, 30, and 33 to help determine where the notch should be shifted to lower DRI (Figures 21, 22, 23, and 24). Review of the results showed that the best force deflection curve was Curve 21 (Figure 16), run numbers 144, 148, and 149 (Table 3). Stroke ranged from 8.2 inches to 18.24 inches and DRI ranged from 18.3 to 24.2. Allowing a reduction of 2 DRI for the ejection seat catapult considerations and the spring stiffness variance, the probability of spinal injury for a 5th percentile troop with no equipment, and a 50th and a 95th percentile troop with full equipment, is determined to be: 1 percent for the 95th, 18 percent for the 50th, and 40 percent for the 5th percentile troops by plotting the DRI for each on the curve in Figure 5.

One of the most important things learned from the exercise with the notched force deflection curves was their extreme sensitivity. A small shift of the notch or a small change in notch width or depth had considerable effect on DRI and stroke levels. Another fact that was evident was that a light seat, such as a troop seat, causes a greater spread in the DRI range for the 5th to the 95th percentile troops when using a notched curve.

Additional computer runs were made using trapezoidal shaped force deflection curves (Figure 25). Results of the runs show very stable and predictable progression in the reduction of seat stroke and increase in DRI as the force is increased. A DRI of 19 was set as the goal for the 50th percentile man and was reached in runs 182 through 187 (Table 3). A DRI of 19 represents the 5 percent probability point of spinal injury after adding one DRI for force tolerance allowed on ejection seats for catapult grain and temperature affects. This DRI level is conservative for energy attenuating seat use, as it is reached for a very short duration of time (less than 0.005 sec) as compared to the longer duration of acceleration experienced with ejection seats.

Seat strokes of 10.5 inches and 13.5 inches occurred in runs 186 and 187 for 36.8 and 42 fps fuselage impact velocities respectively. This makes 4.5 to 1.5 inches of additional stroke available for the 95th percentile occupant using the 15-inch seat stroke capability of a 17- to 18-inch-high troop seat.

Computer runs were not made for the 5th and 95th percentile occupants because the dampening and stiffness coefficient in the computer math model is for a 50th percentile man and cannot effectively be used for other percentile weights. If the

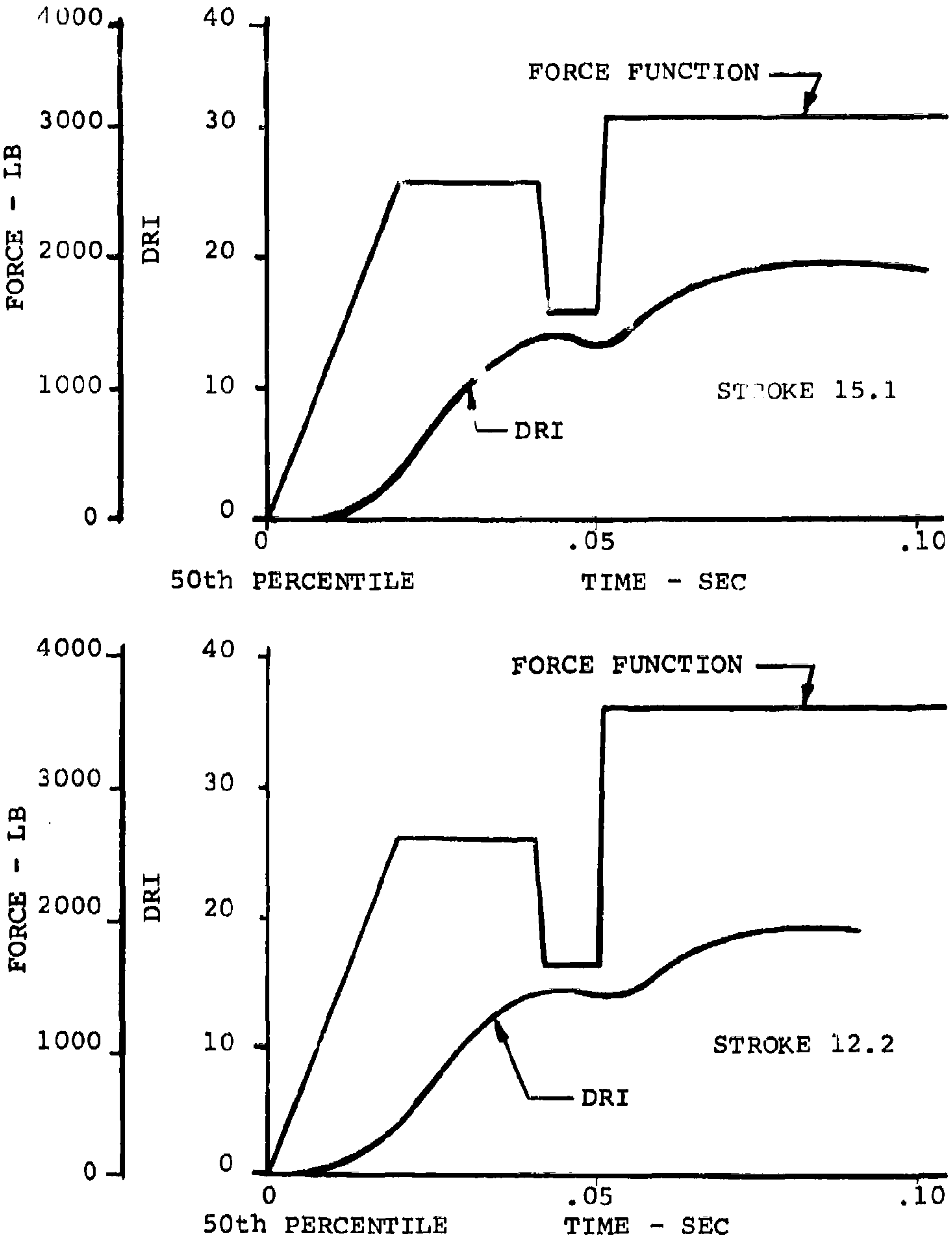


Figure 21. Force Function and DRI for Curve 25.

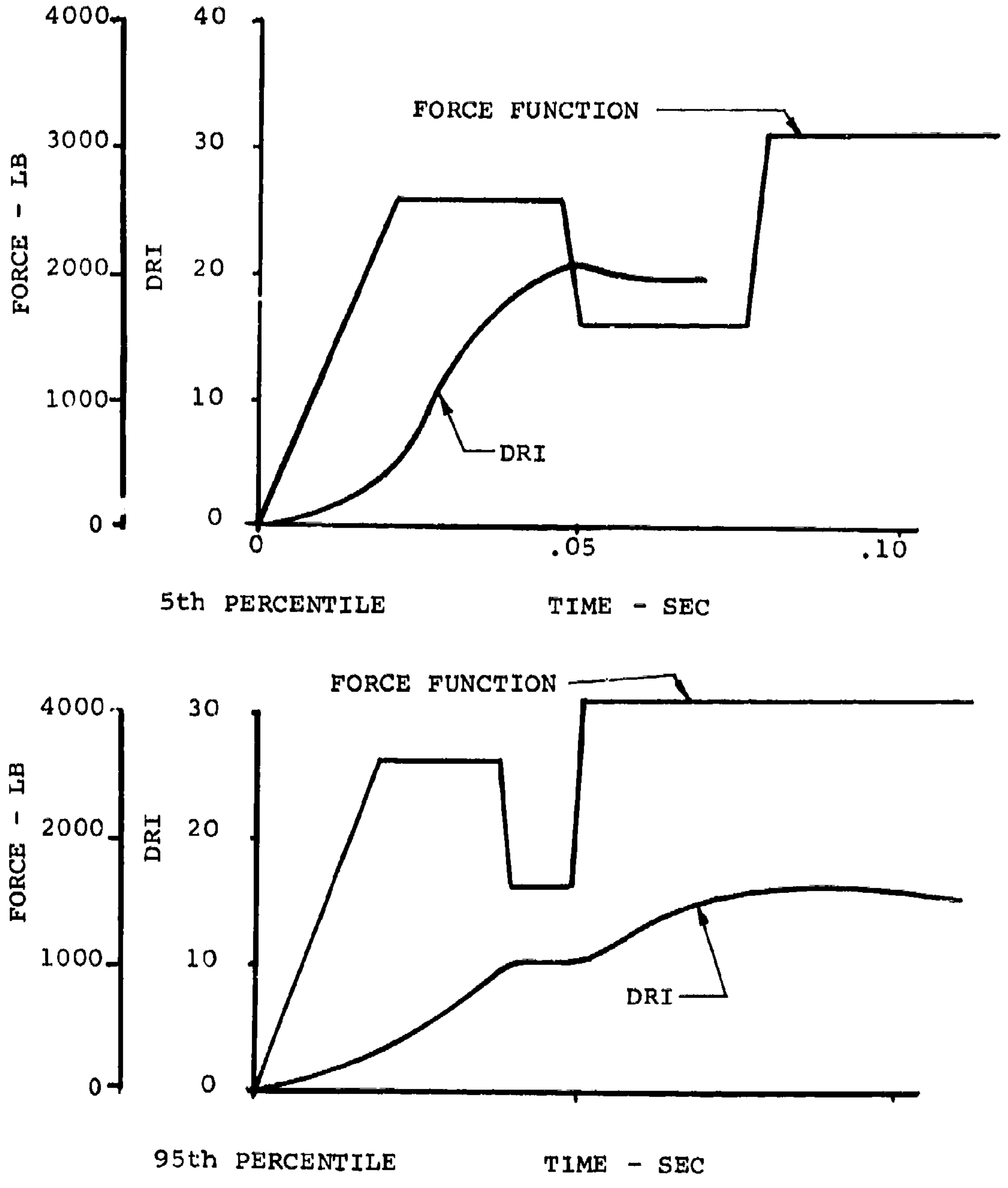
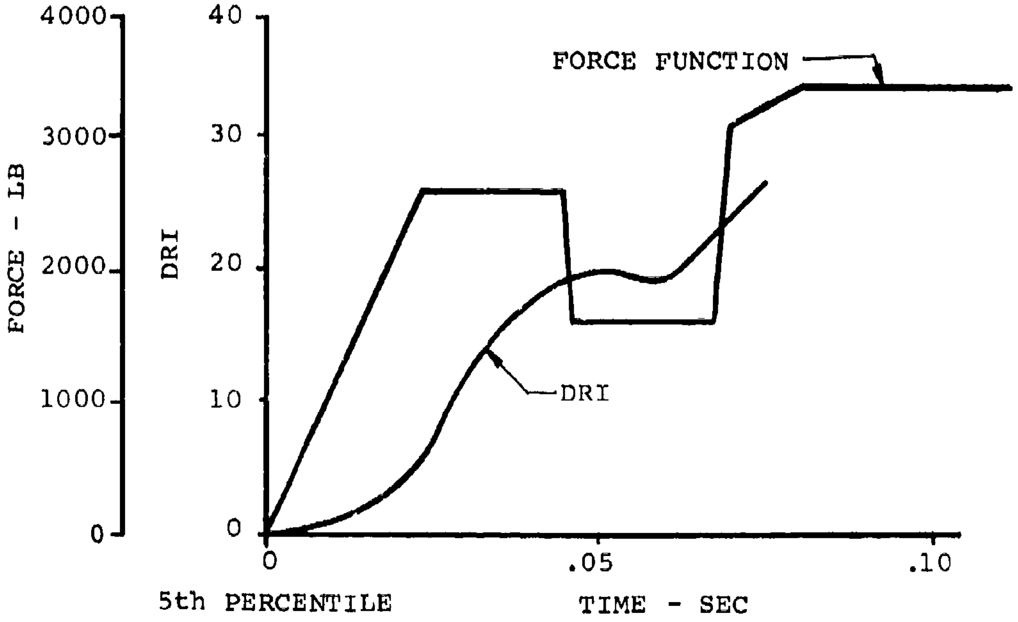
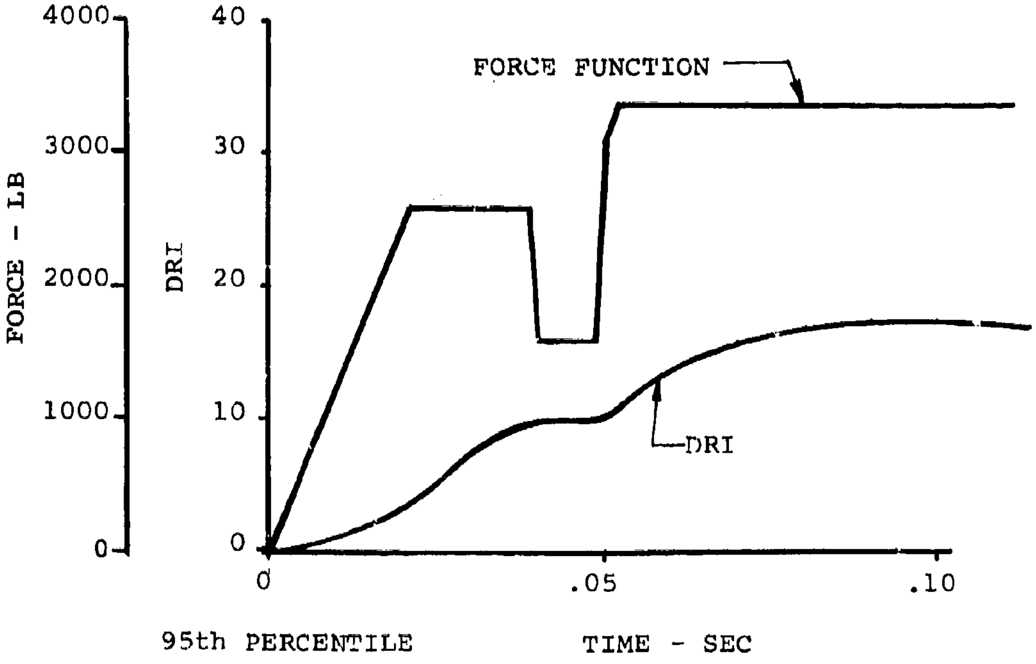


Figure 22. Force Function and DRI for Curve 26.



5th PERCENTILE



95th PERCENTILE

Figure 23. Force Function and DRI for Curve 30.

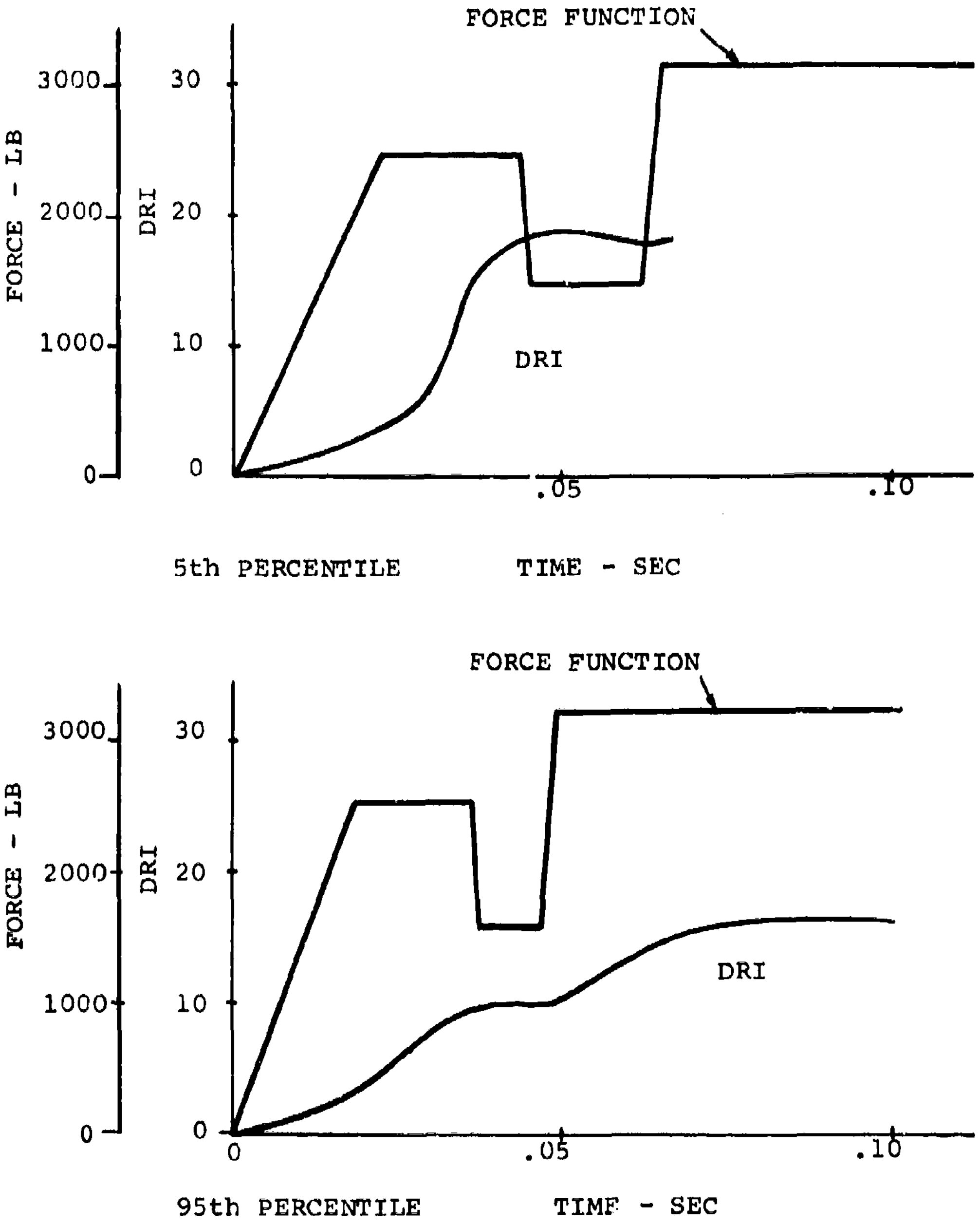
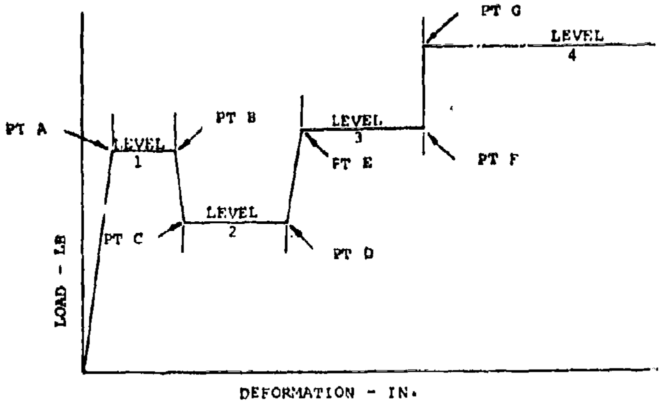
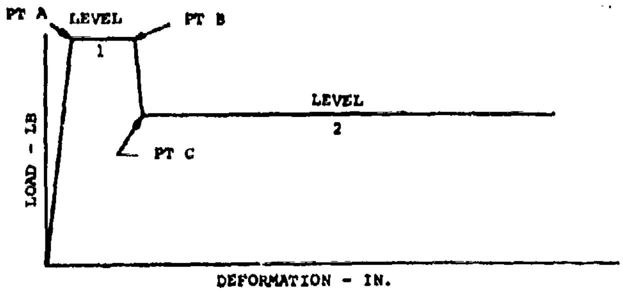


Figure 24. Force Function and DRI for Curve 33.



CURVE NO.	PT A	PT B	PT C	PT D	PT E	PT F	PT G	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
29	.5	4.5	4.6	7.5	7.6	8.6	8.7	2500	1500	2600	3600
30	.5	4.0	4.1	7.7	8.0	-	9.0	2600	1600	3100	3400
31	.5	4.0	3.1	5.0	5.1	8.0	8.1	2600	1300	2600	3600
32	.3	3.0	3.1	6.0	6.1	8.0	8.1	2800	1200	2600	3800

SUMMARY OF SIMILAR NOTCHED CURVES 29 THROUGH 32



CURVE	PTA	PTB	PT C	LEVEL 1	LEVEL 2
35	0.5	1.0	1.5	3000	2430
36	0.5		1.5	3200	2500
37	0.5	1.0	1.5	2800	2600
38	0.5	1.0	1.5	3000	2700
39	0.5	1.0	1.5	3000	2800
40	0.5	1.0	1.5	3100	2900
41	0.5	1.0	1.5	3300	3000
42	0.5	1.0	1.5	3800	3200
43	0.5	1.0	1.5	3800	3300
44	0.5	1.0	1.5	3800	3250
45	0.5	1.0	1.5	4000	3250

SUMMARY OF SIMILAR FORCE DEFLECTION CURVES

Figure 25. Notched And Trapezoidal Curves.

DRI of 19 is maintained for the 50th percentile, the range of 5th through 95th U.S. Air Force population should not exceed the 5 percent probability of spinal injury.

CONCLUSIONS AND ATTENUATOR SELECTION

It was concluded that the notched force deflection curve was not suitable for lightweight troop seats due to the sensitivity of notch placement. A fixed location for the notch was not compatible with the various dynamic responses resulting from the wide range of troop and equipment weights. The trapezoidal force deflection curve, although not as efficient as the notch curve for a specific condition, permits a wider range of weights on the seat.

Desired DRI and seat stroke limitations were marginally met at a fuselage impact velocity of 42 fps. However, due to the conservatism of the impulse requirements which disregard the landing gear effect in reducing fuselage impact velocity and the limitations of the DRI program for determining troop seat response, the trapezoidal force deflection curve energy attenuator appears to be adequate for crashworthy troop seat use. A wire-bending load limiter will produce the trapezoidal force deflection curve and is recommended for vertical force attenuation. The compact wire bending crash force attenuator shown in Figure 2b is recommended with a force deflection curve plateau of 1625 lb each if two devices are used per seat.

RESTRAINT SYSTEM ANALYSIS AND EVALUATION

SCOPE

Requirements were established and three basic restraint systems evaluated for the purpose of selecting an optimum system for use on crashworthy troop seats. The three basic restraint systems evaluated are: (1) lap belt only; (2) lap belt and diagonal shoulder strap; (3) lap belt and double shoulder strap. Variations of these systems were reviewed and their advantages and disadvantages considered in selecting the optimum restraint system. Available restraint systems, components and materials were investigated, and the findings influenced restraint system selection.

RESTRAINT REQUIREMENTS

Troop restraint system crashworthiness requirements for potentially survivable impacts are as follows:

- Retain occupant within the aircraft and attached to the seat or aircraft structure
- Prevent occupant from striking nearby potentially injurious objects
- Distribute acceleration loads over sufficient area of the body so as not to exceed human tolerance limits
- Maintain torso in an erect position to better withstand vertical accelerations
- Prevent lateral rotation of the upper torso
- Minimize restraint elongation and lap belt adjuster slippage to minimize dynamic overshoot
- Provide proper lap belt anchorage geometry and minimize seat cushion deflection to prevent submarining
- Design restraint system to facilitate donning and adjusting by use of retractors or inertia reels when permissible

RESTRAINT CONFIGURATION ANALYSIS AND EVALUATION

Potential troop seat restraint systems have been investigated and evaluated on the basis of human tolerance limits, displacement, crashworthiness, operational use, installation, seat orientation, occupant environment, energy attenuation, simplicity, cost, weight, and human factors. Three basic restraint systems have been investigated· lap belt only, single diagonal shoulder strap, and double shoulder strap systems.

Variations of the three basic restraint systems can be made. Shoulder harness of double or single straps can be continuous with the lap belt or can be independent of the lap belt. Additions can be made to the basic double shoulder strap system by adding bias straps to improve lateral restraint. Hold-down straps can be added to the sides of lap belts or to the lap belt buckle to minimize upward movement when shoulder straps are attached at the center. Various restraint systems included in the evaluation are shown in figures as follows:

- Lap Belt Only (Figure 26)
- Continuous Lap Belt and Diagonal Shoulder Strap (Figure 26)
- Continuous Lap Belt and Double Shoulder Straps (Figure 26)
- Individual Double Shoulder Straps and Lap Belt (Figure 27)
- Individual Diagonal Shoulder Strap and Lap Belt (Figure 27)
- Forward-Facing Harness Concept (Improved Lateral Restraint) (Figure 27)

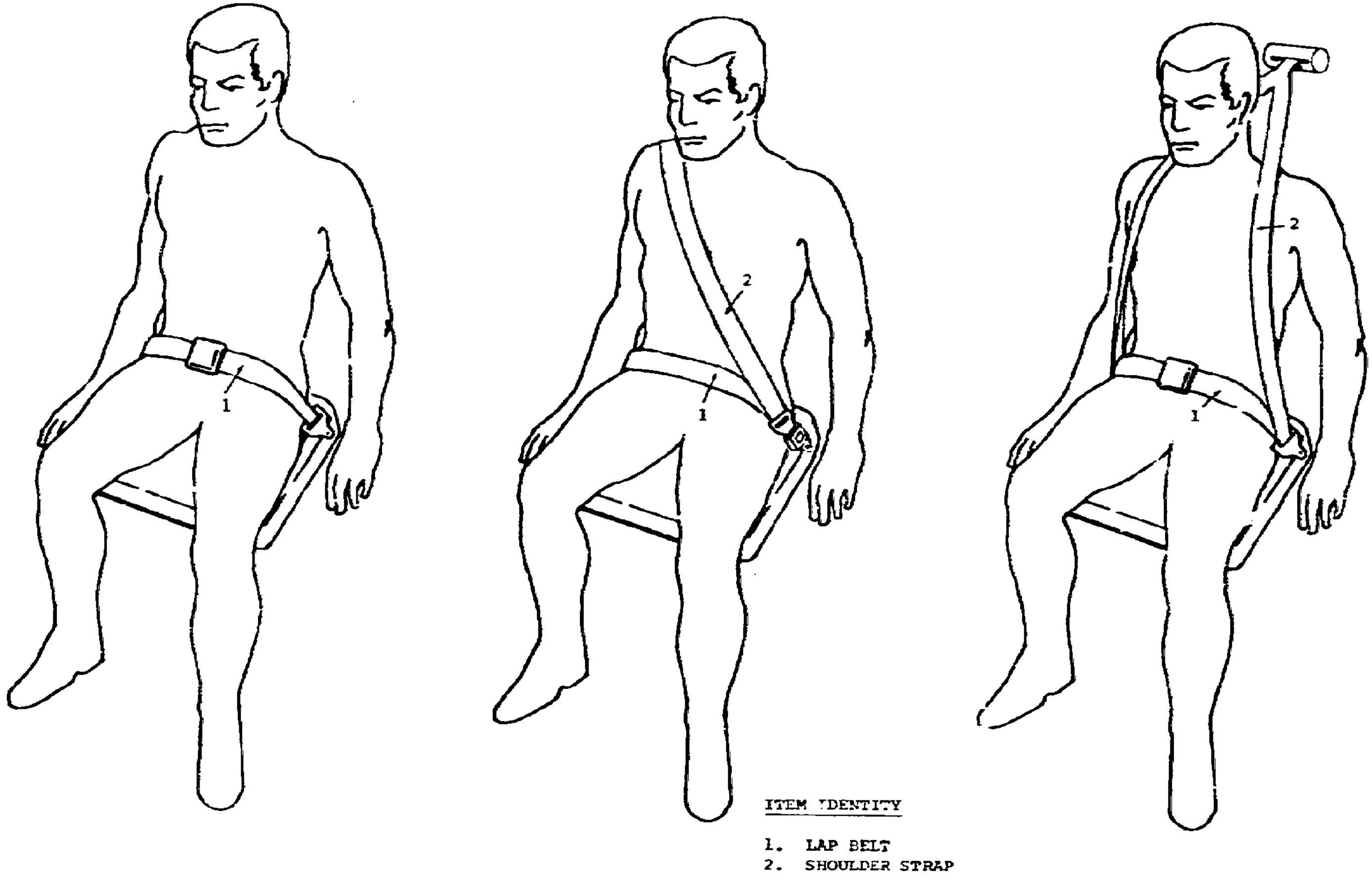
Full restraint such as was used in high-acceleration sled tests using a human subject was not considered in this investigation. Such restraints use head straps, chest straps, or body contoured restraint devices. Simpler restraint devices such as used or are being tested by the auto industry were considered because the more complex or full restraint systems probably are not practical for troops.

Human Tolerance Limitations

The three basic restraint systems were evaluated for human tolerance limitations.

Lap Belt Only

The lap belt is the most widely used form of restraint for passenger cars and aircraft. As stated by Snyder, "Commercial airline transports currently utilize only lap belts for passenger protection as do almost all general aviation aircraft in the United States, military troop transports, and military helicopter transports." "Even such advanced aircraft as the 750 passenger Lockheed C5A, a d the 490 passenger Boeing 747 will have only the lap belt system in all but aircrew cockpit positions."[15]

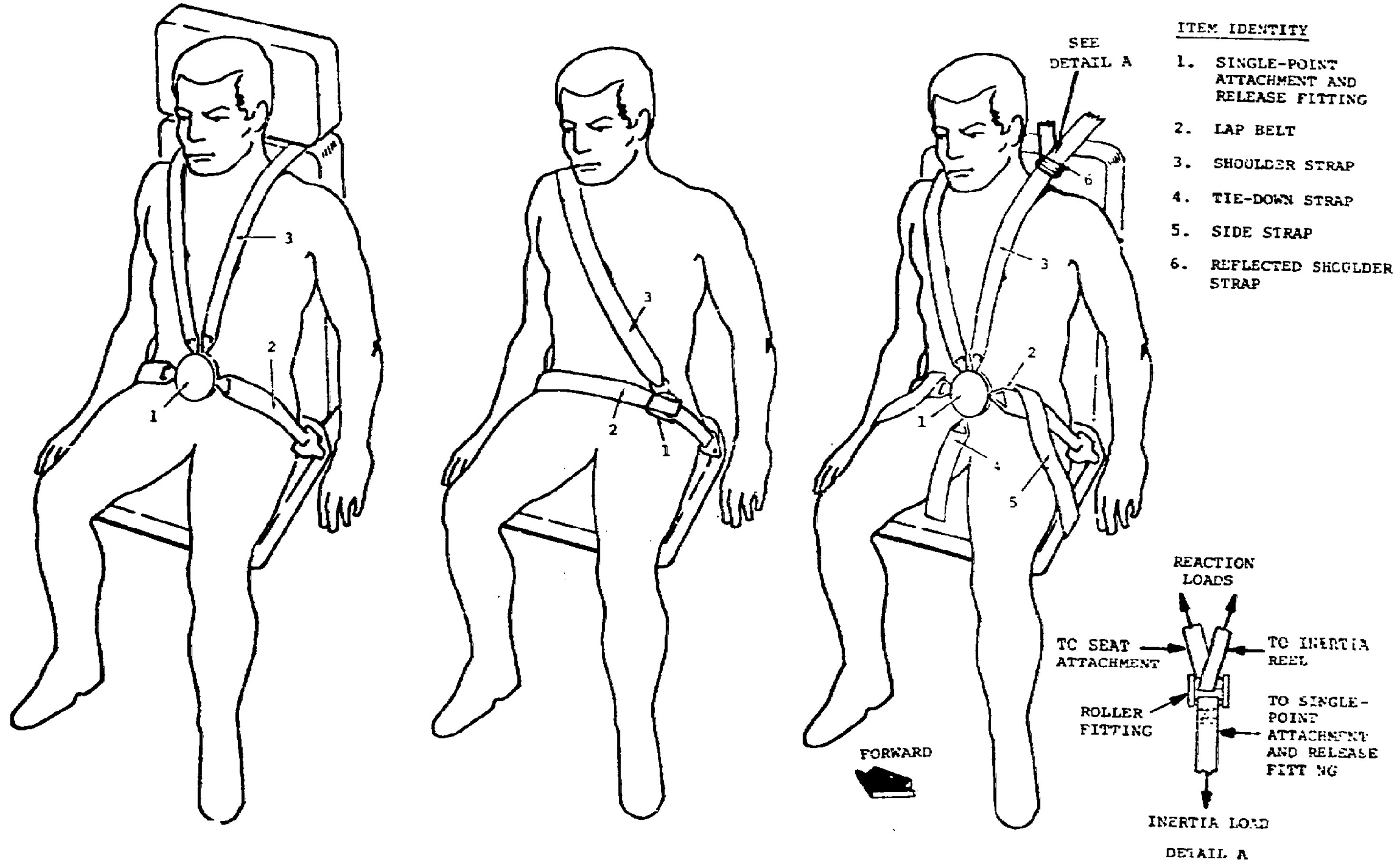


Lap Belt Only Restraint

Continuous Lap Belt and Diagonal Shoulder Strap.

Continuous Lap Belt and Double Shoulder Harness

Figure 26. Restraint System Concepts.



Individual Double Shoulder Harness and Lap Belt.

Individual Diagonal Shoulder Harness and Lap Belt

Forward-Facing Harness Concept (Improved Lateral Restraint)

Figure 27. Restraint System Concepts.

When properly installed, the lap belt restrains the body for forward accelerations at its strongest structural elements and reasonably close to the total body center of gravity.[15] Improperly installed lap belts and excessive acceleration can cause transverse fractures of the vertebral body. This is attributed to "high placement" of the lap belt which allows the belt to "act as a fulcrum literally splitting apart the vertebral body."[16] Few lap belts are properly installed in transport aircraft and automobiles today, where most have the anchor point too high and too far back. The result of properly and improperly installed lap belts is shown in Figure 28. Proper installation is shown in USAAMRDL's Crash Survival Design Guide, TR 71-22 (Figure 29).

Human Tolerance

Haley states that "personnel restrained by lap belts alone can sustain 25G in accordance with the known limits of human tolerance."[17] Tests were performed by Lewis and Stapp on live subjects with lap belt alone at accelerations up to 26G. Stapp concluded that "rates of onset between 250 and 1600G/sec and 11.4 to 32.0 peak G can be sustained against a lap belt restraint up to 90 psi average pressure load, with no significant injuries resulting.[18, 19]

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[15] Snyder, R. G., et al, PATHOLOGY OF TRAUMA ATTRIBUTED TO RESTRAINT SYSTEM IN CRASH IMPACTS, Document No. A68-38085, August 1968, Aerospace Medicine, Vol. 39, P.812-829, Supported by Federal Aviation Administration Research, Oklahoma City, Oklahoma.

[16] DeHaven, H. T., et al, AIRCRAFT SAFETY BELTS: THEIR INJURY EFFECT ON THE HUMAN BODY, Crash Injury Research of Cornell University Medical College, 1953.

[17] Haley, J. L., CRASH INJURY EVALUATION - PERSONNEL RESTRAINT SYSTEMS STUDY, CH-47 VERTOL CHINOOK, TRECOM TECHNICAL REPORT 64-4, by Aviation Safety Engineering and Research, Phoenix, Arizona, for U.S. Army Transportation Research Command, Fort Eustis, Virginia, April 1964.

[18] Stapp, J. P. VOLUNTARY HUMAN TOLERANCE LEVELS, CRASH INJURY AND CRASH PROTECTION (E.S. Gurdjian, W. A. Lange, L. M. Patrick, and L. M. Thomas, Eds.), Springfield, Illinois, Charles C. Thomas 1970, PP 308-349.

[19] Kourouklis, G., et al, THE DESIGN, DEVELOPMENT, AND TESTING OF AN AIRCREW RESTRAINT SYSTEM FOR ARMY AIRCRAFT, USAAMRDL Technical Report 72-26, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, June 1972, AD746631.

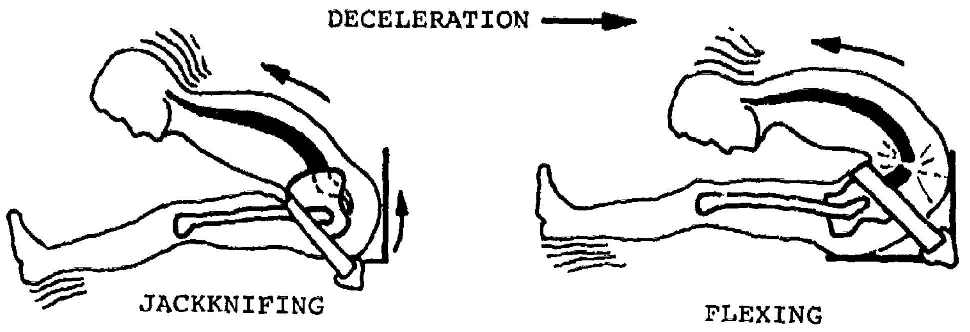

Figure 28. Body Jackknifing and Flexing.

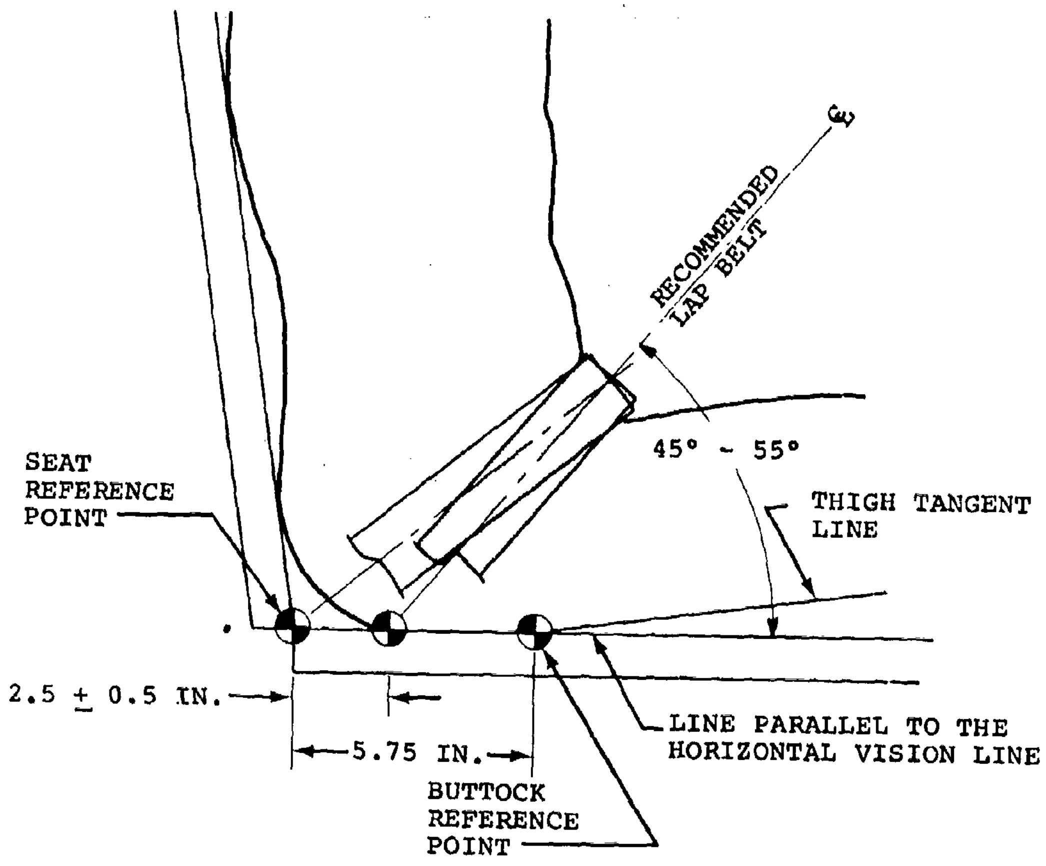

Figure 29. Lap Belt Anchorage Geometry.

Effects of higher loads have been investigated with animal subjects." In tests where the lap belt was purposely positioned high and loose, a 30G peak impact value (74.2 ft/sec entrance velocity, 3000G/sec onset rate, 20 degrees seat pan pitch, 0.055 sec plateau time, and 0.094 sec total impact duration) produced no significant injury.[19, 20] It has been found that seated human occupants restrained only by a 3-inch-wide lap belt can survive a peak deceleration of 30G at rates of onset below 1500G/sec with only minor reversible injurious effects.[18] DeHaven attributed "only bruises" due to the lap belt for "1029 survivors of 670 light aircraft accidents."[15, 16]

Recent tests were conducted by General Motors on human subjects with various restraint systems. Subjective reports on the test results were documented. The results of two tests on the Daisy accelerator at Holloman AFB are as follows:[21]

> Test No. 3514 G Level-20, Entrance Velocity 20.2 fps - Lap Belt Only
>
> "At impact the pressure was increased on my hip bone from the belt, but it did not seem to be as much as the previous day's ride. It seemed to be a much better ride, and I thought that I pulled less g than the previous day's ride, but I pulled more g on this ride. I think that this was due to the strapping and relaxing a little more. I found myself at impact; I let all of my breath out. This is also referred to as a KE-i in Judo. I was not really aware of this until I practiced it on a few rides. I do feel more comfortable when I am strapped in with a 3 inch lap belt, as compared with the 2 inch belt. To me, the 2 inch seems to slide down a little on impact. I held my breath a little after impact, but I felt no pain.

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[20] Snyder, R. G., et al, SEAT BELT INJURIES IN IMPACT, The Prevention of Highway Injury, Highway Safety Research Institute, The University of Michigan, 1967. (See also Federal Aviation Administration, Civil Aeromedical Institute, CAMI report.)

[21] Armstrong, R. W., et al, TESTING PROGRAMS AND RESEARCH ON RESTRAINT SYSTEMS, SAE-690247, Occupant Restraint Systems Section, Office of Vehicle Systems Research, National Bureau of Standards.

> My comments on strapping are: I feel that people do strap down a little bit tighter than I was strapped on Run 3597. And, I prefer the 3 inch lap belt. I really liked this particular ride."

> Test No. 3507 G Level 15.4, Entrance Velocity 19.9 fps - Lap Belt Only

> "Strapping was only on the lap. Strapping on this run seemed a little loose as compared to the way I strap myself in my car. I sat in the sled almost the way a person would sit in a car. I tried to stay fairly relaxed during the whole ride. At impact the pressure was increased on my hip bone, and it seemed as though my body was sliding forward, yet it was not painful. I had no difficulty breathing any time. No faintness or dizziness, and no pain at impact. I felt relieved after the run.

Acceleration levels experienced in these tests are comparable to levels which would be experienced in a 95th percentile forward impact on a troop seat with forward energy attenuation.

Diagonal Shoulder Strap With Lap Belt

Diagonal shoulder straps have rarely been used in aircraft restraint systems; however, current passenger cars are being equipped with this type of restraint. A continuous lap belt/ diagonal shoulder strap is being used in European motor cars; whereas in the American motor car configuration, the end of the diagonal strap is attached independently of the lap belt. Accident experience is limited with the American configuration due to its recent introduction and the infrequent use by occupants of cars that are equipped with the diagonal shoulder straps. Some data, however, is available.

The types of injuries attributed to the diagonal shoulder strap include "rupture of the spleen with fracture of ribs, fractured sternum,[15, 22] and hyper-flexion/hyper-extension cervical injury."[15,23] In a Dutch study, "three times as many chest

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[22] Fish, J., and Wright, R. H., THE SEAT BELT SYNDROME - DOES IT EXIST?, J. Trauma 5:746-750, 1965.

[23] DuBois, E. F., SAFETY BELTS ARE NOT DANGEROUS, British Medical Journal 2:605, 1952.

injuries were found for diagonal and 3 point users as for lap belt users."[15, 24]

Snyder summed up the disadvantages of the diagonal shoulder strap in stating that "it must fit the occupant correctly to be effective, and that in side impact, the occupant on the side opposite the impact may slip out of the harness, while the occupant on the near side might receive cervical injury from neck impingement on the belt."[15]

A properly installed diagonal shoulder strap together with a properly installed lap belt can increase human tolerance to higher accelerations than for lap belt alone. An improper installation of the diagonal strap may lower the human tolerance below the level for a lap belt alone.

Human Tolerance

Minimal data is available on human tolerance to forward acceleration while wearing a diagonal shoulder harness and lap belt. Military testing has been concerned primarily with lap belt alone or full restraint with double shoulder straps. Most of the human tests using diagonal shoulder straps have been conducted by the auto industry.

Tests were conducted by General Motors using human subjects restrained by lap belt and diagonal shoulder strap. Subjective reports on the test results were documented.

The results of three tests on the Daisy accelerator at Holloman AFB are as follows:[21]

Test No. 3498 G Level 16.3, Entrance Velocity 20.7 fps - Diagonal Shoulder Strap

"Firing occurred after a forty second countdown. During the acceleration, I opened my eyes and bit firmly on my mouthpiece. Acceleration was of a longer duration than I have experienced in the past. Firing was slow and smooth and the entire ride was without vibration or roughness. On impact several unusual experiences occurred. First, the force of impact was much greater than anticipated and bracing was not sufficient for the g forces experienced. Impact was of brief duration. As impact occurred I slid forward in the seat until stopped by the lap belt. Then forces loaded on the

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[24] Bastiaanse, J. C., and Boiromon, A. A., STATISTICAL STUDY EFFECTIVENESS (OF) SEAT BELTS, Rapport Rai-Tno, Instituut Voor Wegtransport Middelen., Netherlands, 1966.

upper portion of the body and impact was localized on the chest and neck regions after reaching maximum forward motion and impacting into the chest belting. On impact there was brief disorientation; however, there was no blurring or double vision at anytime. There was a "seeing of stars" experienced. There was no feeling of faintness or dizziness. There were several post-impact pains and sequela. There were strap burns on the neck and cheek regions that have scabbed and are still present at the end of 82 hr. For 48 hr or more, severe neck strain and pain was present. All other post-run feelings are remarkable."

Test No. 3513 - G Level 15.0, Entrance Velocity 19.6 fps - Diagonal Shoulder Strap

"The strapping for this run was purposely left relatively loose. The strapping consisted of a lap belt and a bandolier which ran across my upper body from the left shoulder to the right hip. My body was erect with my hands clasped between my knees. The acceleration was very smooth. At impact, my arms flew up and my head snapped forward. There was little pain at impact, although I did feel considerable pressure on my left shoulder from the bandolier. There was only minor redness of the skin in the area of the left shoulder from the bandolier. I felt almost no pressure at all from the lap belt, although the post run data from strain gauges indicated that I had exerted 900 lb of pressure on the lap belt at impact. The lap belt was relatively high on my waist and not down around the hip bones. From previous sled rides, I have learned that the impact is less painful if the lap belt rides slightly high on the lower abdomen. At the time of impact, there was no neck pain, but the next day I experienced considerable soreness in the muscles in the back of my neck. I feel that this was due to my upper body being stopped by the bandolier, while my head continued forward for a short distance at impact. It would seem that neck injuries of this sort will occur more frequently with the bandolier arrangement than would occur with only the lap belt."

Test No. 3515 - G Level 16.0, Entrance Velocity 20.5 fps - Diagonal Shoulder Strap

"I had very mild apprehension until I was being strapped into the seat. Once I realized how loosely I was being strapped, both lap belt and bandolier, I was quite apprehensive and somewhat dreaded the ride.

As mentioned above, the strapping was looser than on previous rides, and the lap belt would allow at least an inch forward movement of my buttocks. The bandolier would also allow my torso to move 2-3 inches forward. My position was forward, buttocks against the seat, both feet against the footrest, trunk upright in a position similar to normal driving position. My head was held up with some tightening of the neck muscles. My arms were extended toward my feet at about a 45 degree angle to the horizontal.

Acceleration was smooth. During acceleration I held my legs tensed against the footrest, my buttocks against the seat, and my neck muscles tensed with my head upright.

At impact my trunk was thrown forward until restrained by the bandolier. Immediately when my chest hit the bandolier I had a forced expiration. As I recall, I made an audible grunting noise with the expiration at impact.

I experienced no visual aberrations during or after impact. I had no difficulty breathing except that the bandolier knocked the wind out of me at impact. I had no dizziness or faintness.

At impact I didn't appreciate any pain, but very shortly thereafter I was aware of pain bilaterally below the anterior superior iliac spines, where the belt restrained my forward movement.

The day of the ride I noticed only slight discomfort where the lap belt rubbed. Also there were small bilateral bruises at these points. The day after the ride my neck was quite sore and stiff. It was just muscular soreness but involved almost all muscles of the neck. I had no discomfort from the area where the bandolier crossed the body.

> Immediately after impact I felt fine, relieved, and slightly sore where the lap belt hit my body."

Double Shoulder Strap With Lap Belt

The double shoulder strap with lap belt is the principal restraint system in use for pilots in military aircraft. It provides full torso restraint for forward and lateral accelerations. Double shoulder straps can be attached to double or single reels. Double reels permit full and independent retraction of straps. Single reels are connected to double straps by the inverted "Y" or "U" method and do not allow full or independent strap retraction. Side or center tie-down straps are used occasionally for preventing shoulder straps connected to the lap belt at the center from pulling the lap belt up and permitting submarining. Shoulder straps connected at the lap belt anchor fittings will not contribute to submarining.

Human Tolerance

The human tolerance limit to forward acceleration is approximately 50G peak (at 500G/sec rate of onset for 0.25 sec duration). Tolerance is reduced as rate of onset is increased. Rates of onset above 1300G/sec reduced the tolerance to below 38G for 0.16 sec duration.[18], [19] These human tolerance limits were established in experimental tests on human subjects wearing 3-inch-wide double shoulder harness, a seat belt with thigh straps, and a chest belt. Optimum attachment point geometry was used in the restraint installation on rigid structure. Installations of shoulder straps on seat points permitting high elongation or at points excessively above the occupant's shoulders will considerably reduce the human tolerance limits.

Displacement

The magnitude of human displacement in the forward direction due to forward acceleration is dependent upon the type of restraint used and the attachment geometry. Maximum displacement occurs when using a lap belt alone. Use of a diagonal shoulder strap produces somewhat less displacement, and the least displacement occurs when the double shoulder strap is used.

In tests conducted by General Motors using lap belt alone and lap belt with diagonal shoulder strap (Figure 30), the relative displacements of the human test subject's head can be compared. It can be seen in Figures 31 and 32 that the head displacement forward is the same for the subject restrained

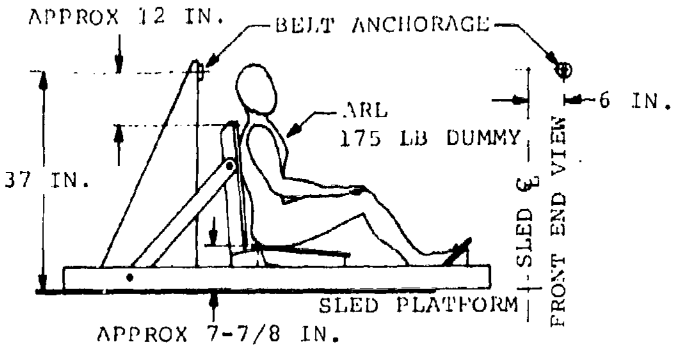

Figure 30. Restraint System Anchorage Geometry.

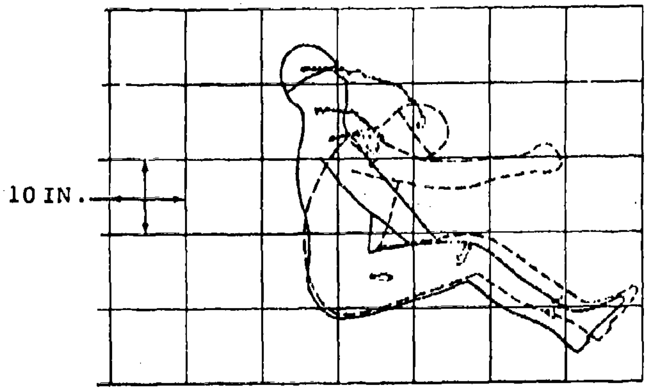

Figure 31. Human Kinematics, Holloman Daisy Sled 3513, 15.0G, Lap Belt/Diagonal Shoulder Strap.

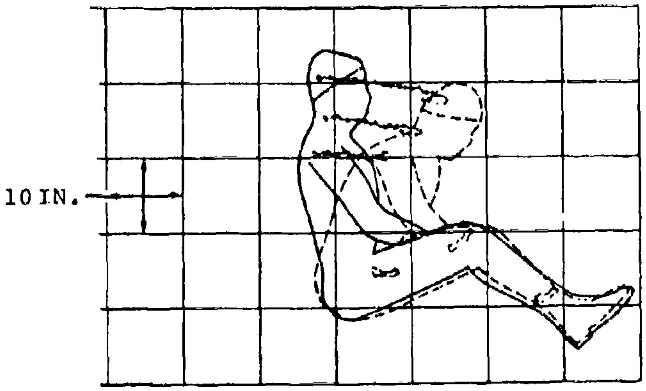

Figure 32. Human Kinematics, Holloman Daisy Sled 3514, 16.0G, Lap-Belt-Only Restraint System.

by the diagonal shoulder strap and the lap belt alone for accelerations of 15 and 16G respectively.

Tests at higher accelerations conducted by the FAA using anthropomorphic dummies give an excellent comparison of forward displacement when wearing lap belt alone, diagonal shoulder strap, and double shoulder straps. The entrance velocity for these tests was 40 fps.

A forward head displacement of approximately 38 inches, when a lap belt alone is used, is shown in Figure 33. Using a diagonal shoulder strap, a displacement of approximately 26 inches is shown in Figure 34. A double shoulder strap reduces the displacement to approximately 24 inches (Figure 35).[25]

In the above tests, the inertia reel for the shoulder straps was mounted on rigid structure directly behind the shoulders. For an installation where the shoulder strap attachment is at the ceiling, which is the most convenient location for a motor car and would also be a possible location for troop seats in low-ceiling utility type helicopters, much greater displacements can be anticipated. Tests were conducted by Hammil with a shoulder harness installation similar to that in a motor car (Figure 36). With a forward impact at 44 fps and a 30G impulse, the single diagonal shoulder strap was almost completely ineffective, as the dummy was completely doubled over (Figure 37).

The effectiveness of a diagonal shoulder restraint during lateral acceleration is minimal when the anchor point is located on the ceiling (Figure 37). In the test photographs (Figure 38) the dummy is shown nearly out of the diagonal shoulder strap and the head is twisted 90°. Only 10G impulse was exerted on the dummy in this test.

Crashworthiness Considerations

A lap-belt-only restraint system, on a troop seat with energy attenuating features for a forward crash impulse, provides adequate forward restraint. This assumes that there would be no contact of the occupant with the surrounding structure. In addition, a high percentage of helicopter accidents result in roll-over, inducing lateral loading on the occupants. Shoulder restraint is needed for this condition; without this restraint, human tolerance to lateral acceleration would be

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[25] Young, J. W., A FUNCTIONAL COMPARISON DECOMPRESSION OF BASIC RESTRAINT SYSTEM, Document No. N67-39865 for Office of Aviation Medicine, Department of Transportation, Federal Aviation Administration, June 1967.

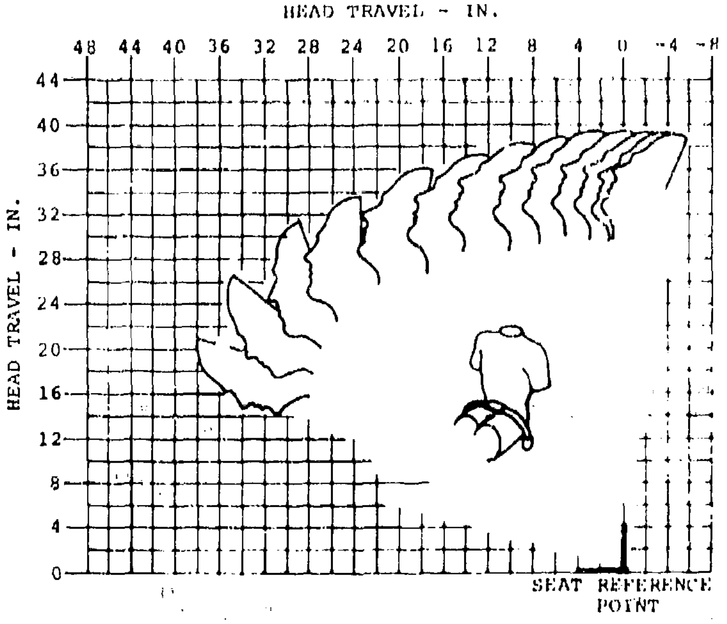


Figure 33. Lap-Belt-Only Restraint System.

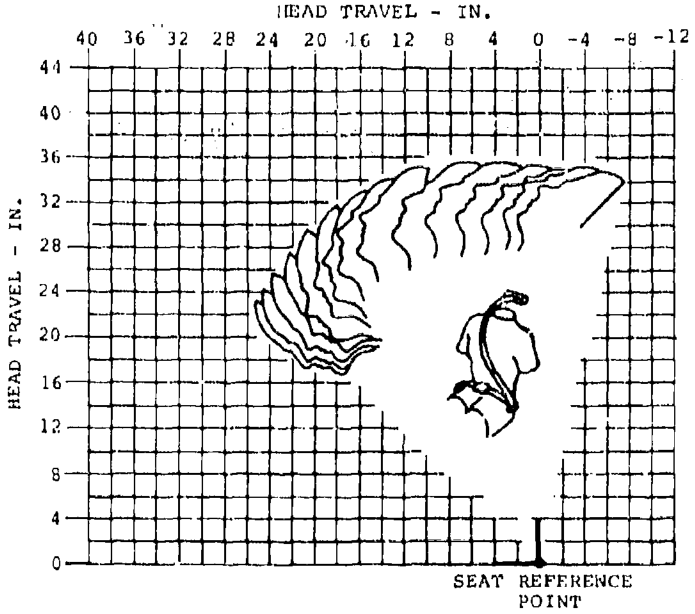


Figure 34. Continuous Lap Belt/Diagonal Shoulder Strap System.

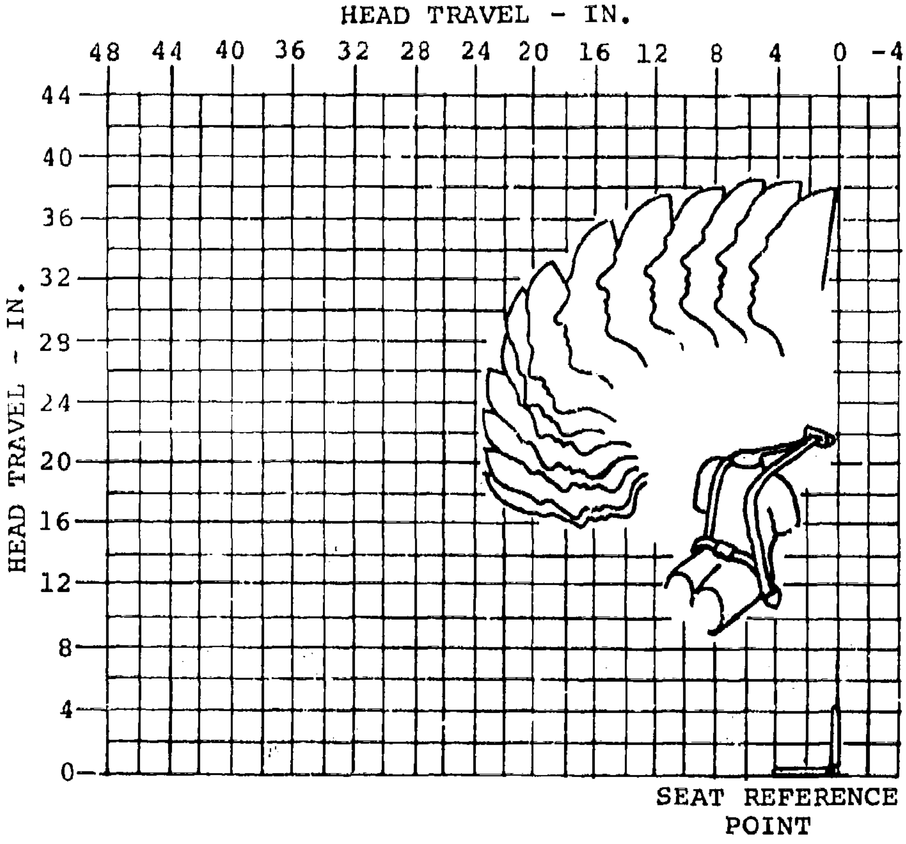


Figure 35. Continuous Lap Belt/Double Shoulder Strap System.

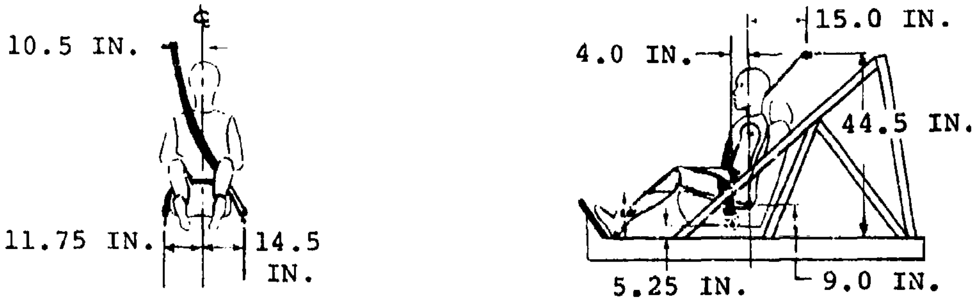


Figure 36. Restraint System Installation Geometry.

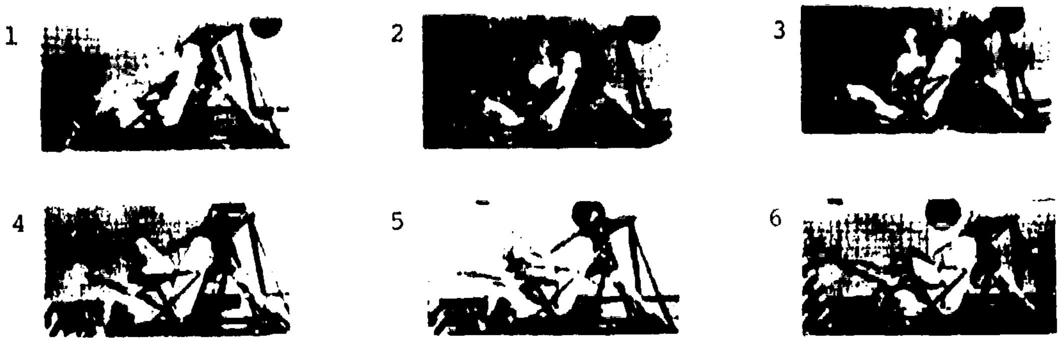


Figure 37. Forward Impact, 44 FPS, 30G Impulse.

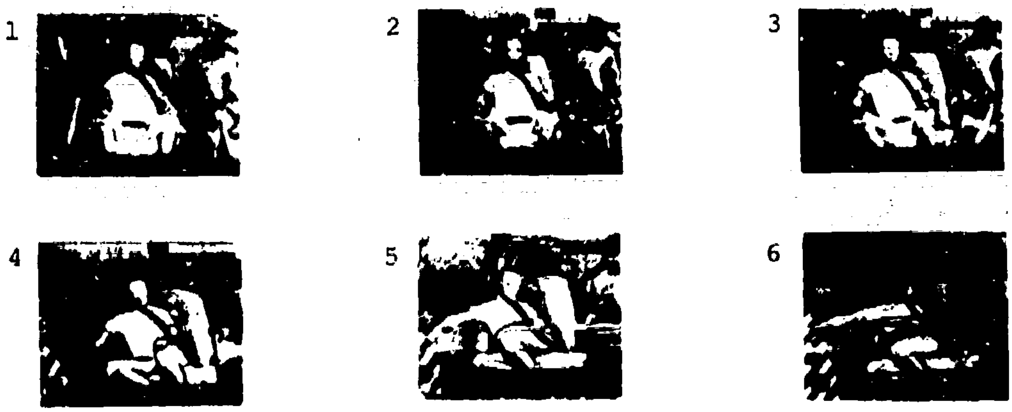


Figure 38. Lateral Impact, 29 FPS, 10G Impulse.

low. A single diagonal strap would provide lateral restraint to one side only; therefore, a double shoulder strap restraint system is more desirable. Shoulder restraint is also necessary to maintain the torso in an erect position for better tolerance to vertical impacts.

Operational Use

Discussions on the use of shoulder straps for troops with the Army operational unit personnel indicated that their use appeared to be impractical. It was the personnel's opinion that snagging and tangling of the shoulder harness on field packs, hand grenades and other equipment hanging from the suspenders and pistol belt are problems which would be encountered and would have to be resolved. Results from the 300 questionnaires returned from the field operations units showed a disfavor of shoulder harnesses for troops. Seventy-four percent felt that shoulder harnesses were unnecessary, and an equal percentage felt that they were impractical. Data from the responders indicate that lap belts are used a high percentage of the time by troops, but the use of shoulder harnesses was considered improbable unless it was a directed action.

Before a restraint system can be selected, a number of operational questions must be resolved.

- Can a shoulder restraint system be designed which would not cause entanglement with troop equipment and impede rapid ingress or egress?
- Should the restraint system be designed so that there is an option to use the lap belt alone even if both lap belt and shoulder harness are provided?
- Should the shoulder harness be incorporated as a continuous part of the lap belt so that if the lap belt is used, the shoulder harness also must be used?
- Should the shoulder harness be designed in a manner to stimulate use by projecting forward, causing discomfort to the occupant until pulled down and fastened to the lap belt?
- Should the restraint system be designed for one-hand fastening?

These questions must be answered before a restraint system can be selected, and the selected system must be evaluated through operational demonstrations before a final configuration is accepted.

In response to the questions, a restraint system can be designed for shoulder straps which would not entangle with troop equipment or impede egress. Such a system would use a fully retracting shoulder strap or straps which retract vertically and would be out of the way by the time troops got out of their seats for egress.

Use of a lap belt alone is not desirable during forward impacts when shoulder straps are provided on a crashworthy troop seat. The ceiling energy attenuators are designed to stroke under the shoulder harness loads, and the under-seat energy attenuators carry the lap belt loads. Use of the lap belt alone would put more load on the lower attenuators, causing them to stroke farther than the upper attenuators. A system should be provided whereby the shoulder straps prevent a person from sitting in the seat comfortably unless the shoulder strap or straps are fastened.

Use of a continuous lap belt/shoulder strap should be avoided, as the loop formed by this arrangement would snag on troop equipment during egress. Snagging would occur with either a single or double continuous shoulder strap system. The continuous strap system would also present more difficulty in donning. If an independently connected lap belt/shoulder harness system is used, ejection springs should be incorporated in the buckle to prevent loops from being formed due to hang-ups.

In considering the necessity of one-hand operation for fastening lap belt and shoulder straps, the only advantage is the ability to hold a weapon in the other hand. The disadvantages far outweigh the advantage, and a weapon can be held by the knees. The disadvantages are that the buckle must be fixed to the side of the seat, which limits the restraint system to a diagonal type with its associated problems, including the problem of reaching across troop equipment to make a side attachment. Results of the questionnaire show that the majority feel a one-hand operation is unnecessary and side attachment would be more difficult than center attachment.

Installation

For a shoulder harness system to be effective, an inertia reel or harness guide is required directly behind the shoulders, mounted on structure which does not deflect excessively. The strap angle must conform to the requirements given in the Troop Seat Draft Military Specification.

Without a rigid support for the shoulder harness reel behind the shoulders, the harness would bow, permitting forward rotation of the upper torso, as was witnessed in tests simulating the shoulder strap anchored to the ceiling of a car (Figure 37).

Such high elongation of the shoulder strap was found to cause whiplash of the head, which would result in cervical injury or even brain stem severance, which is instantly fatal.

Seat Orientation

Seat orientation influences the type of restraint system to be selected. All restraint systems are not equally suitable for all seat orientations. As an example, shoulder straps are not as critical on aft-facing seats as on forward-facing seats due to the restraint afforded by the seat back. For side-facing seats, the emphasis would be on lateral restraint rather than forward restraint. Crotch straps, if used, are more necessary on forward-facing seats than other orientations. A diagonal shoulder strap which may not be adequate for a forward-facing seat is preferable for a side-facing seat because the strap load and elongation are less during forward impact than they would be for vertical shoulder straps. Vertical shoulder straps are subject to the bow string effect during lateral loading, while a diagonal strap is more in line with the load direction. Rearward restraint is compromised when the diagonal strap is used on side-facing seats; but, due to the low probability of rearward crash impacts, the improved restraint for forward crash impacts is worth the risk. The addition of an arm strap on the harness or compartmentation panels on the seat sides could be considered for further improving restraint in side-facing seats.

Occupant Environment

Space availability around a troop seat plays an important part in restraint selection. If rigid objects or structure is within the rotational envelope of the upper torso, the need for shoulder restraint is more acute than if no obstructions are within the envelope. There are several alternatives if obstructions exist. Rigid structure can be padded and auxiliary structure or panels can be designed to yield under impact, or adequate shoulder restraint can be provided to minimize torso rotation.

Energy Attenuation

An energy attenuating troop seat reduces forward acceleration in a 95th percentile impact to within human tolerance limits when using a lap belt alone in forward- or rearward-facing seats. However, lateral impacts on forward- or aft-facing seats at required design impulses cannot be tolerated without shoulder restraint. It is difficult to design side-facing seats to attenuate forward impact pulses to within human tolerance limits with shoulder restraint, and without restraint it is improbable. For these reasons shoulder restraint is necessary for lateral restraint.

Simplicity, Cost and Weight

In considering only simplicity, cost, and weight, the lap belt alone would be the best restraint system selection. Other considerations dictate the use of shoulder restraint. Therefore, of necessity, weight and cost will be increased to provide shoulder straps. The use of one or two shoulder harness reels, depending upon the operational requirements, will add more complexity. Reel weight and cost can be minimized by adapting commercially available, nonaircraft reels to troop seat use.

Human Factors

Human factor effects on the design and selection of an optimum restraint system involve the consideration of variable occupant sizes, variety of clothing and equipment worn by troops, and the adjustments necessary to accommodate these conditions. Adjustments of restraint systems can be automatic or manual depending upon the degree of weight and complexity acceptable. Locking reels or inertia reels can be used to provide automatic adjustment for lap belts or shoulder harnesses. Restraint system stowage is another factor, the necessity of which depends upon restraint access for donning and encumbrances during egress. These factors can best be evaluated by actual mockup involving the use of troops with the variety of troop sizes and equipments. Such evaluation was conducted and is discussed later in this report.

AVAILABLE RESTRAINT SYSTEMS

The use of standard restraint systems or components of previously used systems in general is not acceptable to the troop seat restraint system. The principal reason is their inadequacy of size and load-carrying capability. The troop seat restraint system must be simple to operate by troops inexperienced with the system; and fast ingress, hookup, release and egress are prime considerations. Standard restraint systems and components will not meet these requirements. An investigation was made of existing restraint systems and components as follows:

Restraint System Components

Hardware for restraint systems presently used in aircraft is for webbing widths of 1.75, 2.00 and 3.00 inches nominal. Data on detail components are shown in Table 4, and data on lap belt and shoulder harness assemblies are shown in Table 5. The load capabilities given are from MIL-SPECS, and these loads indicate that the present hardware is inadequate for the required loads of crashworthy seats. Actual hardware may be

TABLE 4. AVAILABLE RESTRAINT HARDWARE

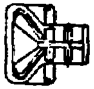
ITEM	PART NUMBER	SKETCH OF PART	WEB WIDTH (in.)	PROOF TENSILE LOAD (lb)	ULTIMATE TENSILE LOAD (lb)
Link - Lap Belt Buckle	MS 22003 USAF 50B3949		3.00	3,000	4,500
Latch - Lap Belt Buckle	MS 3488 NAF 311518-8		3.00	3,000	4,500
Anchor - Lap Belt	MS 22010 USAF 51B3978		3.00	3,000	4,500
Adjuster - Lap Belt	MS 22004 USAF 51A3697		3.00	3,000	4,500
Latch - Lap Belt Buckle	USAF 44B26452		1.75	2,250	
Anchor - Lap Belt	USAF 44B26454		1.75	2,250	
Anchor - Lap Belt	USAF 42A4029 USAF 49B7414		1.75		
Adjuster Belt or Shoulder Strap	MS 22007		1.75	2,000	

TABLE 4. (CONTD) AVAILABLE RESTRAINT HARDWARE

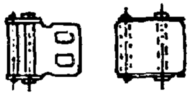
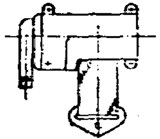
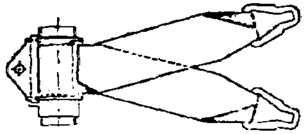
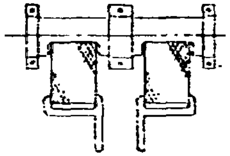
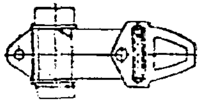
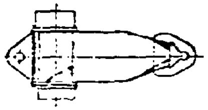
ITEM	PART NUMBER	SKETCH OF PART	WEB WIDTH (in.)	PROOF TENSILE LOAD (lb)	ULTIMATE TENSILE LOAD (lb)
Anchor - Lap Belt	FD-1497 Davis Aircraft		2.00	2,500	2,700
Anchor - Lap Belt	FDA-1677-1 Davis Aircraft		2.00	3,000	
Adjuster - Lap Belt or Shoulder	FDA-4937		2.00	2,500	2,700
Buckle & Link-Lap Belt	FDA-2707M6 FDA-3105M3 Davis Aircraft		2.00	2,500	2,700
Buckle & Link Lap Belt	449345 American Safety		2.00		3,000

TABLE 5. AVAILABLE RESTRAINT ASSEMBLIES

ITEM	PART NUMBER	WEB WIDTH (in.)	WORKING LOAD (lb)	PROOF TENSILE LOAD (lb)	ULTIMATE TENSILE LOAD (lb)
Safety Belt Assembly	NAF 1201-8 MS 22033	3.00		3,000	4,500
Safety Belt Assembly	USAF 51H3977	3.00		2,500	
Safety Belt Assembly	MS 90368	3.00	1,250	2,500	
Safety Belt Assembly	AN 6506	1.75	1,250	[illegible],250	
Shoulder Harness	MS 16069	1.75	3,000	4,000	
Shoulder Harness	MS 16068	1.75	2,775	3,775	

TABLE 6. AVAILABLE SHOULDER HARNESS REELS

ITEM	PART NUMBER	SKETCH OF PART	WEB WIDTH (in.)	PROOF LOAD (lb)	ULTIMATE LOAD (lb)
1	MIL-R- 8236 TYPE MA-6		1.75	2,660	4,000
2	2B25D4X Pacific Scientific Company		2.00		2,000
3	3C25D4Y Pacific Scientific Company		2.00		4,000
4	Airstyle 1 Retractor American Safety Inc.		2.00	1,500	2,100
5	Airstyle 11 Inertia Reel American Safety Inc.		2.00	3,000	4,000

capable of higher loads, but tests would be required to determine the additional capability above the MIL-SPEC requirements.

Data on available shoulder harness reels is shown in Table 6. This data indicates that available reels will meet the shoulder harness load requirements.

Restraint System Webbing

The restraint system webbing must have high-strength and low-elongation properties and must meet environmental, abrasion and life requirements. It must be sufficiently flexible to loop through adjusters and not slip. Nylon has been the principal material used in restraint system webbing and meets most of these requirements, but it does not meet the low elongation requirement. Polyester webbing acceptably meets all of the requirements and has a longer life than nylon. The low elongation feature is accomplished by processing during or after weaving. The webbing can be woven under tension or can be tensioned and heat-set after weaving.

Low-elongation polyester webbing was investigated for design load conditions. Forward, lateral and vertical loading was considered separately as well as combined three-axis loading. The critical loading conditions are shown in Table 7 assuming three-axis energy attenuation.

TABLE 7. CRITICAL DESIGN LOADS (TENSILE), THREE-AXIS ACCELERATION

Restraint Item	Design Load (lb)	Ultimate Load (lb)
Lap belt without shoulder straps	4000	6000
Lap belt with shoulder straps	2600	4000
Shoulder straps full load on 1 strap	2100	3000

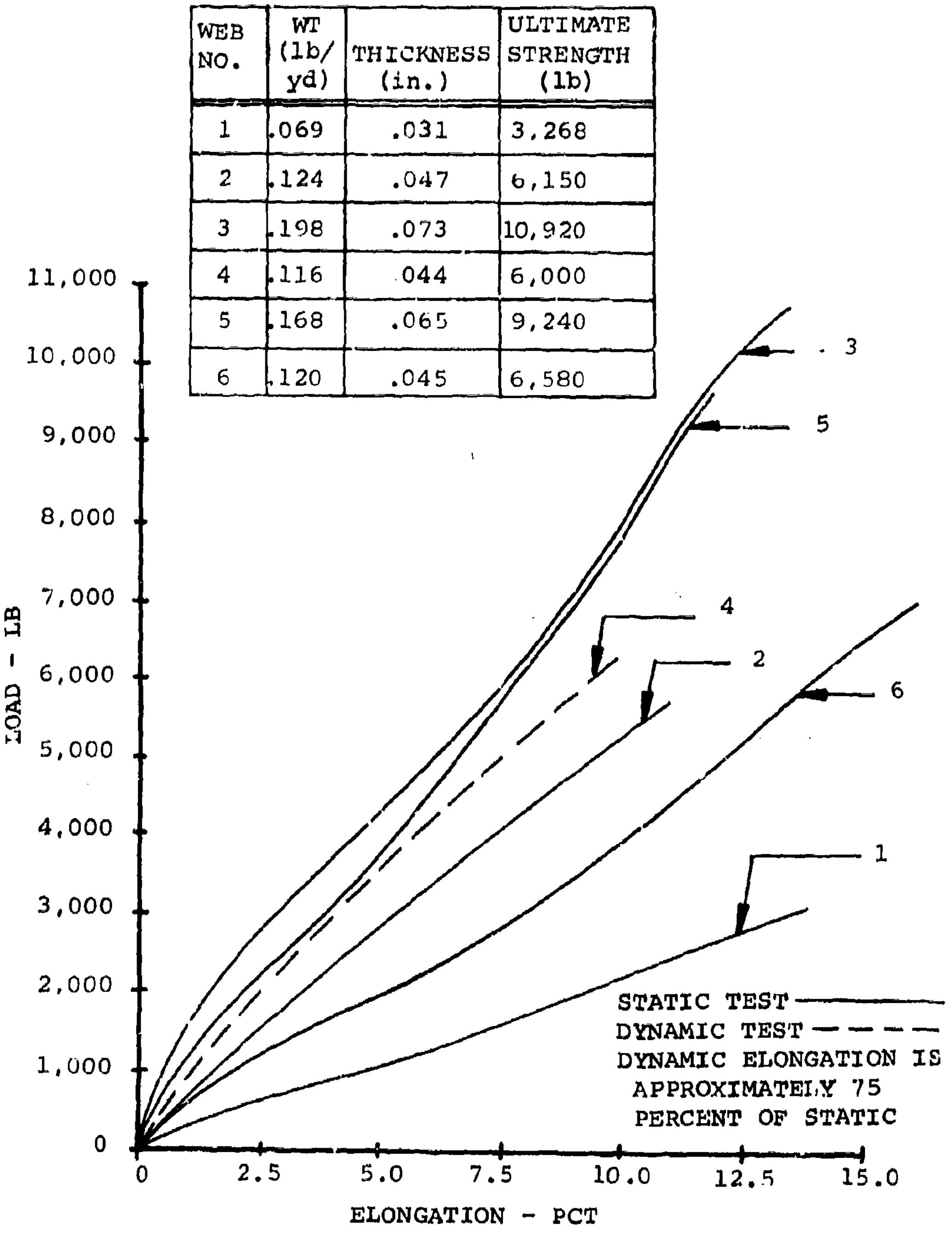
Loads are based on the weight of a 95th percentile troop with equipment totaling 242.3 lb.

Elongation tests were conducted by the webbing manufacturer on polyester webbing of nominal 2-inch width. Load elongation curves are shown in Figure 39 for six thicknesses. Although the data is on 2-inch webbing, the load and elongation characteristics can be extrapolated for various webbing widths. The data shows that load and elongation requirements for the restraint system can be met with polyester webbing in reasonable thicknesses. A shoulder strap of 1.75- or 2.00-inch width and .047-inch thickness will elongate much less than the specification limit of 4.5% at the design load of 2100 pounds (Table 8). The lap belt has a design load of 2600 pounds when used with shoulder straps and 4000 pounds when used alone. A 2.25-inch-wide, .065-inch-thick polyester webbing will not exceed the 4.5% elongation limits for either condition (Table 9). This data is based on static tests, whereas dynamic loading will cause approximately 25% less elongation. In addition to the strength and elongation characteristics, polyester webbing has the following features:

1. Hexagonal bar abrasion is equivalent to nylon. Buckle abrasion is somewhat less than nylon but only on the order of 2 to 5 percent.
2. Coatings generally are not used to improve abrasion resistance and may not be necessary.
3. Can be yarn dyed or piece dyed.
4. Requires tensioning heat setting and quenching to improve low-elongation qualities.
5. Resistance to adjuster slippage is equivalent to nylon for equal thickness material. Polyester webbing is usually thinner and requires an increased angle through adjuster.
6. Cost relative to nylon would be approximately 20 to 25% higher.

RESTRAINT SYSTEM SELECTION

The selection of a restraint system for troops cannot be made on the merits of a restraint system alone. If this were the case, the selection would be a full restraint system with double shoulder straps for forward acceleration, bias straps at the shoulders for lateral acceleration, and a tie-down strap to minimize submarining. Consideration must be given specifically for a restraint system suitable for troop use. In addition, the requirements for installation, orientation, operations, energy attenuation and other requirements discussed in the evaluation section were considered.



WEB NO.	WT (lb/ yd)	THICKNESS (in.)	ULTIMATE STRENGTH (lb)
1	.069	.031	3,268
2	.124	.047	6,150
3	.198	.073	10,920
4	.116	.044	6,000
5	.168	.065	9,240
6	.120	.045	6,580

Figure 39. Polyester Webbing Load Deflection Curves.

TABLE 8. PERCENTAGE OF WEBBING ELONGATION

(EXTRAPOLATED FROM 1-15/16-INCH POLYESTER WEBBING STATIC TESTS)

DESIGN LOAD (lb)	WEBBING WIDTH (IN.) FOR .047 IN. THICKNESS					
	1.75	2.00	2.25	2.50	2.75	3.0
4000	8.25	7.20	6.25	5.50	4.90	4.50
3000	5.90	5.20	4.50	4.00	3.55	3.25
2600	5.1	4.4	3.8	3.45	3.10	2.75
2100	4.00	3.40	3.00	2.70	2.40	2.20

TABLE 9. PERCENTAGE OF WEBBING ELONGATION
(EXTRAPOLATED FROM 1-15/16-INCH POLYESTER WEBBING STATIC TEST)

DESIGN LOAD (lb)	WEBBING WIDTHS (IN.) FOR .065 IN. THICKNESS					
	1.75	2.00	2.25	2.50	2.75	3.0
4000	5.85	5.15	4.40	3.85	3.40	3.10
3000	4.30	3.60	3.10	2.60	2.25	2.00
2600	3.50	2.90	2.50	2.25	1.80	1.60

Restraint System Selection Criteria

After considering the evaluations and features of the various restraint systems, the following restraint system criteria are established for restraint system selection:

1. The selected restraint system shall consist of a lap belt and shoulder harness. It is preferable that the shoulder harness be a two-strap system connected to the lap belt buckle at the center of the occupant. In the event that a single diagonal strap is used, preferably on side-facing seats, it shall be connected to the lap belt buckle, the center of which shall be 7.5 inches ± 1 inch from the anchor point.
2. A flexible sleeve shall be provided on the lap belt near the anchor points. The sleeve shall stiffen the lap belt, causing it to project upward 5 inches above the seat pan to facilitate donning and differentiating with lap belts of adjacent seats.
3. Release of the lap belt and shoulder harness shall be simultaneous by a single operation with either wrist using a lift lever release.
4. The shoulder strap or straps shall disconnect from the lap belt so that a loop is not formed which would snag on troop equipment.
5. The lap belt strength shall be sufficient to withstand the full load of the accelerated occupant without the shoulder harness attached.
6. The lap belt buckle shall provide for attachment of the shoulder harness after the lap belt is fastened.
7. The lap belt buckle on double shoulder strap systems shall be easily adjustable so that the buckle can be centered.
8. The shoulder harness shall be fully retractable to a position easily reached over the occupant's shoulder when wearing combat equipment.
9. Restraint system webbing shall be made of low-elongation, high-strength polyester material.

Selected Restraint System

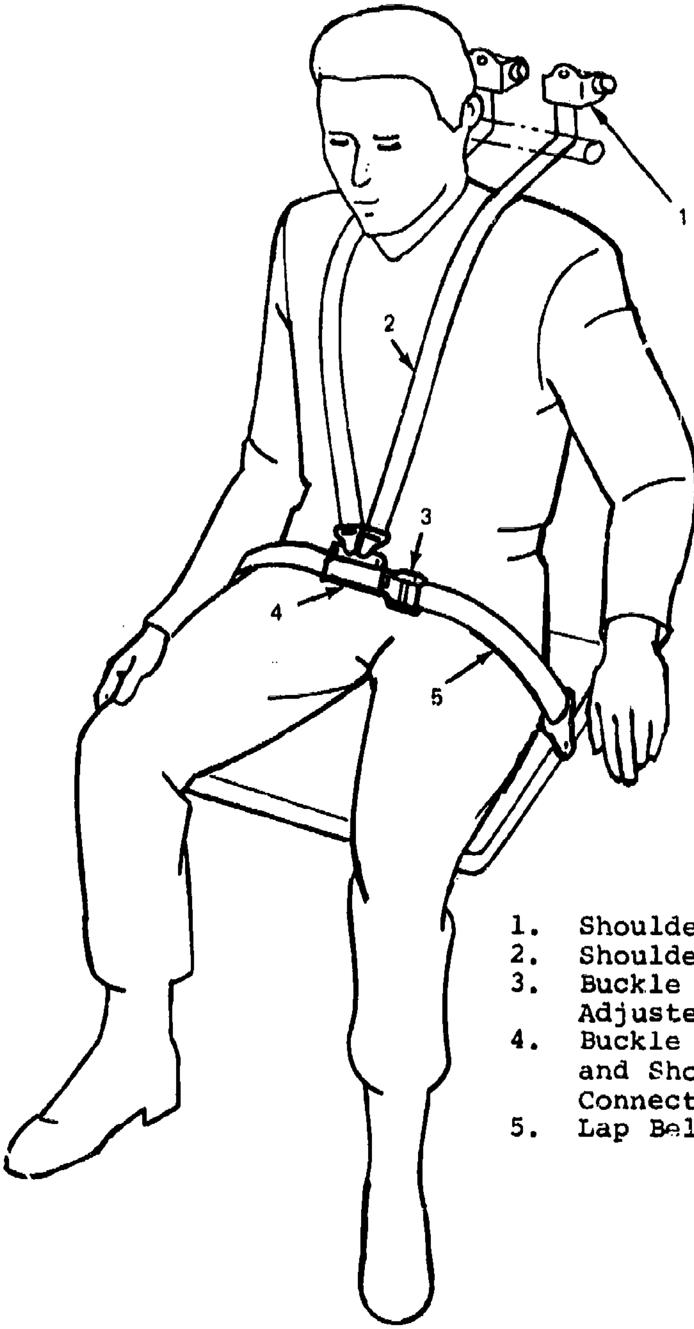
Of the six types of restraint systems considered, two were selected as optimum for use on crashworthy troop seats. The lap-belt-only system was not selected primarily because it does not provide lateral restraint, which is necessary to increase human tolerance to impacts in the direction where human tolerance is lowest. Continuous lap belt/shoulder strap configurations are not acceptable because they form loops when disconnected and will snag on combat equipment during egress. Configurations with reflected shoulder straps and lap belt tie-down straps were rejected because of their complexity. Tie-down straps, intended to prevent submarining, are not necessary on troop seats because submarining is minimal in seats without seat cushions.

A restraint system which can most nearly meet all the requirements and conditions considered in the evaluations is the individually attached double shoulder strap system (Figure 40). This system is preferred for forward- and aft-facing seats. It uses a lap belt with four-point metal-to-metal cam buckle and lift lever latch. Tapered slots in the top of the buckle accept the shoulder strap end fittings, which can be inserted after the lap belt is fastened. Adjusters are incorporated in the buckle on one side and latch plate on the other side. Lap belt reels or retractors are preferred to help the occupant find the lap belt straps for donning and to automatically tighten the belt; however, reels were not used in the selected restraint configuration because of added weight and cost and the lack of space between seats for installation. To install reels under the seat pan is not practical because seat stroke would be reduced at least 2 inches. If space is available and additional cost and weight can be afforded, lap belt reels should be used. The selected restraint concept provides manual adjustment and flexible sleeves at the anchor fittings, which cause the lap belt to stand up and which help in donning (to be discussed later in the report; Figure 94).

Shoulder harness reels are provided which fully retract the shoulder harness until the end fittings are within easy reach behind the occupant's shoulders. Two reels are used to permit the full retraction of the straps. Each shoulder strap is extended forward from the seat back by a flexible guide sleeve so that it can be reached when combat packs are worn. The presence of the guides beside the head would be uncomfortable and would induce the occupant to pull them down to the shoulders by fastening the shoulder straps to the lap belt buckle.

The system when released does not form loops which can snag troop equipment. Spring ejectors for the strap fittings in the lap belt buckle prevent the straps from hanging up and forming loops. Shoulder straps are immediately retracted after release to prevent egress encumbrance and to reposition them for easy access during ingress.

The restraint system concept recommended for side-facing seats is an independently attached lap belt/diagonal shoulder strap



1. Shoulder Strap Reel
2. Shoulder Strap
3. Buckle Link With Adjuster
4. Buckle With Adjuster and Shoulder Harness Connections
5. Lap Belt

Figure 40. Forward- and Aft-Facing Seat Restraint System Configuration.

system (Figure 41). It is similar to the above selected system with the exception that a single diagonal shoulder strap is provided. The diagonal strap is placed over the forward shoulder to restrain the occupant under the higher and more predominant forward accelerations. The same lap belt buckle is used as in the forward- and aft-facing seats, but only one of the shoulder strap connections is used. A single, fully retractable shoulder harness reel with strap guide is provided. The lap belt buckle is fixed to the left side of the seat with a flexible sleeve, causing the buckle to project upward.

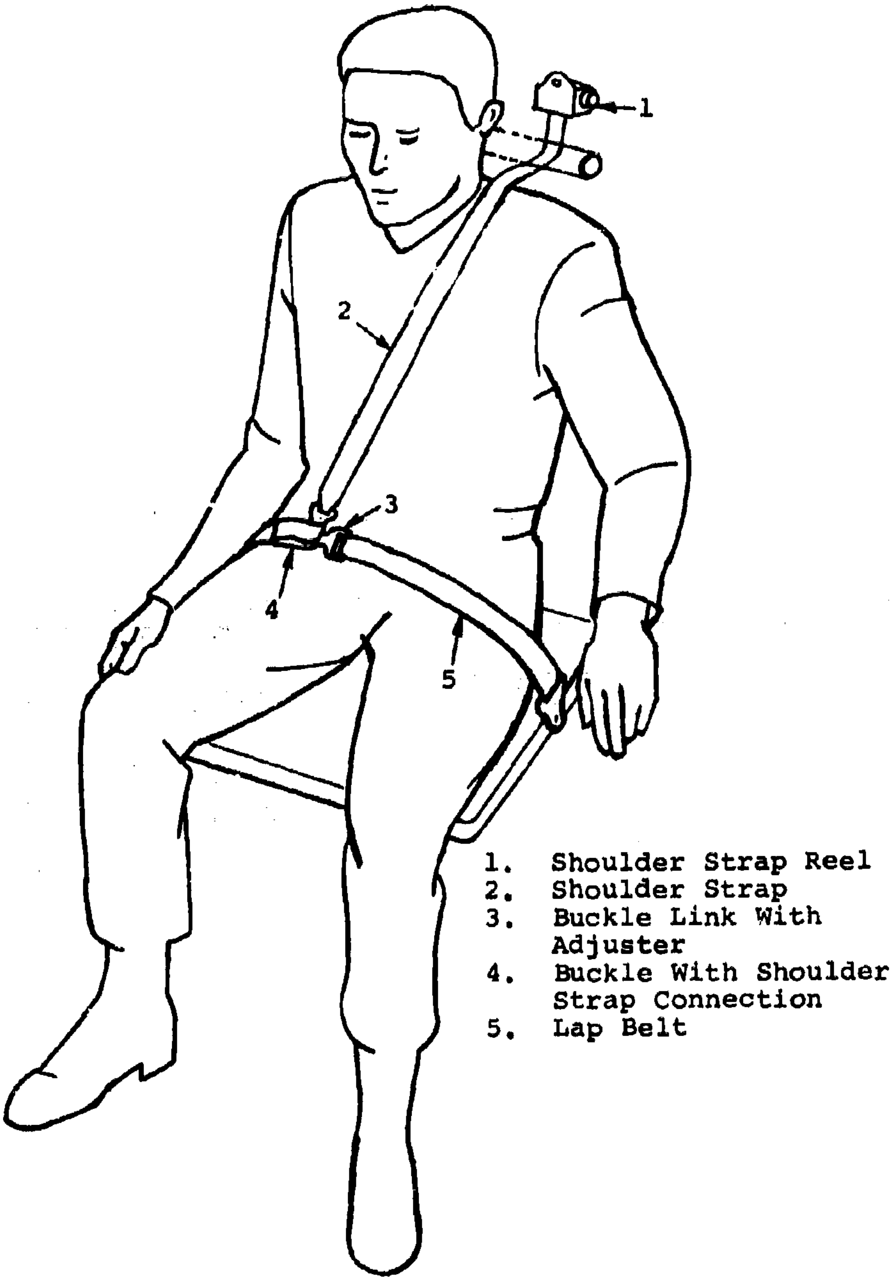


Figure 41. Side-Facing Seat Restraint System Configuration.

CRASHWORTHY TROOP SEAT SYSTEMS CONCEPT DEVELOPMENT

DESIGN CRITERIA

In developing the troop seat systems concepts, the criteria used for the various design considerations are as follows:

Seat Configuration

1. The seat pan shall be 22 inches wide and 15 inches deep and shall have an 8-inch extension to accommodate a combat assault pack.

2. An auxiliary back shall be provided and shall be attached to the seat pan at the 15-inch seat depth point. It shall be readily released for occupants wearing a pack. The maximum height shall be 26 inches so as not to interfere with shoulder straps.

3. The seat pan height shall be no less than 17 inches nor more than 18 inches.

4. The seat pan support shall be provided considering maximum freedom for ingress and egress.

5. The seat bucket shall be designed such that openings or loops are not formed which could snag on troop-carried equipment.

6. The seat shall fold to a maximum thickness of 6 inches.

Restraint System

The detail criteria for the restraint system are covered in a previous section on restraint analysis and evaluation. Those aspects of the restraint system which affect seat design are as follows:

1. A lap belt and shoulder harness shall be provided for all seat concepts. A double shoulder strap system is preferred for forward- or aft-facing seats, and a single diagonal shoulder strap is preferred for side-facing seats.

2. The shoulder strap or straps must disconnect from the lap belt so that a loop is not formed which would snag on troop equipment.

3. The lap belt anchor fittings shall be located on the seat pan in accordance with the Draft Troop Seat Military Specification.

4. The shoulder harness must be fully retractable to a position where the end fittings are easily reached over the occupant's shoulders when wearing combat equipment.

5. The seat shall be designed to minimize the possibility of the lap belt falling behind or below the seat.

6. Provisions shall be made to assist in differentiating between the lap belt of one seat and that of the adjacent seat.

7. The seat shall be designed such that the shoulder harness reel is mounted on sturdy seat structure which reacts to the shoulder harness loads with minimum deformation. Seats without back structure shall require auxiliary structure rigid with the aircraft structure on which to mount the reel. The reel, if mounted on structure other than the seat, shall be capable of moving with the seat in a vertical direction and shall have a load-limiting provision which allows the reel to pay out when the seat strokes in the forward direction.

8. The shoulder harness reel or shoulder strap guide shall be located in accordance with Figure 6 of the Draft Troop Seat Military Specification.

Crashworthiness

1. The seat shall have an energy attenuation capability in the vertical direction to prevent the 5th through 95th percentile occupants from experiencing decelerations in excess of 23G.

2. Vertical seat stroke shall be not less than 14 inches for a maximum seat height of 18 inches.

3. Energy attenuation devices are not required for forward and lateral crash impact loads; however, attenuation provisions shall be considered in an effort to reduce seat loads, thereby minimizing weight.

4. Energy attenuating devices which produce a trapezoidal-shaped force deflection curve shall be favored for vertical crash load attenuation.

5. Use of energy attenuators in series (above and below the seat) for vertical crash load attenuation shall be avoided if possible.

6. Energy attenuators shall be positioned such that a shift in the center of gravity of the mass on the seat pan does not appreciably affect seat attitude during stroking.

DESIGN CONSIDERATIONS

Basic Seat Configuration

In establishing the basic crashworthy troop seat configuration, the dimensions shown on Figure 14 of the Draft Troop Seat Military Specification were used. These dimensions for the seat pan were verified by using a 95th percentile occupant with combat equipment and a combat assault pack (Figures 42 and 43). A planform was used with a width of 22 inches and depth of 15 inches in the seating area. An extension of the seat pan 8 inches to the rear to accommodate the 8-inch-deep butt pack brings the seat pan depth to a total of 23 inches. This extension can be the full width of the seat or can be limited to the 10-inch width of the butt pack. An auxiliary back should be provided from the 15-inch seat pan depth point for use when a pack is not worn. The top of the seat pan frame should be located 17 to 18 inches above the floor. This will form the basic geometry from which all the seat concepts will be constructed.

Seat Pan Support

The seat pan can be supported by being slung from the top with tension members, supported from the bottom with compression members, or supported by a combination of these methods. Above-the-seat suspension with straps or braces must be accomplished without encumbering ingress or egress and must not produce open loops which can snag on troop equipment. The sides of the seat in the seating area should be maintained as free as possible from braces and supports. Methods of suspending a seat pan are shown in Figure 44. Support of the seat pan from the bottom with members in compression must be done in a manner which will not limit vertical seat stroke to less than 14 in. Bottom-supported seat pans require guides or stabilizing devices to maintain seat stability during vertical stroking, whereas seat pans fully suspended from the ceiling are inherently stabilized during vertical stroking by the tension attachments to the ceiling. Combination seat support system designs must avoid energy attenuator arrangements which are subject to unequal loading, which causes instability during stroking.

Figure 42. Troop and Combat Assault Equipment on Seat Planform.

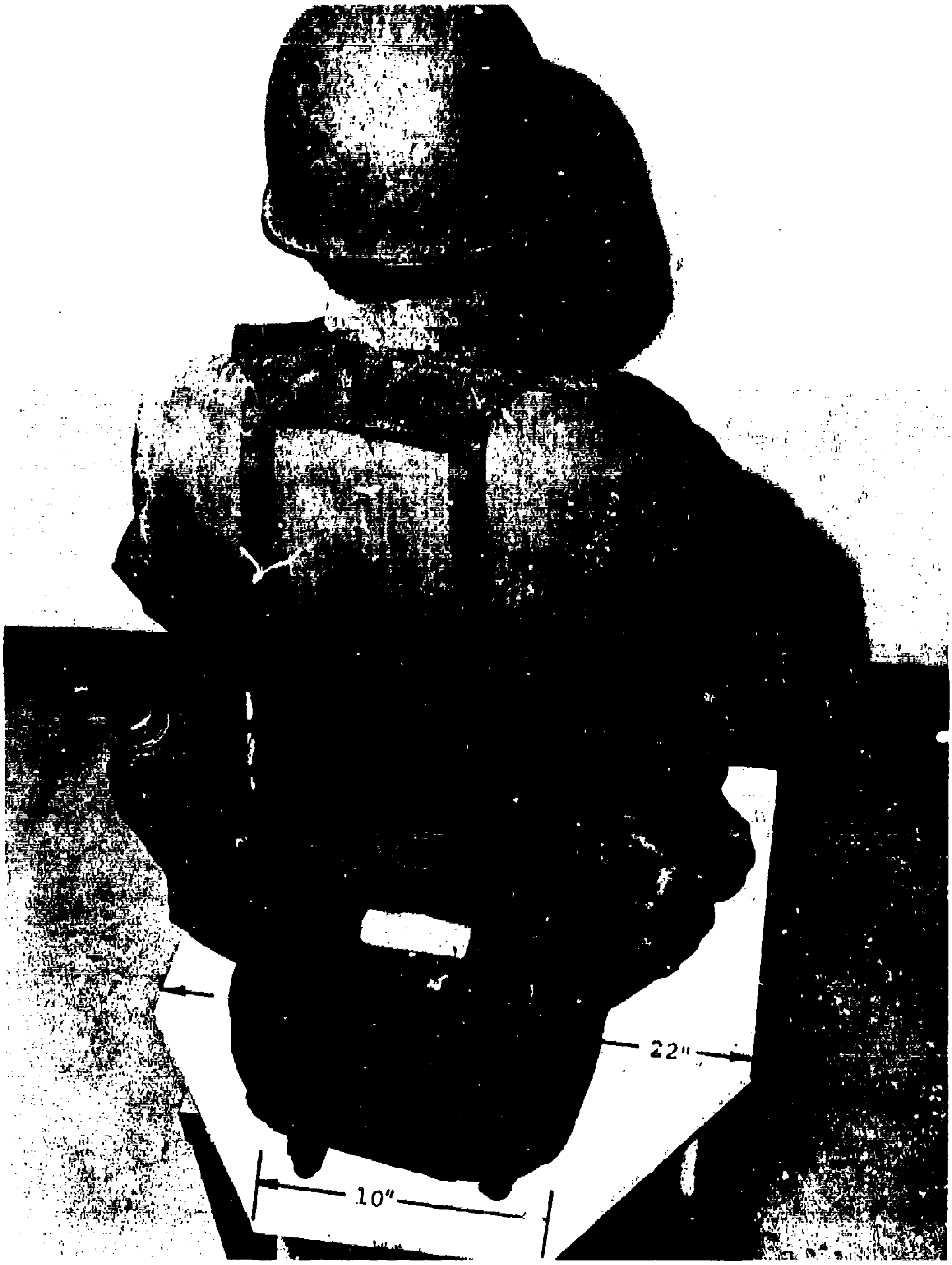


Figure 43. Troop and Combat Assault Equipment on Seat Planform.

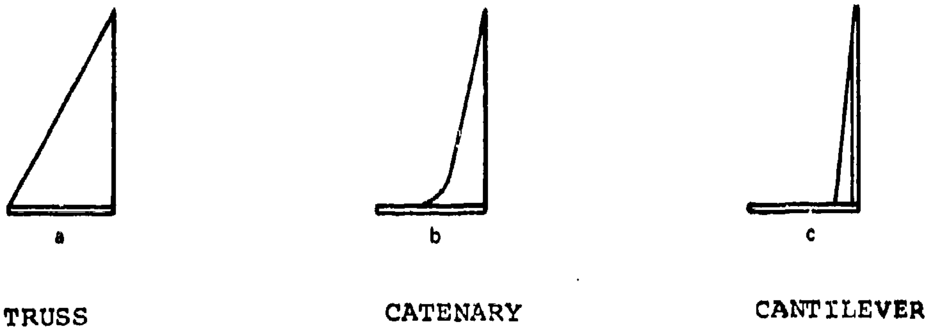


Figure 44. Typical Ceiling Suspension Methods.

A seat slung from the ceiling with tension straps appears to be the preferable approach and is rated as such in the Draft Troop Seat Military Specification. It provides the necessary guidance and restraint for the least weight. This assumes that the ceiling strength is adequate for the seat loads and is sufficiently rigid so as not to deform downward, lessening seat stroking space. Allowing for aircraft ceiling deformation in place of seat stroking is not desirable because aircraft structural deformation is generally about half as efficient, in terms of energy absorbed per unit stroking distance, as an energy absorption device. Aircraft structural characteristics should be determined before the seat configuration is selected. For those aircraft whose structure does not meet the deformation or strength requirements, a floor-mounted or wall-mounted seat should be considered.

Supporting the seat for normal use and yet allowing it to stroke freely and predictably during impact is a problem. With a ceiling-suspended seat, the energy attenuating device must be located above the seat and the seat pan should be fully suspended from it (Figure 44). Supports below the seat pan should only stabilize the seat, such as diagonal braces or cables that freely collapse as the seat moves down. Rigid legs, even with deforming or stroking features, are unpredictable because attenuating devices above and below the seat pan tend not to act together. Center-of-gravity shifts due to variations in troop weight, position, or equipment carried will cause the load distribution to the attenuators to vary. As the load is shifted toward one or the other attenuator, only that attenuator will stroke, because the threshold stroking load of the other attenuators has not been reached (Figure 45).

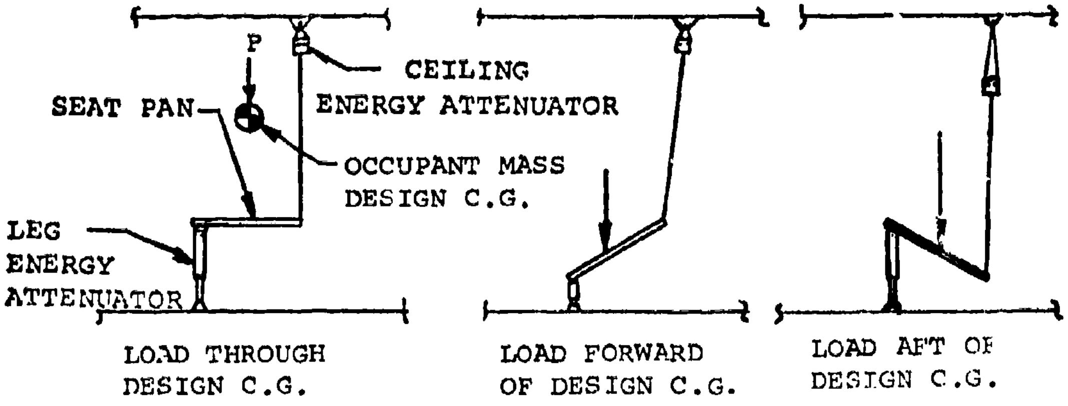


Figure 45. Effects of Attenuators in Series.

Seat Stabilization

A seat should be designed to maintain stability for normal use, as well as during and after stroking. It should stroke freely and predictably in the direction of impact. Maintaining stability after impact may be the more difficult provision. Seats supported or stabilized by tension members tend, after impact, to become loose or unstable in the reverse direction or perpendicular to the initial stroke direction. Although it is necessary that the seat remain stable in all directions during the stroking operation, some instability during rebound may have to be accepted for the sake of minimum weight. After stroking has occurred, rebound due to the inherent elasticity in the seat and aircraft structure causes the seat to move in the opposite direction to the impact. Test experience has shown that the amount of rebound motion is minimal even if the seat has become partially unrestrained in the reverse direction.

SEAT DESIGN CONCEPTS

Common Features

The following systems provide common features for all or most of the seat concepts. Exceptions will be covered in each concept description.

Restraint System

A common restraint system is used for all forward- and aft-facing seats, and a similar common restraint system is used for all side-facing seat concepts. Methods of supporting the shoulder harness reel vary with concepts; however, all hardware is identical. The restraint concepts used for forward- and aft-facing seats (Figure 32) and for side-facing seats (Figure 33) are designed to meet the functional and installation criteria previously specified. The restraint system for forward- and aft-facing seats consists of a lap belt, two shoulder straps and shoulder harness reels. The lap belt is provided with a lift lever latch buckle. Adjusters are incorporated in the buckle on one side and in the latch plate on the other side. Slots in the top of the buckle accept the shoulder strap end fittings, which can be inserted after the lap belt is fastened. Two shoulder harness reels are provided which fully retract the shoulder harness until the end fittings are within easy reach behind the occupant's shoulders. The double reel is required when mounted at the top of the seat back, to permit the full retraction of the straps. A single reel would be sufficient if mounted at the bottom of the seat back, thereby allowing the double straps to retract to the guides at the top of the seat back. The disadvantage is the greater elongation of the straps due to additional length.

The restraint system concept for side-facing seats is similar to the configuration for forward-facing seats with the exception that a single diagonal shoulder strap is provided. The diagonal strap is preferable for side-facing seats because of reduced loading and elongation due to the strap being more in line with the higher and more predominant forward accelerations. The same lap belt is utilized as in the forward- and aft-facing seats, but only one of the shoulder strap connections is used. A single, fully retractable shoulder harness reel is provided.

Shoulder Harness Reel Auxiliary Support Structure

The effectiveness of a shoulder harness is seriously compromised if the reel or guide is supported from a flexible seat back attached to the ceiling, or the strap location exceeds the limitations imposed by Figure 6 of the Draft Troop Seat Military Specification. For seats which do not have a rigid seat back to support the shoulder harness reel or strap guide at the prescribed location, an auxiliary support structure is necessary.

An approach which can be taken in providing the necessary support for the shoulder harness at the proper location is to provide an auxiliary structure supported by the aircraft wall or ceiling (Figure 46). In this concept the reel is mounted

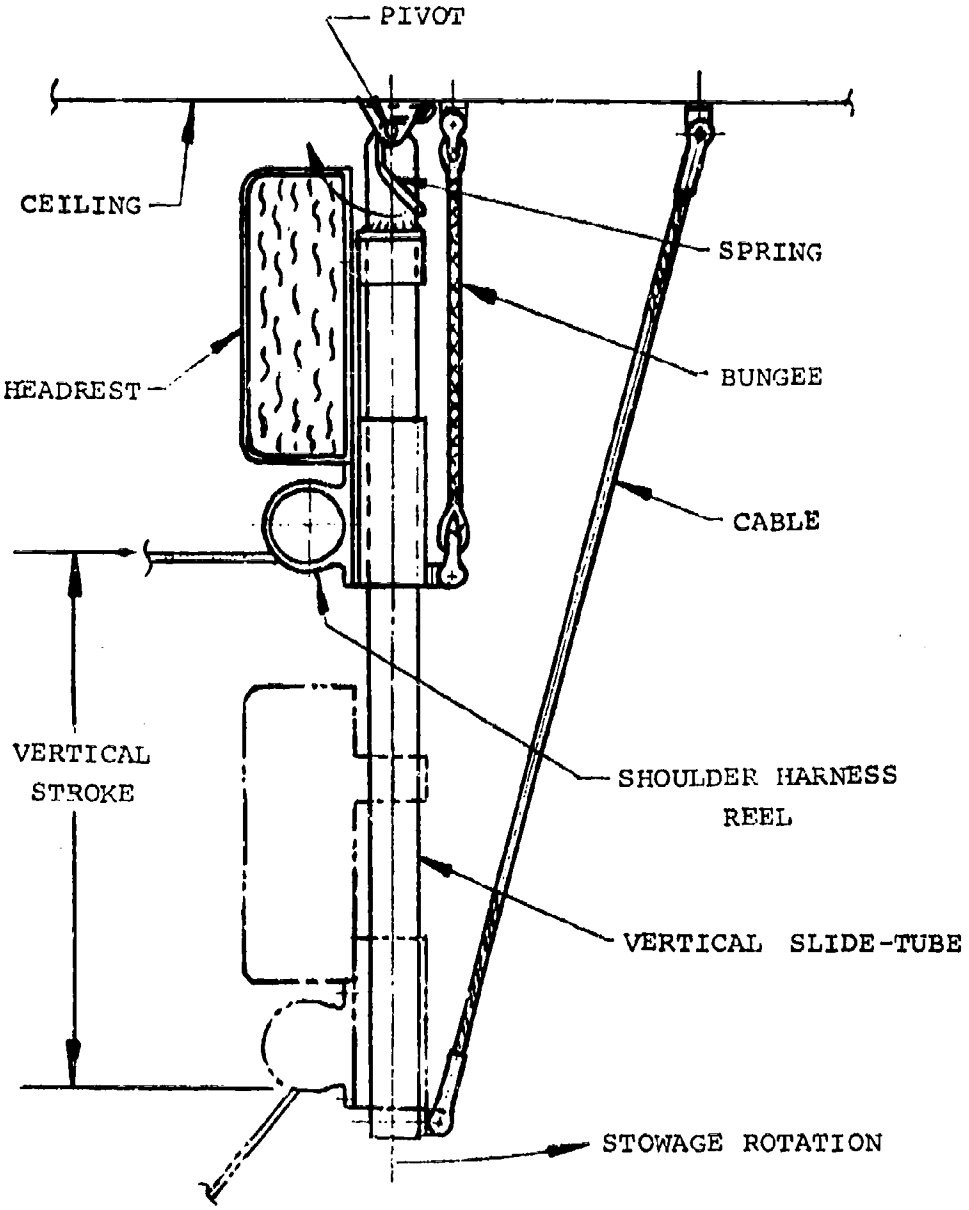


Figure 46. Auxiliary Support - Shoulder Harness Reel.

on a bracket which is free to slide down on tubes as the seat strokes. An elastic bungee cord holds the reel in the up position during normal flight. Seats with forward attenuation features and stroke in the forward direction can be provided with reels having load-limiting drums which pay out at a specified load.

Energy Attenuation System

Vertical energy attenuation is accomplished in all concepts, with the exception of two, by using the wire bending attenuator of Figure 47. Controlled force-deflection is produced by bending and unbending wire as it passes over rollers during the stroking operation. Stroke length is limited only by the length of the wire used. The wire can be stowed in a sleeve, sewn into fabric backs, or inserted in the tube of a tubular back. Long stroke lengths can be obtained and the wire coiled for stowage. This device weighs 3.0 oz per unit. Energy attenuation in forward and lateral directions is provided by various devices for the different seat concepts and will be described with each concept.

Seat Pan

For all seat concepts the seat pan is constructed of a tubular frame and covered with a polyester fabric. The frame is positioned parallel to the floor to permit the maximum seat stroke. The fabric covering of the tubular frame is tailored with slack so as to better conform with the occupant's buttocks and to allow approximately a 5° slope back from the front of the seat to improve occupant comfort.

Auxiliary Back

All seat concepts have an auxiliary back constructed of polyester fabric and polyester webbing. At the top, hooks attach the auxiliary back to the fixed back. The auxiliary back supports the occupant's back when he is not wearing a combat pack. When a pack is worn, the auxiliary back is released by lifting the hooks and dropping the back panel. Some concepts employ a flap as the auxiliary back which covers a pocket in the fixed back and is attached with hook and pile tape.

Design Loads

The seats are designed for loads induced by a 95th percentile, fully equipped troop for all directions except vertical. In the vertical direction, weight of a 50th percentile troop with full equipment is used. The acceleration in various directions and effective design loads are shown in Table 10.

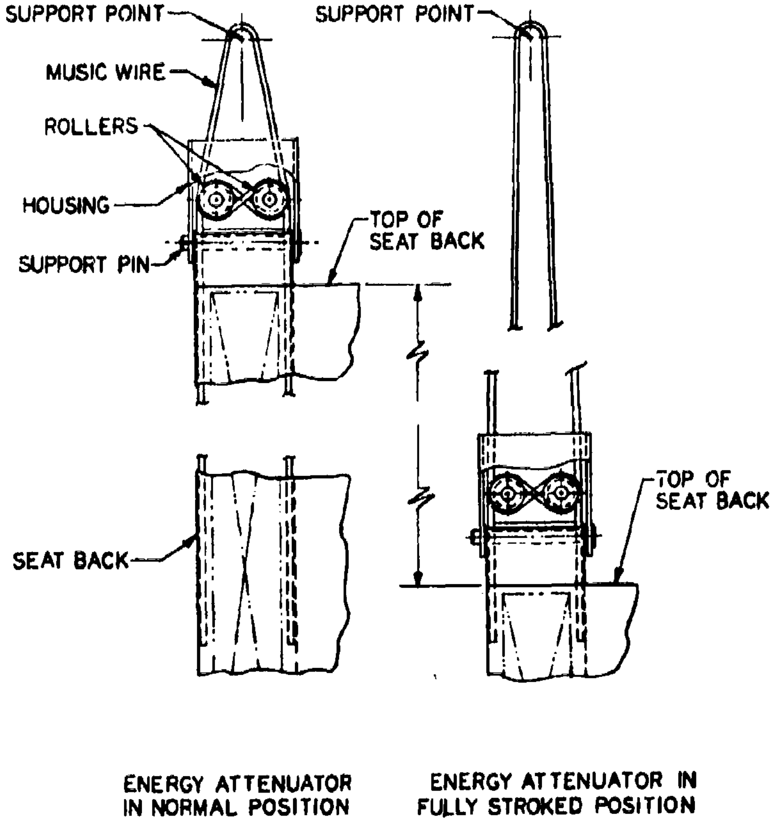


Figure 47. Wire-Bending Energy Attenuator.

TABLE 10. CRASHWORTHY TROOP SEAT SYSTEM LOAD REQUIREMENTS

INDIVIDUAL LOAD REQUIREMENTS (ULTIMATE)

APPLICATION RELATIVE TO AIRCRAFT	FORWARD FACING			AFT FACING		
	G's	WEIGHT (lb)	ULTIMATE LOAD (lb)	G's	WEIGHT (lb)	ULTIMATE LOAD (lb)
FORWARD	15* TO 20	242.8	3642 TO 4856	15* TO 20	249.8	3747 TO 4996
AFT	12	249.8	2998	12	242.8	2914
UP	8	242.8	1942	8	242.8	1942
DOWN	14.5	161	2335	14.5	161	2335
LATERAL	10* TO 20	242.8	2428 TO 4856	10* TO 20	242.8	2428 TO 4856

COMBINED LOAD REQUIREMENTS

APPLICATION RELATIVE TO AIRCRAFT	G's	WEIGHT (lb)	ULT LOAD (lb)
FORWARD	15* TO 20	249.8	3747 TO 4996
DOWN	14.5	161	2335
LATERAL	9	242.8	2185

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*DEPENDENT UPON THE STROKE OF THE ATTENUATOR (IF ANY)

SEAT CONCEPTS

Troop seat concepts consist of ceiling mounting, floor mounting, wall mounting, or various combinations of these. Ceiling-mounted seats are seats which are supported solely from the ceiling and, if disconnected from the ceiling, will drop freely to the floor. This principle is most popular and is used on seat concepts A through F and P, Q and T.

Concept A

Concept A, shown in Figure 48, is a ceiling-mounted, forward-facing seat suspended by wire bending energy attenuators. Seat suspension straps or braces are not required above the seat other than at the back. An auxiliary back is provided which can be dropped when a pack is worn.

The seat pan is stabilized in the forward and aft directions by a scissor linkage system which is free to fold during vertical seat stroke. Crossed cables stabilize the seat laterally.

Energy attenuation is provided in the vertical, forward and lateral directions. A compact wire bending attenuator is used for vertical impact loads. Forward attenuation is achieved by incorporating a torsion wire attenuator in the diagonal tube under the seat. The seat is attenuated laterally by yielding annealed stainless-steel cables which form cross braces under the seat. For a seat height of 17 inches, seat stroke is limited to 13 inches due to the geometry of the folded scissor linkage under the seat. Rod end bearings in the ends of the scissor linkage permit rotation of the legs in forward and lateral directions during seat stroke. Quick-disconnect fittings attach the legs to the floor.

The lap belt is attached to the seat pan in a conventional manner. Insufficient rigidity is available in the seat back to support the shoulder harness reel or strap guides; therefore. an auxiliary structure is needed to support the reel (Figure 46). Seat weight is 38.1 pounds with shoulder harness and 32.4 pounds without shoulder harness and reel support structure.

Concept B

Concept B, shown in Figure 49, is a ceiling-mounted, aft-facing seat. This concept is similar to forward-facing Concept A with the exception that the scissor linkage geometry is reversed under the seat. This is done to facilitate stroking during predominantly forward and vertical impacts. Forward energy attenuation is accomplished similarly to Concept A. Vertical stroke is 13 inches for a 17-inch-high seat. Seat

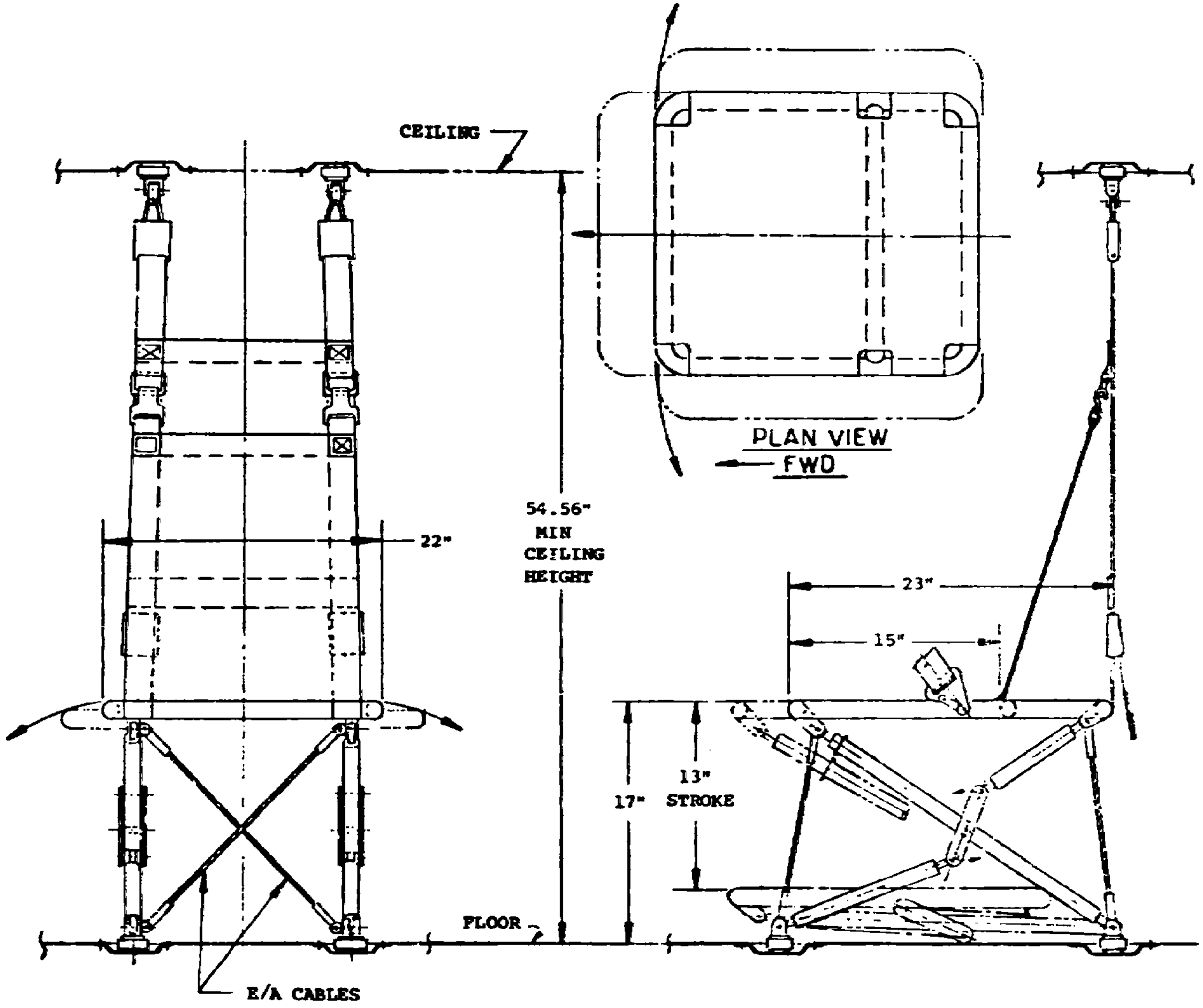


Figure 48. Concept A - Ceiling-Mounted, Forward-Facing Troop Seat.

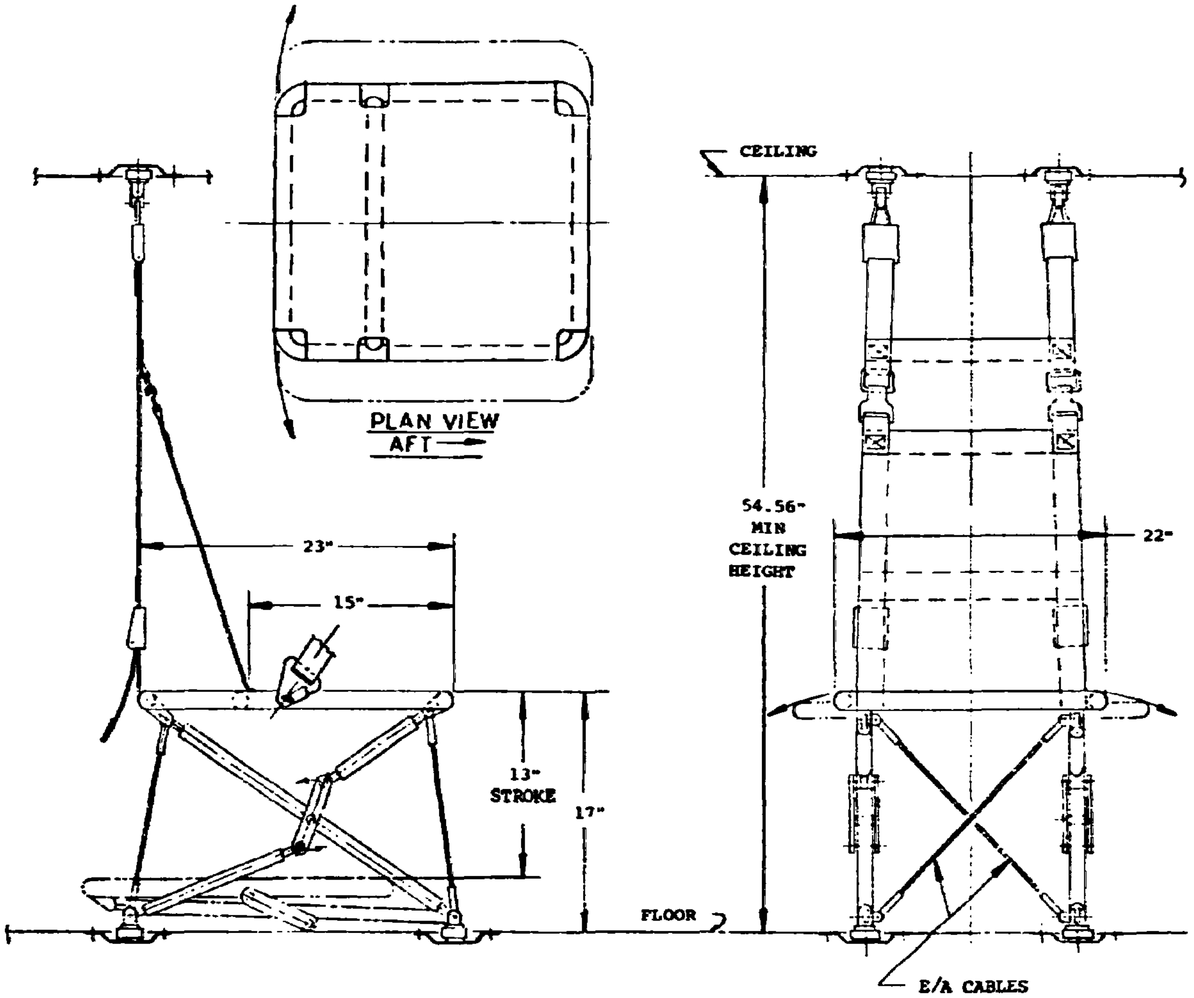


Figure 49. Concept B - Ceiling-Mounted, Aft-Facing Trocp Seat.

weight is 38.1 pounds with shoulder harness and 32.4 pounds without harness.

Concept C

Concept C, shown in Figure 50, is a ceiling-mounted, forward-facing seat. The seat pan, constructed of tubing and covered with fabric, is suspended by webbing and fabric panels at the back and on the sides of the seat. A fabric auxiliary back is provided for use when a pack is not worn.

The seat is stabilized in the forward and aft directions by torsion-wire telescoping-tube energy attenuators attached diagonally from the front of the seat pan to the floor. These struts are free to rotate downward without stroking under vertical crash impact conditions. The seat is stabilized laterally by crossed cables.

Energy attenuation is provided in the vertical, forward and lateral directions. A compact wire bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 14.5 inches for the 17-inch-high seat and would be 15.5 inches for an 18-inch-high seat. The diagonal stabilizing struts under the seat incorporate a torsion-wire energy-attenuation feature for forward impact loads. The seat is attenuated in lateral impacts by the cross cables which yield under lateral crash loads. The seat will move freely in all three axes under crash loading through the use of ball type rod end bearings which attach the stabilizing struts to the seat pan. Four quick-disconnect fittings attach the struts and cables to the floor studs.

The lap belt anchor fittings are attached to the seat pan tube on both sides of the seat. No provision is made on the seat for shoulder harness reel attachment due to the flexible nature of the seat back. For shoulder straps to be used with the seat, an auxiliary reel support structure is required (Figure 46). Seat weight is 16.7 pounds with shoulder harness and 11.0 pounds without harness and reel support structure.

Concept D

Concept D, shown in Figure 51, is a ceiling-mounted aft-facing seat. This concept is similar to forward-facing Concept C except that the diagonal stabilizing brace under the seat is attached to the back instead of the front of the seat. This is done to facilitate stroking during predominantly forward and vertical impacts. Vertical stroking is 14.5 inches for the 17-inch-high seat. Seat weight is 16.7 pounds with shoulder harness and 11.0 pounds without harness and reel structure.

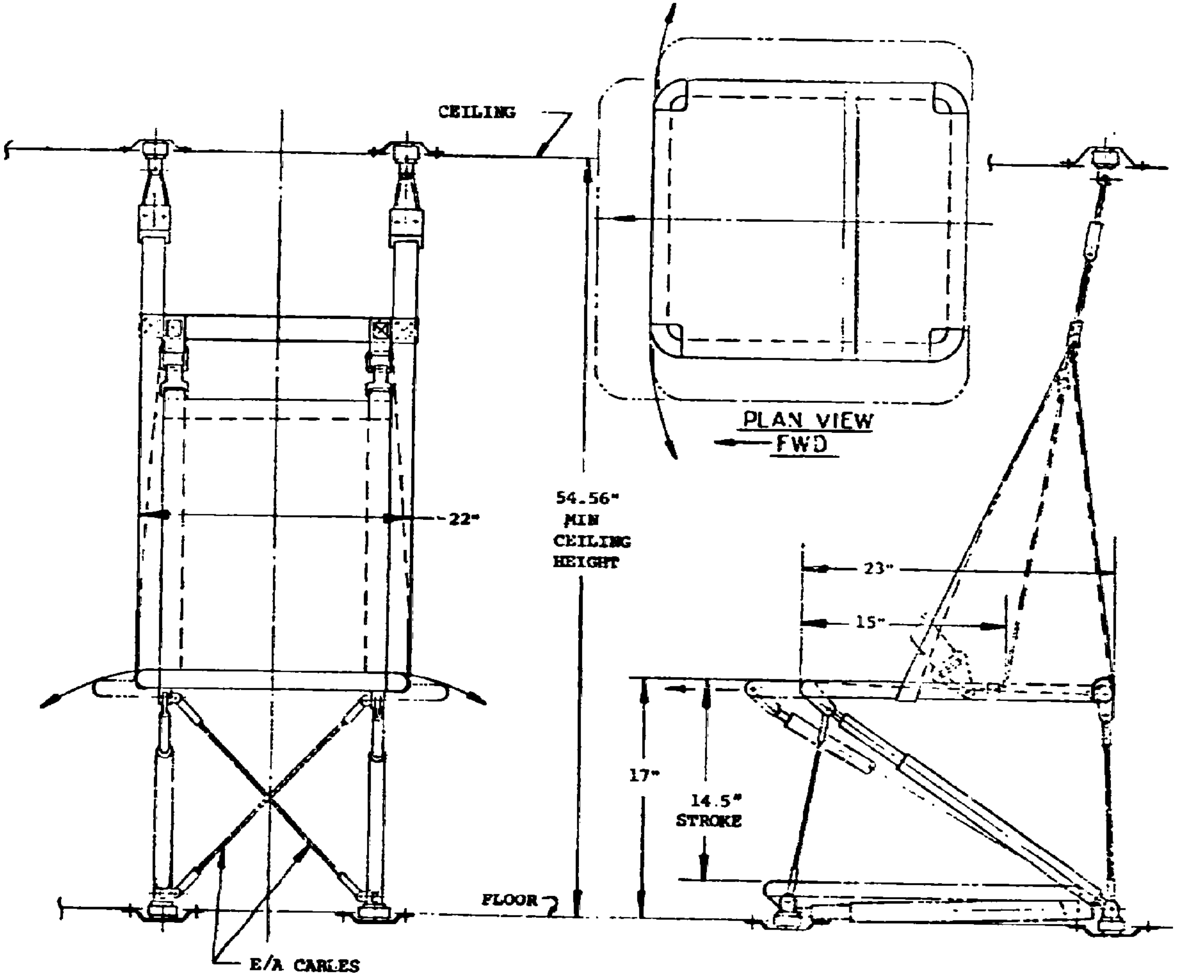


Figure 50. Concept C - Ceiling-Mounted, Forward-Facing Troop Seat.

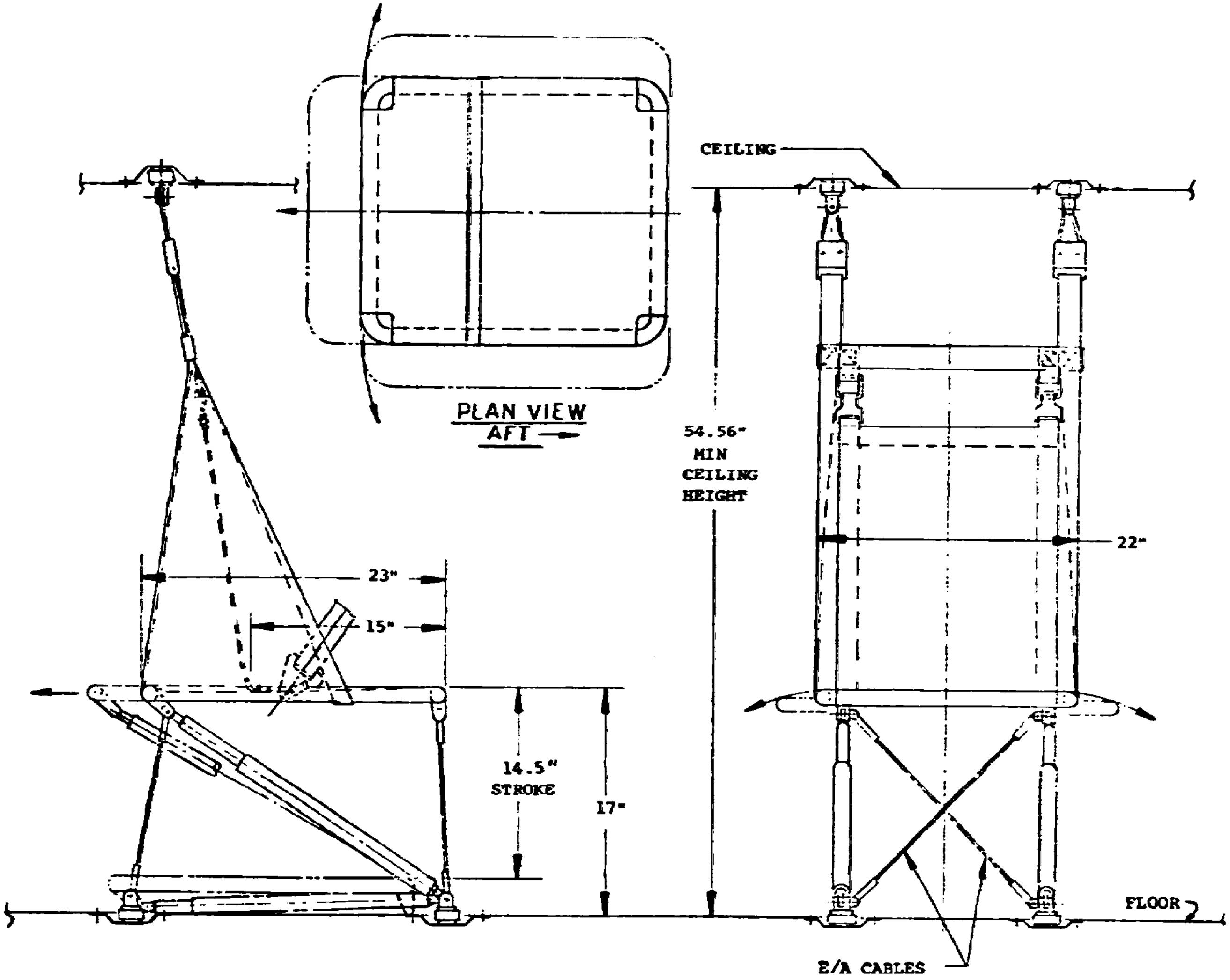


Figure 51. Concept D - Ceiling-Mounted, Aft-Facing Troop Seat.

Concept E

Concept E, shown in Figure 52, is a ceiling-mounted side-facing troop seat suspended by wire bending attenuators. The seat bucket, consisting of seat pan and back, is of welded tubular construction. The 15-inch section of the seat pan folds against the tubular back. An auxiliary fabric back is provided for use when the occupant is not wearing a pack.

Seat stability is provided by a parallel tube linkage. A diagonal cable between the links takes uploads and tensions the seat for normal flight loads. Under vertical crash impact, the parallel linkage rotates freely and stabilizes the seat as it strokes to the floor. Cables arranged in a "V" and attached to the parallel links provide side stability for the seat.

Energy attenuation is provided in the vertical, forward and lateral directions. Compact wire bending attenuators are used for vertical impact loads. The same attenuators serve for inboard or outboard load attenuation due to the vertical component of the load acting through the parallel linkage system. Forward impact loads are attenuated by yielding the "V" cables between the parallel links. The seat is designed to move sideways by tapering the seat pan butt pack support extension to the width of the pack as shown in Figure 52. This permits the parallel links to rotate sideways. Ball joints at the ends of the parallel link tubes allow free motion in the vertical and side directions.

Seat stroke in the vertical direction is 13.75 inches for the 15-inch-high seat and would be 16.75 inches for an 18-inch-high seat. The lap belt anchor fitting is attached to the seat pan tube. A single shoulder harness reel is supported from the top of the tubular seat back frame. Seat weight including shoulder restraint is 19.7 pounds.

Concept F

Concept F, shown in Figure 53, is a ceiling-mounted, side-facing troop seat. The seat pan, constructed of tubing and covered with fabric, is suspended by webbing and fabric panels at the back and on the sides of the seat. A fabric auxiliary back is provided for use when a pack is not worn.

The seat is stabilized by torsion-wire telescoping-tube energy attenuators attached diagonally from the side of the seat pan to the floor. These struts are free to rotate downward without stroking under vertical crash impact conditions. The seat is stabilized in the front and back directions by crossed cables at each side of the seat.

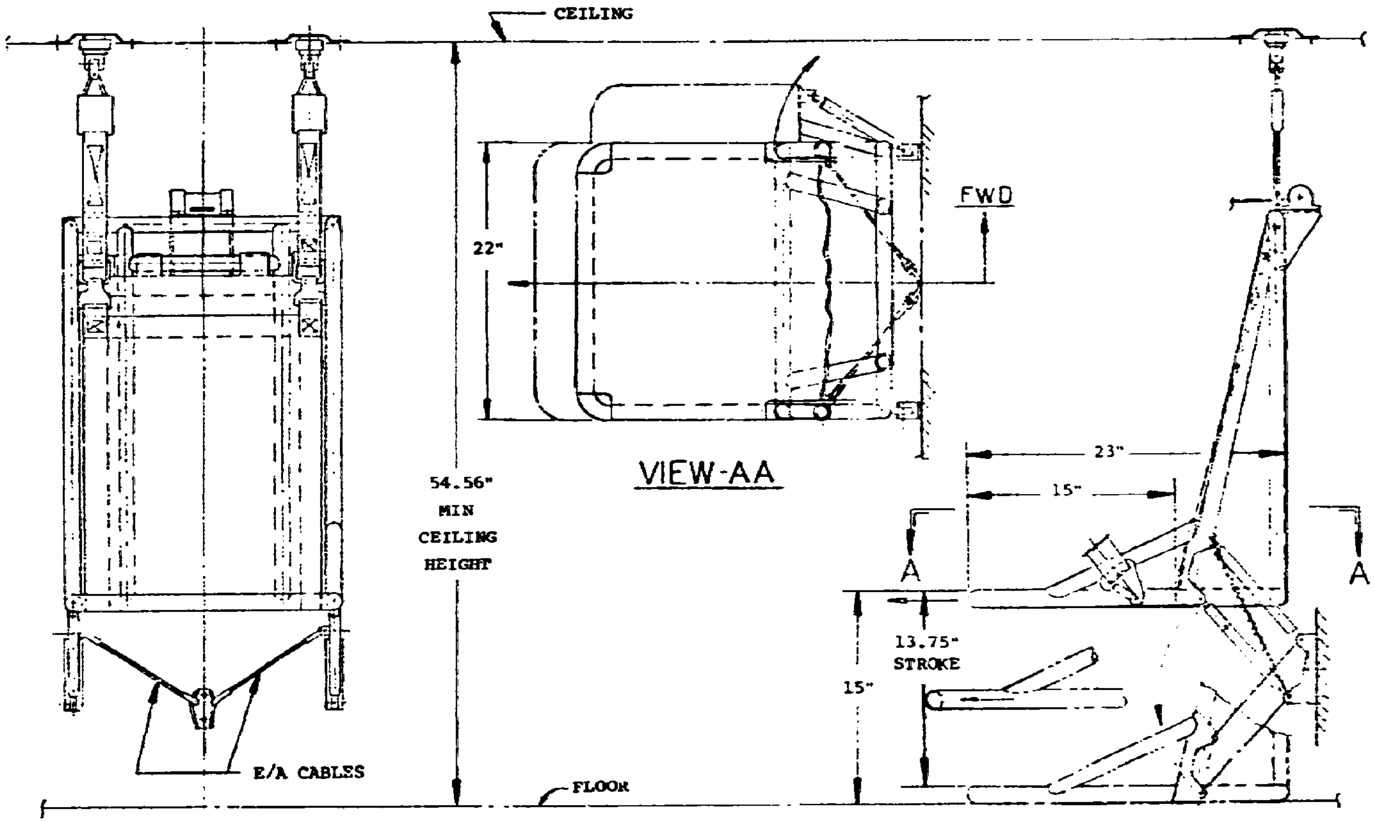


Figure 52. Concept E - Ceiling-Mounted, Side-Facing Troop Seat.

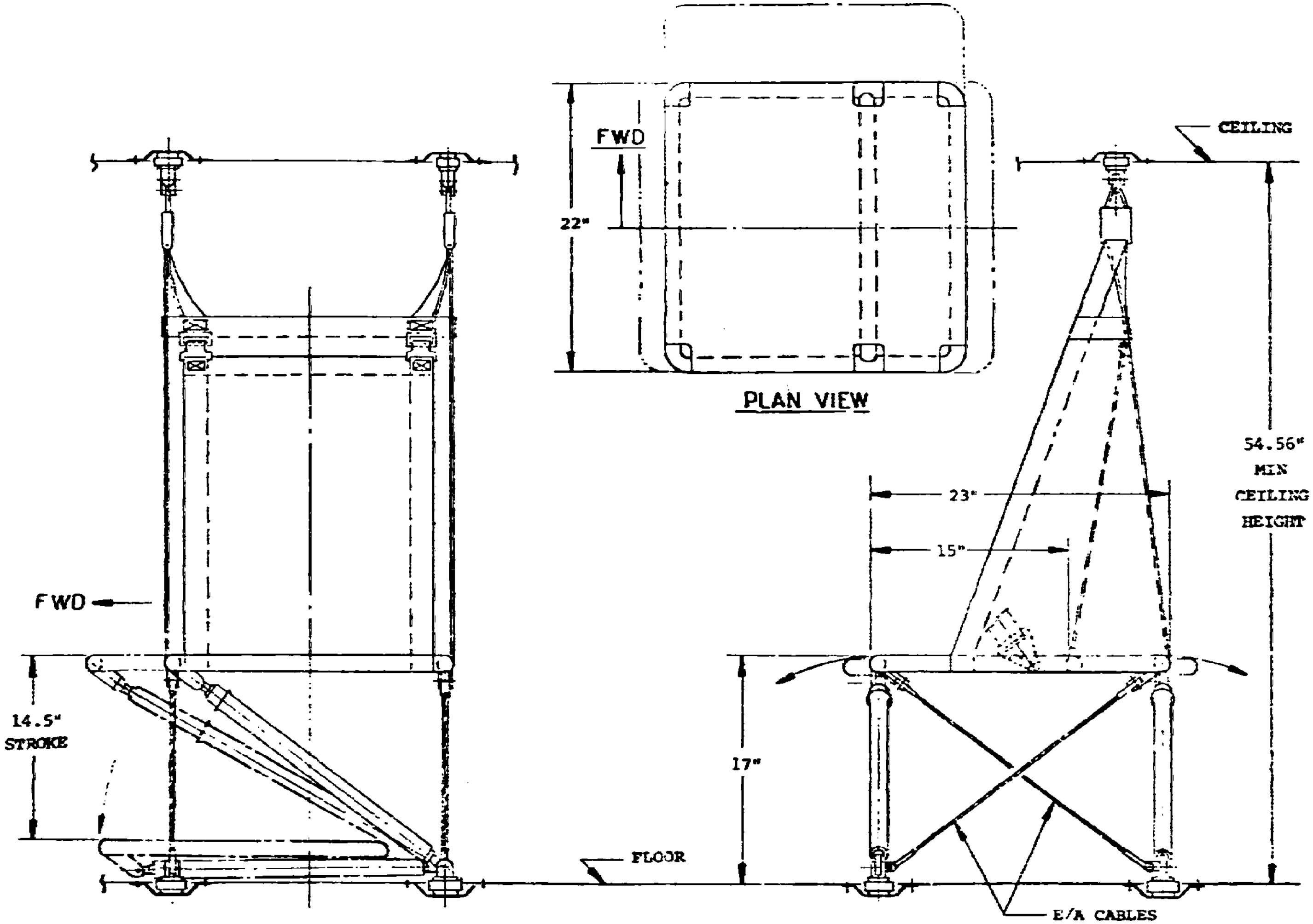


Figure 53. Concept F - Ceiling-Mounted, Side-Facing Troop Seat.

Energy attenuation is provided in the vertical, forward, and lateral aircraft directions. A compact wire bending attenuator is used for vertical impact loads. The diagonal stabilizing struts under the seat incorporate a torsion-wire energy-attenuating feature for forward impact loads. The seat is attenuated laterally by the cross cables, which yield under lateral crash impact loads. The seat will move freely in all three axes under crash loading through the use of ball type rod end bearings, which attach the stabilizing struts to the seat pan. Seat stroke in the vertical direction is 14.5 inches for the 17-inch-high seat and would be 15.3 inches for an 18-inch-high seat. Four quick-disconnect fittings attach the struts and cables to the floor studs.

The lap belt anchor fittings are attached to each side of the seat pan. No provisions are made on the seat for shoulder harness reel attachment due to the flexible nature of the seat back. For shoulder straps to be used with the seat, an auxiliary reel support structure is required (Figure 46). Seat weight is 16.7 pounds with shoulder harness and 11.0 pounds without harness and reel support structure.

Concept G

Concept G, shown in Figure 54, is a floor-mounted, forward-facing troop seat. The seat bucket, consisting of seat pan and back, is of welded tubular construction. Although the seat bucket does not fold, it can be designed to fold. The seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack.

The seat is supported by four legs and is stabilized in the forward and aft directions by diagonal struts attached from the front of the seat to the floor. The seat is stabilized in the lateral direction by cross cables at the front and back of the seat.

Energy attenuation is provided in the vertical, forward, and lateral directions. Under vertical impact loads, the diagonal strut rotates as the four energy attenuator legs stroke. Curl tube attenuators are used for the legs to obtain maximum stroke for a given length of leg. The diagonal struts consist of torsion-wire telescoping-tube attenuators which stroke under forward impact loads. Lateral attenuation is provided by yielding the cross cables. Ball joints at the end of the legs and stabilizing struts permit free motion for attenuation in all three axes. Seat stroke in the vertical direction is 14 inches for the 17-inch-high seat and would be 15 inches for an 18-inch-high seat.

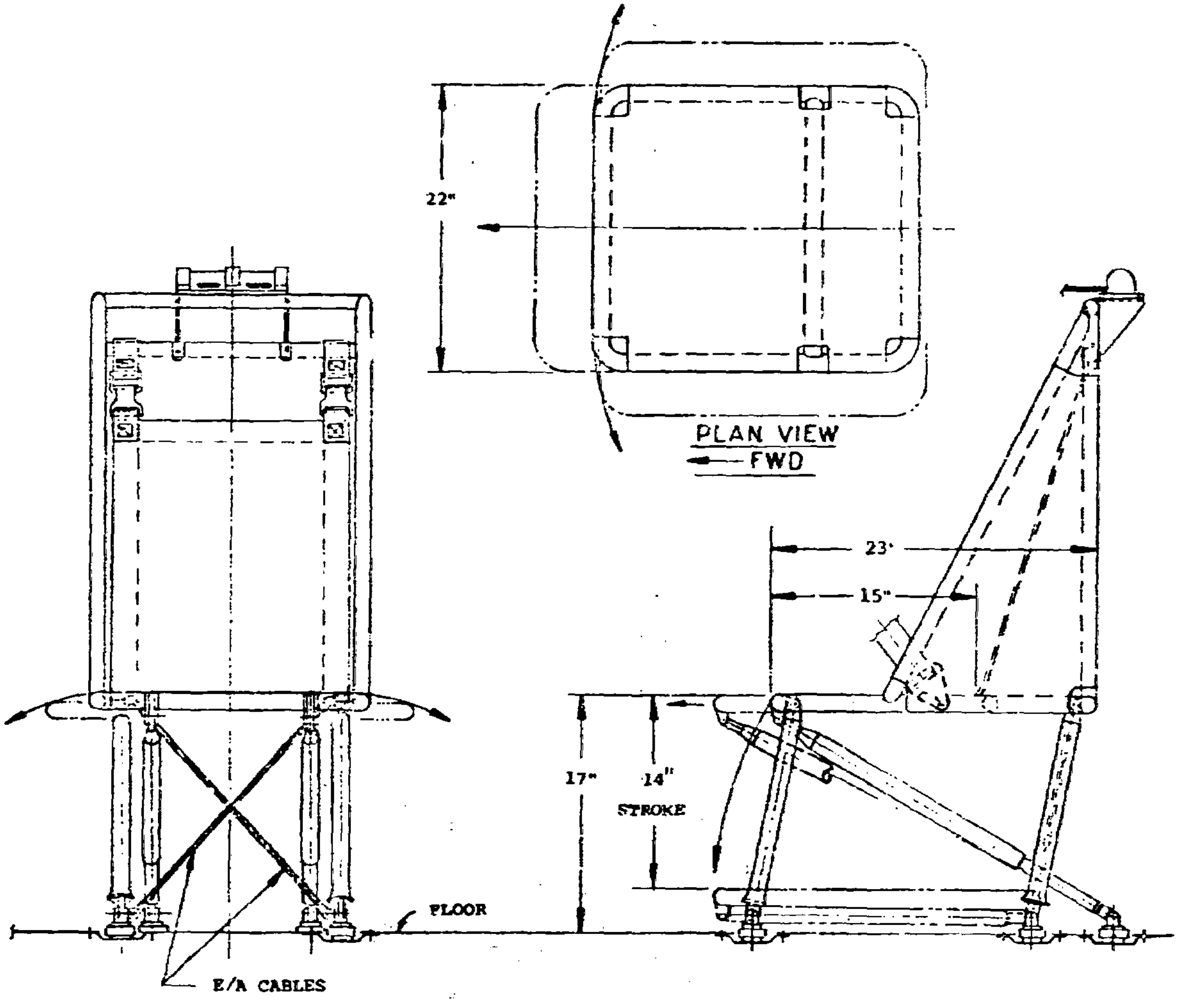


Figure 54. Concept G – Floor-Mounted, Forward-Facing Troop Seat.

Lap belt anchor fittings are attached to the seat pan tube. A double shoulder harness reel is supported from the top of the tubular seat back frame. A single reel can be used if attached to the bottom of the seat back, and shoulder strap guides are provided at the top of the seat back. Seat weight including shoulder restraint is 18.1 pounds.

Concept H

Concept H, shown in Figure 55, is a floor-mounted, aft-facing troop seat. This concept is similar to forward-facing concept G except that the diagonal stabilizing brace under the seat is attached to the back instead of the front of the seat. This is done to facilitate stroking during predominantly forward and vertical impacts. Seat stroke in the vertical direction is 14 inches for the 17-inch-high seat. Seat weight including shoulder restraint is 18.1 pounds.

Concept J

Concept J, shown in Figure 56, is a floor-mounted, forward-facing troop seat. The seat bucket, consisting of seat pan and back, is of welded tubular construction. Although the seat bucket does not fold, it can be designed to fold. The seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack.

The bucket is supported by "A" frames at each side, stabilized by cross tubes. Slide blocks and energy-attenuating rods attach the bucket to the "A" frame. Vertical support of the bucket is through wire bending energy attenuators attached between the "A" frame and the slide blocks. Forward and lateral stability is maintained by the attachments between the bucket and "A" frame.

Energy attenuation is provided in the vertical, forward and lateral directions. For vertical impact, the seat bucket slides down the "A" frame as the wire bending attenuators stroke. During forward impact, the seat bucket moves forward as the energy-attenuating rods yield in bending. The same rods serve for lateral impact, bending sideways and allowing the seat bucket to move to the side. The seat remains stable and restrained during stroking motions in all three axes. Seat stroke in the vertical direction is 15.75 inches for the 17-inch-high seat and would be 16.75 inches for an 18-inch-high seat.

Lap belt anchor fittings are attached to the seat pan tube. A double shoulder harness reel is supported from the top of the tubular seat back frame. A single reel can be used if attached to the bottom of the seat back, and shoulder strap

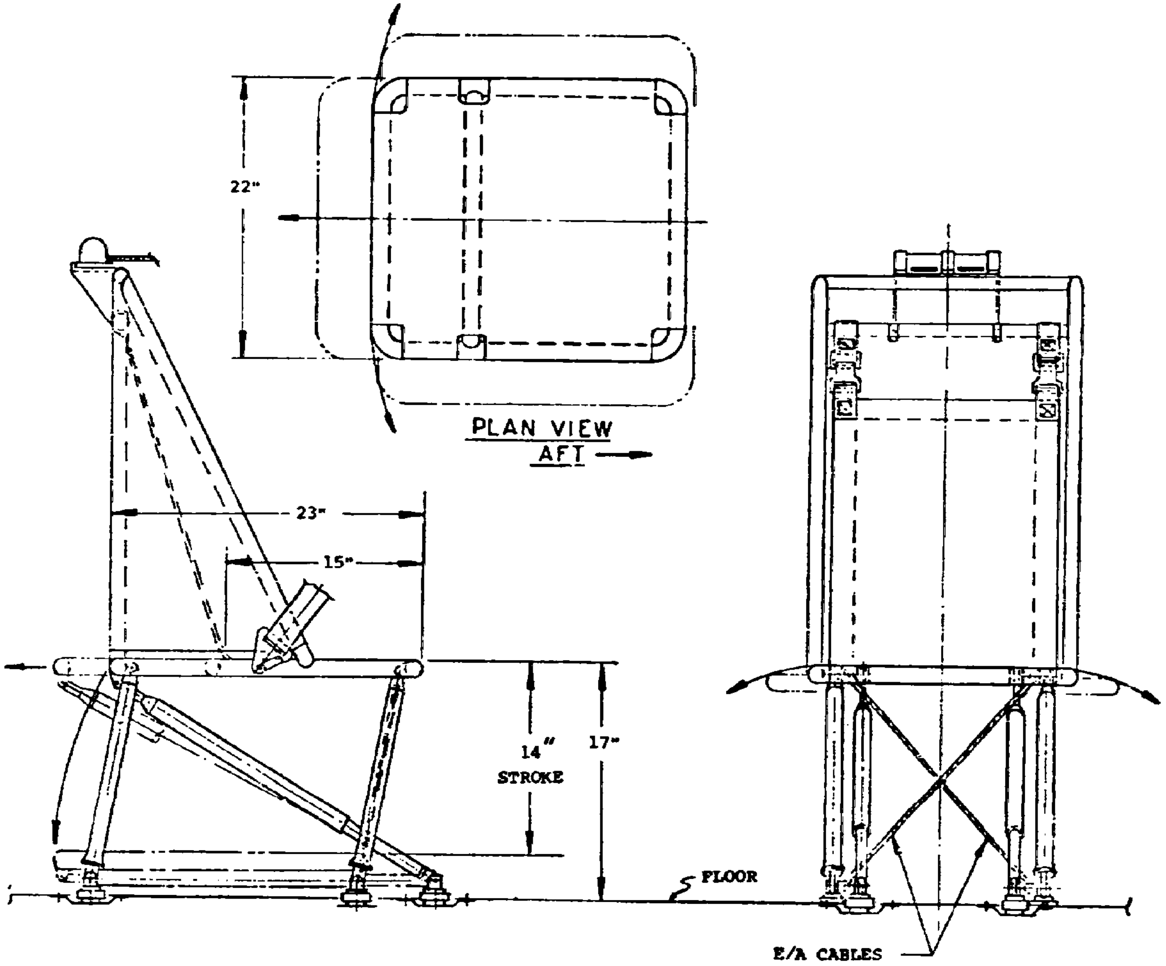


Figure 55. Concept H - Floor-Mounted, Aft-Facing Troop Seat.

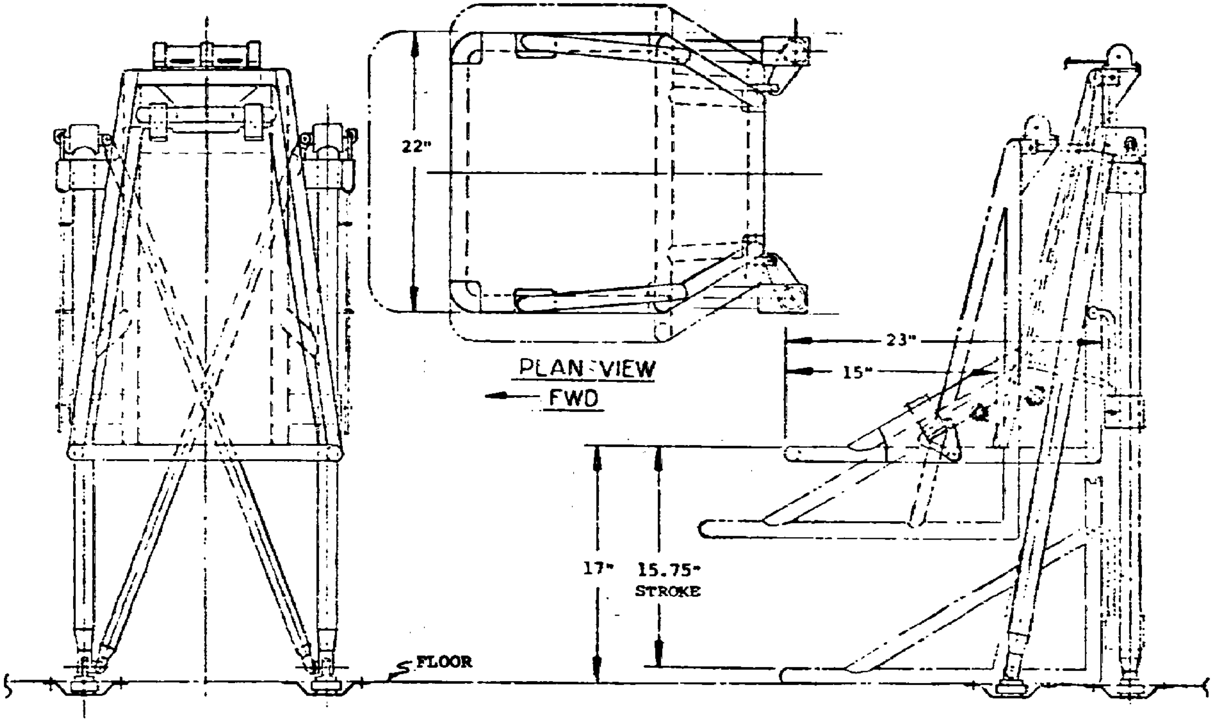


Figure 56. Concept J - Floor-Mounted, Forward-Facing Troop Seat.

guides are provided at the top of the seat back. Seat weight including shoulder restraint is 31.8 pounds.

Concept K

Concept K, shown in Figure 57, is an aft-facing, floor-mounted troop seat. The seat bucket, consisting of seat pan and back, is of tubular construction. Hinge points at the intersection of the seat pan and back allow the seat pan to be folded up against the back. A diagonal brace hinged at the top of the back is connected to the seat pan by a quick-disconnect fitting. The seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack.

The bucket is supported by "A" frames at each side, stabilized by cross tubes. Slide blocks attach the bucket to the "A" frame. Vertical support of the bucket is through wire-bending energy attenuators attached between the "A" frame and the slide blocks. Forward and lateral stability is maintained by attachment of the bucket to the "A" frame.

Energy attenuation is provided only in the vertical direction. For vertical impact, the seat slides down the "A" frame as the wire-bending attenuators stroke. Seat stroke in the vertical direction is 15.75 inches for the 17-inch-high seat and would be 16.75 inches for an 18-inch-high seat.

Lap belt anchor fittings are attached to the seat pan tube. A double shoulder harness reel is mounted at the top of the tubular seat back frame. A single reel can be used if it is attached at the bottom of the seat back and if shoulder strap guides are provided at the top of the seat back. Seat weight including shoulder restraint is 29 pounds.

Concept L

Concept L, shown in Figure 58, is a side-facing, floor-mounted troop seat. The seat bucket, consisting of seat pan and back, is of welded tubular construction. Although the seat bucket does not fold, it can be designed to fold. The seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack.

The seat is stabilized by a parallel tube linkage between the seat bucket and an "A" frame structure mounted on the floor. A diagonal cable between the parallel links takes upload and tensions the seat for normal flight loads. The seat is stabilized laterally by positioning the wire-bending attenuators at an angle to vertical.

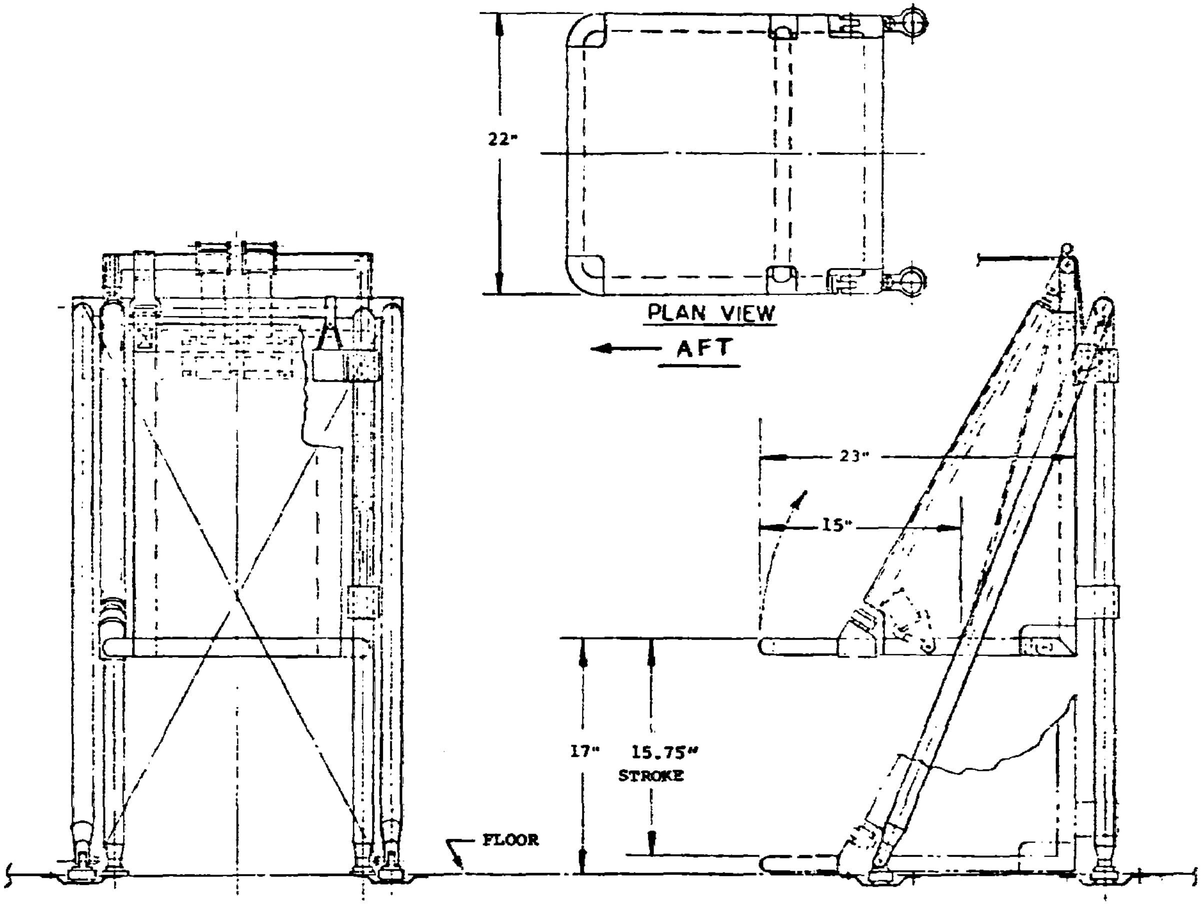


Figure 57. Concept K - Floor-Mounted, Aft-Facing Troop Seat.

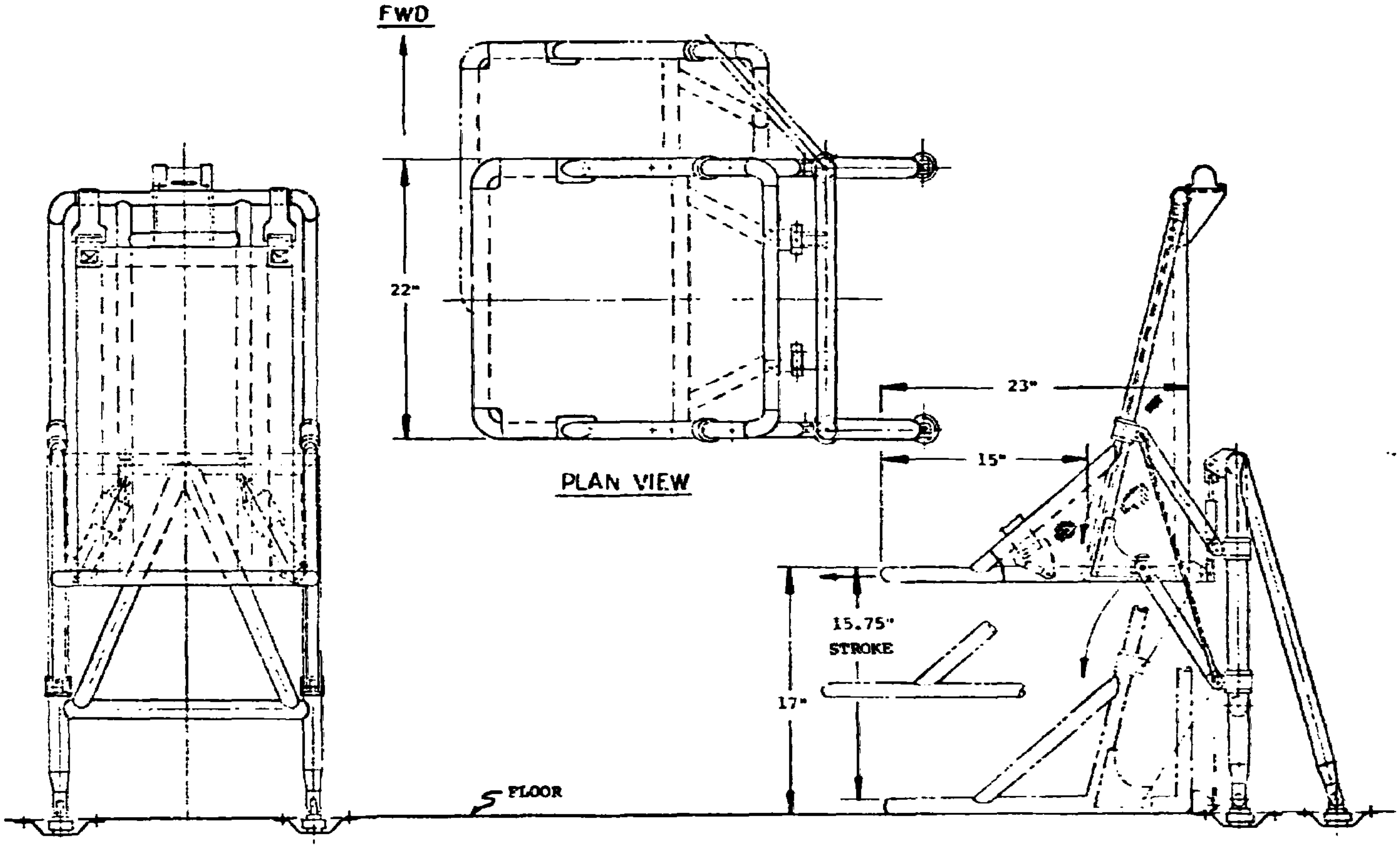


Figure 58. Concept L - Floor-Mounted, Side-Facing Troop Seat.

Energy attenuation is provided in the vertical, forward, and lateral directions. Compact wire-bending energy attenuators are used for vertical impact loads. The same attenuators serve for forward or lateral impact loads. The parallel links rotate in the direction of impact, and the vertical component of the load causes the attenuators to stroke. Seat stroke in the vertical direction is 15.75 inches for the 17-inch-high seat and would be 16.75 inches for an 18-inch-high seat.

Lap belt anchor fittings are attached to the seat pan tube. A single shoulder harness reel is supported from the top of the seat back frame. Seat weight including shoulder restraint is 35.6 pounds.

Concept M

Concept M, shown in Figure 59, is a floor-mounted, side-facing troop seat. The seat bucket, consisting of seat pan and back, is of tubular construction. The seat pan is supported from the back by a diagonal brace. A quick-disconnect fitting attaches the brace to the seat pan. Hinge points at the intersection of the seat pan and back allow the seat pan to be folded up against the back. The seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack. The bucket is supported by wire bending energy attenuators attached to an "A" frame behind the seat.

The seat is stabilized by torsion-wire telescoping-tube energy attenuators attached diagonally from the front of the seat pan to the floor. These struts are free to rotate downward, without stroking, under vertical crash loads. The seat is stabilized in the side direction by crossed cables. Six quick-disconnect fittings attach the "A" frame and stabilizing cables to the floor.

Three-axis energy attenuation is provided. A compact wire-bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 14.5 inches for the 17-inch-high seat and would be 16.5 inches for an 18-inch-high seat. The diagonal stabilizing struts under the seat incorporate a torsion-wire energy-attenuation feature for impact loads toward the front of the seat. The crossed cables, which yield under impact loads, attenuate the seat in the side direction. The seat moves freely in all three axes under crash loading through the use of ball joints at the attachment of the stabilizing strut to the seat pan.

Lap belt anchor fittings are attached to both sides of the seat pan. A single shoulder harness reel is supported at the top of the seat back frame. Seat weight including shoulder restraint is 26.7 pounds.

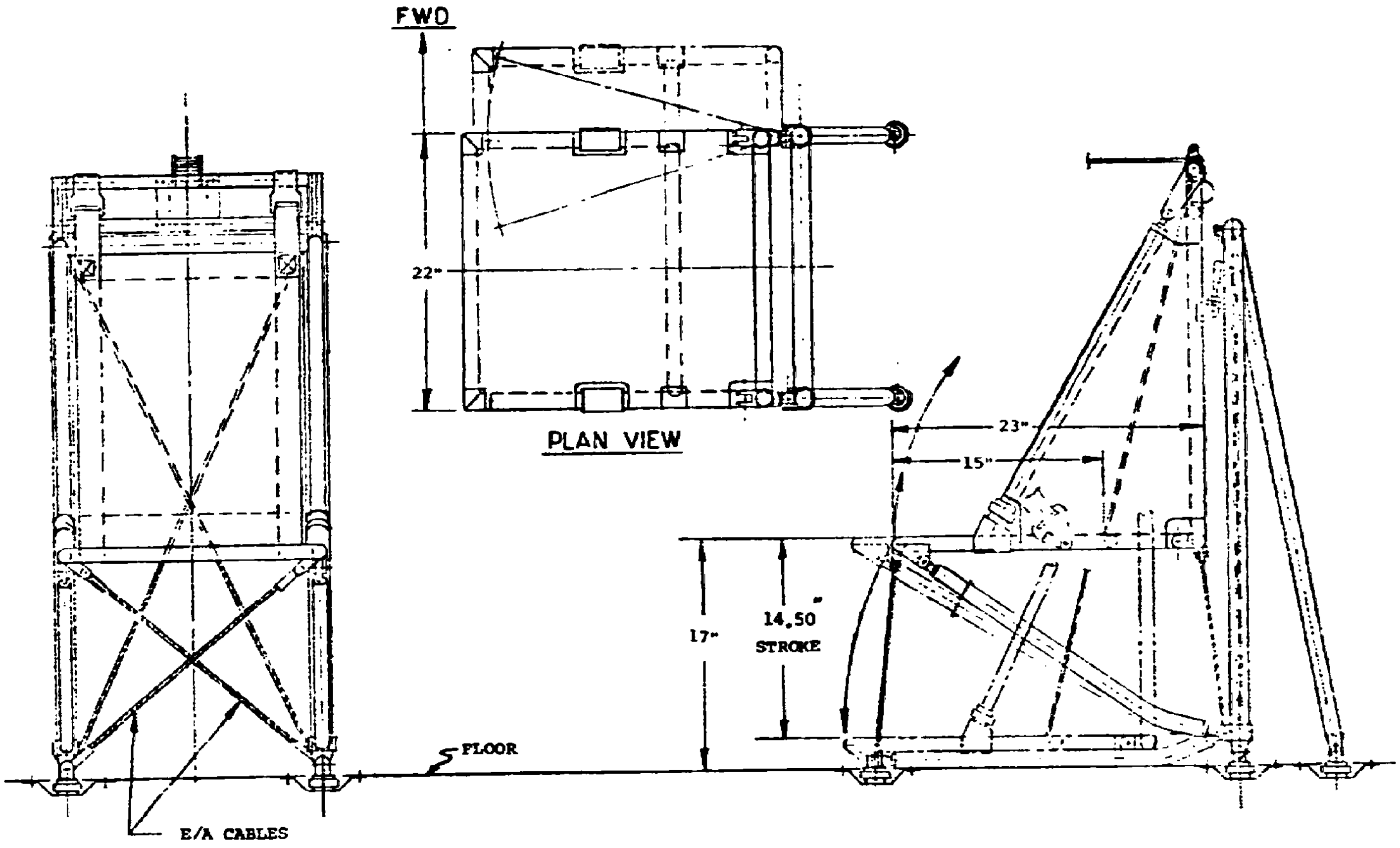


Figure 59. Concept M - Floor-Mounted, Side-Facing Troop Seat.

Concept N

Concept N, shown in Figure 60, is a wall-mounted, side-facing troop seat suspended by wire-bending attenuators. Seat suspension straps are not required above the seat other than at the back. The seat back is constructed of fabric and webbing. A fabric auxiliary back is provided which can be dropped when the occupant wears a pack. Fabric covers the tubular seat pan frame.

The seat is stabilized by a parallel tube linkage. The linkage extends between fittings on the wall and a truss attached to the seat pan. A diagonal cable between the links takes up-loads and tensions the seat for normal flight loads. During vertical impact, the parallel linkage rotates freely and stabilizes the seat as it strokes to the floor. Cables arranged in a "V" and attached to the parallel links stabilize the seat laterally.

Energy attenuation is provided in the vertical, forward, and lateral directions. Compact wire-bending attenuators attached to the wall are used for vertical impact loads. The same attenuators serve for crash loads toward the front of the seat due to the vertical component of the load acting through the parallel linkage system. Forward impact loads are attenuated by yielding the "V" cables between the parallel links. The seat is designed to stroke sideways by tapering the butt pack support extension to the width of the pack as shown in Figure 43. This permits the parallel links to rotate to the side through the use of ball joints at the ends of the link tubes. Seat stroke in the vertical direction is 13.75 inches for the 15-inch-high seat and would be 16.75 inches for an 18-inch-high seat.

The lap belt is attached by anchor fittings to each side of the seat pan. A single shoulder harness reel is attached by slide blocks to tubes mounted on the wall. The reel is free to move down as the seat strokes. Seat weight is 20.9 pounds with shoulder harness and 18.1 pounds without harness.

Concept P

Concept P, shown in Figure 61, is a ceiling-mounted, side-facing, back-to-back troop seat. The seat pan, constructed of tubing and covered with fabric, is suspended at the back and on the sides by fabric and webbing panels, which are attached to the ceiling by wire-bending attenuators. A fabric auxiliary back is provided when the occupant does not wear a pack.

The seat is stabilized in the inboard and outboard directions by torsion-wire telescoping-tube energy attenuators attached diagonally from the front of the seat pan to the floor.

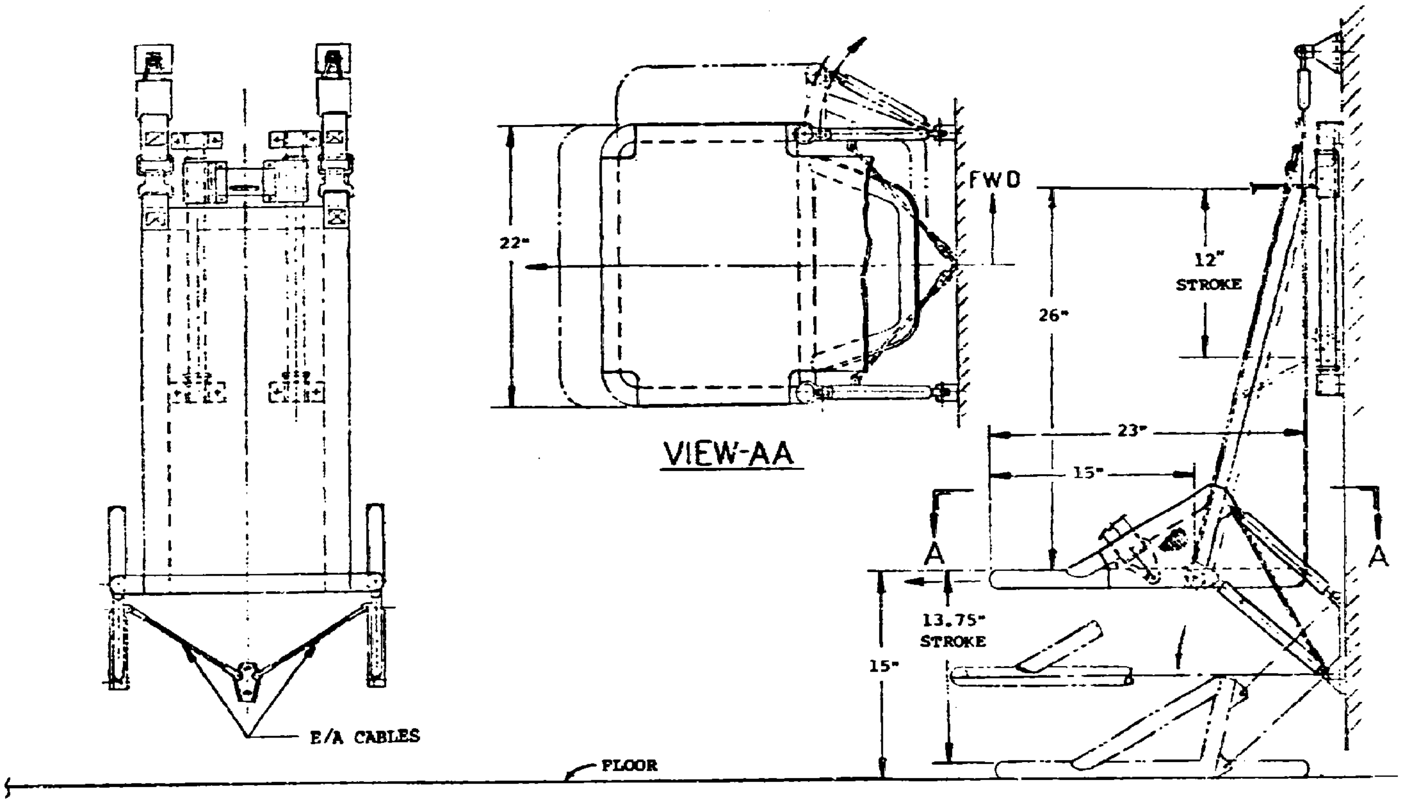


Figure 60. Concept N - Wall-Mounted, Side-Facing Troop Seat.

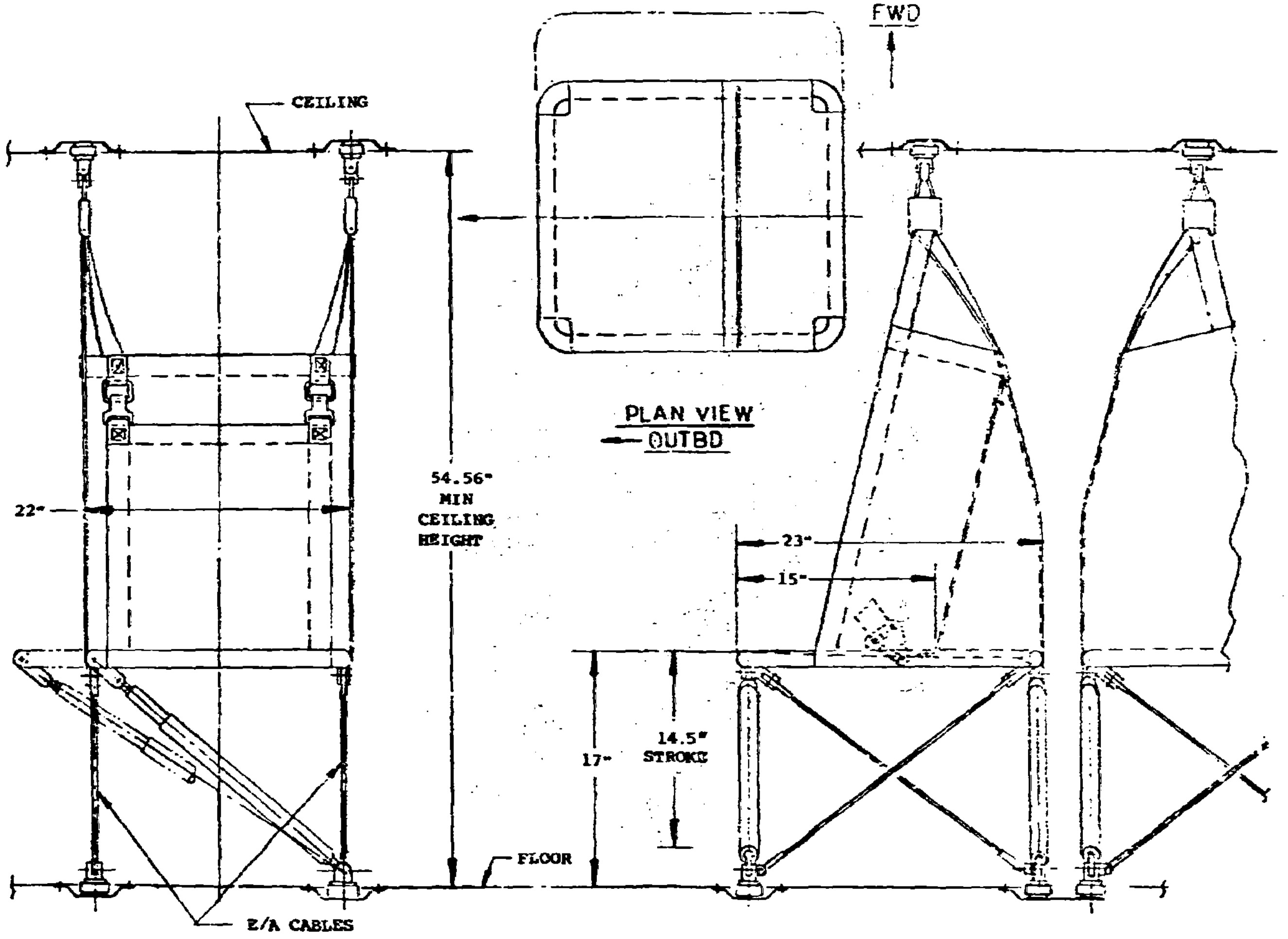


Figure 61. Concept P - Ceiling-Mounted, Side-Facing, Back-to-Back Troop Seat.

These struts are free to rotate downward, without stroking, during vertical crash impact loading. The seat is stabilized in the forward and aft directions by crossed cables.

Energy attenuation is provided in the vertical, forward, and lateral directions. A compact wire-bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 14.5 inches for the 17-inch-high seat and would be 15.5 inches for an 18-inch-high seat. For lateral impact load attenuation, a torsion-wire energy-attenuator feature is incorporated in the diagonal struts under the seat. The seat is attenuated for forward impact loads by the annealed stainless steel cross cables. The seat moves freely in all three axes, under crash loading, through the use of ball type rod end bearings, which attach the stabilizing struts to the seat pan. Four quick-disconnect fittings attach the struts and cables to the floor studs.

The lap belt is attached to both sides of the seat pan. No provisions are made on the seat for shoulder harness reel attachment due to the flexible nature of the seat back. Fabric side panels provide lateral restraint in forward impacts. For shoulder straps to be used with the seat, an auxiliary reel support structure is required (Figure 46). Seat weight is 16.7 pounds with shoulder harness and 11 pounds without harness or reel support structure.

Concept Q

Concept Q, shown in Figure 62, is a ceiling-mounted, side-facing, back-to-back troop seat. The seat bucket, consisting of seat pan and back, is of tubular construction. The seat pan is supported from the back by a diagonal brace. A quick-disconnect fitting attaches the brace to the seat pan. Hinge points at the intersection of the seat pan and back allow the seat pan to be folded up against the back. The seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack. The bucket is supported by wire-bending energy attenuators attached to the ceiling.

The seat is stabilized by stanchions attached to the floor and the ceiling with quick-disconnect fittings. Telescoping stanchions are used to allow for ceiling deflection. Slide blocks attach the seat bucket to the stanchions through energy attenuating bending rods. The rods serve to stabilize the seat while stroking toward the front or sides. Stops on the stanchions above the slide blocks prevent upward motion of the seat. The seat is fully restrained against rebound after stroking.

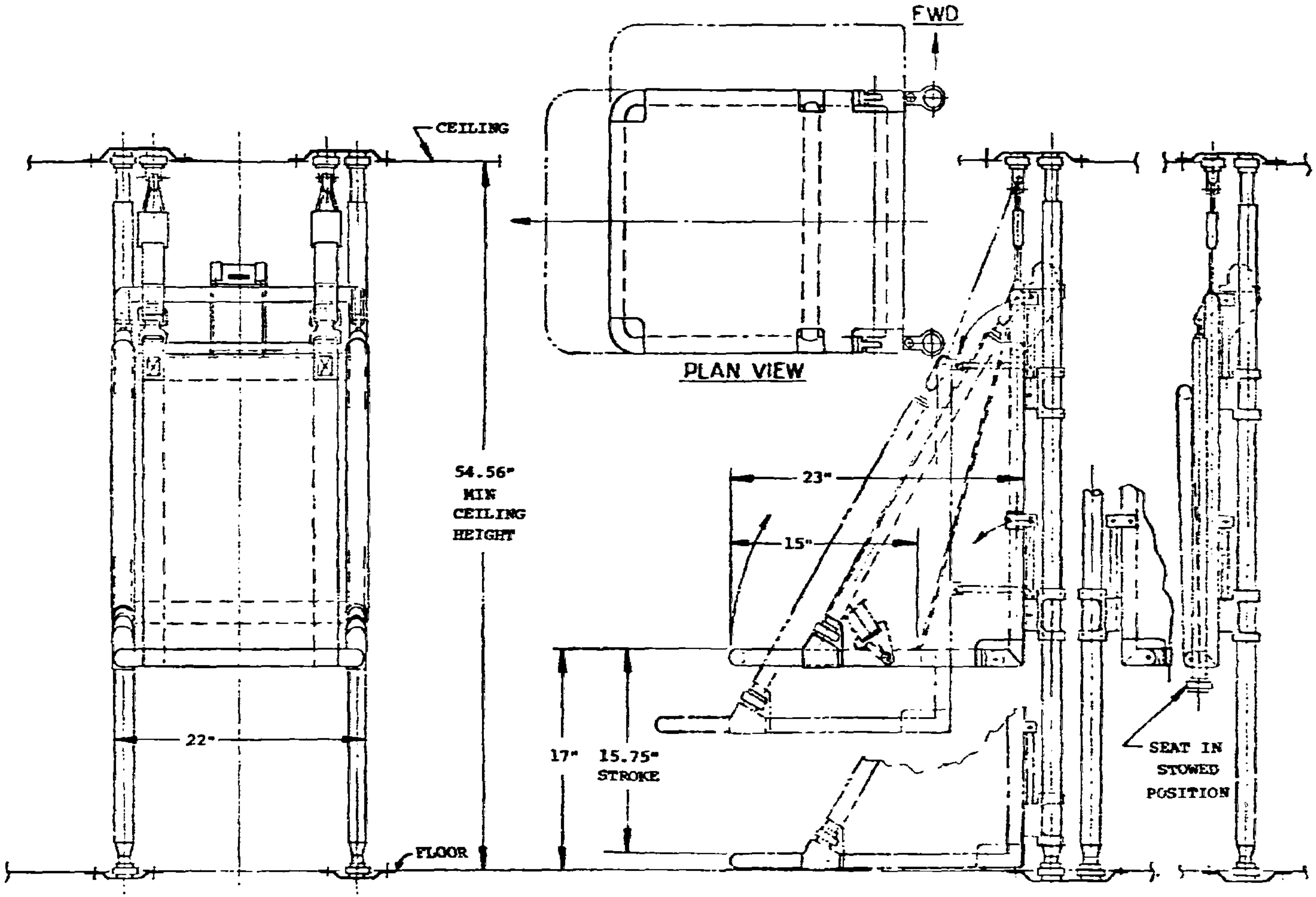


Figure 62. Concept Q - Ceiling-Mounted, Side-Facing, Back-to-Back Troop Seat.

Three-axis energy attenuation is provided. A wire-bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 15.75 inches for the 17-inch-high seat and would be 16.75 inches for an 18-inch-high seat. The seat is attenuated in the forward and lateral directions by bendable cantilevered rods which bend in the direction of impact.

Lap belt anchor fittings are attached to both sides of the seat pan. A single shoulder harness reel is supported at the top of the seat back frame. Seat weight including shoulder restraint is 35.8 pounds.

Concept R

Concept R, shown in Figure 63, is a ceiling- and floor-mounted, forward-facing troop seat. The seat pan, constructed of tubing, is covered with fabric. Legs support the seat pan at the front, and the back is supported by a fabric and webbing panel. Wire-bending energy attenuators attach the back panel to the ceiling through quick-disconnect fittings. Seat suspension straps or braces are not required above the seat other than at the back. An auxiliary back is provided which hooks onto the back panel and can be dropped when the occupant is wearing a pack.

The seat is stabilized in the forward and aft directions by torsion-wire telescoping-tube energy attenuators attached diagonally from the front of the seat pan to the floor. Crossed cables stabilize the seat laterally.

Energy attenuation is provided in the vertical, forward, and lateral directions. A compact wire-bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 14 inches for the 17-inch-high seat and would be 15 inches for an 18-inch-high seat. Peel tube energy attenuators are used for the front legs, which stroke to the smallest height of any tubular energy attenuators. The stabilizing strut incorporates a torsion-wire energy attenuator for forward impact loads. The seat is attenuated in lateral impacts by the cross cables of annealed stainless steel which yield under lateral crash loads. The seat moves freely in all three axes through the use of ball type rod end bearings at the ends of the front legs and the diagonal stabilizing strut. Four quick-disconnect fittings attach the struts, legs and cables to the floor.

The lap belt anchor fittings are attached to the seat pan tube on both sides of the seat. No provision is made on the seat for shoulder harness reel attachment due to the flexibility of the seat back. For shoulder straps to be used with the seat, an auxiliary reel support structure is required such as

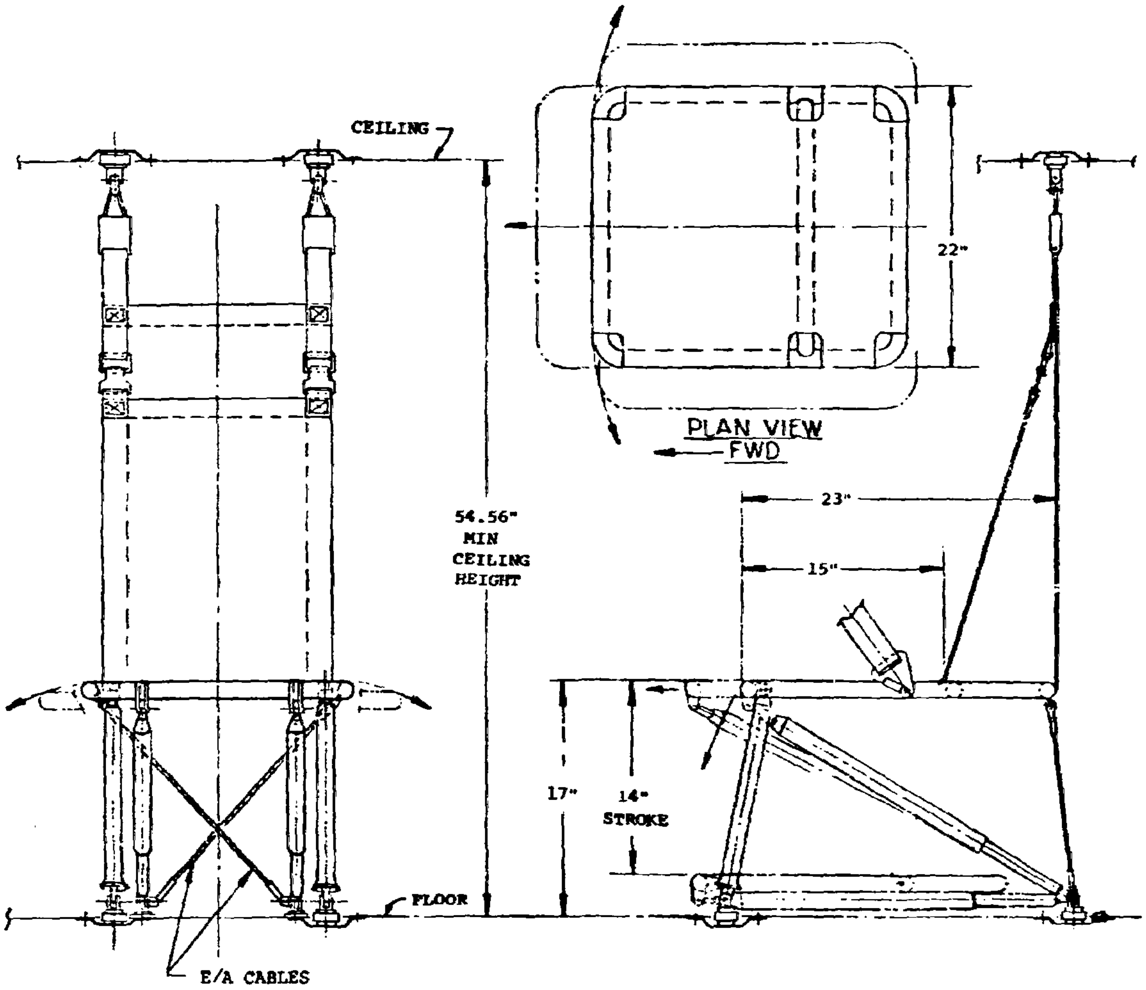


Figure 63. Concept R - Ceiling- and Floor-Mounted, Forward-Facing Troop Seat.

shown on Figure 46. Seat weight is 18.2 pounds with shoulder harness and 12.5 pounds without harness and reel support.

Concept S

Concept S, shown in Figure 64, is a ceiling- and floor-mounted, aft-facing troop seat. This concept is similar to forward-facing concept R with the exception that the diagonal stabilizing strut is attached to the back of the seat rather than the front. This is done to facilitate seat stroking during predominantly forward and vertical impacts. Forward and vertical energy attenuation is accomplished in a similar manner to concept R. Vertical stroke is 14 inches for a 17-inch-high seat. Seat weight is 18.2 pounds with shoulder harness and 12.5 pounds without harness or reel support.

Concept T

Concept T, shown in Figure 65, is a ceiling-mounted, forward- or aft-facing troop seat. The seat bucket, consisting of seat pan and back, is of tubular construction. The seat pan is supported from the back by a diagonal brace. A quick-disconnect fitting attaches the brace to the seat pan. Hinge points at the intersection of the seat pan and back allow the seat pan to be folded up against the back. Seat pan, back, and sides are fabric covered, and an auxiliary fabric back is provided for use when the occupant is not wearing a pack. The bucket is supported by wire-bending energy attenuators attached to the ceiling.

The seat bucket is stabilized in all directions by stanchions attached to the floor and ceiling with quick-disconnect fittings. Telescoping stanchions are used to allow for ceiling deflection. Slide blocks connect the seat bucket to the stanchions. Stops on the stanchions above the slide blocks prevent upward motion of the seat. The bucket is suspended from the ceiling by wire-bending energy attenuators attached with quick-disconnect fittings.

Energy attenuation devices are provided in the vertical direction only. A compact wire-bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 15.75 inches for the 17-inch-high seat and would be 16.75 inches for an 18-inch-high seat.

Lap belt anchor fittings attach the belt to each side of the seat pan. A double shoulder harness reel is supported at the top of the seat back frame. Seat weight including shoulder restraint is 32.7 pounds.

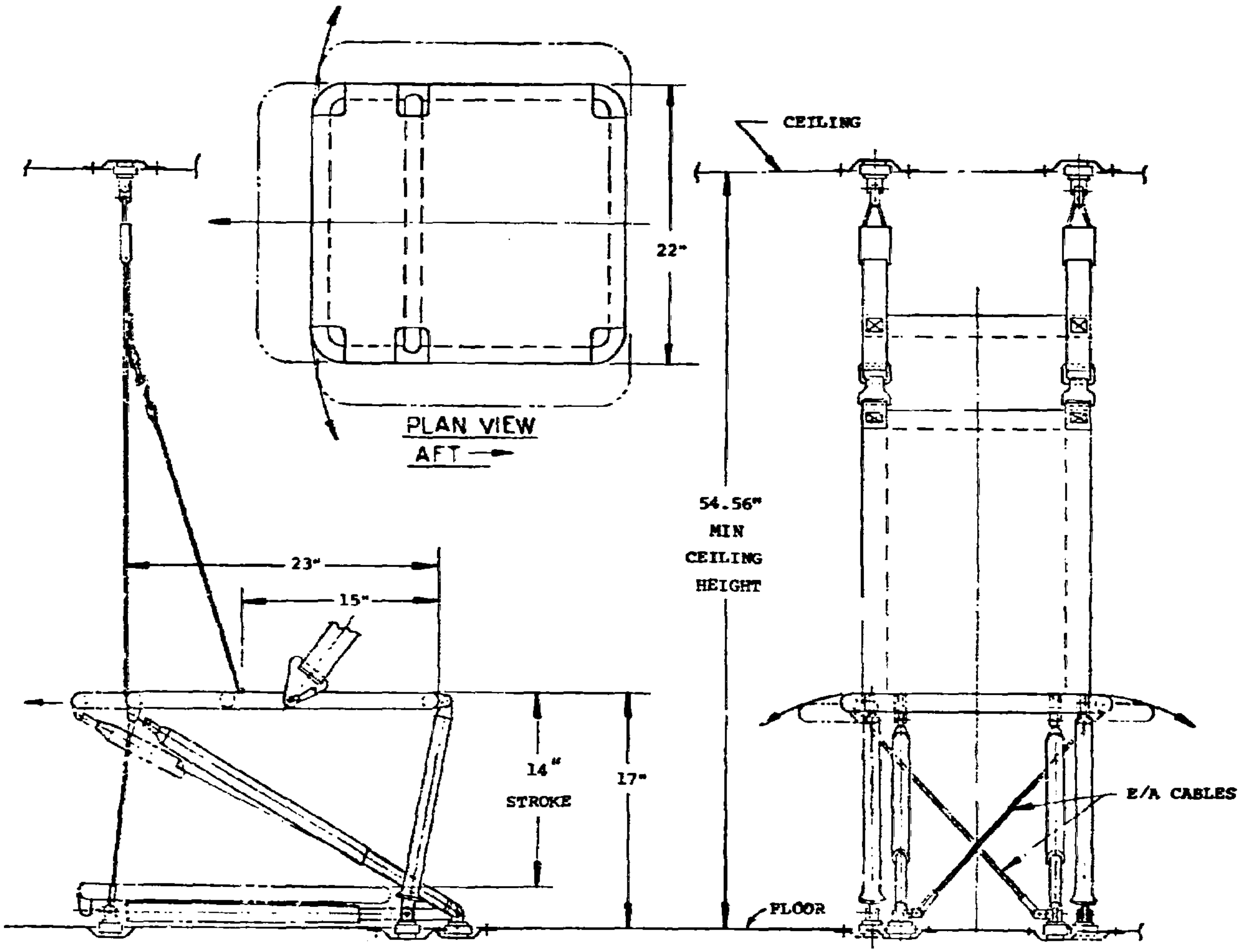


Figure 64. Concept S - Ceiling- and Floor-Mounted, Aft-Facing Troop Seat.

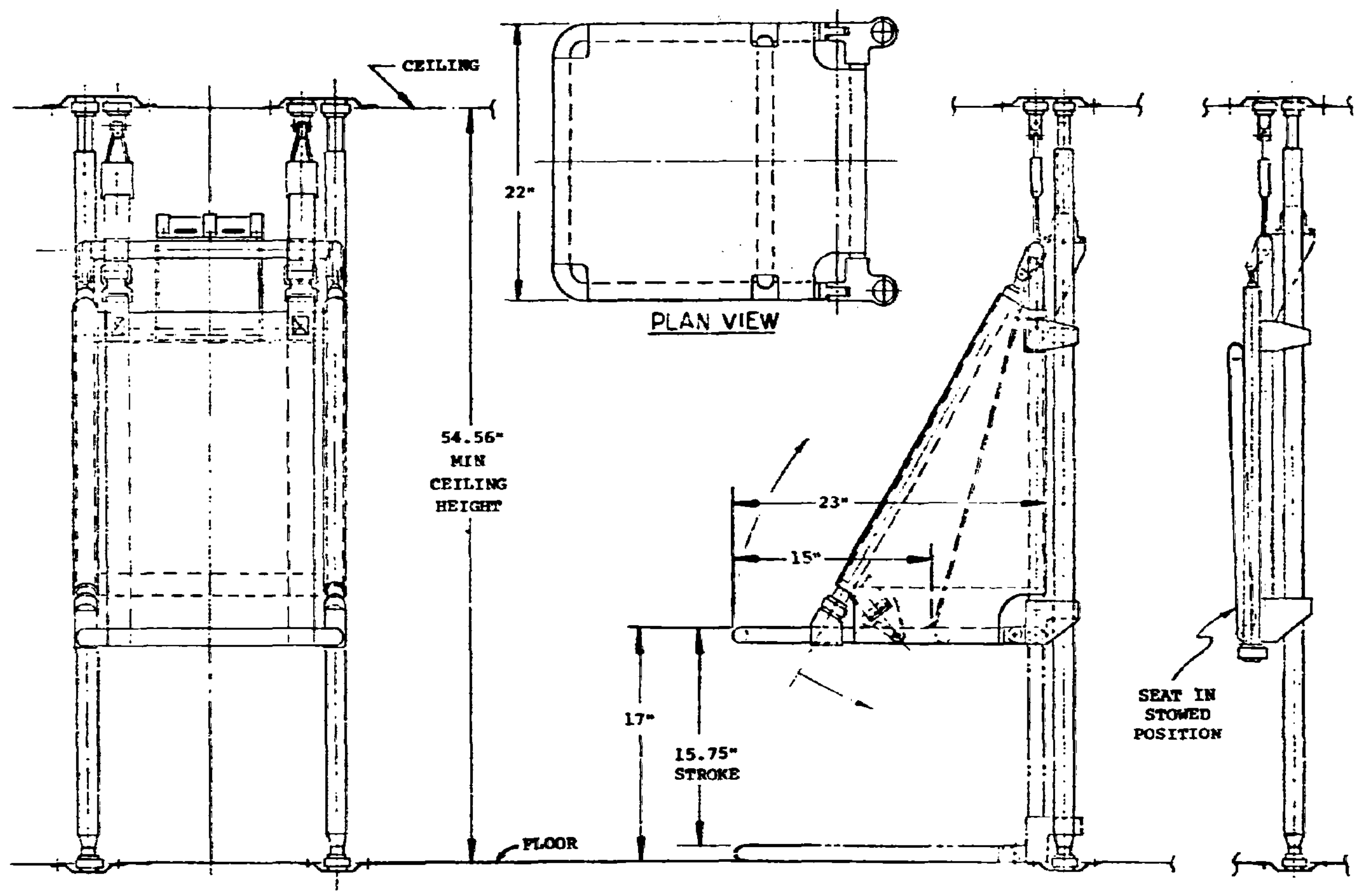


Figure 65. Concept T - Ceiling- and Floor-Mounted, Forward- or Aft-Facing Troop Seat.

Concept U

Concept U, shown in Figure 66, is a ceiling-mounted, forward-facing seat. The seat pan, constructed of tubing and covered with fabric, is suspended in a cantilever fashion. The back, a tubular compression member in combination with a webbing tension member, forms a truss which supports the seat pan. A fabric auxiliary back is provided along the plane of the tension webbing. A flap in the auxiliary back is removable, uncovering a pocket which will accommodate a combat pack when the occupant wears one.

The seat pan is maintained in a level attitude during stroking by the cantilever suspension system. Stability in the longitudinal direction is maintained by energy attenuator struts attached diagonally from the front of the seat pan to the floor. These struts are free to rotate downward without stroking during vertical crash impact conditions. Lateral stability is accomplished by crossed cables at the front and back of the seat.

Energy attenuation is provided in the vertical, forward, and lateral directions. A compact wire-bending energy attenuator is used for vertical impact loads. Seat stroke in the vertical direction is 14.5 inches for the 17-inch-high seat and would be 15.5 inches for an 18-inch-high seat. Longitudinal energy attenuation is accomplished during forward crash impact by the diagonal struts under the seat. These struts incorporate an energy attenuation feature consisting of wire wrapped between telescoping tubes. A load-limiting effect is produced by wire rolling between the tubes as the tubes separate during stroking. Lateral impact loads are attenuated by the crossed cables which yield under crash loads. Seat freedom of movement in all three axes is permitted during a crash by ball type rod end bearings, which attach the stabilizing strut to the seat pan. The struts and energy attenuating cables are permitted to rotate at the floor by the four quick-disconnect fittings attached to the floor studs.

Lap belt anchor fittings are connected to the seat pan tube on both sides of the seat. Two shoulder harness reels, permitting full and independent strap retraction, are attached to the tubular seat back. Guides are provided to position the shoulder straps at the location specified in the Troop Seat Military Specification. Seat weight is 11.4 pounds without restraint and 13.9 with restraint system.

This concept can be converted to a rear-facing or side-facing concept by rotating the diagonal struts under the seat to the forward direction.

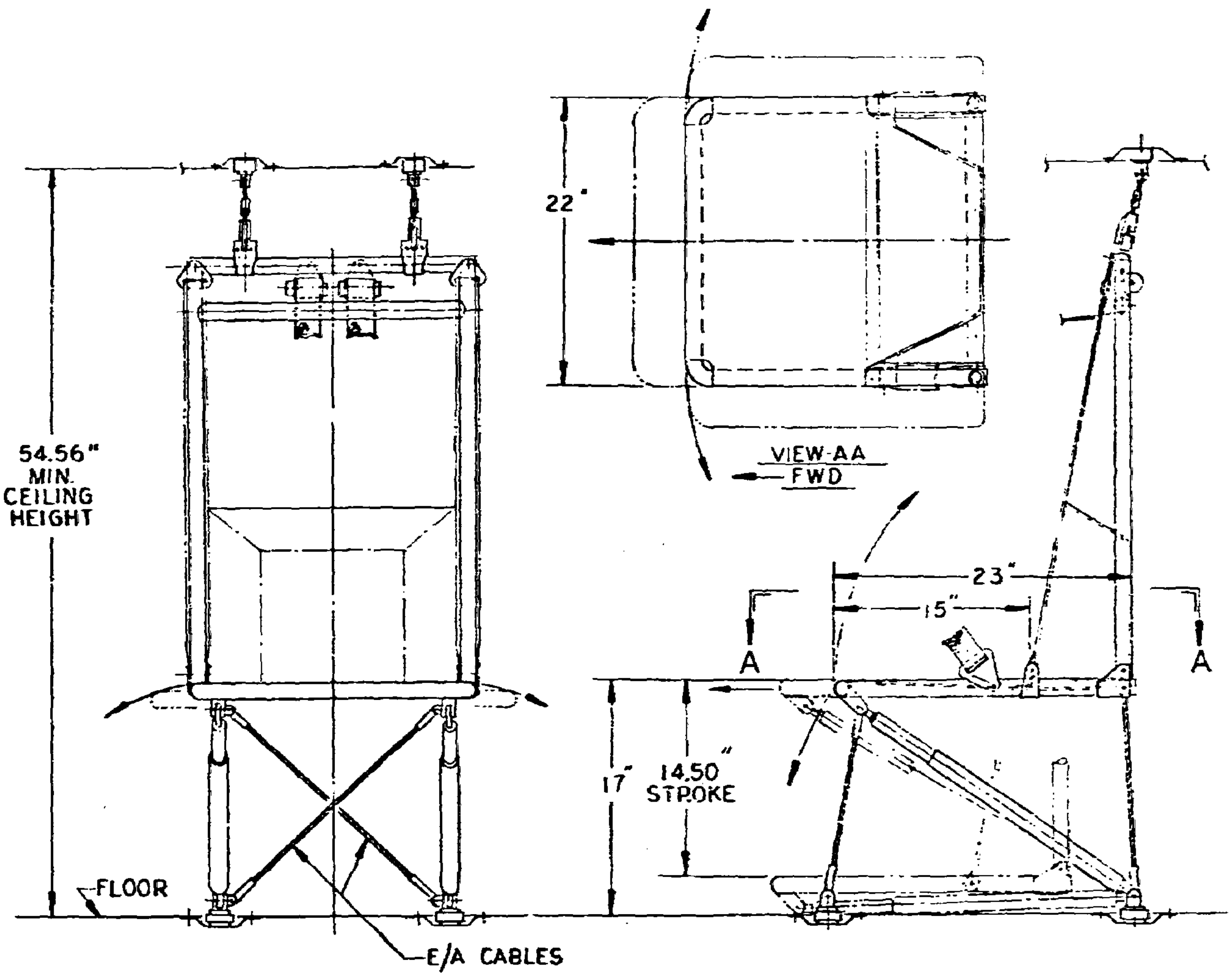


Figure 66. Concept U - Ceiling-Mounted, Forward-Facing Troop Seat.

SEAT SYSTEM CONCEPT COMPARISON AND SELECTION

CONCEPT EVALUATION

Each of the nineteen seat concepts developed was evaluated for weight, human factors, shoulder restraint, simplicity, cost, operational suitability, and crashworthiness. The concepts are scored from zero to five. A score of zero indicates that the concept is unacceptable in that particular category, while a score of five indicates that the concept meets all of the requirements.

WEIGHT

A detailed weight analysis was made for each concept. Weight totals and scores are tabulated in Table 11.

Weights varied from a low of 13.9 pounds to a high of 38.1 pounds. Concept U has the lowest weight. Although the basic seat is heavier than some concepts without back frames, the total seat system with adequate shoulder restraint is lighter. The reason is that an auxiliary shoulder harness reel support is not required, as the back frame adequately supports the reels.

HUMAN FACTORS

The principal considerations in the human factors evaluation were the problems that may occur with the seats during troop use in combat operations. Each seat was evaluated for the ease of ingress and egress while the troop was wearing combat equipment. Seats with supports on the sides of the seating area were evaluated lower than seats which were clear of any side obstructions. Of the seats with side supports, those with rigid supports received lower ratings than those with flexible supports. The degree of encumbrance caused by the side supports influenced the evaluation. Consideration was also given to areas of the seats where openings or edges existed which could cause snagging of troop equipment.

SHOULDER RESTRAINT

Effective shoulder harness systems require that the reels be mounted in a manner to resist horizontal crash impulse loads without excessive deflection of the occupant's shoulders relative to the seat pan. The reels must also be located in accordance with the Draft Troop Seat Military Specification.

TABLE 11. SEAT CONCEPT WEIGHT SUMMARY

CONCEPT	SEAT WEIGHT (lb)	RESTRAINT SYSTEM WEIGHT (lb)	TOTAL WEIGHT (lb)	SCORE
A	32.4	5.7	38.1	0
B	32.4	5.7	38.1	0
C	11.0	5.7	16.7	4
D	11.0	5.7	16.7	4
E	16.9	2.8	19.7	3
F	11.0	5.7	16.7	4
G	15.3	2.8	18.1	3
H	15.3	2.8	18.1	3
J	29.0	2.8	31.8	0
K	26.2	2.8	29.0	0
L	32.8	2.8	35.6	0
M	23.9	2.8	26.7	1
N	18.1	2.8	20.9	2
P	11.0	5.7	16.7	4
Q	33.0	2.8	35.8	0
R	12.5	5.7	18.2	3
S	12.5	5.7	18.2	3
T	29.9	2.8	32.7	0
U	11.4*	2.5*	13.9*	5

*actual measured weights
I and O omitted for clarity

The seat concepts evaluated provided shoulder harness reel installations integral with the seat back or mounted on structure external to the seat. External reel supports were provided for all flexible-back seats, as these backs inadequately support reels or guides. Seats with integral reel installations received higher scores in the evaluation. The rigidity of the seat backs also influenced scoring. Shoulder harness reels on all concepts were located in accordance with the specification and therefore did not influence scoring.

SIMPLICITY AND COST

Simplicity and cost are directly proportional. The number of parts and the intricacy of the parts affect both cost and simplicity. Seat concepts with the most parts received low scores. Concepts with slides or guides requiring machining or close-tolerance fits were also rated low. Concepts with apparent simplicity such as ceiling-mounted, fabric-back seats may have received lower scores than seats with tubular-back frames. The reason is that concepts with flexible backs require auxiliary provisions for shoulder harness reel installation. The overall cost is less for rigid seat backs and integral reel installations than for auxiliary structure and sliding reels mounted externally to the seat.

OPERATIONAL SUITABILITY

The principal considerations for operational suitability are reliability and maintainability. In evaluating the seat concepts for reliability, the basic construction was discounted, as all seats are constructed of tubular frames and fabric covers. Energy attenuators used are generally common to all concepts and were also discounted. The features which were evaluated are the devices used for seat guidance and stability during the stroking motions. Seats employing slides for guidance are considered to be less reliable than seats using radius arms. Concepts with scissor linkage or parallel bar linkage were rated between the above stabilizing methods. The use of slide type shoulder harness reel supports external to the seat also lowered the score. Seats were rated from one to five, one being the least reliable and five the most reliable.

Relatively little maintenance would be required on all seat concepts presented. Ceiling-suspended and floor-stabilized seats will require occasional tensioning to maintain tautness. Turnbuckles are provided, in the toggle release latches at the ceiling, to remove any seat slack which develops. Fabric seat pans are attached with screws which can be removed to readjust or replace fabric. Energy attenuators are simple wire-bending or torsion-wire devices which require no maintenance. Seats which slide on tubes or guideways have permanently lubriplated surfaces and require no further lubrication. Rod end bearings at the ends of energy attenuating struts are permanently lubricated sealed units requiring no maintenance.

CRASHWORTHINESS

Each seat concept was evaluated for the degree of seat motion freedom, energy attenuation capability, vertical stroke length, stabilization during and after stroking, and linear guidance during stroking.

All seat concepts do not provide freedom of motion during stroking to the same degree, and some do not provide three-axis attenuation. Due to the manner in which the seats are stabilized or guided during vertical impact, motion in the horizontal directions may be restricted or prevented. In some concepts, vertical motion may be restricted or deviated from. Seat concepts using a tubular guide for vertical motion were given the highest rating for stabilization and guidance during and after stroking. When a radius rod or cable is used for guidance and stabilization, the stroking path is altered from a straight line to an arc, and concepts with this feature received lower guidance ratings. Seats using cables and straps for seat stabilization received lower ratings because they go slack after stroking, thereby reducing seat stability (Table 12).

EVALUATION RESULTS

The categories for which the seat concepts were evaluated are considered about equal in importance; therefore, no weighting was given for a particular category. The scores for each concept were tabulated and are shown in Table 13.

CONCEPT SELECTION

The results of the concepts evaluation show that Concept U received the highest score in all categories evaluated. The evaluation scores for most concepts were well below those for Concept U, and the second highest scores were 35% lower. Five concepts were rated in second place, two of which have a potential stability problem during stroking when the C.G. is shifted on the seat pan. Two of the second-place concepts require external supports for the shoulder harness reels. The remaining concept is limited to wall mounting. All other concepts received ratings up to 62% lower than the highest scoring Concept U.

TABLE 12. CRASHWORTHINESS EVALUATION

Concept	Seat Motion Freedom			3-Axis E/A	Vert. Stroke Length	Guidance & Stability	Total	Score Total
	Vert.	Fwd.	Lateral					
A	4	3	4	5	1	4	21	3.5
B	4	3	4	5	1	4	21	3.5
C	4	4	4	5	4	3	24	4.0
D	4	4	4	5	4	3	24	4.0
E	3	2	3	5	2	3	18	3.0
F	4	4	4	5	4	3	24	4.0
G	3	3	4	5	3	0	18	3.0
H	3	3	4	5	3	0	18	3.0
J	5	2	2	5	5	5	24	4.0
K	5	0	0	2	5	5	17	2.8
L	5	2	2	5	5	4	23	3.8
M	4	4	4	5	4	3	24	4.0
N	3	2	2	5	2	4	18	3.0
P	4	4	4	5	4	3	24	4.0
Q	5	2	2	5	5	5	24	4.0
R	2	3	3	5	2	1	16	2.6
S	2	3	3	5	2	1	16	2.6
T	5	0	0	2	5	5	17	2.8
U	4	4	4	5	4	4	25	4.2

TABLE 13. TROOP SEAT CONCEPTS EVALUATION

Seat Concept	Weight	Human Factors	Shoulder Restraint	Simplicity And Cost	Operational Suitability	Crash-Worthiness	Total Score
A	0	5	1	3	2	3.5	14.5
B	0	5	1	3	2	3.5	14.5
C	4	4	1	3	3	4.0	19.0
D	4	4	1	3	3	4.0	19.0
E	3	3	3	3	4	3.0	19.0
F	4	2	1	3	3	4.0	17.0
G	3	1	3	4	5	3.0	19.0
H	3	1	3	4	5	3.0	19.0
J	0	3	4	1	1	4.0	13.0
K	0	1	5	2	1	2.8	11.8
L	0	3	3	1	3	3.8	13.8
M	1	1	3	3	4	4.0	16.0
N	2	3	2	2	2	3.0	14.0
P	4	1	1	3	3	4.0	16.0
Q	0	1	4	1	1	4.0	11.0
R	3	5	1	3	3	2.6	17.6
S	3	5	1	3	3	2.6	17.6
T	0	1	5	2	1	2.8	11.8
U	5	5	5	5	5	4.2	29.2

The selection of Concept U as the optimum concept is conclusive. This concept provides a seat pan that is unencumbered by braces beside the seating area. It maintains a stable attitude during vertical stroking even if the C.G. on the seat pan is shifted due to various percentile troop weights or combat equipment carried. It is capable of three-axis energy attenuation, and vertical stroking distance is adequate. Rigid seat back structure is provided for mounting the shoulder harness reels integral with the seat. Weight and cost are reasonable for the protection afforded. Cost of this seat concept in production quantities has been estimated by a troop seat fabricator and was determined to be approximately 25% higher than the standard one-man, free-standing, noncrashworthy troop seat currently in use in the UH-1 aircraft. This is a small price to pay, considering the improved protection afforded by a crashworthy seat. Comparing the two types of seats, the noncrashworthy seat is designed to withstand 8G in the forward, vertical, and lateral directions, while the crashworthy seat will withstand crash impact loads of 24G, 48G, and 18G in the forward, vertical, and lateral directions respectively. The crashworthy seat also provides shoulder restraint in addition to the lap belt provided for both seats.

The need for crashworthy troop seats is shown in the noncombat fatality figures for survivable Army aircraft accidents from July 1964 through June 1969. The figures show that 51.2 percent of the fatalities were troop/passenger and 21.3 percent were crew chief/gunner, as compared to 27.5 percent for pilot/copilot.

CRASHWORTHY TROOP SEAT SYSTEM DETAIL DESIGN

DESIGN APPROACH

The Statement of Work required that detail designs be performed on one forward-, one aft-, and one side-facing troop seat concept. Each of the three designs was to be presented in the Type I (one-man seat) and Type II (two-man seat) arrangements.

The selected concept, Concept U, which is a one-man, forward-facing concept, was modified for aft-facing and side-facing arrangements. The diagonal stabilizing strut under the seat was reversed 180° to make an aft-facing seat and 90° to make a side-facing seat. To produce a two-man seat, common components at the two-seat juncture area were investigated. Common components included were: vertical energy attenuator, diagonal stabilizing strut, seat back tube and seat pan tube. It was found that the weight of a tube with the same diameter as that in the one-man seat and designed for twice the bending load would be at least 50% heavier than two tubes of the lighter wall thickness. This was true for the seat back tube and the seat pan tube. Difficulty was experienced in designing an aluminum diagonal strut, energy attenuator capable of twice the load of the one-man seat strut. Such loads were outside the capability of an aluminum strut, and a single steel strut was nearly double the weight of two lighter struts. Similar difficulties were experienced in designing the vertical wire-bending energy attenuator for double the load. Cost for a two-man seat with single components in the joining area was considerably more than that for two one-man seats because of the additional dissimilar components required. It was concluded that the least expensive and lightest weight two-man seat is one which effectively joins two one-man seats together.

DESIGN REFINEMENTS

The selected concept was refined as detailed components were investigated. Conventional troop seat leg-to-floor quick-disconnect fittings were found to be inadequate for use on the crashworthy troop seats due to the high moment they impose on floor studs and also due to their looseness. A new quick-disconnect fitting was developed which carries the load to the base of the stud, inducing no moment, and was designed for a snug fit. A picture of this quick disconnect is shown in Figure 76 (discussed later), and detail drawings are given in Appendix A.

To provide maximum seat stability for normal flight loading, a method of tensioning the seat is necessary. A combination turnbuckle and overcenter toggle latch was developed and used at the attachment of the seat to the ceiling. A picture of the latch is shown in Figure 67 (discussed later), and the detail drawings are given in Appendix A.

The pocket in the auxiliary back for accommodating troop combat packs was developed by constructing a mockup. There was a tendency at first for the combat pack to catch on the top of the pocket until it was raised several inches. The drawings were made to reflect the developed pocket configuration. Several methods of fastening the auxiliary back flap over the pocket were investigated, including hooks, buckle and straps, and a hook and pile tape. The hook and pile tape appeared to be the most satisfactory and was incorporated on the drawings.

Methods of saving weight in the diagonal strut energy attenuators were investigated. Previously, all telescoping-tube torus-wire energy attenuators have been made of steel. An energy attenuator fabricator was requested to investigate a lightweight version of his tubular steel unit. He developed an aluminum, telescoping-tube, torus-wire attenuator which he tested, and these initial tests proved to be satisfactory.

Detail and assembly drawings were made of the remaining seat components. The drawings are for forward-facing, side-facing, and aft-facing seat concepts for both Type I (one-man) and Type II (two-man) seats (Appendix A).

A load and stress analysis was made for the basic concept and is on file at the Eustis Directorate.

TROOP SEAT SYSTEM DESIGN, FABRICATION AND EVALUATION

DESIGN

It was a program requirement to install the most promising troop seat concept in the Boeing UTTAS aircraft mockup for evaluation using combat assault troops. Two rows of face-to-face seats totaling eight seats were specified. The seats were to be designed to be capable of future crash load dynamic and static testing and were also to serve as mockups for human factors evaluations.

Design modifications of the previously selected seat concept were required to adapt it to the Boeing UTTAS aircraft mockup. The aircraft is configured with its sides curving in at the ceiling. Straight-sided seat backs designed as an idealized seat configuration (Appendix A) would not fit into the aircraft, so the mockup seats were designed with tapered backs. Aircraft space limitations did not permit use of the idealized 22- by 23-inch seat pan, so a 20- by 20-inch pan was designed. Connections at the ceiling required revision to attach the seat to a suspension beam rather than to the ceiling, as the positioning of the transmission prohibited ceiling structural provisions. A false floor with quick-disconnect stud plates for attaching the seats was designed for the UTTAS so as not to disturb the fittings on the UTTAS floor. The mockup/crashworthy seat was designed as a single-unit seat. A design variation was made of single-unit seats by joining them together to produce a multi-unit seat. Two of these were required by the contract Statement of Work.

FABRICATION

Four single-unit seats (Type I) and two double seats (Type II) were fabricated. This provided a total of eight places or two rows of four. Seats were fabricated by an experienced producer of troop seats. Many techniques employed in conventional troop seat fabrication were also used for the crashworthy seats.

CRASHWORTHY TROOP SEAT SYSTEM HUMAN FACTORS EVALUATION - FIRST MOCKUP DEMONSTRATION

Crashworthy troop seats developed for the Eustis Directorate and installed in the Boeing UTTAS mockup were evaluated in tests conducted at the Boeing Vertol Company. Government evaluators were present to view the proceedings; the eight people involved represented the following organizations:

U.S. Army Human Engineering Laboratories Aberdeen, Md.	(USAHEL)
U.S. Army Aeromedical Research Laboratory Ft. Rucker, Ala.	(USAARL)
U.S. Army Aviation Systems Command St. Louis, Mo.	(AVSCOM)
U.S. Naval Air Development Center Johnsville, Pa.	(NADC)
U.S. Army Air Mobility Research and Development Laboratory, Ft. Eustis, Va.	(USAAMRDL)

Eleven troops were provided by USAHEL, Aberdeen, and were selected to represent the percentile range from the 5th to the 95th. Table 14 gives relevant anthropometric data for troops used in the evaluation. Percentile data was obtained from report number TR-72-51-CE, U.S. Army Natick Laboratories, for measurements of the troops used in the first mockup evaluation.

The troops were used in the individual evaluation of the crashworthy seat and restraint systems and for ingress-egress tests using eight troops. Tests were conducted which included evaluations of the seat and restraint system with troops wearing various combinations of combat assault packs, rucksacks, back pack radio, cold-weather and arctic clothing, body armor, and other combat gear. The following combinations of clothing and equipment were evaluated:

1. Warm-weather clothing and no equipment
2. Intermediate-weather clothing, fragmentation vest, butt pack, and full combat assault equipment
3. Intermediate-weather clothing, fragmentation vest, medium rucksack with Lincloe frame, and full combat assault equipment

TABLE 14. SUMMARY OF ANTHROPOMETRIC DATA FOR TROOPS USED IN FIRST EVALUATION

TROOP REF. NO.	WEIGHT		LINEAR DIMENSIONS				CIRCUMFERENTIAL DIMENSIONS			
			HEIGHT		SITTING SHOULDER HT		WAIST		CHEST	
	LB	*	IN.	*	IN.	*	IN.	*	IN.	*
1	180	82	73.2	95	23.5	23	31.1	52	35.9	38
2	193	91	73.0	94	25.1	71	31.9	62	36.4	41
3	185	86	72.1	90	24.5	50	34.5	83	40.2	89
4	171	73	71.6	86	24.6	52	32.1	64	38.2	72
5	183	85	70.9	80	23.6	24	31.5	57	36.6	50
6	159	54	69.9	68	23.1	14	31.5	57	37.4	61
7	161	57	68.6	49	23.6	24	32.7	70	37.0	57
8	126	5	66.4	18	22.1	4	27.6	6	32.7	3
9	128	7	66.3	17	21.9	3	28.0	9	32.8	4
10	125	5	65.3	9	21.2	1	30.5	42	34.2	14
11	107	1	63.2	2	20.8	0.5	25.6	0.5	30.5	0.5

NOTE:

(1) Percentile values based on TR-72-51-CE;[17] 1966 Army Anthropometric Data.

(2) Troops listed in order of decreasing height.

* Troop Percentile

4. Cold-weather (arctic) clothing, fragmentation vest, butt pack, and full combat assault equipment

5. Cold-weather clothing, fragmentation vest, medium rucksack with Lincloe frame, and full combat assault equipment

SEAT STOWAGE AND INSTALLATION

The ease with which the crashworthy troop seat can be stowed or installed was amply demonstrated. A seat in the installed position was released, folded, and stowed in 21 seconds by a representative of USAHEL who was not familiar with the seat. The seat was reinstalled from the stowed position in 24 seconds. These values are within the time limitations specified in the Draft Troop Seat Military Specification. Details and times for specific operations are given in Table 15, with Figures 67 through 70 showing pictorially the five phases of the stowage operation.

The five basic phases of the stowage operation are in order:

- Release the headrest (Figure 67)
- Release the vertical tensioning latches (Figure 67)
- Release the floor quick-disconnects at the back of the seat (Figure 64)
- Release the floor quick-disconnects at the front of the seat (Figure 69)
- Fold seat and position in stowage location against the aircraft ceiling (Figure 70)

The installation from the stowed positions entails the same operations as above but in the reverse order.

SEAT INSTALLATION CONFIGURATION

The crashworthy troop seats used for this demonstration and evaluation were those designed and manufactured under this contract. (See section on Testworthy Seat.) Eight seats (four single and two double) were used, and they were constructed to standards suitable for mockup demonstration and the simulated crash load testing required by the proposed Troop Seat Military Specification. Per contract requirements, the eight seats were installed in the Boeing UTTAS mockup in a face-to-face configuration, four seats facing forward and four facing aft. This configuration is shown in Figure 71, and

TABLE 15. ONE-MAN SEAT DISCONNECT, STOWAGE, AND RECONNECT PROCEDURE, AND TIMES TO COMPLETE EACH OPERATION

OPERATION	PROCEDURE SEQUENCE	TIME TO COMPLETE (SEC)
Seat Disconnect	● Disconnect headrest latch ● Release vertical tensioning latches (2) ● Disconnect floor quick-disconnect at rear of seat (2) ● Disconnect floor quick-disconnect at front of seat (2) ● Ensure all attachments released	15(Test 1)
Seat Stowage	● Seat Disconnect Procedure Plus Folding and Stowage	24(Test 1) 21(Test 2)
Seat Installation From Stowed Position	● Release stowed seat ● Unfold seat ● Connect floor attachments at front of seat (2) ● Connect floor attachments at rear of seat (2) ● Operate levers to tighten the vertical tensioning latches (2) ● Connect headrest latch	24(Test 1) 30(Test 2)

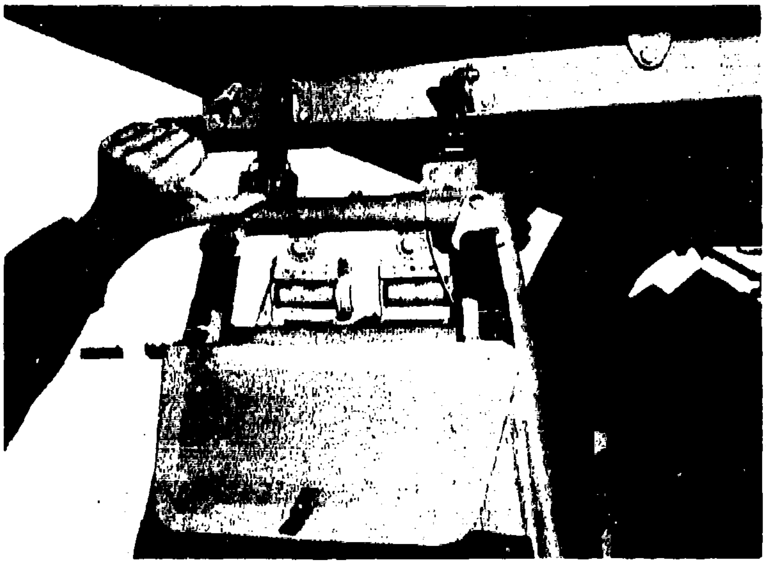


Figure 67. Headrest and Toggle Latch Release.

Figure 68. Back Floor Attachment Release.

Figure 69. Front Floor Attachment Release.

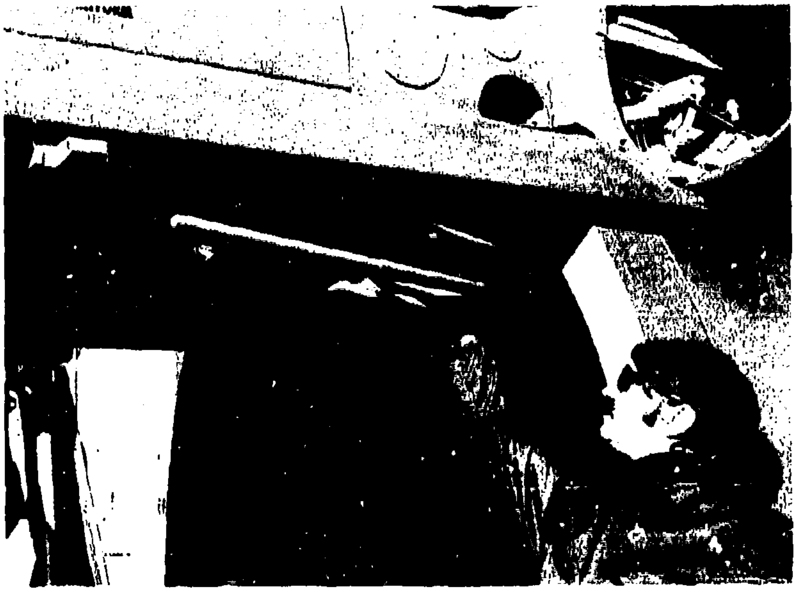


Figure 70. Seat Folded to Ceiling.

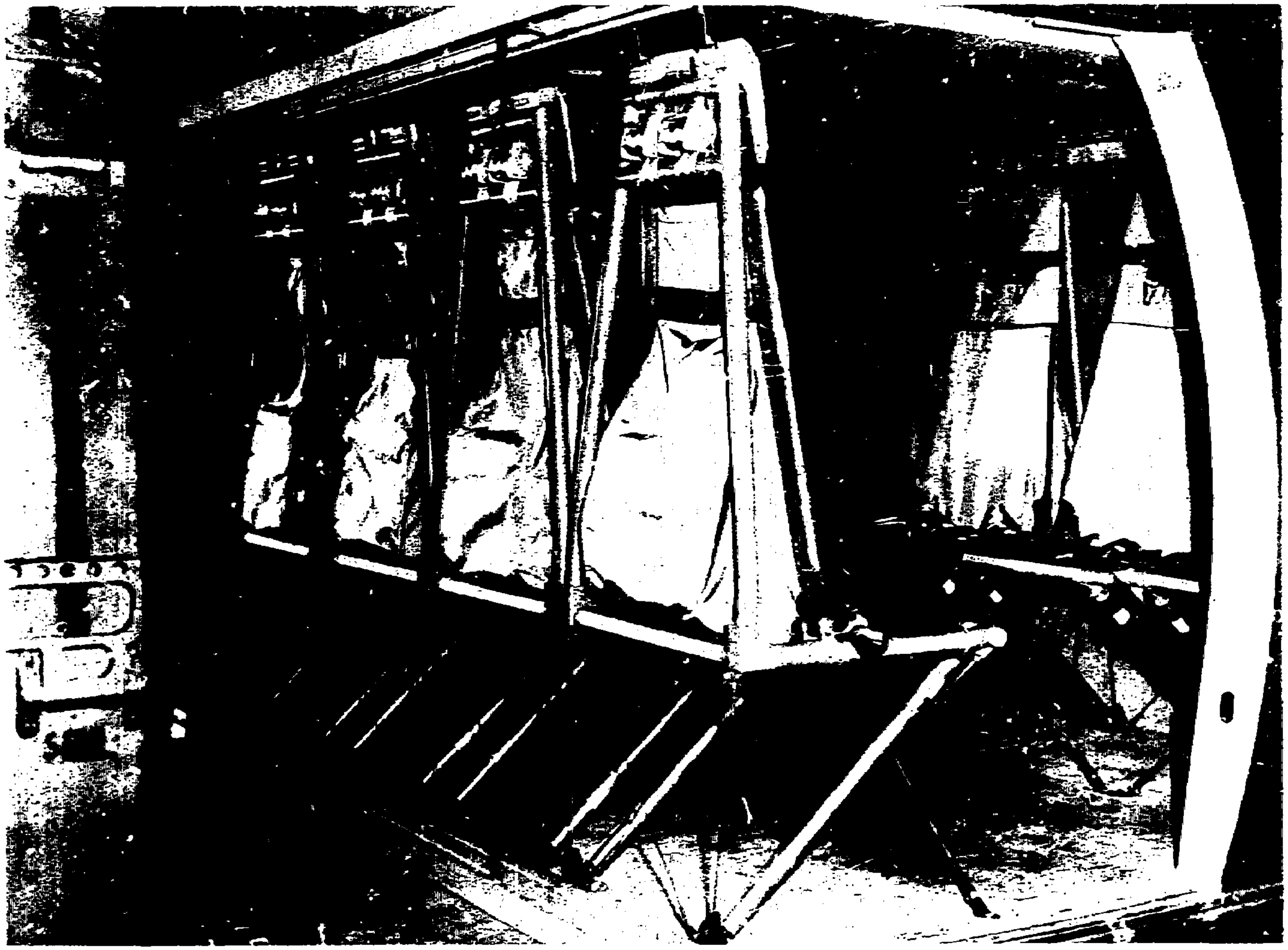


Figure 71. Seats Installed in Boeing UTTAS Mockup.

cabin dimensions are shown in Figure 72. Two differences are to be noted between this and a final aircraft configuration. All the seats used for the demonstration are designed for forward-facing locations, whereas aft-facing seats will be configured with the diagonal strut under the seat in a reversed direction. The overhead clearance in the cabin is reduced by 0.75 inch because it was necessary to provide a plywood floor mounting plate for this installation.

Several seat features are considered to be worthy of emphasis:

- A back pocket is provided to accommodate combat packs, rucksacks, etc., which troops may be wearing (Figure 73). A cover for this area of the seat back is provided for use when troops are not wearing packs.
- A rear view of the seats shows the back pockets, inertia reels for the shoulder harness straps, and the vertical attenuators (Figure 74).
- A view of the floor attachments and longitudinal and lateral attenuators is shown in Figure 75; the rear floor attachment is shown in more detail in Figure 76.
- The headrest, shoulder strap locations, back pack pocket, and lap belt locations are shown in Figure 77, and a view from the front of the seat (Figure 78) gives details of the vertical tensioning latches, vertical attenuators, inertia reel locations and tension strap attachments.

INDIVIDUAL SEAT AND RESTRAINT EVALUATION

A 2d, a 50th, and a 95th percentile troop were installed in a seat and relevant dimensions were recorded. In addition, times taken to enter the aircraft and completely hook up the restraint system were measured, as were egress times. Each of the percentiles was checked for leg height relative to seat pan height, adequate seat pan support area, head height relative to headrest, seat back angle, contact area with back of seat, back relationship while wearing combat pack or rucksack, any tendencies for snagging pack on seat pocket, and areas where equipment could snag or catch on the seat. The seat proved to be adequate in all these areas and no problems were encountered. All the troops involved in the evaluation agreed that the seats were very comfortable and roomy and that the restraint system posed no unacceptable problems.

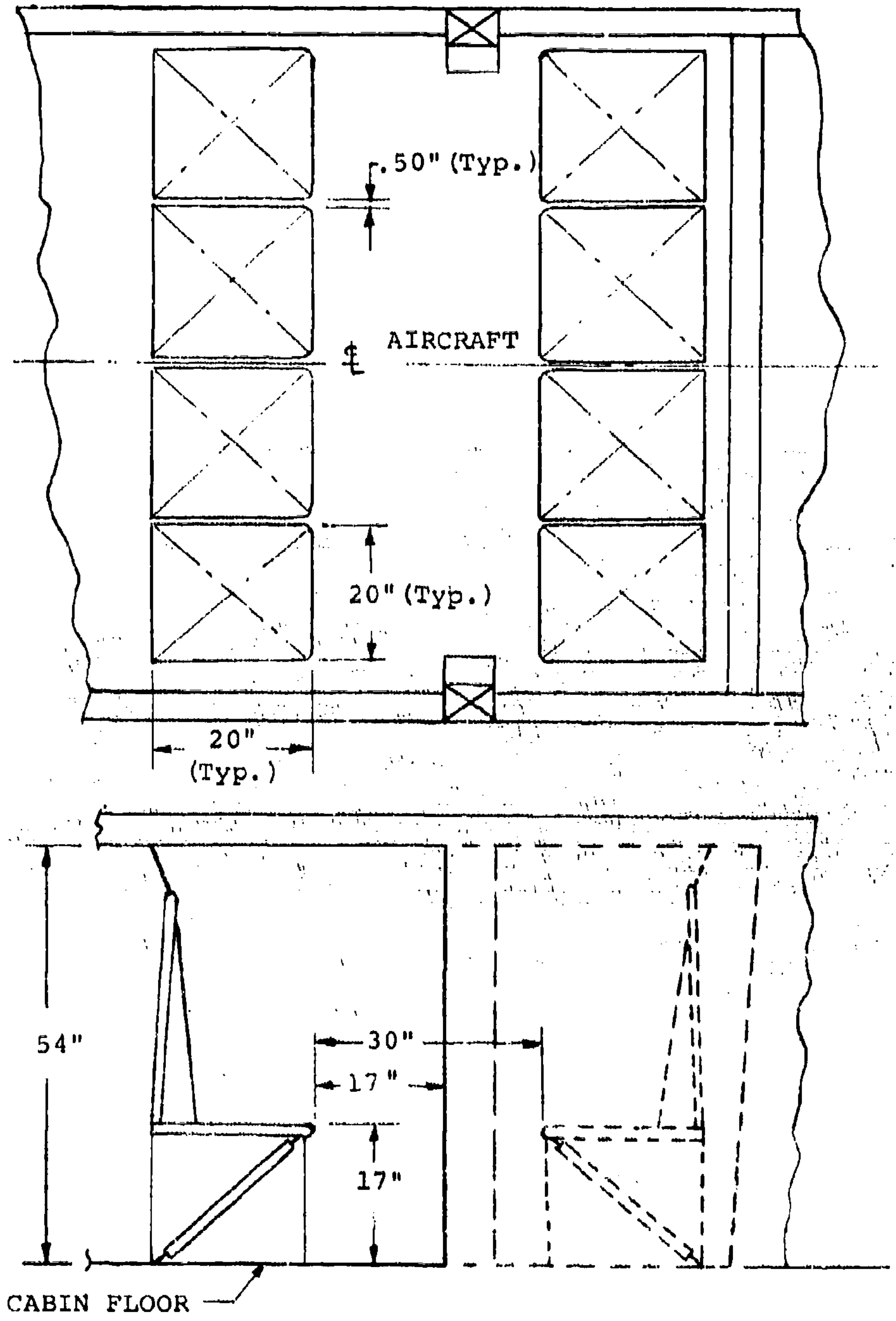


Figure 72. Geometry of Seat Installation in UTTAS Cabin.

Figure 73. Pack Accommodation Pocket - Flap Stowed.

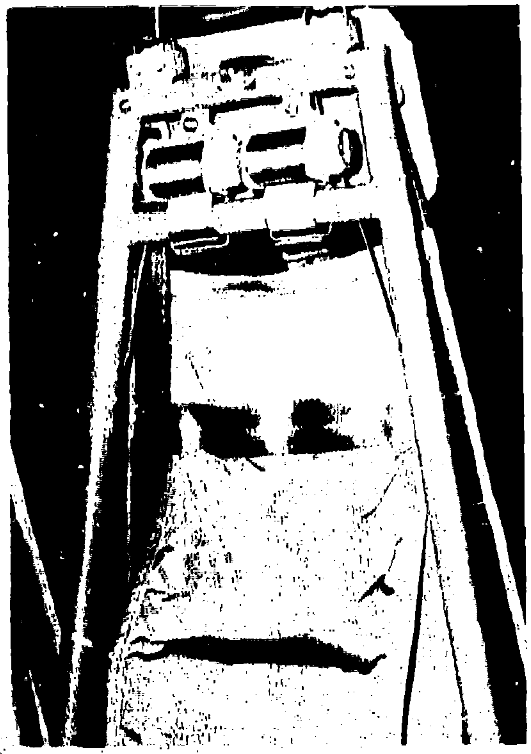


Figure 74. Rear View Showing Reels, Attenuators and Pocket.

Figure 75. Longitudinal and Lateral Attenuators.

Figure 76. Floor Attachment Quick-Disconnect.

Figure 77. Side View Showing Headrests and Pack Pockets Opened.

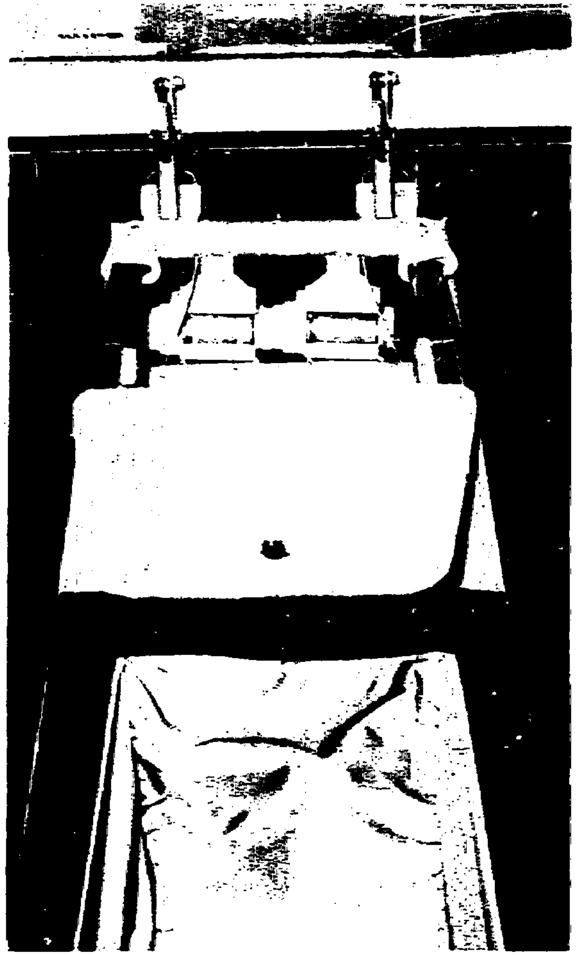


Figure 78. Detail Of Energy Attenuators and Tensioning Latches.

Table 16 gives a summary of relevant geometrical data and hookup and egress times together with details of the types of clothing and equipment worn. Restraint systems evaluated were:

- Double shoulder straps and lap belt
- Single diagonal shoulder strap and lap belt with four different fixed lengths for the right-hand lap belt: 10.0, 5.5, 4.5 and 3.3 inches measured from the centerline of the attachment bolt to the centerline of the buckle.

The 2d percentile troop, dressed in warm-weather clothing, experienced no difficulty in hooking up the restraint systems used.

Figure 79 shows the seat occupant restrained with three types of harness: double shoulder straps and two configurations of the single diagonal shoulder strap.

The only problems noted for the 2d percentile seat occupant are:

- Seat headrest slightly high. This is only marginally so, and it is considered that there will be no problem for the 5th through 95th percentile troops. The illustrations in the figures quoted above show the magnitude of the problem for the 2d percentile occupant. The headrest cannot be lowered, as it would interfere with the shoulder straps.
- In a bent-forward, psuedo-crash position, without shoulder restraint, the single diagonal shoulder strap end fitting protrudes from the lap belt buckle and digs into the body of the seat occupant. Such a design feature is undesirable and does not occur when the double shoulder strap system is used. Figure 80 shows the effect of the protrusion from the belt buckle for two right-hand belt lengths with the seat occupant in a bent-forward position.

A 50th percentile troop, wearing intermediate-weather clothing and a short rucksack, was selected for assessment of the double shoulder strap restraint system (Figure 81). The seat back pocket was opened to allow room for the rucksack, and hookup times were recorded. Initially, the troop experienced difficulty in locating the shoulder straps, which were behind his head. Subsequent tests, with the straps held forward and up at an angle of 45 degrees, showed a large improvement in hookup time (Table 16). This incident exposed the need for

TABLE 16. RESTRAINT SYSTEM EVALUATION

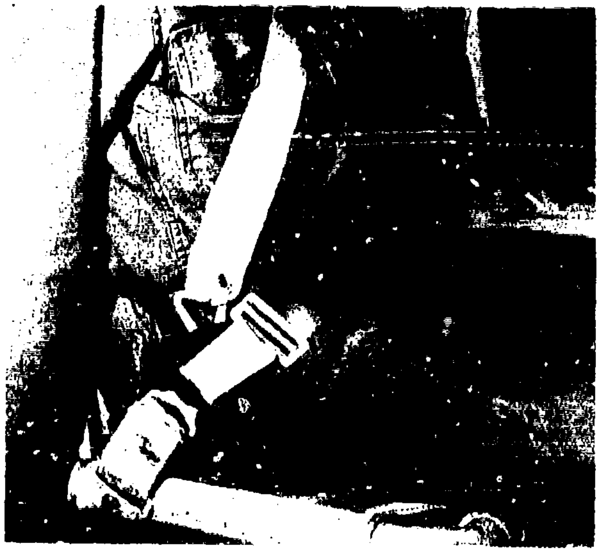
TROOP REFERENCE NUMBER	TROOP PERCENTILE	EQUIPMENT WORN	RESTRAINT SYSTEM	HOOKUP TIME (sec)	STRESS TIME (sec)	SHOULDER STRAP HEIGHT (IN.)	SHOULDER STRAP LENGTH (IN.)		LAP BELT LENGTH (IN.)		LAP BELT EXCESS (IN.)	
							R	L	R	L	R	L
11	2	Warm-Weather Clothing Only	Double Shoulder Straps	15.4 15.0	-	5.75	[illegible]	[illegible]	[illegible]	10.0	[illegible]	[illegible]
11	2	Warm-Weather Clothing Only	Single Shoulder Strap	7.4 6.	-	-		[illegible]	[illegible]	14.75	10.25	-
11	2	Warm-Weather Clothing Only	Single Shoulder Strap	6.7	-	-	-	[illegible]	[illegible]	[illegible]	13.[illegible]	-
[illegible]	[illegible]	Intermediate-Weather Clothing & Equipment [illegible]	Double Shoulder Straps	33.0* 16.0** 16.0**	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
* Shoulder Strap Accessibility Problem **Straps held up for better access by troop												
[illegible]	[illegible]	Intermediate-Weather Clothing & Equipment A	Double Shoulder Straps	17.[illegible] 14.[illegible]	-	[illegible]	27.	[illegible]	[illegible]	[illegible]	11.75	11.75
5	95	Cold-Weather (Arctic) Clothing & Equipment A	Double Shoulder Straps	31.2 14.0 23.8	1.5 - 1.5	-	24.		[illegible]	17.0	13.25	12.25
	95	Cold-Weather (Arctic) Clothing & Equip. A	Single Shoulder Strap	16.0 16.[illegible]	3.2 2.5	-	-	[illegible]	[illegible]	[illegible]	-	-
[illegible]	95	Intermediate-Weather Clothing & Equip. A	Single Shoulder Strap	15.4 14.2	- -	- -	-	[illegible]	[illegible]	3[illegible]	-	-
5	95	Intermediate-Weather Clothing & Equip. A	Single Shoulder Strap	11.3 19.5* 10.5	-	-	-	[illegible]	[illegible]	24.	-	4.[illegible]
*Inertia Reel Locked Up Due to Pulling too Quickly												
[illegible]	95	Cold-Weather (Arctic) Clothing & Equip. B	Single Shoulder Strap	-	-	-	-	32. *	[illegible]	39.0*	-	-

*These values were estimated. Both belts too short for engagement.

NOTES:
(1) Extended Shoulder Strap Length [illegible] inches
(2) Equipment A - Combat Assault Pack and Full Combat Gear
(3) Equipment B - Full Combat Gear and Medium Rucksack with [illegible] Frame 11 inches deep)

Double Shoulder Harness System

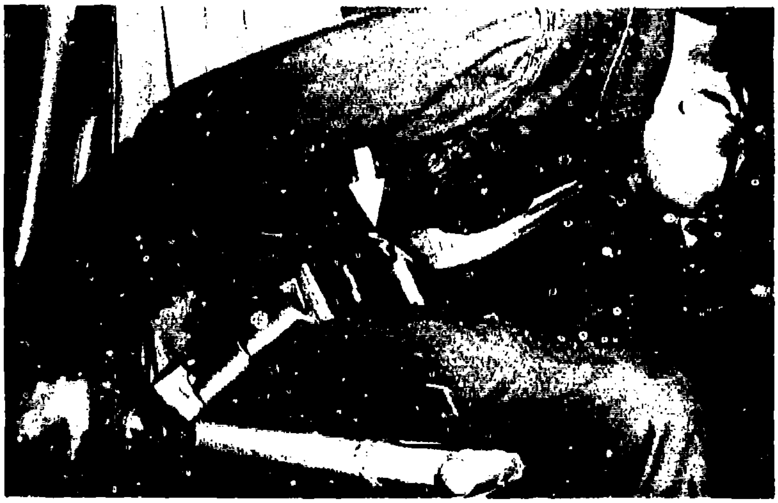
Diagonal Shoulder Strap -
Long Buckle Anchor



Diagonal Shoulder Strap - Short Buckle Anchor

Figure 79. Various Restraints - 2d Percentile Troop.

Fitting Clears With Short Buckle Anchor



Fitting Impingement With Long Buckle Anchor

Figure 80. Shoulder Strap Fitting Impingement on 2d Percentile.

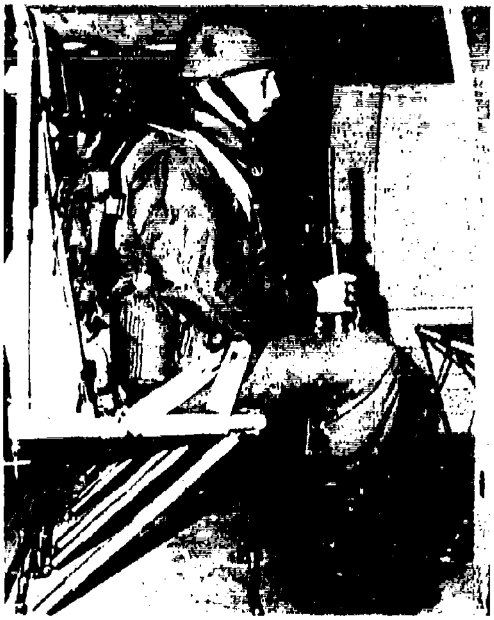


Figure 81. 50th Percentile – Rucksack With Lincloe Frame.

Figure 82. 95th Percentile Troop With Butt Pack.

Figure 83. 95th Percentile – Arctic Clothing, Rucksack and Frame.

Figure 84. 95th Percentile – Arctic Clothing and Butt Pack.

more accessible and visible shoulder strap ends when troops are wearing rucksacks.

Evaluations were made using a 95th percentile troop wearing various combinations of clothing and equipment up to the most severe combination of cold-weather (arctic) clothing with a rucksack and frame and full combat gear. Figures 82 through 84 are illustrations of the various clothing, equipment, and restraint systems used. Table 16 gives a listing of the equipment and clothing used for the 95th percentile tests.

The restraint harness employing double shoulder straps did not pose any appreciable problems, although the lap belt lift lever release tab should be enlarged to improve rapid use with arctic gloves.

Diagonal shoulder strap configurations presented the most problems. As previously noted, the shoulder strap end fitting protrudes and digs into the seat occupant's body as a bent-forward position is attained. A progressive shortening of the right-hand lap belt to minimize the digging-in effects moves the belt buckle toward the seat pan frame, making progressively more difficult the engagement of the shoulder strap end into the buckle. This was especially evident when the occupant was wearing arctic clothing with gloves and full combat gear.

Another problem experienced was the imcompatibility between the combat equipment worn and the position of the diagonal shoulder strap/seat belt combination. Overriding of worn equipment by the belts is undesirable since an adverse effect on the correct operation of the restraint system is possible in a crash environment. Figures 85 and 86 illustrate the types of problems encountered and further emphasize the superiority of the double shoulder strap system.

INGRESS/EGRESS EVALUATION

The UTTAS mockup was configured for two rows of facing seats, each row containing four seats. Two doors were available for entry and exit, one on each side of the aircraft situated between the two rows of seats.

Tests were performed using various clothing and equipment, using one door or two, and using double shoulder strap and single diagonal shoulder strap restraint systems. Some tests were conducted where the seat allocation was specified beforehand and others with random seat selection. Table 17 contains details of the tests completed together with times for restraint system hookup and egress.

Figure 85. Diagonal Shoulder Strap Over Equipment - Short Buckle Anchor.

Figure 86. Diagonal Shoulder Strap Around Equipment - Long Buckle Anchor.

TABLE 17. TROOP SEAT EVALUATION - INGRESS/EGRESS TIMES

EQUIPMENT	NUMBER OF ENTRANCES	NUMBER OF TROOPS PER ENTRANCE	RESTRAINT SYSTEM	HOOKUP TIME (sec)	EGRESS TIME (sec)
INTERMEDIATE CLOTHING ONLY	2	4	None (Ingress/ egress to seated position only)	4.3 4.0	3.0 3.0
	1	8	"	8.2 8.5	5.0 5.0
	2	4	Diagonal Strap	20.0 21.0	3.2 3.2 3.0
COMBAT GEAR PLUS COMBAT ASSAULT PACK	2	4	"	45.0* 24.8 26.0	4.0 3.5 4.7**
	*Strap Location Problem; **Buckle Release Problem				
	1	8	Double Shoulder Strap	40.0 48.5*	8.0 7.8
	*Buckle Under Seat; Location Problem by Troop				
	2	4	"	29.0 30.0	4.0 3.4
	1 (Nonassigned Seating)	8	"	31.5 40.0*	7.0 6.5
	* One Strap Under Shoulder Flap (Epaulet)				
<u>NOTES:</u>	(1) Four-abreast seating; four forward- and four aft-facing. (2) Random percentile troops with allocated seat locations except where noted. (3) Knee-to-knee clearance: 12 to 14.5 inches.				

Isolated problems experienced were:

- Sitting on lap belt left on seat.
- Differentiating between own and adjacent seat lap belt strap.
- Engaging the lap belt buckle when turned over, thus making it impossible to insert shoulder strap end fittings without correcting the buckle position.
- Even when positioned right side up, difficulty in plugging the shoulder strap end fittings into the lap belt buckle.
- Shoulder strap end fitting, after release during an egress exercise, catching in a zipper of one of the troops, causing the zipper to tear out.

In the succeeding recommendations section, changes are listed which are intended to overcome or minimize the above effects.

In general, comments obtained from the troops involved were good from the viewpoints of seat comfort, space, restraint system, and relative ease of engagement even when all seats were full.

It must be noted that none of the troops involved had previous knowledge of the type of seat used or the restraint systems, and they rapidly became accustomed to the ingress and egress procedures.

RECOMMENDATIONS

At the completion of the evaluation, several design features were highlighted as either desirable or needing further study and modification. These are as follows:

Desirable Features

- Double shoulder straps are highly recommended. Of the several diagonal shoulder strap anchor locations demonstrated, none were completely satisfactory.

Suggested Modifications

- A stiffened strap or guide assembly is needed for each shoulder strap to project the strap ends forward and preclude the straps from hanging limply from the back of the seat. This will project one strap on each side of the head of a seated occupant, thus providing for easy accessibility in addition to encouraging the use of the straps.

Such changes will preclude the straps from being trapped behind the back of a seated occupant, as proved to be the case with several of the larger troops.

- Increase distance between the shoulder harness inertia reels to alleviate the head clearance problem which results from the requirement for straps which project from the back of the seat.
- Add short, flexible sleeves at the lap belt anchor locations to make the straps stick up. This will permit a troop to differentiate between the lap belt segment from his own seat and the adjacent seat and will facilitate donning.
- Add leather pad to the lap belt buckle to discourage connecting upside down.
- Add taper or funnel at shoulder strap plug-in to lap belt buckle to alleviate shoulder strap fitting plug-in problems.
- Extend the lift lever of the lap belt buckle to improve harness removal when wearing gloves.
- Shorten the shoulder strap plug-in fitting to minimize the probability of its catching on buttons, zippers and equipment during egress.
- Provide bumpers between seat pans at front of seat to prevent the lap belt from slipping between the seats.
- Add a fabric skirt to the lateral attenuator cross cables at the front of the seat to prevent occupant legs from being thrown under the seat during impacts and also to prevent tripping over the cables during egress.
- Add placard to seat with statement:

<u>WARNING</u>

Do Not Stow
Equipment
Under Seat

- Add placard to seat giving disconnect and stowage instructions.

TEST CONCLUSIONS

The consensus of the evaluators was most favorable regarding the comfort of the seats, their function, operational suitability, pack and equipment accommodation, and ease of installation and stowage. No equipment snagging or other problems were encountered with the seats during the evaluation.

The restraint systems exhibited some problems, the principal one being the difficulty experienced by larger troops in reaching the shoulder straps. Improvements to minimize this and other problems identified during the evaluation were made to the eight mockup seats and were evaluated during the second mockup demonstration discussed later.

CRASHWORTHY TROOP SEAT SYSTEM HUMAN FACTORS EVALUATION - SECOND MOCKUP DEMONSTRATION

A second mockup evaluation was conducted using eight crashworthy mockup troop seats installed in the Boeing UTTAS mockup. The seats had been modified with changes recommended from the first mockup evaluation. Thirteen Government personnel were present to evaluate the seats, and they represented the following agencies:

U.S. Army Human Engineering Laboratories Aberdeen, Md.	(USAHEL)
U.S. Army Aeromedical Research Laboratory Ft. Rucker, Ala.	(USAARL)
U.S. Army Combat Development and Training Ft. Benning, Ga.	(USACDT)
U.S. Army Air Mobility Research and Development Laboratory, Ft. Eustis, Va.	(USAAMRDL)
U.S. Naval Air Development Center Johnsville, Pa.	(NADC)

Eight troops were provided by USAHEL and were selected to represent the percentile range from the 5th through the 99th. Weights and heights of the troops used in the evaluation with their percentile are given in Table 18.

TABLE 18. SUMMARY OF ANTHROPOMETRIC DATA FOR TROOPS USED IN SECOND EVALUATION

Troop Ref. No.	Weight (lb)	Weight Percentile	Height (in.)	Height Percentile
1	255	99+	74.5	99
2	205	96	70	70
3	182	85	73	95
4	145	30	71	85
5	140	20	69	55
6	145	30	67	25
7	140	20	64	5
8	121	2	64	5

INGRESS/EGRESS EVALUATION

The troops were used singly and as an eight-man squad to evaluate the seat and restraint systems for ingress and egress under the following conditions:

1. One-man ingress/egress using Type I and Type II restraint systems with 5th and 99th percentile troops. Evaluations were made (1) without equipment, (2) with combat equipment and rucksack including Lincloe frame, (3) with combat equipment and rucksack without frame, and (4) with combat equipment and butt pack. Troops with the various packs are shown in Figure 87.

2. Eight-man ingress/egress from one side and both sides of aircraft, warm-weather clothing, no equipment, Type II restraint system.

3. Eight-man ingress/egress from one side and both sides of aircraft, intermediate-weather clothing, full combat equipment with rucksacks (including Lincloe frames), Type II restraint system.

4. Eight-man ingress/egress from one side and both sides of aircraft, intermediate-weather clothing, full combat equipment with rucksacks without frame, Type II restraint system.

5. Eight-man ingress/egress from one side and both sides of aircraft, intermediate-weather clothing, full combat gear with butt packs.

Time data for all ingress/egress tests are shown in Table 19. Data on the one-man operations show that ingress time for the Type I and Type II restraint system was the same when not

Butt Pack

Rucksack With Frame

Rucksack Without Frame

Figure 87. Various Packs Used in Evaluation.

TABLE 19. SEAT AND TROOPS HUMAN FACTORS EVALUATION

	ONE-MAN INGRESS/EGRESS EVALUATION TIMES					
RESTRAINT SYSTEM	TYPE I			TYPE II		
TIME (SEC)	A	B	$\overline{T}$	A	B	$\overline{T}$
WARM-WEATHER CLOTHING						
a. 5th PERCENTILE SOLDIER	7	7	7	10	7	8.5
b. 99th PERCENTILE SOLDIER			*			
INTERMEDIATE-WEATHER CLOTHING W/RUCKSACK (NO FRAME) & FULL COMBAT GEAR						
a. 5th PERCENTILE SOLDIER	50	14	32	18	10	14
b. 99th PERCENTILE SOLDIER			*	**	35	35
INTERMEDIATE-WEATHER CLOTHING W/RUCKSACK & LINCLOE FRAME & FULL COMBAT GEAR						
a. 5th PERCENTILE SOLDIER				15	13	14
b. 99th PERCENTILE SOLDIER			*			**
EGRESS - 1 to 3 SEC *Lap Belt Strap Too Short	**99th percentile man had difficulty reaching shoulder straps (had very heavy arms)					

EIGHT-MAN INGRESS/EGRESS - WARM-WEATHER CLOTHING

INGRESS/EGRESS	FROM BOTH SIDES OF AIRCRAFT			FROM ONE SIDE OF AIRCRAFT		
RESTRAINT	TYPE II			TYPE II		
TIME (SEC)	A	B	$\overline{T}$	A	B	$\overline{T}$
INGRESS	20	15	17.5	21	22	21.5
EGRESS	3	3	3	6	5	5.5

A - First test time
B - Second test time
C - Third test time
$\overline{T}$ - Average time

TABLE 19. CONTINUED

EIGHT-MAN INGRESS/EGRESS - INTERMEDIATE-WEATHER CLOTHING WITH COMBAT ASSAULT PACKS AND FULL COMBAT GEAR

INGRESS/EGRESS	FROM BOTH SIDES OF AIRCRAFT			FROM ONE SIDE OF AIRCRAFT		
RESTRAINT	TYPE II			TYPE II		
TIME (SEC)	A	B	$\bar{T}$	A	B	$\bar{T}$
INGRESS	24	23	23	30	25	27.5
EGRESS	4	4	4	7	6	6.5

EIGHT-MAN INGRESS/EGRESS - INTERMEDIATE-WEATHER CLOTHING WITH RUCKSACK AND FULL COMBAT GEAR (LINCLOE FRAME)

INGRESS/EGRESS	FROM BOTH SIDES OF AIRCRAFT				FROM ONE SIDE OF AIRCRAFT			
RESTRAINT	TYPE II				TYPE II			
TIME (SEC)	A	B	C	$\bar{T}$	A	B	C	$\bar{T}$
INGRESS	80	49	42	57	137	78	60	92
EGRESS	6	4	5	5	14	10	9	11

EIGHT-MAN INGRESS/EGRESS - INTERMEDIATE-WEATHER CLOTHING WITH RUCKSACK AND FULL COMBAT GEAR (NO LINCLOE FRAME)

INGRESS/EGRESS	FROM BOTH SIDES OF AIRCRAFT			FROM ONE SIDE OF AIRCRAFT		
RESTRAINT	TYPE II			TYPE II		
TIME (SEC)	A	B	$\bar{T}$	A	B	$\bar{T}$
INGRESS	36	30	33	42	39	40.5
EGRESS	5	4	4.5	8	7	7.5

wearing equipment. Slightly longer time was experienced in fastening the Type I (diagonal shoulder strap system) than the Type II (double shoulder strap system) when wearing full combat equipment. The reason is that it is harder to fasten the lap belt and shoulder strap at the side than at the center when bulky equipment is being worn.

Ingress times for the eight-man operation increased proportionately with the bulk of equipment worn. For the four conditions - (1) no equipment, (2) combat equipment with butt pack, (3) combat equipment with rucksack, and (4) combat equipment with rucksack and Lincloe frame - the ingress and fastening times were 15, 23, 30, and 42 seconds respectively. These times are for the double shoulder strap system; times for the diagonal shoulder strap system would probably be slightly greater when wearing combat equipment based on the times required for the one-man operation.

The greatest time was required for a troop wearing a medium rucksack mounted on a Lincloe frame. This is, however, an unrealistic situation, as rucksacks on a Lincloe frame will not be used on combat assault operations. The Lincloe frame is used primarily for heavy subsistance loads of approximately 70 pounds. The butt pack or the medium rucksack without Lincloe frame will be used on assault operations with approximately 20-pound loads. Rucksacks on a Lincloe frame measure approximately 11 and 17 inches deep for the medium and large sizes respectively. Restrictions on seat depth forced by the cabin geometry and practical considerations do not permit a troop to sit on the seat adequately while wearing this equipment, and it creates a problem in his reaching the shoulder straps. No problems were encountered with the seat system by a troop wearing a butt pack, and problems were minimal with the rucksack without Lincloe frame, which is 8 inches deep.

Seats should be designed to accommodate size and load of a butt pack and medium rucksack without Lincloe frame. Troops with either rucksacks and frames or subsistance loads should remove the packs and place them on the floor while sitting in the troop seats.

Type I and II restraint system fastening times are comparable and reasonable. Either system is practical from an operational standpoint, but the double shoulder strap system is recommended because of its improved crash restraint. Egress time, which is critical from a combat operation standpoint and a crashworthiness standpoint, is not increased by using the double or single shoulder strap systems when compared to no restraint usage.

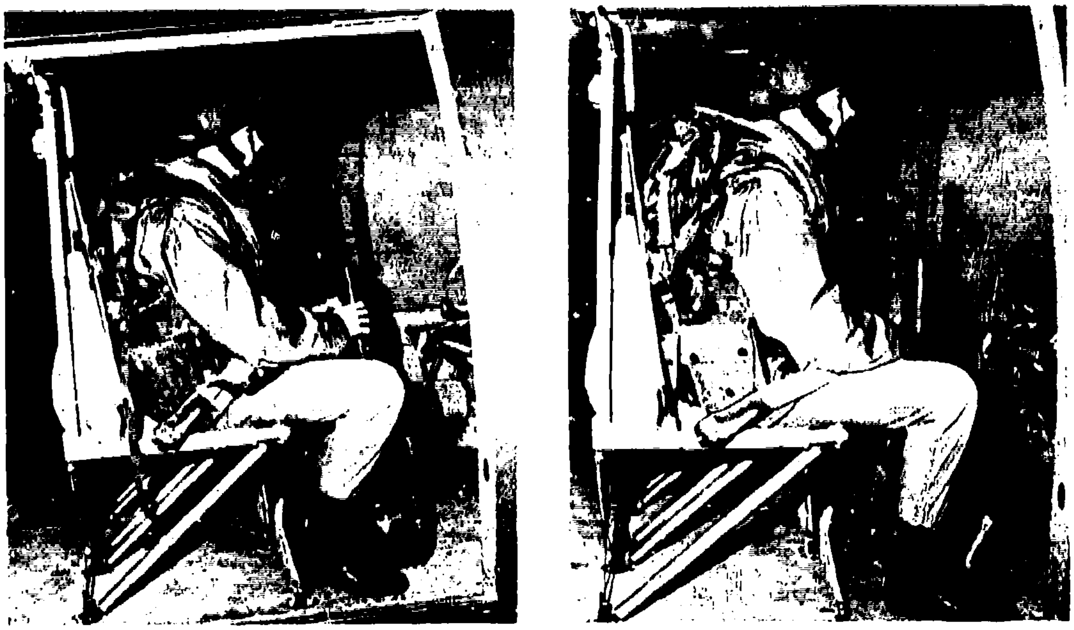
RESTRAINT SYSTEM AND COMBAT PACK ACCOMMODATION EVALUATION

The seat and Type II restraint system were evaluated using a 5th percentile occupant with a minimum of clothing and equipment to full clothing and equipment. With no equipment and warm-weather clothing, the seat was adequate and comfortable with the auxiliary back flap in place (Figure 88). A problem was experienced with the strap guides. The spring tension in the guide was too great to allow the strap to pull the guide down to the shoulder of small troops, so the straps were loose after fastening (Figure 88). A thinner gage material in the guide will resolve the problem. Releasing the back flap and exposing the pocket, the seat was evaluated with an occupant in full combat equipment including fragmentation vest and rucksack without Lincloe frame (Figure 88). Shoulder straps were easily reached and fastened to the lap belt buckle. The seat back provided adequate accommodation for the rucksack. Using the same equipment, the seat was evaluated with the rucksack mounted on a Lincloe frame. Shoulder straps were more difficult to reach, as the frame pushed the rucksack higher, causing the strap guides to rest on top of the pack (Figure 88). The occupant's shoulders were pushed farther from the seat back due to the additional depth of the Lincloe frame.

Under similar conditions, the seat was evaluated with a Type I restraint system. The buckle stand-up (7.5 inches - anchor bolt to center of buckle) provided easy access for attaching the lap belt and the diagonal shoulder strap. No problems were encountered by the 5th percentile troop in reaching or fastening the diagonal shoulder strap without equipment (Figure 89) or with full combat equipment and rucksack without frame (Figure 89).

The seat and Type II restraint system were evaluated using a 99th percentile occupant without equipment and with full combat equipment. With the occupant in warm-weather clothing and no equipment, the seat was adequate and comfortable with the auxiliary back flap in place (Figure 90). Releasing the auxiliary back flap and exposing the back pocket, the 99th percentile occupant with full combat equipment and rucksack was able to sit comfortably in the seat. The occupant found difficulty in reaching directly back for the shoulder straps. Figure 90 shows a distance of about 6 inches from his finger tips to the end of the shoulder straps, which are lying on top of the rucksack. To reach the shoulder straps, he had to twist in the seat. The angle of the shoulder strap over the rucksack is shown after fastening in Figure 90. The Type I restraint evaluation was similar but the lap belt was too short.

During the eight-man ingress/egress exercise while using butt packs, rucksacks, or rucksacks with Lincloe frames, a



Rucksack and Fragmentation Vest   Rucksack With Lincloe Frame

Warm-Weather Clothing

Figure 88. Type II Restraint System and 5th Percentile Troop.

Warm-Weather Clothing

Rucksack and Fragmentation Vest

Figure 89. Type 1 Restraint System and 5th Percentile Troop.

Shoulder Strap Reach Distance Shoulder Straps Up Over Racksack

Warm-Weather Clothing

Figure 90. Type II Restraint System and 99th Percentile Troop.

comparison of crowding was made and is shown in Figure 91. Crowding is quite noticeable when the Lincloe frame is worn. There was adequate room with just the rucksack and ample room with the butt pack.

SEAT MODIFICATION EVALUATION

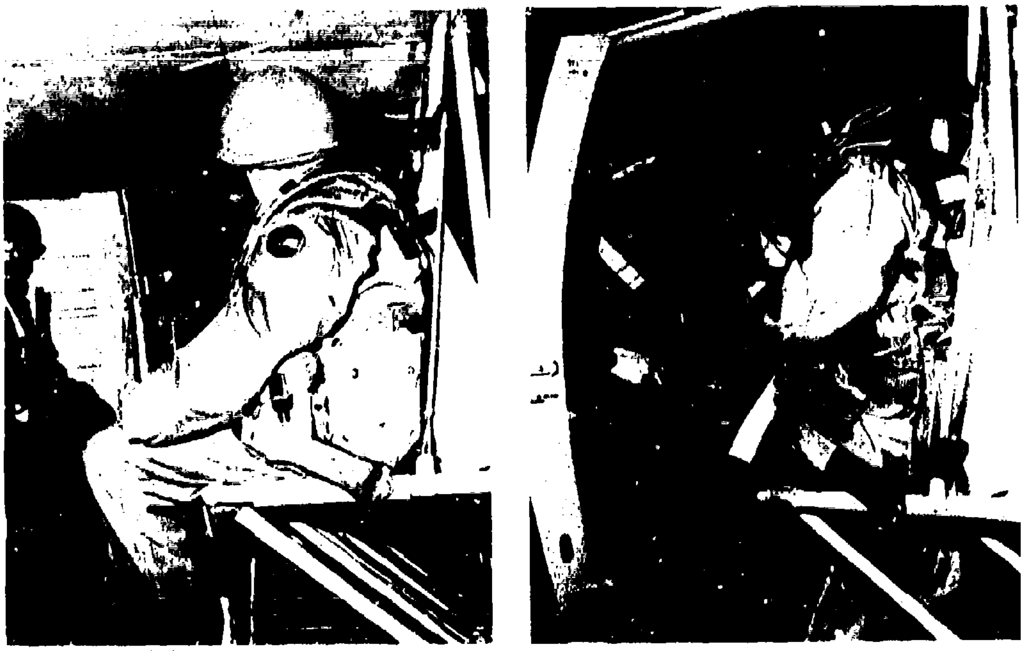
The six modifications recommended during the first mockup evaluation were made to the eight mockup seats. The reasons for the modifications are as follows:

1. Shoulder Strap Guides - To project straps forward to facilitate reaching.
2. Skirt on Cables Under Front of Seat - To prevent tripping on cables during egress and to prevent legs from being thrown under seat in crash.
3. Rubber Sleeve on Lap Belt at Anchor Fitting - To cause lap belt to stand up and to facilitate finding and fastening.
4. Bumpers Between Seat Leading Edges - To prevent lap belt from falling between seats.
5. Stencil Warning on Seat Not To Stow Equipment Under Seat - Equipment under seat would prevent seat from stroking vertically for crash load attenuation.
6. Stencil Seat Disconnect and Stowage Instructions on Seat - To facilitate stowage

The shoulder strap guides functioned as desired, thereby permitting troops to reach the shoulder straps. Most of the troops could reach both straps simultaneously. The 99th percentile with rucksack reached the straps by twisting slightly in the seat, while the 95th percentile in the first mockup evaluation required assistance in reaching the straps. One guide was made 2 inches longer than the others, but the shorter guides proved to be long enough (Figure 92).

Skirts on cables performed their intended function during egress. No one tripped on the cables, and black shoe scuff marks on the skirts showed that they were deflecting the feet away from the cables (Figure 93).

Rubber sleeves on lap belts at the anchor ends performed as required. Finding the lap belt was much easier. Grabbing the lap belt from the adjacent seat was not encountered as was frequently done during the first mockup evaluation (Figure 94).



Full Combat Gear and Butt Pack Full Combat Gear and Rucksack

Full Combat Gear and Rucksack With Frame

Figure 91. Crowding Comparison for Various Types of Packs.

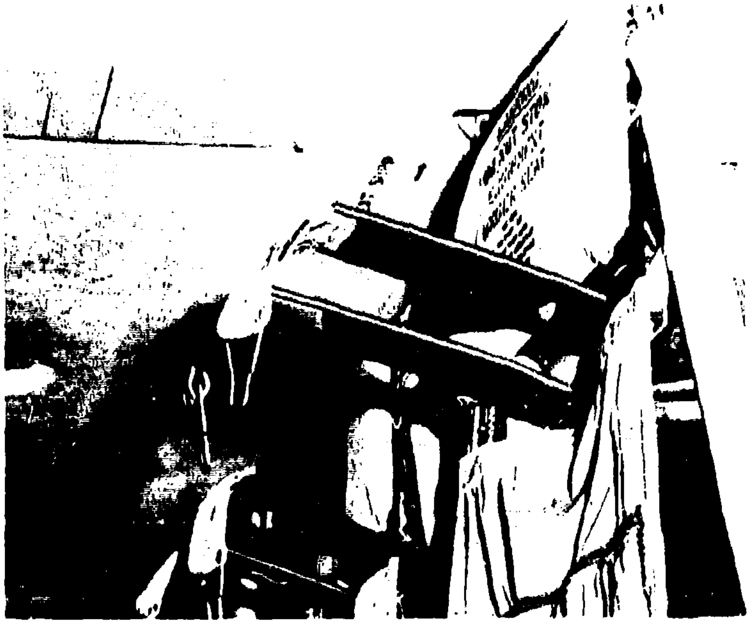


Figure 92. Shoulder Strap Guides.

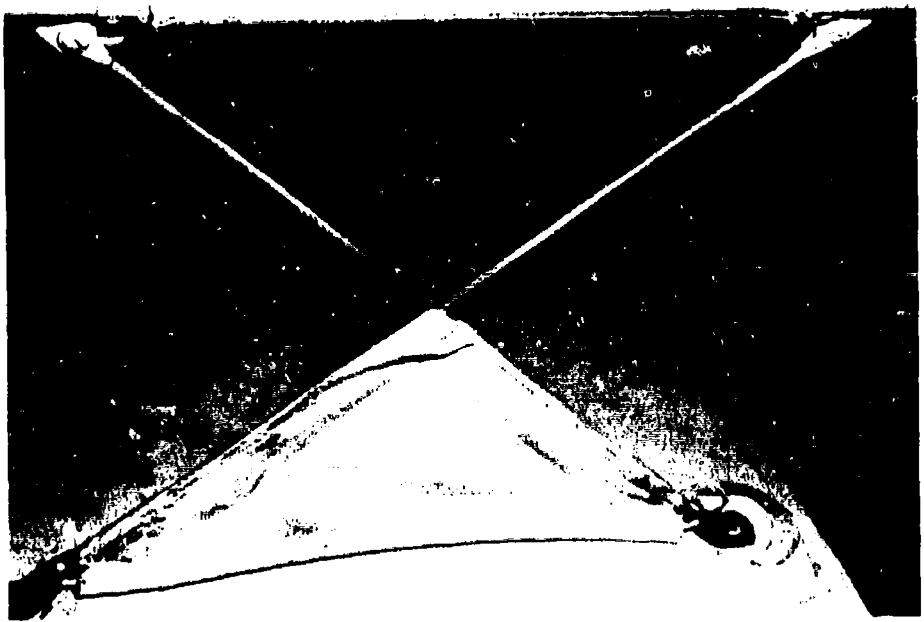


Figure 93. Cable Truss Skirt.

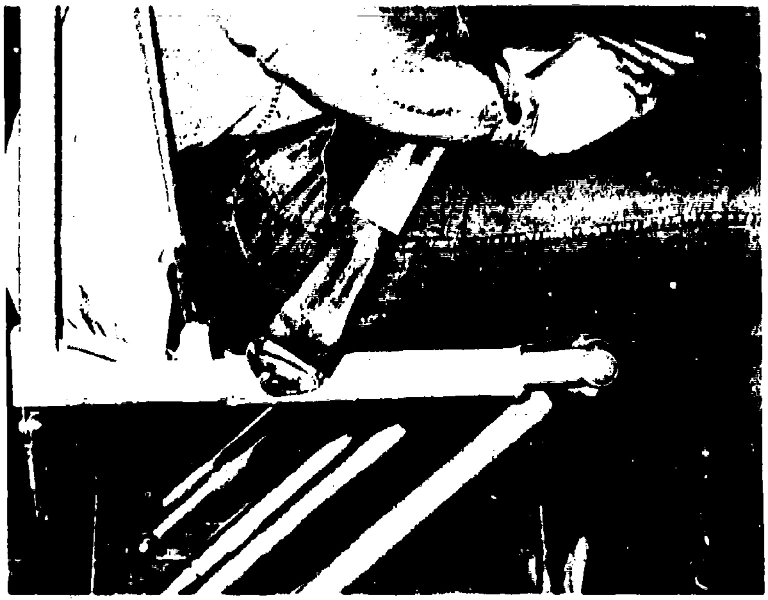


Figure 94. Lap Belt Stand-Up Sleeve.

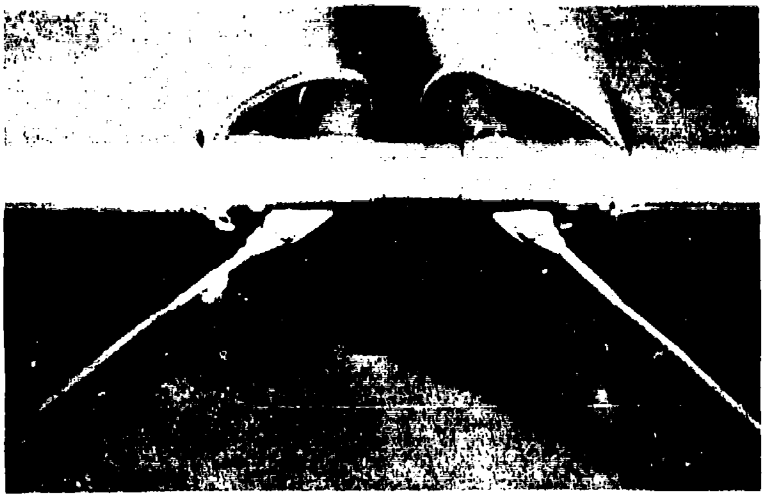


Figure 95. Adjacent Seat Bumpers - Lap Belt Retaining.

Bumpers added between seats at the leading edge prevented lap belts from slipping between the seats (Figure 95).

The location and wording of the warning stencil and stowage instruction stencil on the headrest were considered to be adequate (Figure 96).

ADDITIONAL MODIFICATION RECOMMENDATIONS

Several additional modifications were recommended at the second evaluation. One recommendation was to apply hook and pile tape to the end of the shoulder strap and to the ceiling of the aircraft for stowing the shoulder strap against the ceiling to improve access. This provision is not acceptable because it would require someone to stow each strap after use and this is impractical.

Modification of the shoulder strap guide was recommended to raise the straps higher and at the same time to clear the headrest. It was suggested that an additional curve be added to the guide under the headrest and that the guide be bent up at 45 degrees. The curve would be required at the top to reduce friction on the strap during retraction. This feature was added to the idealized seat drawings (Appendix A).

Concern was shown about load distribution on the spine of troops in rear-facing seats during longitudinal impacts while wearing a rucksack high on the back. The gap from the bottom of the rucksack to the seat pan could be as much as 12 inches. This portion of the spine would be unsupported, and in a longitudinal impact the lower torso would tend to be forced under the pack into the pocket or toward the main back panel. It was recommended that a fixed panel approximately 5 inches high be added at the base of the auxiliary seat back. This would support the lower spine during rearward accelerations (aft-facing seats) when rucksacks are worn. The seat would also have to accommodate troops with butt packs. A mockup of the fixed panel was added to the base of the auxiliary back, and the seat was occupied by a troop wearing full combat equipment and a butt pack. The height of the panel was varied from 5 to 6 to 7 inches, and no encumbrance was experienced with the butt pack during incress or egress at these panel heights.

CONCLUSIONS

A direct comparison of first and second mockup evaluations on all tests conducted cannot be made because the 95th percentile man used actually was a 99th percentile in the second evaluation and a 91st percentile in the first evaluation; also, different types of packs were supplied for each evaluation. However, an estimated comparison can be made based on no equipment tests and simulated equipment tests. Single-man

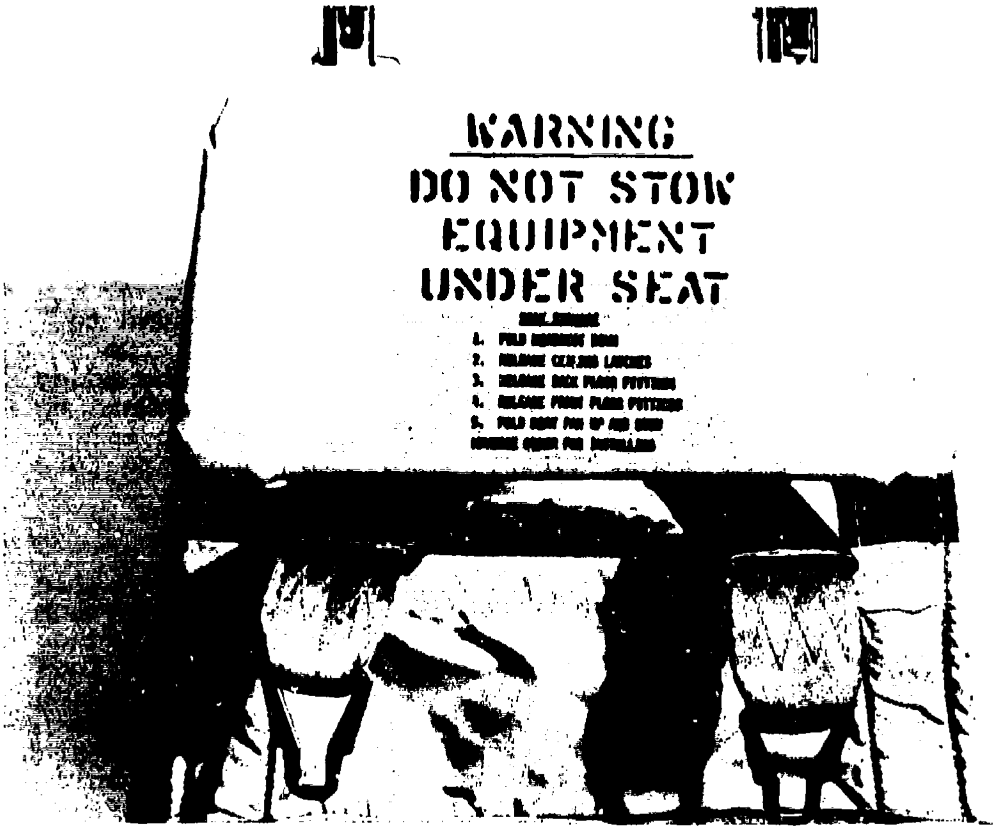


Figure 96. Equipment and Seat Stowage Instructions.

operations without equipment showed a marked reduction in time when the shoulder strap guides were used. Time was reduced from 15 to 7 seconds. Having both straps accessible simultaneously permitted simultaneous reaching and fastening of double shoulder straps. Time reductions also occurred in the eight-man operations with butt packs. Ingress and fastening time was reduced from 30 to 23 seconds during both-sides ingress and from 49 to 25 seconds for one-side ingress. Ingress was improved by adding spacers between seats which prevented lap belts from falling between seats, and lap belt stand-ups facilitated donning lap belts.

CONCLUSIONS

Detail conclusions have been presented at the end of each section. This section summarizes the significant conclusions reached on the total program.

A crashworthy troop seat designed to the requirements of the Draft Military Specification - Seat, Helicopter, Troop, is feasible and practical. A restraint system is presented in the specification which is easy to use by troops wearing combat equipment. The system is configured in a manner to make it conducive for troops to use in spite of concern by operational unit personnel that troops would be reluctant to use shoulder straps if provided. Fears of encumbrance due to shoulder straps have been allayed by egress demonstrations in which the shoulder straps were quickly retracted out of the way and egress time was no greater than without restraint. The double shoulder strap system is recommended for forward- or aft-facing seats. The diagonal shoulder strap, although preferred for forward crash impacts in side-facing seats, has many disadvantages; e.g., it provides no rearward restraint, interferes with combat equipment, and is more difficult to reach while wearing equipment.

A ceiling-suspended troop seat is the optimum seat installation. It is simple, lightweight and easy to stabilize during vertical stroking. Seat pan suspension must be accomplished without supporting the front of the seat pan with vertical energy attenuator legs while the back is supported by attenuators at the ceiling. Attenuators above and below the seat are unlikely to stroke together, causing the seat to drop at the front or at the back depending upon which attenuator strokes first. Vertical attenuators should be located at the ceiling only and should be designed to produce a trapezoidal force deflection curve.

The minimum seat pan dimensions are 14 by 20 inches in the seating area, and a minimum of 6 inches additional depth is required for field pack accommodations. The sides of the seating area should be as free as possible from braces or obstructions which could impede ingress and egress. A structural seat back or other means to adequately support shoulder harness reels or strap guides is necessary to minimize upper torso movement relative to the seat.

Use of the seat should be limited to occupants without equipment and troops with combat assault equipment. Seats should not be designed to accommodate troops wearing large rucksacks with subsistance loads because of the excessive seat size required, the difficulty in designing an attenuation system to handle the wide weight range, and the injurious effect on the troops' spines caused by the weight of heavy rucksacks in a crash environment.

The Draft Military Specification for crashworthy troop seats, prepared by the Eustis Directorate and modified in accordance with the recommendations section of this report, offers a practical specification for the design of crashworthy troop seats.

RECOMMENDATIONS

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

Draft Troop Seat Military Specification Change Recommendations

Changes were recommended to the Draft Specification titled MIL-S-XXXX(AV), Seat, Helicopter, Troop. The entire specification is reproduced including the figures which were unaffected by modifications. Modification recommendations are noted by crosshatching (////) those portions deleted; portions which were added are underlined (_ _ _ _). The circled numbers in the margins opposite changes refer to the explanations for the respective changes which follow the specification.

1. SCOPE

1.1 This specification establishes the performance, design, development and test requirements for standard, lightweight, folding, crashworthy seats for use by troops/passengers in transport-type helicopters.

1.2 Classification. Troop seats shall be of the following types and classes, as specified (see 6.2):

Type I	One-man seat
Type II	Two-man seat
Type III	Three-man seat
Type IV	Four-man seat

Class A	Forward-facing
Class B	Aft-facing
Class C	Side-facing

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of 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, Fiberboard

Military

MIL-P-116	Preservation, Methods of	
MIL-D-1000	Drawings, Engineering and Associated Lists	
MIL-W-4088	Webbing, Textile, Woven, Nylon	
MIL-C-7219	Cloth, Duck, Nylon, Parachute Packs	
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys	
MIL-R-8236	Reel, Shoulder Harness, Inertia Lock	
MIL-W-8604	Welding of Aluminum Alloys: Process for	
MIL-F-8905	Adapter, Tie Down, Aircraft Floor	
~~MIL-A-21165~~	~~Adapters, Quick-Disconnect, Passenger Seat to Floor~~	①
MIL-W-25361	Webbing, Textile, Polyester, Low Elongation	
MIL-R-XXXX(AV)	Restraint System, Aircraft Troop/Passenger	

STANDARDS

Federal

FED-STD-595	Colors
FED-STD-751	Stiches, Seams, and Stichings

Military

MIL-STD-22	Welded-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	②

MIL-STD-471	Maintainability Demonstration
MIL-STD-785	Reliability Program for Systems & Equipment Development & 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 Steels
MIL-STD-1290	Light Fixed- and Rotary-Wing Aircraft Crashworthiness

PUBLICATION

MILITARY HANDBOOK

MIL-HDBK-5	Metallic Materials and Elements for Aerospace Vehicle Structures

REPORTS

USAAMRDL TR 71-22	Crash Survival Design Guide

(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 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 6.3.5) without the occupant being subjected to conditions in excess of human tolerance (see 6.3.9). The seat system shall also provide maximum comfort and ease of folding and stowing. ~~The area above, beneath, and to each side of the seat bottom pan shall allow rapid ingress and egress. Specifically, braces, cables, or other structure shall not be located outside the space beneath the seat pan, i.e., the volume bounded by the pan width & depth from the pan to the aircraft floor (see 3.8)~~ Seat suspension or support systems shall not interfere with rapid ingress or egress. Braces, legs, cables, straps and other structures shall be designed to prevent snagging on ③ troop equipment or tripping or encumbrance during ingress and egress. The occupant restraint subsystem and the means of attaching the seat to the basic aircraft structure ~~, any seat cushions required (see 6.2)~~ are a part of the seat system. The seat system shall accommodate the number of persons specified for each respective type (see 1.2). To the maximum extent practical, seat classes shall be interchangeable to enhance standardization. ④

3.1.1 Orientation. - Seating systems shall be aft-facing whenever operational requirements permit. Seating systems shall not be side-facing unless it can be demonstrated that side-facing seats are absolutely necessary to meet operational requirements. It is preferred that all seats face in the same direction so that the seat backs protect troops from loose or handheld weapons and equipment which become flying projectiles during crash impact. ⑤

3.1.2 Folding & Stowing. -

3.1.2.1 All seats shall be so designed that the leg or legs, if applicable, and seat bottom may be quickly folded and secured.

~~3.1.2.1.1 Folding and unfolding time. - Each seat shall be capable of being folded and secured, or released and unfolded, quickly and easily, by one man in a period not to exceed 10 seconds.~~ ⑥

~~3.1.2.1.2 Stowing & unstowing time. - All seats shall also be capable of being stowed or unstowed, quickly, and easily by one man, in a period not to exceed 2 minutes.~~ ⑥

3.1.2.2 Seat Disconnect Time - The time for disconnecting each type I seat (one-man seat) by one man shall not exceed 15 seconds. The time for disconnecting multi-unit seats (type II, III and IV) by one man shall not exceed 15 seconds multiplied by the type number. ⑥

3.1.2.3 Folding and Stowage - Each seat shall be capable of being folded, stowed, and secured or unstowed quickly and easily by one man in a period not to exceed 15 seconds multiplied by the seat type number.

3.1.2.4 None of the operations outlined in 3.1.2.2 and 3.1.2.3 shall require the use of tools or special equipment or the removal of parts. All securing of seats must be positive in order that no portions of the seats protrude into the designated cargo ~~compartment~~ area. If straps are used to secure seats, they shall be 1-inch-wide webbing conforming to type II of MIL-W-4088. ⑦

3.1.2.5 Size of package. - The seat package, when it is in the stowed position, shall be held to a minimum size, not to exceed a thickness of 6 inches.

3.1.3 Seat bottom and back. - The seat bottom and back shall be fabricated to provide maximum comfort and durability. They shall be tailored to follow the general contour of the occupant's body and to distribute suitably the acting loads to the seat frame. Seat bottoms made of fabric shall be provided with means for tightening the seat bottom to correct for ~~any~~ ⑧ snagging due to use. Sufficient clearance between fabric seat bottoms and any ~~spreaders~~ under-seat structure used shall ⑧ be provided in order that the seat bottom will not contact the ~~spreader~~ structure under specified load.

~~3.1.4 Leg supports. - When leg supports are used, the base of the legs shall contain fittings in accordance with MIL-A-21165.~~ ⑨

3.1.4 Seat Floor Connection - When a seat is designed for connection to the floor, the attachment shall incorporate a quick-disconnect fitting. The quick-disconnect fitting~~s~~ shall be capable of attaching the seat securely to the stud ~~of anchor plate~~ shown in MS26504, MS21234, and MS21235. ~~and the stud of the tie-down fitting shown in MIL-A-25959. The~~ Anchor ⑨ plates and ~~the~~ tie-down ~~fitting are~~ studs shall be installed in the ~~airplane~~ aircraft flush with the floor surfaces.

~~The leg fittings shall be of the quick-release type. The release shall be capable of being actuated at the base of the leg.~~ ⑩ The ~~legs~~ floor attachments shall be capable of a small movement in the fore and aft and lateral directions of the location of the floor fittings~~.~~ to facilitate seat installation.

3.1.5 Attachment. - Whenever feasible and practical, seats shall be ~~ceiling and floor mounted. The various acceptable means of attaching seats to the cabin interior are ranked below in order of descending desirability.~~ ⑪

~~(1) Ceiling and floor mounted~~

~~(2) Ceiling, wall, and floor mounted~~

~~(3) Floor mounted~~

~~(4) Wall and floor mounted~~

~~(5) Wall mounted~~

suspended from the ceiling with energy attenuators. 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). ⑪

Acceptable means of attaching seats to the cabin interior are ranked below in order of desirability, with the assumption that the ceiling structure and side frames are of sufficient strength and integrity to support the load with acceptable deflection during impact. ⑪

1. Ceiling suspended with attenuator and wall stabilization

2. Ceiling suspended with attenuator and floor stabilization

3. Floor mounted

4. Wall mounted

5. Ceiling and floor mounted (vertical energy attenuators above and below seat).

3.1.6 Occupant restraint subsystem - Seats shall provide an integral restraint system with lap belt and self-retracting and self-locking ~~restraint~~ shoulder harness complying with the criteria of 3.3.2 and ~~3.4.12~~ 3.4.11 for each potential seat occupant. ⑫

3.2 Preproduction. - Unless otherwise specified (see 6.2), this specification requires a complete seat system(s) for preproduction examination and testing (see 4.3). The preproduction test sample(s) shall conform to all requirements of this specification. The preproduction test sample(s) shall be identical with the production items in accordance with the terms of the contract. Approval of the preproduction test sample(s) shall not relieve the supplier of the responsibility to furnish equipment in accordance with this specification.

3.3 Materials. - Materials shall be as specified herein. When specifications and standards are not specifically designated, selection of materials and processes shall be in accordance with MIL-STD-143. The seat shall be built of materials which do not support the growth of fungus. 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 fungicidal agent acceptable to the procuring activity.

3.3.1 Seat bottom and back. - Cloth materials for the seat back and bottom shall be vat-dyed a color selected by the procuring activity. The color shall conform to FED-STD-595. 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.

3.3.2 Occupant restraint subsystem. - Metal materials of all restraint subsystem fittings shall be fabricated from materials with characteristic elongation values of not less than 10 percent prior to failure. Strap webbing shall be constructed of a material that will not allow harness slackness due to slippage.

3.3.3 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.

3.3.4 Flammability and toxicity. - Materials which will support a self-sustained combustion and materials which, when burned or exposed to high temperatures, give off toxic fumes shall be prohibited.

3.4 Construction. - The inside surface and all exposed edges of the seat shall be free from projections and sharp edges that could catch or damage by abrasion the clothing or the equipment of the occupant. The exterior surfaces of the seat shall be free from both sharp edges and corners, or any other projections that could scratch the hands or clothing of the occupant.

3.4.1 Standard parts. - MS or AN standard parts shall be used wherever they are suitable for the purpose, and shall be identified on the drawings by their part numbers. Commercial parts such as screws, bolts, and nuts may be used provided they possess suitable properties and are replaceable by MS or AN standard parts without alteration.

3.4.2 Interchangeability of parts. - Components shall be functionally and dimensionally interchangeable (without requiring modification for replacement) with similar components furnished under the same contract or order.

3.4.3 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.

3.4.4 Protective treatment. - When materials that are subject to corrosion in salt air or any other atmospheric condition liable to occur during service usage (see 3.7) are used in the construction of the seat, they shall be protected against such corrosion in a manner that will in no way prevent compliance with the performance of the seat system. The use of any protective coating that will crack, chip, or scale with age or extremes of atmospheric conditions shall be prohibited.

3.4.5 Finishes. - Aluminum alloy parts shall be anodized in accordance with type II of MIL-A-8625. Magnesium alloy parts shall be treated in accordance with MIL-M-3171. Noncorrosive-resistant steel parts shall be either cadmium-plated in accordance with QQ-P-416 or zinc-plated in accordance with QQ-Z-325.

3.4.6 Joining and fastening. - Riveting and welding may be used for assembling the component parts fabricated from materials which are suitable for this type of construction. Fittings and joints requiring disassembly for installation and removal of the seat from the aircraft, or disassembly of the component parts of the seat system, shall be bolted.

3.4.7 Structural strength and deformation. - Longitudinal, lateral, and upward seat structural strength and deformation requirements stated herein are based on the 95th percentile clothed occupant weight (see 6.3.2) plus the weight of the seat and any equipment attached to or carried in the seat. Downward seat structural strength and deformation requirements specified herein are based on the effective weight of the 50th percentile clothed occupant ~~(see 6.3.10)~~ (see 6.3.2) plus the ⑬ weight of that portion of the seat which must stroke during vertical crash force attenuation (see 3.4.8).

3.4.7.1 Longitudinal strength and deformation. - Controlled deformation of seats shall not exceed ~~8~~ 12 inches displacement ⑭ measured along the longitudinal (roll) axis of the aircraft or be sufficient to permit occupant contact with surrounding structure.

3.4.7.1.1 Forward load. - The seat shall have a characteristic 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 on Figure 1. Acceptable and unacceptable sample static forward load-deflection curves are illustrated on Figure 1.

3.4.7.1.2 Aftward loads. - 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.

3.4.7.2 Lateral strength and deformation. - The seat shall have a characteristic 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 on Figure 2.

3.4.7.3 Vertical strength and deformation. - Human tolerance to vertical impact (see 6.3.9) limits the acceptable forces measured along the vertical ~~seats suspended from the aircraft~~ ⑮

~~ceiling may be~~ (yaw) axis of the aircraft, ~~designed to peak~~ ⑮
~~vertical loads as low as 40% of the peak vertical design loads~~
~~for floor and wall mounted seats if the procuring activity~~
~~concurs in the contractor's substantiating data.~~

3.4.7.3.1 Downward load. - The seat shall have a downward load-deflection curve measured along the vertical (yaw) axis which falls within the acceptable area on Figure 3. The seat ultimate failure value shall not be less than 25G after the seat has stroked through the available seat stroking distance unless the seat pan is permitted to bottom out on floor structure. ⑯

3.4.7.3.2 Upward load. - The design load factor (G) shall not be less than 8G parallel to the vertical (yaw) axis.

3.4.8 Crash force attenuation. - The seat system, to perform its intended occupant retention function, shall possess sufficient energy-absorption capability and structural strength to reduce the occupant velocity relative to the cabin floor structure to zero before structural failure of the seat occurs, and to prevent the 5th through 95th percentile occupants (see 6.3.1) from experiencing decelerations in excess of human tolerance (see 6.3.9) during crash pulses of the severity of up to and including the 95th percentile potentially survivable accident pulse (see 6.3.5). Energy shall be absorbed either by plastic deformation of the seat structure or by load-limiting devices (see 6.3.8) or a combination of both. The energy-absorption mechanism stroke shall be the maximum attainable in the space between the seat bottom and the aircraft floor. In any case, not less than ~~12~~ 14 inches of usable vertical stroking distance shall be provided. ⑰

3.4.9 Seat attachments. - Provisions shall be made for the seat system to be attached to the basic aircraft structure with connectors of sufficient strength to preclude attachment failure under the maximum loads specified herein, and under all conditions as specified in 4.5. These seat attachments shall be designed to provide occupants with an obvious warning whenever seats are not entirely locked in place.

~~3.4.10 Cushions. - Unless otherwise specified (see 6.2),~~ ④
~~seat cushions shall be provided for all seats in which the~~
~~absence of such cushions would either allow occupant contact~~
~~with injurious components during deformation or~~
~~detract from the effort to design a comfortable seat for the~~
~~occupant. Seat cushions provided shall have inherent flota-~~
~~tion characteristics on water and be designed primarily for~~
~~occupant comfort, not as a device to absorb crash energy in~~
~~the vertical direction. The desired crash energy absorption~~
~~capability shall be obtained in the seat energy absorber~~
~~mechanism specified in 3.4.8. Cushions shall be contoured for~~

~~the human body in a fashion which does not subject the occupant's torso or extremities to constrictions, or localized pressures, that could either cause a reduction in normal body circulatory functions or eventual deterioration of occupant comfort. The thickness of soft, elastic foam-type material required for a comfort cushion shall not exceed 0.5-inch thickness when compressed by the 95th percentile clothed occupant (see 6.3.2). A net-type seat cushion may be used provided it prevents contact between the occupant and the seat pan under vertical loading as specified in 3.4.7.3, and that its rebound characteristics limit occupant return movement from the point of maximum deformation to 1.5 inches. If net-type cushions are employed, they shall neither permit snagging with occupant clothing or equipment nor inhibit occupant ingress or egress. Any cushion provided shall minimize both occupant submarining (see 6.3.6) and dynamic overshoot (see 6.3.7).~~

3.4.11 Occupant restraint subsystem. - It is preferable that the seat restraint subsystem for forward- or aft-facing seats have double shoulder straps and ~~shall~~ that the system conform ⑱ to the configuration in Figure 4. All occupant restraint subsystems shall minimize occupant submarining (see 6.3.6) and dynamic overshoot (see 6.3.7). ~~Lap belts and shoulder straps~~ ⑫ ~~must retract automatically and stow in a flush position so that the occupant can slide across the seat for rapid ingress and egress. The restraint harness shall include a lap belt, two shoulder straps, and a single point of attachment-release with a single-action-release buckle.~~ The shoulder straps ⑫ shall fully retract independently to a position where the end fittings are accessible by reaching over the shoulder. The lap belt shall be capable of connection prior to connection of the shoulder straps. Restraint release shall be by a single-action release buckle. Loops shall not be formed when the restraint system is released. Lap belt ends shall be readily ⑲ accessible for fastening. Lap belt retractors or inertia reels shall be used when space or weight limitations permit. In any event, lap belts shall not be capable of falling behind or below the seat. Common anchor connections for adjacent seats shall not be used. Flexible stand-ups shall be provided at ⑳ the lap belt anchor points to project the lap belt upward 5 inches; and lap belt adjusters shall be provided on each side of the buckle when lap belt reels are not used (Figure 5).

The restraint harness shall be comfortable, light in weight, and easy for the occupant to put on and remove. The restraint harness straps shall provide the occupant as much area as feasible for force distribution in the upper torso and pelvic regions, and still provide for freedom of movement. Loss of support of the occupant shall not occur due to straining of the seat energy absorption mechanisms, plastic deformation of the seat, or a combination of both actions.

The diagonal shoulder strap system shall conform to Figure 4A and shall meet all the requirements set forth for the double shoulder strap system. The diagonal shoulder strap system is preferred for side-facing seats due to the lower diagonal strap loading and elongation during forward crash impacts when compared to the vertical straps of the double shoulder strap system.

3.4.11.1 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. Quality welding shall be in accordance with MIL-W-6873, MIL-W-8604, MIL-W-45205, MIL-STD-22, and MIL-STD-1261.

3.4.11.2 Strap design loads. - Strength and elongation of restraint harness strap materials shall be as specified in Table 1.

TABLE 1.- Restraint Harness Components Load-Elongation Design and Test Requirements.

(Delete this Table)

㉑

~~Harness components~~	~~Maximum elongation (inch) (a)~~	~~Minimum load (pounds) (b)~~
~~Shoulder harness~~	~~1.5 (d)~~	~~4,000 (c)~~
~~Lap belt~~	~~1.0~~	~~4,000~~

~~NOTES:~~

~~(a) Total length of harness component tested shall be the same as its length as installed on the seat when adjusted for a 95th percentile clothed occupant (see 3.5.2).~~

~~(b) This load shall be applied in straight tension.~~

~~(c) This represents the total load on two shoulder straps.~~

~~(d) This applies only to shoulder harness exclusive of the webbing wound on the spool of the retractor.~~

(Add this table) ㉑

TABLE 1. Restraint Harness Webbing
Load - Elongation Design and Test Requirement

Use	Strap Width (in.)	Thickness (in.±0.010)	Maximum Elong. at Design Load (pct)	Design Load (lb)	Ultimate Load (lb)
Lap Belt	2.25	.055	5	4,000	6,000
Double or Single Shoulder Straps-Each	2.00	.055	5	4,000	6,000

NOTE: All loads are applied in straight tension

3.4.11.3 Lap belt. - The lap belt centerline shall be 2 to 3 inches forward of the seat reference point. The lap belt anchorage geometry shall be as shown on Figure 5. The lap belt ~~and attachments~~ anchor fittings shall be capable of displacing plus or minus 30 degrees vertically. ~~and plus or minus 60 degrees laterally from the normal positions without producing eccentric loads in either the straps or the attachment fittings.~~ These fittings shall be capable of withstanding lateral design load when the webbing is pulling at an angle of plus or minus 60 degrees to the normal plane of the fitting. ~~Lap belts must automatically adjust to, and lock at, the occupant's torso size without adjustment fittings.~~ ㉒

3.4.11.4 Shoulder straps. - Shoulder harness anchorage geometry shall be as shown on Figure 6. 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. Flexible guides shall be provided on the seat back as shown on Figure 6 to project the shoulder strap fittings 6 to 8 inches in front of the seat back. ㉓

3.4.11.5 Strap attachment methods.-

3.4.11.5.1 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.

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

3.4.11.5.3 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.

3.4.11.5.4 Surface roughness of fittings. Fittings in contact with the straps shall have a maximum surface roughness of RMS-32 to prevent fraying of the strap due to frequent movement over the metal.

3.4.11.5.5 Belts, harnesses, and straps. - Belts, harnesses, and straps shall be attached in a manner to preclude either improper alignment of the occupant or premature failure due to stress concentrations caused by misalignment of components during any possible seat deflection, body orientation, or a combination of both during the crash sequence. Distance between the inner edges of the shoulder straps at the seat back shall ~~not exceed 2 inches. Both shoulder/straps shall/be~~ ㉔ ~~served by a single retractor.~~ be within 3 to 5 inches. ㉕

3.4.11.6 Inertia reel. - Shoulder strap inertia reel or reels, as required, ㉖ shall be provided which will fully retract the shoulder strap or straps to shoulder height in the guides described in 3.4.11.4. The reel shall be located close to the shoulder strap guide point at the back of the seat to minimize strap elongation. The strength requirement shall be as shown in Table 1. The shoulder strap reel or guide at shoulder height (see Figure 6) shall be attached to rigid seat structure to prevent excessive deflection.

~~3.4.11.7~~ 3.4.11.6 Attachment-release buckle. - The restraint ㉗ harness attachment-release buckle shall be of the quick-release type and require intentional release by the occupant to activate the release mechanism. A positive locking device shall be incorporated in the attachment-release buckle to prevent unintentional release of any component of the restraint harness. This device shall give positive indication of any unlocked condition. The intentional release of the restraint harness shall be uncomplicated, and the buckle shall be capable of being operated with only one finger of either hand while tension equal to the occupant's weight is supported by the harness. The force required to release the harness with only one finger shall not be less than 15 pounds and not more than 25 pounds. The buckle shall be of a lift lever release configuration. Lap ㉘ belt and shoulder strap fittings shall be ejected simultaneously when the lever is lifted even when there is no load within the restraint system straps. Hardware components shall carry the restraint harness design loads without permanent deformation. The positive locking mechanism of the attachment-release buckle shall be protected to prevent fouling of the mechanism by clothing or equipment worn by the seat occupant.

3.5 Dimensions. - Seats shall comply with the dimensions shown in Figure 14. Unless otherwise specified, a tolerance of ± 1/16 inch will be allowed for seat overall dimensions. Restraint system webbing dimensions shall comply with Table ~~III~~ 1. ㉙

3.6 Weight - The completed seat system of each type, including the restraint subsystem and all parts and adequate finish coating, shall not exceed the total weight tabulated below: ②

Type of Seat	Weight (Lb)
I	~~10~~ 14
II	~~15~~ 28
III	~~20~~ 42
IV	~~25~~ 56

㉚

3.7 Environment. The seat system shall be designed to meet the requirements of paragraph 3.4 after exposure to the following conditions:

3.7.1 Temperature. - The seat system shall withstand non-operating exposure as well as deliver specified operational and crashworthiness performance when subjected to the high- and low-temperature tests in accordance with Methods 501 (Procedures I and II) and 502, respectively, of MIL-STD-810. The test temperature for Method 502 shall be as specified by the procuring activity (see 6.2).

3.7.2 Sunshine. - All materials used in the construction of any seat system component or assembly which may be subjected to prolonged exposure to sunshine shall show no evidence of any degrading effect when subjected to the sunshine test specified in Procedure I of Method 505 of MIL-STD-810.

3.7.3 Humidity. - The seat system shall operate satisfactorily during and after being subjected to the humidity test(s) specified in Method 507 of MIL-STD-810. The procedure to be employed shall be specified by the procuring activity (see 6.2).

3.7.4 Fungus. - If any material utilized in the construction of the seat system is suspected to be a nutrient to fungi, the material shall show no deterioration when subjected to fungus tests in accordance with Method 508 of MIL-STD-810.

3.7.5 Salt fog. - All materials used in the construction of the seat system shall be corrosion-resistant or processed to withstand the salt fog test of Method 509 of MIL-STD-810 when in the "as-installed" condition.

3.7.6 Dust. - The seat system shall be capable of satisfactory operation after exposure to the dust test specified in Method 510 of MIL-STD-810.

3.7.7 Vibration. - The seat system shall be capable of satisfactory operation after being subjected to the vibration tests of Method 514, Procedure I (parts 1, 2, and 3) of MIL-STD-810.

3.7.8 Mechanical shock. - Components and equipment shall withstand normal shipping, handling, and installation without damage to required functional operation.

3.8 Maintainability. - The procuring activity will specify the acceptable level of maintainability for the seat system (see 6.2). The maintainability program to achieve, demonstrate, and assure retention of the seat system maintainability shall be in accordance with MIL-STD-471.

3.9 Reliability. - Because of the emergency requirement of the seat system, prime importance shall be placed upon the attainment of a high overall degree of reliability. A reliability program shall be established in accordance with MIL-STD-785. The goal for the probability of success shall be as specified by the procuring activity (see 6.2). As a part of the reliability analysis, the contractor shall conduct a failure mode analysis for each seat system component and subsystem which could, by failing, adversely affect the crash survival of the occupant. This analysis shall provide (1) the probability of failure, (2) the expected mode(s) and cause(s) of failure, and (3) the consequence of each mode of failure.

3.10 Finish. - Aluminum-alloy parts shall be anodically treated in accordance with the MIL-A-8625, type II, undyed; and non-corrosion resistant steel parts shall be cadmium plated in accordance with QQ-P-416 or zinc plated in accordance with QQ-Z-325.

3.11 Identification of product. -

3.11.1 Seat System. - A ~~cloth~~ nameplate, permanently and legibly filled in with the following information, shall be securely sewn ~~to the underside of the seat bottom,~~ or ~~the nomenclature may be~~ stamped on the ~~underside of the~~ seat ~~bottom~~ in a location capable of being read after the seat is installed. The information marked in the spaces provided on the nameplate shall be in accordance with MIL-STD-130.

Seat, Helicopter, Troop
Type (I, II, III, or IV, as applicable)
Class (A,B,orC, as applicable)
Specification MIL-S-XXXX (AV)
Stock No.______________

Manufacturer's Part No. ________________
Contract or Order No. ________________
Weight ______________
US Property

3.11.2 Restraint subsystem identification. - Both the shoulder harness and the lap belt shall have a permanent nameplate (label) securely attached on a strap in a location for easy detection and installation. Each nameplate (label) shall contain the following information:

Nomenclature ________________
Specification ________________
Date of manufacture ________________
Name of manufacturer ________________
Federal stock number ________________
Retirement date ________________

3.11.3 Warning Placard. - A cloth placard, permanently and legibly inscribed using 1/2-inch letters with the following statement, shall be securely sewn to the front of the seat back in a conspicuous location: ㉛

WARNING

DO NOT STOW

EQUIPMENT

UNDER SEAT

3.11.4 Instruction Placard. - A cloth placard, permanently and legibly inscribed using a minimum of 1/8-inch letters giving the procedure for disconnecting and stowing the seat, shall be securely sewn to the seat in a location visible when the seat is installed. ㉛

3.11.5 Placards for Type II, III and IV Seats - All multi-unit crashworthy troop seats shall have a cloth placard, permanently and legibly inscribed using 1/2-inch letters with the following statement, sewn to the front of the seat back in a conspicuous location: ㉛

MULTI-UNIT SEATS MUST

BE FULLY OCCUPIED

TO BE CRASHWORTHY

3.12 Workmanship. - The seat, including all parts and accessories, 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, painting, freedom of parts from burrs and sharp edges, 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 tests. - The inspection and testing of the seat systems shall be classified as follows: (1) preproduction and (2) quality conformance.

4.3 Preproduction testing. -

4.3.1 Test samples. - The contractor shall subject test samples of the seat system to the preproduction tests specified in 4.3.3. The number of preproduction samples to be tested by the contractor shall be as specified by the procuring activity (see 6.2).

4.3.2 Test sample for the procuring activity. - When specified (see 6.2), complete sample seat system(s) shall be submitted to the procuring activity. The number of sample seat systems shall be as specified by the procuring activity.

4.3.3 Preproduction tests. - The preproduction tests shall consist of all the tests specified under 4.5.

4.4 Quality conformance tests. - Quality conformance tests shall consist of the following: (1) individual and (2) sampling.

4.4.1 Individual. - Each seat system shall be subjected to the examination of product test specified in 4.5.1.

4.4.2 Sampling. - Seat systems shall be selected at random (see 4.4.2.1) by the authorized Government representative or inspector and subjected to the following tests:

(a) Interchangeability (see 4.5.2).

(b) Dynamic (see 4.5.3.2).

4.4.2.1 Test quantities. - Seat systems in the quantities specified below shall be subjected to the sampling tests:

(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. ②

(c) One seat system from each additional lot of 500, or fraction thereof above 500, of each type and class.

4.4.2.1.1 Lot. - A lot shall consist of seat systems manufactured under essentially the same conditions and submitted for acceptance at substantially the same time.

4.4.2.2 Rejection and retest. - Failure of any seat system to pass the sampling tests shall be cause for rejection of the entire representative lot. If, in the opinion of the inspector, such failure is attributable to faulty workmanship or other defects unlikely to occur throughout the lot, subsequent tests may be made on three additional seat systems chosen at random from the suspected faulty lot. Failure of any one of these additional systems shall be cause for the final rejection of the entire lot represented.

4.4.2.3 Individual tests may continue. - For production reasons, individual tests may be continued pending the investigation of a sampling test failure. But final acceptance of the entire lot or lots produced later shall not be made until it is determined that all items meet all the requirements of the specification.

4.4.3 Defects in items already accepted. - The investigation of a test failure could indicate that defects may exist in items already accepted. If so, the contractor shall fully advise the procuring activity of all the defects liable to be found and the method of correcting them.

4.5 Test methods. -

4.5.1 Examination of product. - Each seat system shall be carefully examined to determine conformance with this specification and the manufacturer's drawings with respect to materials, workmanship, design, standard parts, weight, finish, adjustments, dimensions, and markings. Special attention shall be given to the crash energy absorption mechanism(s).

4.5.2 Interchangeability. - Conformance to the requirements for interchangeability of component parts shall be determined by means of suitable jigs and sample parts.

4.5.3 Performance tests. - The seat system shall be tested as a complete unit and shall be mounted in a suitable jig or fixture by using the normal seat system to aircraft structure tie-down provisions. It shall then be subjected to, and withstand without failure, the applicable loads specified in 4.5.3.1 and 4.5.3.2. All static tests shall be conducted under simultaneous conditions of floor buckling and warping as shown on Figure 10. The seat system shall be loaded to either a plus or minus angle for the floor buckling, whichever is more critical, as determined by the procuring activity.

4.5.3.1 Static tests. - The occupant restraint subsystem shall be tested with the rest of the seat system during the static tests specified below. In addition, the lap belt and shoulder harness shall be statically tested separately to determine compliance with Table 1, thereby insuring that all components possess the required strength and elongation.

4.5.3.1.1 Unidirectional loads. - Where separate strength and deformation requirements have been specified in Table 3 for longitudinal, vertical, and lateral loading of seat systems, the seat system shall be tested under these loads applied separately.

4.5.3.1.2 Combined loads. - The seat system shall not lose structural integrity under conditions of combined loads as specified in Table 3.

4.5.3.1.3 Static load application method. - The static test loads shall be applied as shown on Figure ~~7~~ 11 through a body block which is contoured to approximate the torso of the 95th percentile occupant (see 6.3.1) in the seated position. The body block shall include representations of the neck, the shoulders, and the upper legs. ㉜

The buttock contours over the ischial tuberosities of a seated occupant shall be simulated as shown on Figure ~~71~~ 11. The loads calculated by multiplying the weight of the occupant and equipment plus the weight of the seat by the required load factor (G) shall be applied in increments of 275 pounds, plus or minus 25 pounds, while the load-deformation performance of ㉜ the seat is recorded (see 4.5.3.1.5). That portion of the static loading that must be withstood by the occupant restraint subsystem shall be applied to the static test loading body block (Figure ~~7~~ 11), and the remainder of the load representing inertial loading of other seat components shall be applied separately to the appropriate structure.

4.5.3.1.4 Load determination. - Total static test load to be applied, for all directions other than downward, shall be determined by multiplying the required design load factor (G) specified in Table 3 by the sum of the 95th percentile clothed occupant weight (see 6.3.2) plus the weight of the seat. In the case of downward loads, the required G load from Table 3 shall be multiplied by the sum of the weight of that portion of the seat system which moves vertically during the stroking of the energy absorption mechanism plus the effective weight of the 50th percentile clothed occupant ~~(see 6.3.10)~~ (see 6.3.2). ⑬

4.5.3.1.5 Deflection measurements. - Deflection shall be measured from the seat pan (see Figures 1 and 2).

4.5.3.2 Dynamic tests. - Dynamic preproduction tests of the seat system shall be conducted to the conditions specified in Table 4, and the seat system shall evidence no loss of structural integrity. Dynamic sampling tests of the seat systems shall be conducted in accordance with Test I specified in Table 4 and the seat system shall evidence no loss of structural integrity. The energy absorption mechanism(s) (see 3.4.8) in both preproduction and sampling dynamic tests shall limit the acceleration measured on the seat pan to a value which insures that future 5th through 95th percentile clothed seat system occupants will not experience vertical accelerations in excess of human tolerance (see 6.3.9) during crash pulses up to and including the 95th percentile potentially survivable accident pulse (see 6.3.5). A 95th percentile clothed anthropomorphic dummy occupant (see 6.3.2) shall be used to simulate each seat system occupant for these tests.

4.5.4 Environmental tests. - At least one test sample shall be subjected to each of the following environmental tests in the order listed. Upon completion of all environmental tests the seat system test sample that was subjected to 4.5.4.1 through 4.5.4.8 shall be subjected to pass Test I of Table 2.

4.5.4.1 High temperature. - High-temperature tests shall be conducted in accordance with Method 501, Procedures I and II of MIL-STD-810.

4.5.4.2 Low temperature. - Low-temperature tests shall be conducted in accordance with Method 502 of MIL-STD-810. The test temperature shall be as specified by the procuring activity (see 6.2).

4.5.4.3 Humidity. - Humidity tests shall be conducted in accordance with Method 507 of MIL-STD-810. The procedure to be employed shall be as specified by the procuring activity (see 6.2).

4.5.4.4 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.

4.5.4.5 Salt fog. - Salt fog tests shall be conducted in accordance with Method 509 of MIL-STD-810 with the seat system in the "as-installed" condition.

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

4.5.4.7 Vibration. - Vibration tests shall be conducted in accordance with Method 514, Procedure I (Parts 1, 2, and 3) of MIL-STD-810.

4.5.4.8 Maintainability. - The maintainability program to demonstrate and assure retention of seat system maintainability shall be in accordance with MIL-STD-471.

4.5.5 Human Engineering Mock-up. - A human engineering mockup of each new troop seat system concept shall be fabricated and ㉜
demonstrated. The seat mock-up shall include a complete and operable restraint system, and the seat's quick-disconnect, folding and stowage features shall be capable of being demonstrated. A minimum of three seats, installed adjacent to each other, shall be used and occupied. Occupants representing 5th and 95th percentile troops with and without combat assault equipment shall be used to demonstrate satisfactory restraint system use, seat accommodations, and lack of encumbrances during ingress and egress. Occupants shall wear warm-weather, intermediate-weather, and cold-weather clothing for each of the demonstrations. Medium rucksacks and butt packs with combat assault loads shall be demonstrated. A report shall be prepared documenting ingress, hookup and egress times for each combination of clothing, equipment and personnel percentile. Times for seat installation, disconnect, folding, and stowage shall be recorded.

4.6 Inspection of preparation for delivery. - Packaging and marking shall be inspected to determine compliance with section 5 of this specification.

5. PREPARATION FOR DELIVERY. -

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 ~~unit~~ container conforming to PPP-B-636. ②

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 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 (see 6.2).

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 PP-B-601 or PPP-B-621. As far as practicable, shipping containers shall be of uniform shape and size, or 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 specification and appendix thereto.

5.2.2 Level B. - Seats preserved and packaged as specified in 5.1.1 shall not be overboxed for domestic shipments. The ~~unit~~ container, closed and strapped in accordance with the applicable appendix of the container specification, shall be the shipping container. ②

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 for immediate use. 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 of the item are for immediate use 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 troops and passengers in helicopters. To ensure the long-term success of the seat system in achieving its purpose, the designers of the system and its components, subassemblies, and subsystems must consider throughout the design and development phases the ease or difficulty with which required maintenance tasks may be accomplished. Degradation of system performance may result over a long period if maintenance access is extremely restricted, numerous special tools are required, frequent system/component maintenance is required, and/or maintenance instructions are inadequate. Seat system useful life should be equal to, or greater than, the expected life of the aircraft in which the seats are to be installed.

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).

(c) If preproduction inspection and testing are required (see 3.2):

    (1) The number of preproduction test samples required (see 4.3.1); and

    (2) Whether sample seat systems shall be submitted to the procuring activity (see 4.3.2 and 4.5.4).

(d) Requirement for test temperature (see 3.7.1 and 4.7.4.2).

(e) Procedure for humidity test (see 3.7.3 and 4.5.4.3).

(f) Acceptable level of maintainability for the seat system (see 3.8).

(g) The goal for the probability of seat system success (see 3.9).

(h) Seat dimensions (see 3.5).

(i) ~~Whether seat cushions are required (see 3.4.10).~~ ④

(j) Any special painting requirements (see 3.10).

(k) Levels of preservation, packaging and packing required (see 5.1, and 5.2).

(l) Whether special marking for shipment is required (see 5.4).

(m) Where the preproduction test sample should be sent, the activity responsible for testing, and instructions concerning the submittal of the test reports (see 4.3.2).

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

~~TABLE III. WEBBING WIDTH AND THICKNESS REQUIREMENTS~~ ㉑

~~WEBBING IDENTITY~~	~~MINIMUM WIDTH - IN.~~			~~MINIMUM THICKNESS - IN.~~		
	~~SEATING POSITION~~			~~SEATING POSITION~~		
	~~Fwd. Facing~~	~~Aft Facing~~	~~Side Facing~~	~~Fwd. Facing~~	~~Aft Facing~~	~~Side Facing~~
~~Lap Belt~~	~~2.25*~~	~~2.0~~	~~2.25*~~	~~0.09*~~	~~0.07~~	~~0.09~~
~~Shoulder Strap~~	~~1.75~~	~~1.5~~	~~1.75~~	~~0.09*~~	~~0.07~~	~~0.09~~

~~*A greater width (up to 4 inches) is desirable in the center abdominal area.~~

~~**If suitable load-spreading pads are used between the webbing and the collarbone and pelvic bone, the webbing thickness can be reduced to 0.06 inch.~~

6.3.1 Anthropometric data. - ~~MIL-STD-1472~~ U.S. Army Natick Labs Report 72-51-CE shall be referred to as a source document for anthropometric data on troop/passenger personnel. ㉝

~~6.3.2 95th percentile clothed occupant. - Unless otherwise specified by the procuring activity, the 95th percentile clothed occupant is defined as the 95th percentile occupant, in accordance with MIL-STD-1472, wearing the following items:~~ ㉞

	~~Weight (lbs.)~~
~~Soldier~~	~~192.0~~
~~Clothing~~	~~3.2~~
~~Boots~~	~~4.6~~

~~Protective Vest~~	~~8.5~~
~~Helmet~~	~~3.0~~
~~Equipment~~	~~27.3~~
~~Field Pack with Sleeping Bag~~	~~17.2~~

TOTAL WEIGHT ~~258.2~~

6.3.2 Occupant Weights. - Unless otherwise specified by the procuring activity, the weights for the man, clothing and equipment and the effective weights for various impact directions and orientations shall be as follows: ㉞

(Add the following)

Item	95th Percentile Actual Wt-lb	50th Percentile Actual Wt-lb	95th Percentile Vertical Effective Wt-lb	50th Percentile Vertical Effective Wt-lb
Troop Weight	203.5	159.0	162.8	127.2
Boots	4.0	4.0	-	-
Shirt	1.1	1.1	1.1	1.1
Sox	0.2	0.2	-	-
Trousers	1.2	1.2	1.0	1.0
Underwear	0.5	0.5	0.5	0.5
Clothing	7.0	7.0	2.6	2.6
M-16 Rifle	7.0	7.0	-	-
Ammunition	6.5	6.5	6.5	6.5
Field Equipment				
Canteen with Water and Cup				
Pistol Belt				

㉞

Item	95th Percentile Actual Wt-lb	50th Percentile Actual Wt-lb	95th Percentile Vertical Effective Wt-lb	50th Percentile Vertical Effective Wt-lb
First Aid Pouch				
Suspenders				
Butt Pack				
Bayonet with Scabbard ㉞				
Poncho				
Helmet				
Trenching Tool with Cover				
Etc.				
TOTAL	16.8	16.8	16.8	16.8
Additional Equipment				
Fragmentation Grenades (2)				
Claymore Mine (1)				
Personal Equipment				
"C" Ration				
TOTAL	10.0	10.0	10.0	10.0
TOTAL Wt-lb	250.8*	206.3*		
TOTAL Vert Effect. Wt			198.8	163.4

*Subtract rifle weight for forward acceleration on forward- and side-facing seats and for aft acceleration on aft-facing seats.

6.3.3 Effective weight of occupant. - The effective weight of a seated occupant in the vertical direction as shown in 6.3.2 is the sum of the following quantities: 80% of the occupant's body weight, 80% of the weight of the occupant's clothing less boots, and 100% of the weight of any equipment carried totally on the occupant's body above knee level. The weight of the rifle is not included in vertical effective weight. It should also be subtracted from the total weight for forward and lateral accelerations on forward-facing seats and aft accelerations on aft-facing seats. Rifle weight is not effective due to the weapon's being thrown away from the troop during horizontal crash accelerations. ㉞

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 95th percentile potentially survivable accident. - Table 5 specified the period (T), the peak G values, and velocity change (ΔV) for the triangular pulse shape illustrated on Figure 12. The pulses described by the values given in Table 5 are design pulses representative of the crash pulses occurring at the aircraft floor line in 95 percent of the potentially survivable rotary-wing Army aircraft accidents. The pulse parameters peak G, T, and ΔV are obtained from USAAMRDL Technical Report 71-22, entitled "Crash Survival Design Guide".

TABLE 5. DESIGN PULSES CORRESPONDING TO THE 95TH PERCENTILE POTENTIALLY SURVIVABLE HELICOPTER ACCIDENT

Impact Direction	ΔV Velocity change (fps)	Peak G (G)	Pulse duration T (sec)
Longitudinal	50	24	0.130
Vertical	42	48	0.054
Lateral	30	18	0.104

6.3.6 Occupant submarining. - In a crash with high vertical and longitudinal forces (measured along the seat longitudinal axis) present, the restrainted body will tend to sink down into the seat first and then almost simultaneously be forced forward. If the seat system is provided with an improperly designed restraint system or seat cushion, the inertia load of the hips and thighs will pull the lower torso under the lap belt during the crash sequence. This phenomenon is referred to as occupant submarining.

6.3.7 Dynamic overshoot. - Dynamic overshoot exists when the seat occupant receives an amplification of the accelerative force applied to the seat. A loose or highly elastic restraint system, or a cushion with a high rebound potential which permits "bottoming out" on the seat pan, can facilitate dynamic overshoot.

6.3.8 Load-limiting device. - A load-limiting device is a device which limits the load in a structure to a preselected value.

6.3.9 Human tolerance to vertical accelerations. - For all vertical crash pulses up to and including the 95th percentile potentially survivable accident pulse (see 6.3.5), the 5th through 95th percentile clothed occupants (see 6.3.1) shall not experience accelerations with plateaus lasting longer and/or greater in magnitude than the values represented by the maximum acceptable acceleration duration-magnitude curve illustrated on Figure 13.

~~6.3.10 50th percentile clothed occupant weight. - Unless otherwise specified by the procuring activity, the 50th percentile clothed occupant effective weight is defined as 168 pounds.~~ ⑬

Custodian:

Army

Review Activities:

User Activities:

Preparing Activity:

Army -- Eustis Directorate
USAAMRDL

TABLE 3. SEAT DESIGN AND STATIC TEST REQUIREMENTS

Test Ref No.	Loading Direction With Respect to Fuselage Floor	Load Required	Deformation Requirements[a]
1	Forward	See Figure 1	See Figure 1
2	Aftward	12G Minimum	No Requirement
3	Lateral[b]	See Figure 2	See Figure 2
4	Downward	<14.5 G[d]	See Paragraph 3.4.7.3.1
5	Upward	8G Minimum	No Requirement
6 Combined	Forward[c,e,f]	See Figure 1	See Figure 1
	Downward	≤ 14.5 G	Same as Test 4
	Lateral[c]	9G Minimum	No Requirements

[a] The aircraft floor or sidewall shall be deformed in the xz and yz planes, as detailed in Figure 10, simultaneously with the "G" loads specified.

[b] The lateral loads shall 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 shall be used for this combined loading.

[d] If more than one load-limiter setting is provided, each should be tested.

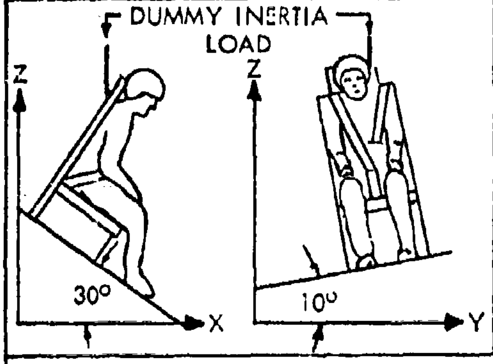
[e] The forward and lateral loads should be applied prior to the downward load application/ on seats which have vertical guides which could distort and impede vertical travel. ㉟

[f] Resultant load of combined load conditions shall not exceed vertical attenuator stroking load for seats where the vertical attenuator would stroke before reaching a higher resultant load. ㊱

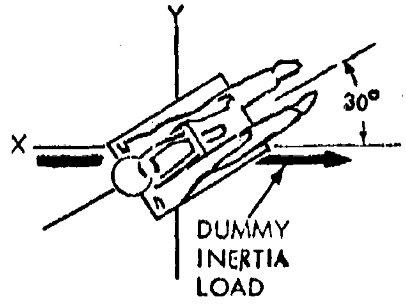
TABLE 4. DYNAMIC TEST REQUIREMENTS

TEST CONDITIONS AND SEAT ORIENTATION

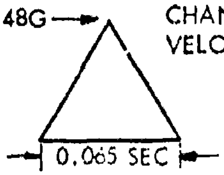
TEST 1:
DOWNWARD, FORWARD, AND LATERAL LOADS



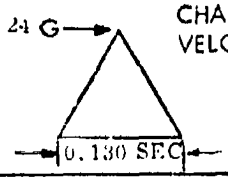
TEST 2:
FORWARD AND LATERAL LOADS



TEST PULSE REQUIRED*

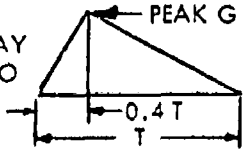


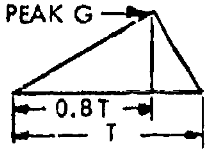
CHANGE IN VELOCITY = 50 FPS



CHANGE IN VELOCITY = 50 FPS

*THE RISE TIME FOR THE TRIANGULAR PULSES MAY VARY BETWEEN THE TWO VALUES ILLUSTRATED (T = TIME):





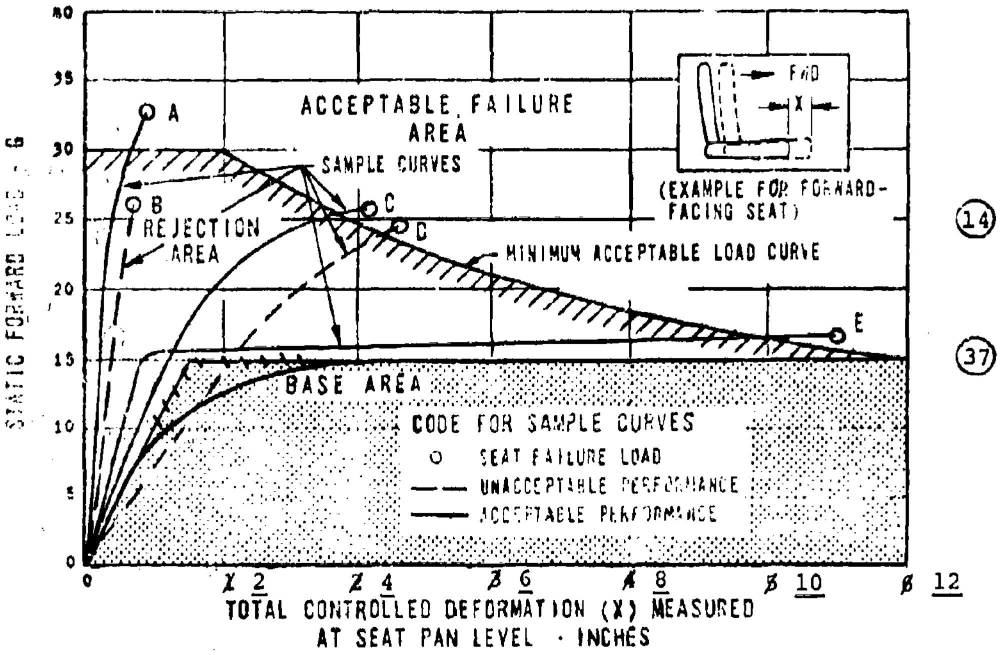


Figure 1. Seat Forward Load and Deflection Requirements.

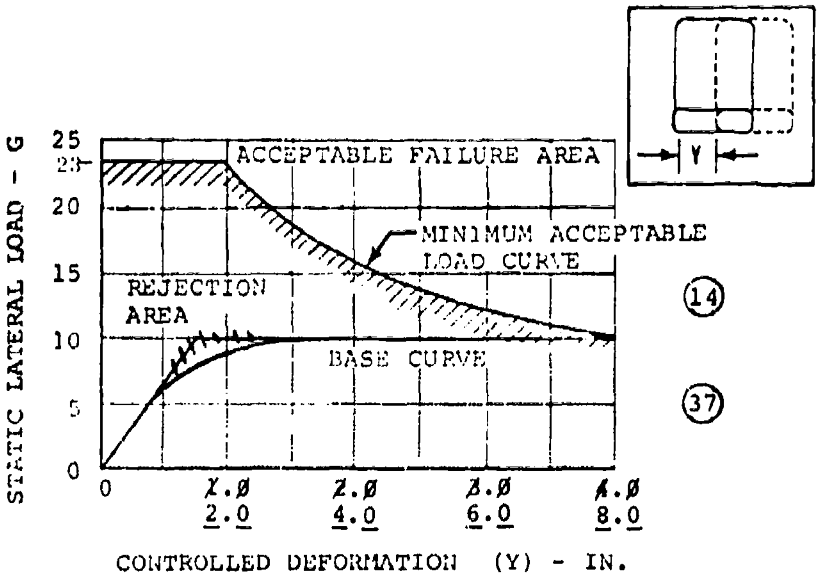


Figure 2. Lateral Seat Load and Deformation Requirements.

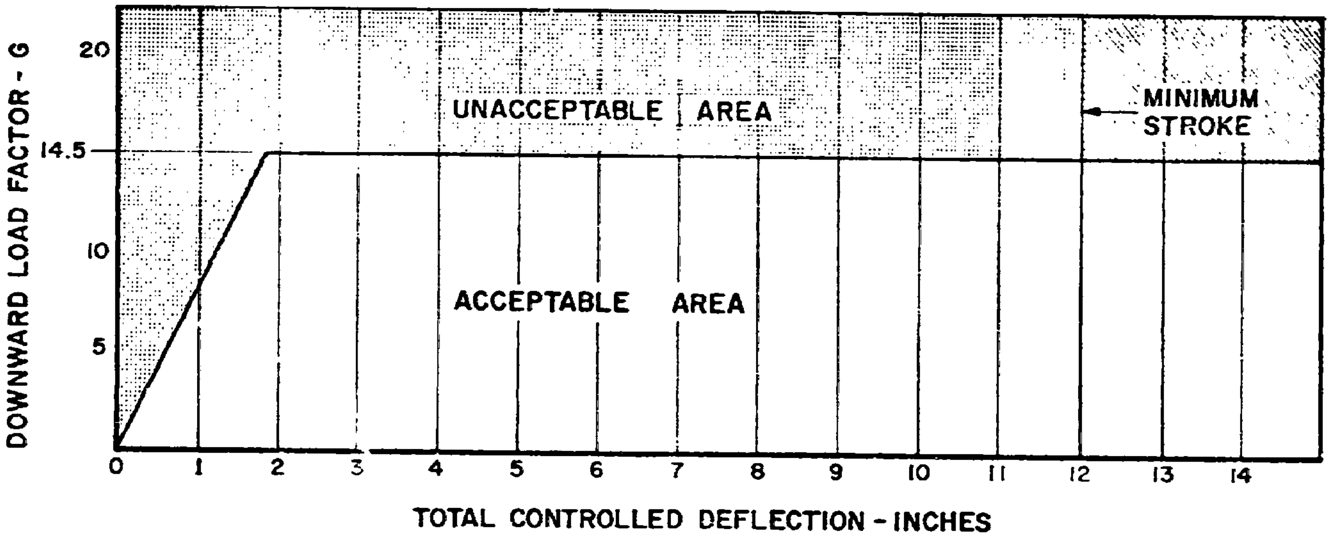


Figure 3. Seat Downward Load and Deflection/Requirements. ㊳

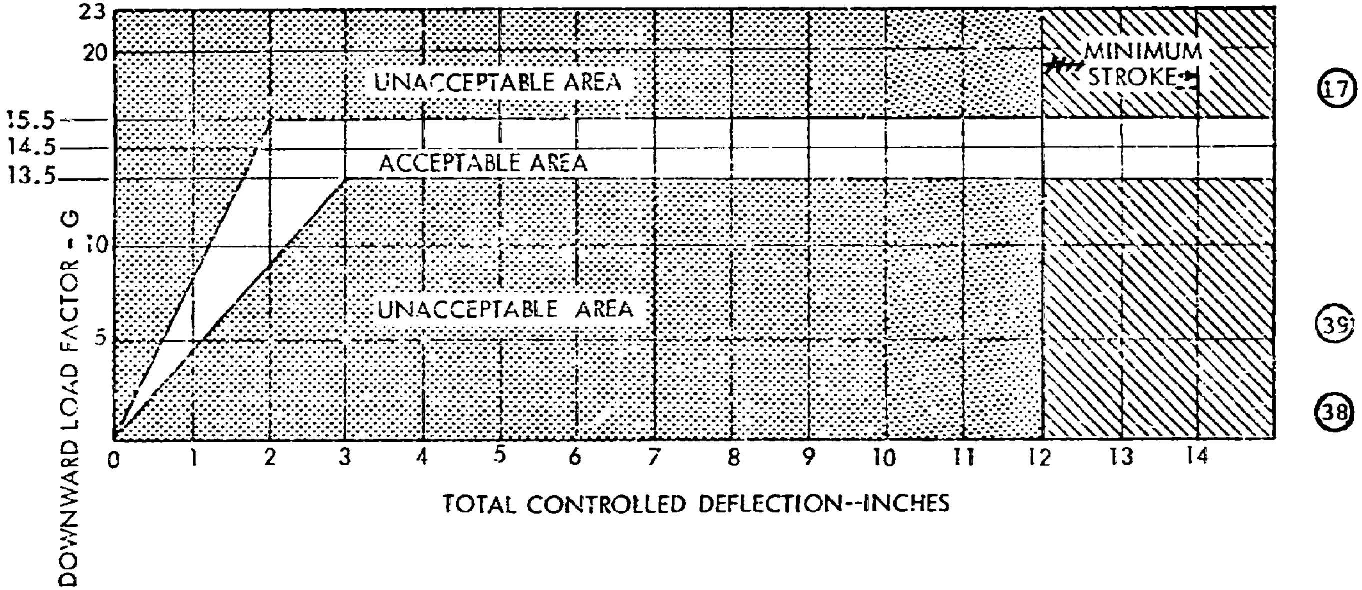
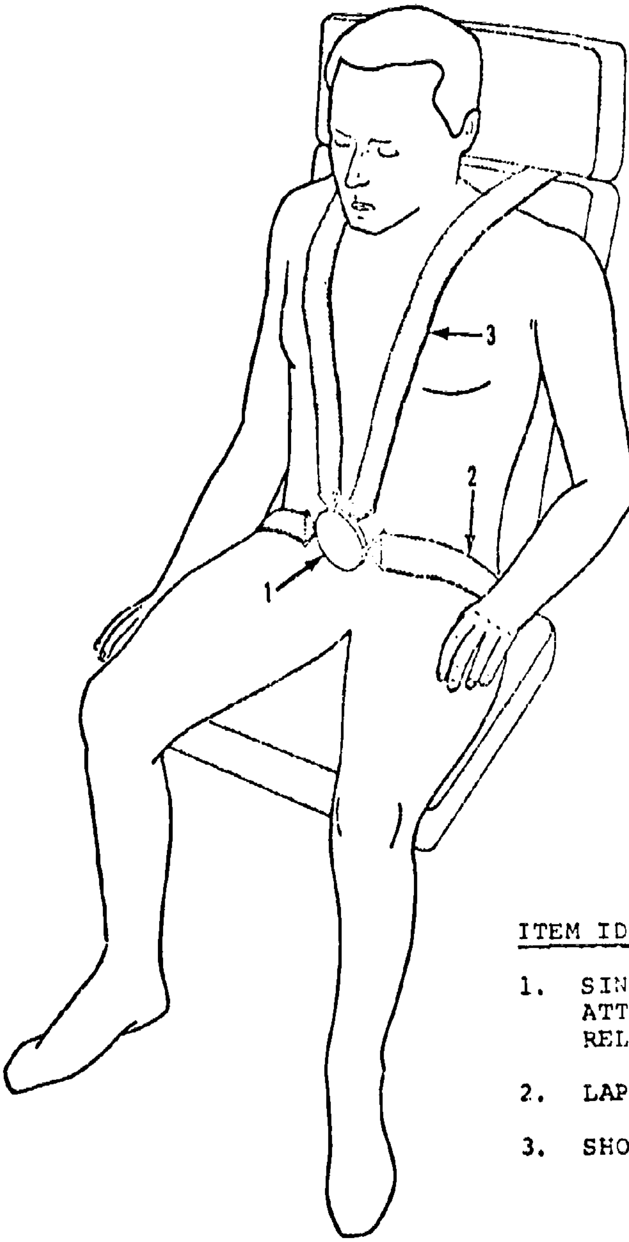


Figure 3. Seat Downward Load and Deflection Requirements for 50th Percentile.



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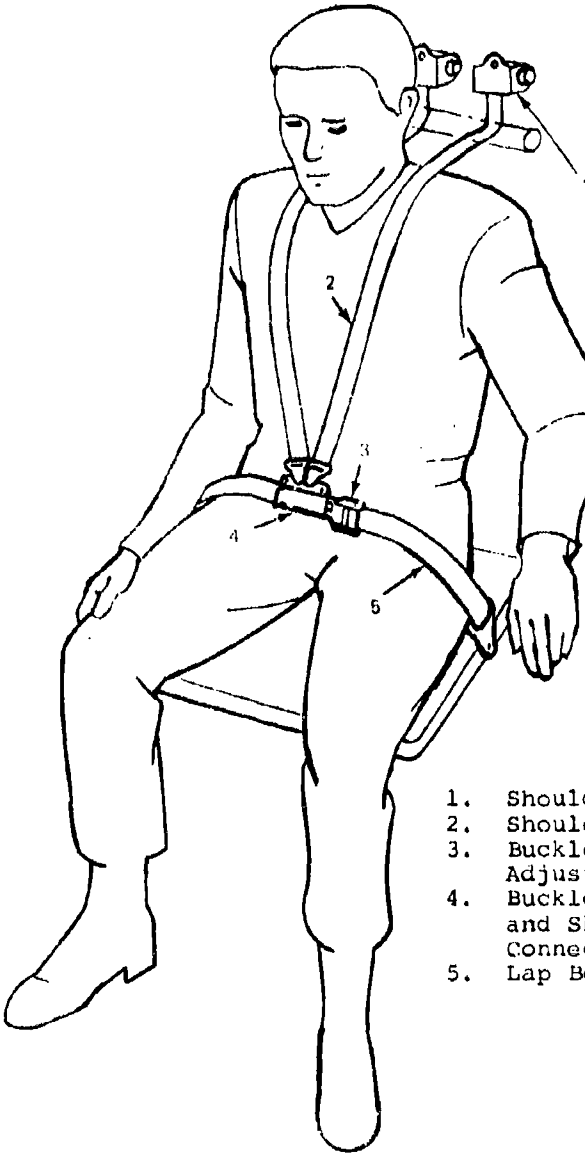
ITEM IDENTITY

1. SINGLE-POINT ATTACHMENT AND RELEASE FITTING
2. LAP BELT
3. SHOULDER STRAP

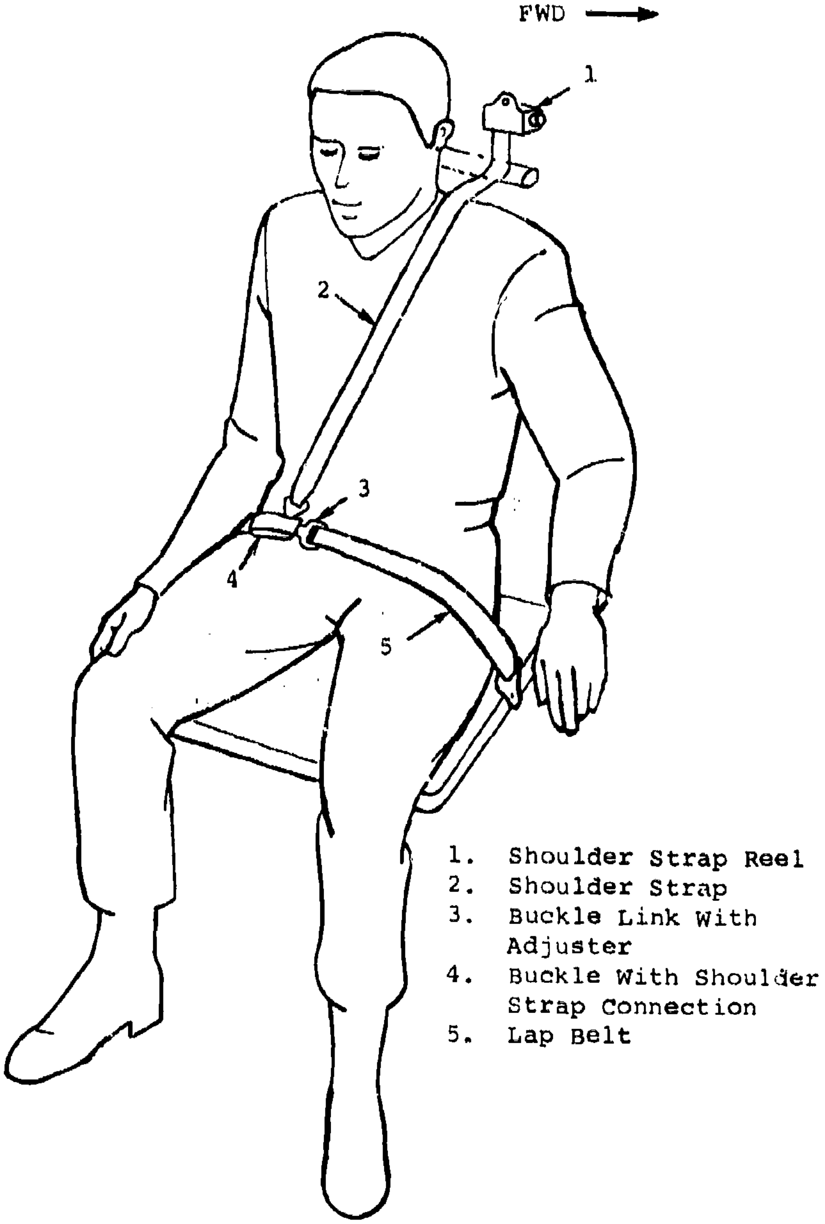
~~Figure 1. Harness/Configuration.~~



1. Shoulder Strap Reel
2. Shoulder Strap
3. Buckle Link With Adjuster
4. Buckle with Adjuster and Shoulder Harness Connections
5. Lap Belt

㊵

Figure 4. Forward- and Aft-Facing Seat Restraint System Configuration.



1. Shoulder Strap Reel
2. Shoulder Strap
3. Buckle Link With Adjuster
4. Buckle With Shoulder Strap Connection
5. Lap Belt

Figure 4a. Side-Facing Seat Restraint System Configuration.

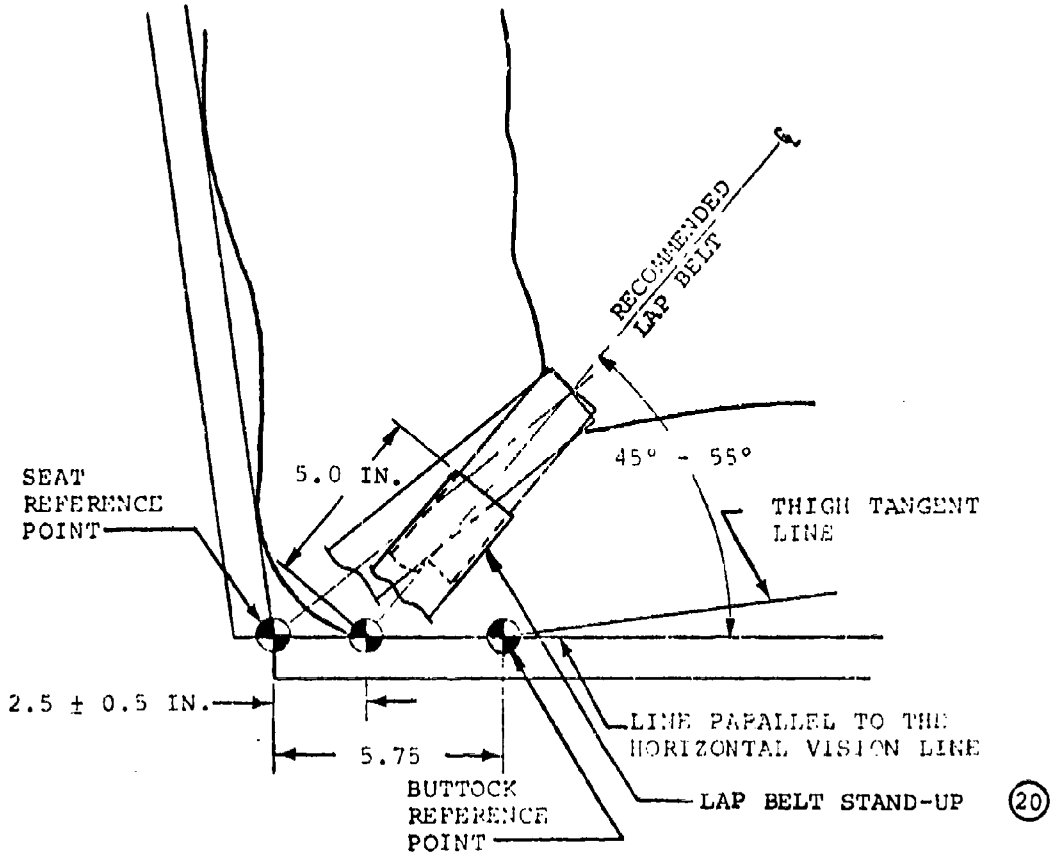


Figure 5. Lap-Belt Anchorage Geometry.

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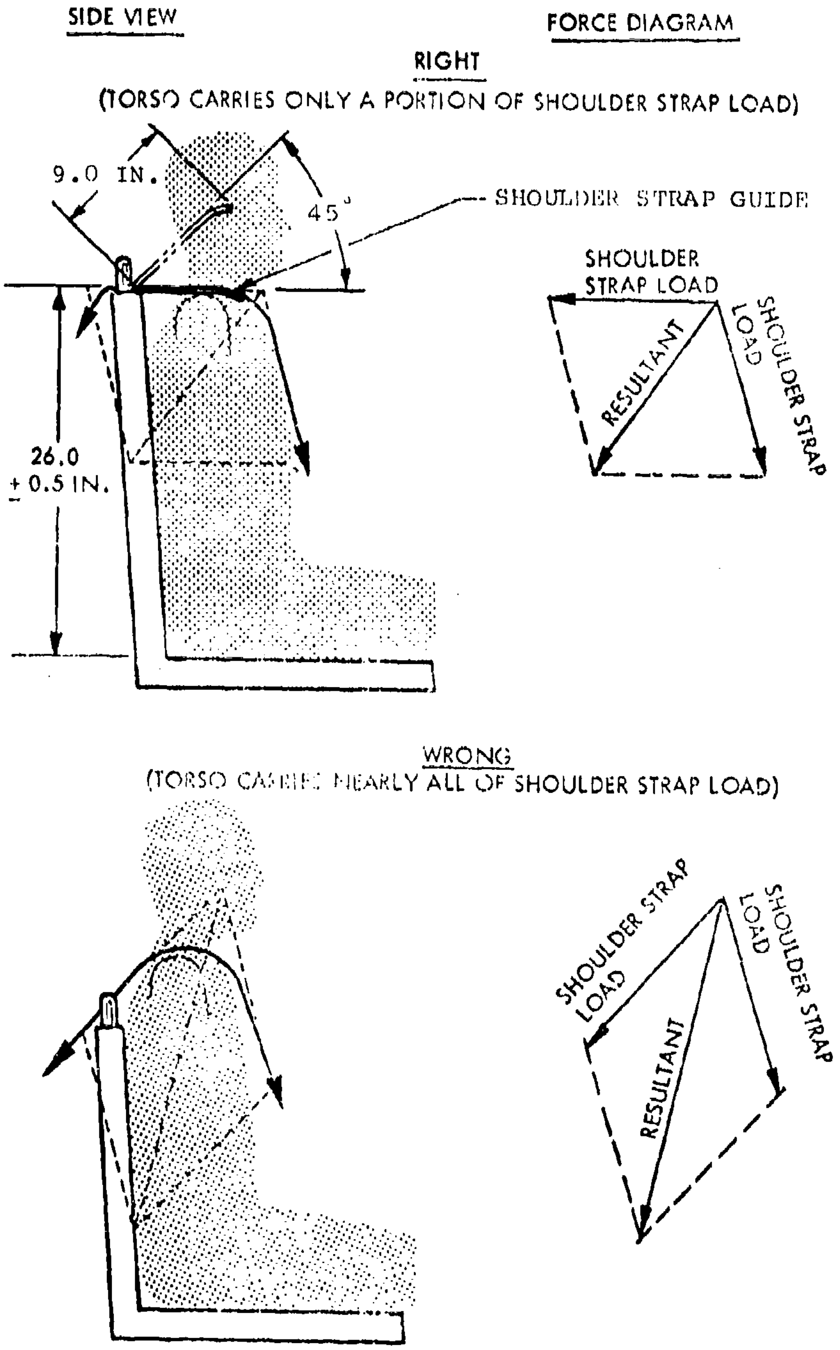


Figure 6. Shoulder Harness Anchorage Geometry.

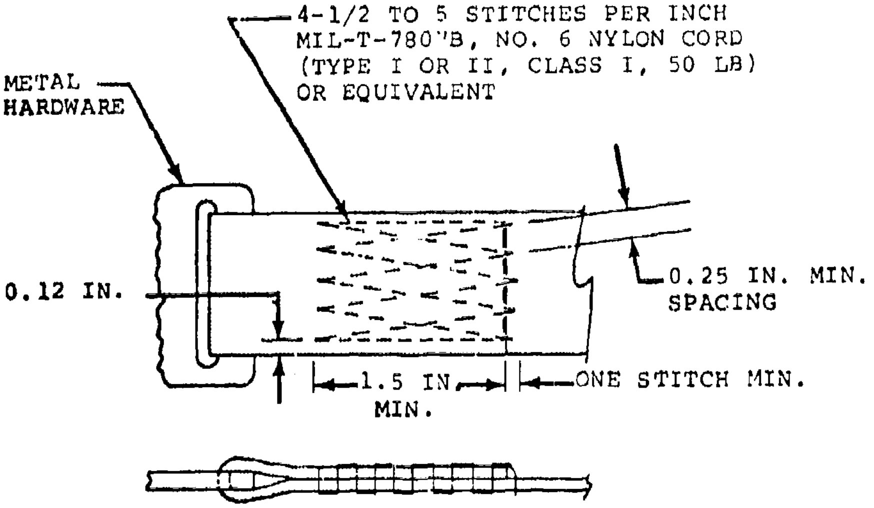


Figure 7. Stitch Pattern and Cord Size.

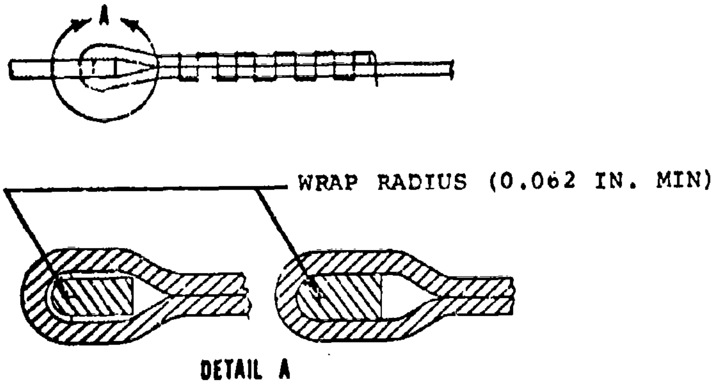


Figure 8. Wrap Radius for Webbing Joints.

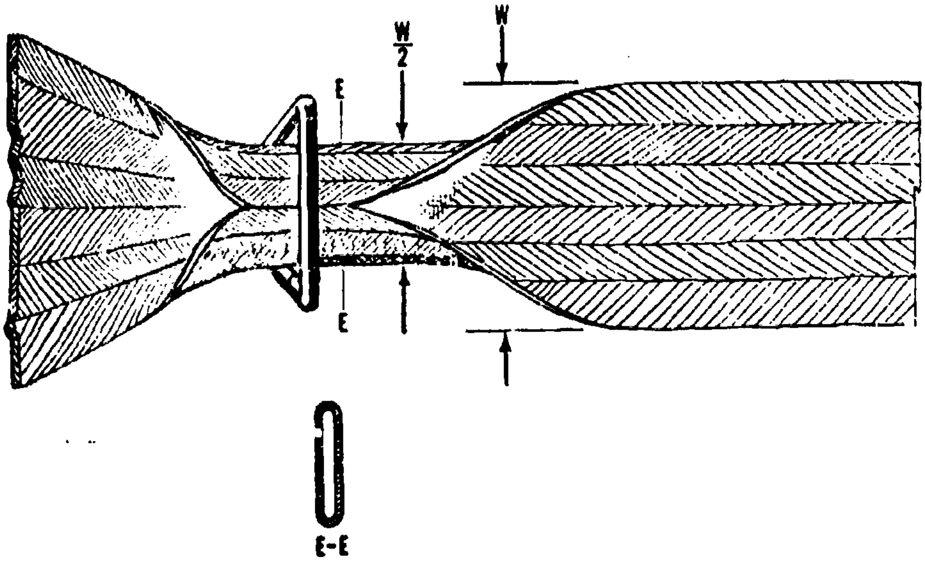


Figure 9. Webbing Fold at Metal Hardware Attachment.

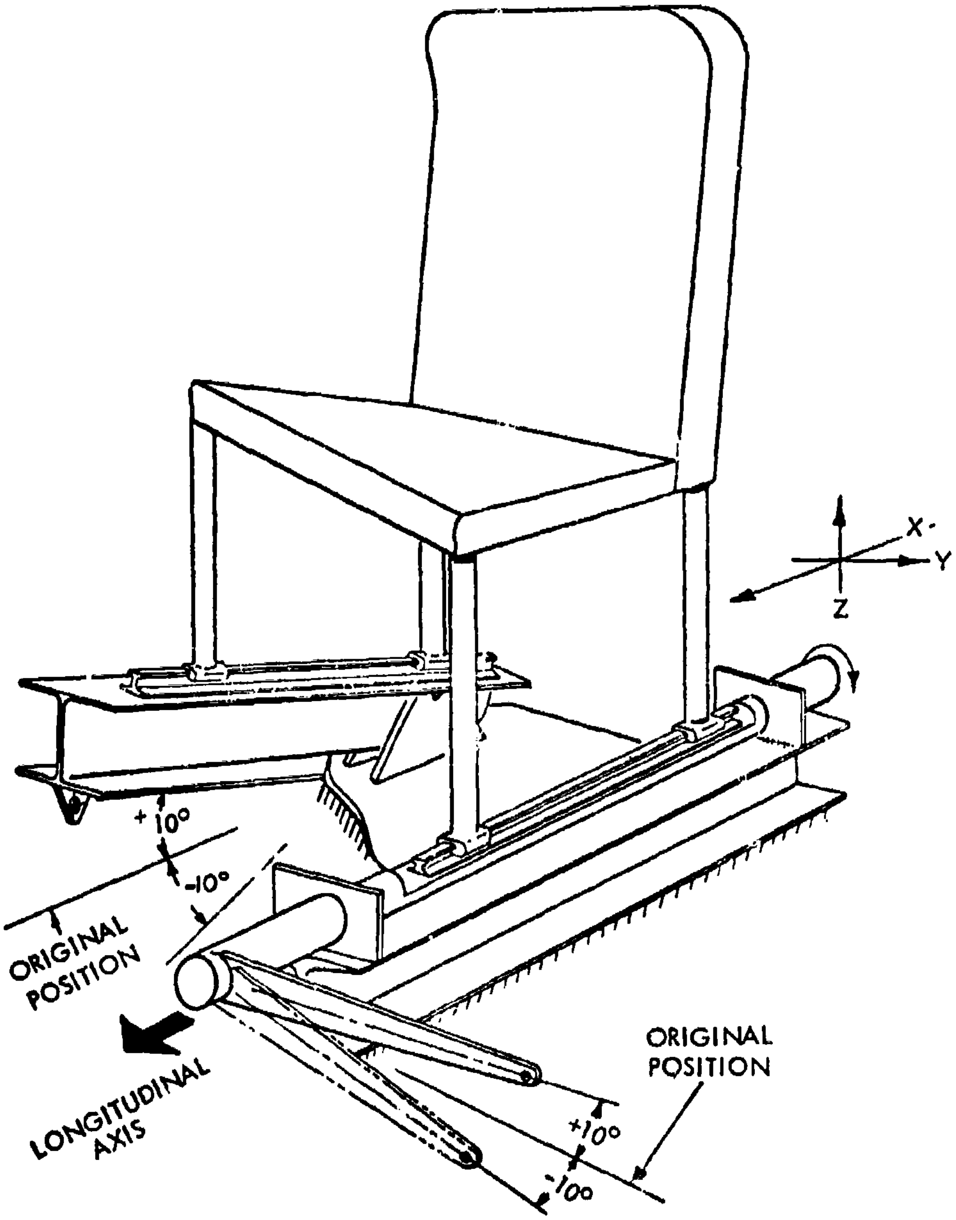


Figure 10. Diagram Illustrating Floor Warpage Requirement for Static Loading of Seat(s) (This Diagram Only Illustrates Floor Warpage and Is Not Intended To Illustrate Seat Design).

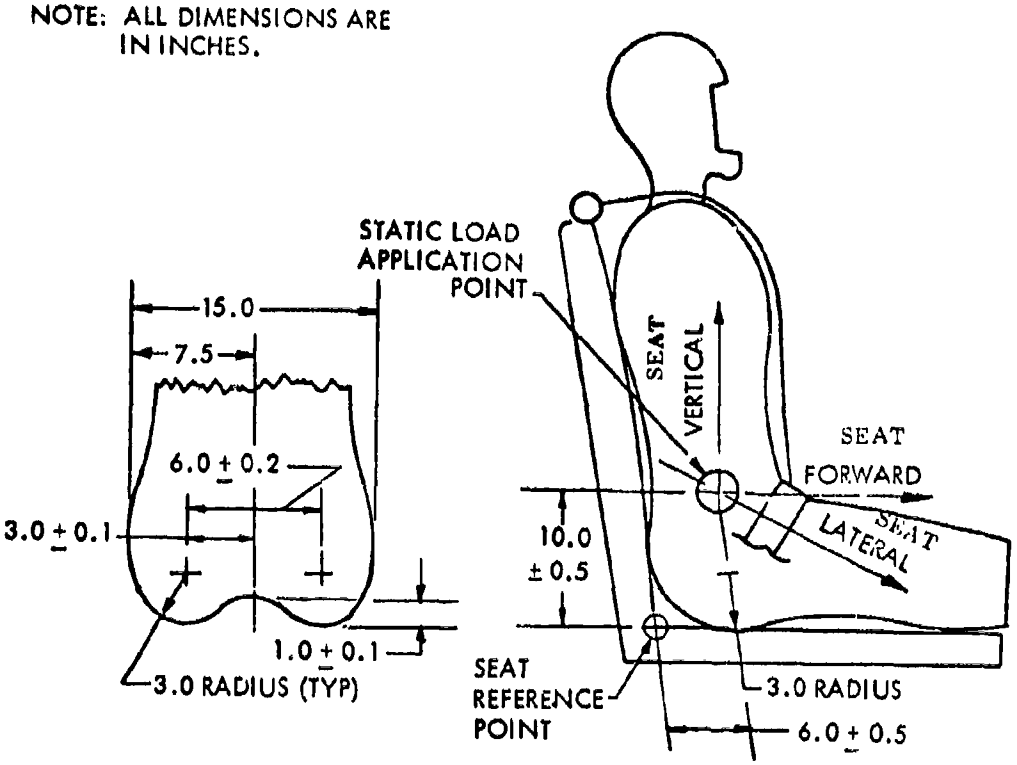


Figure 11. Static Load Application Point and Critical Dummy Pelvis Geometry.

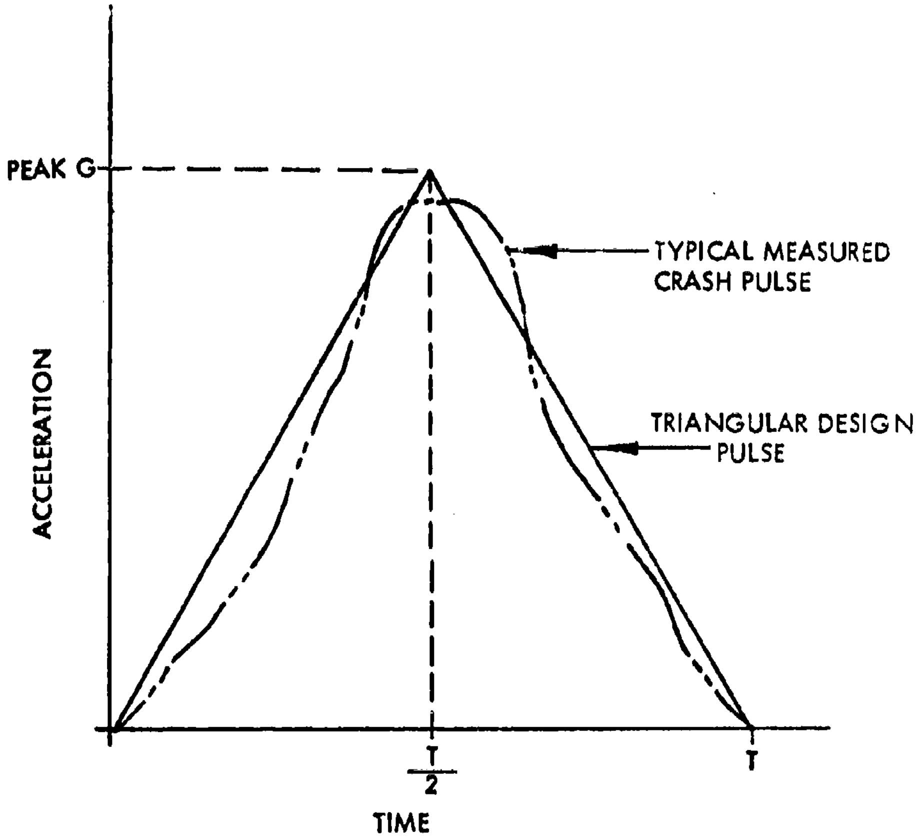


Figure 12. Typical Impact Pulse.

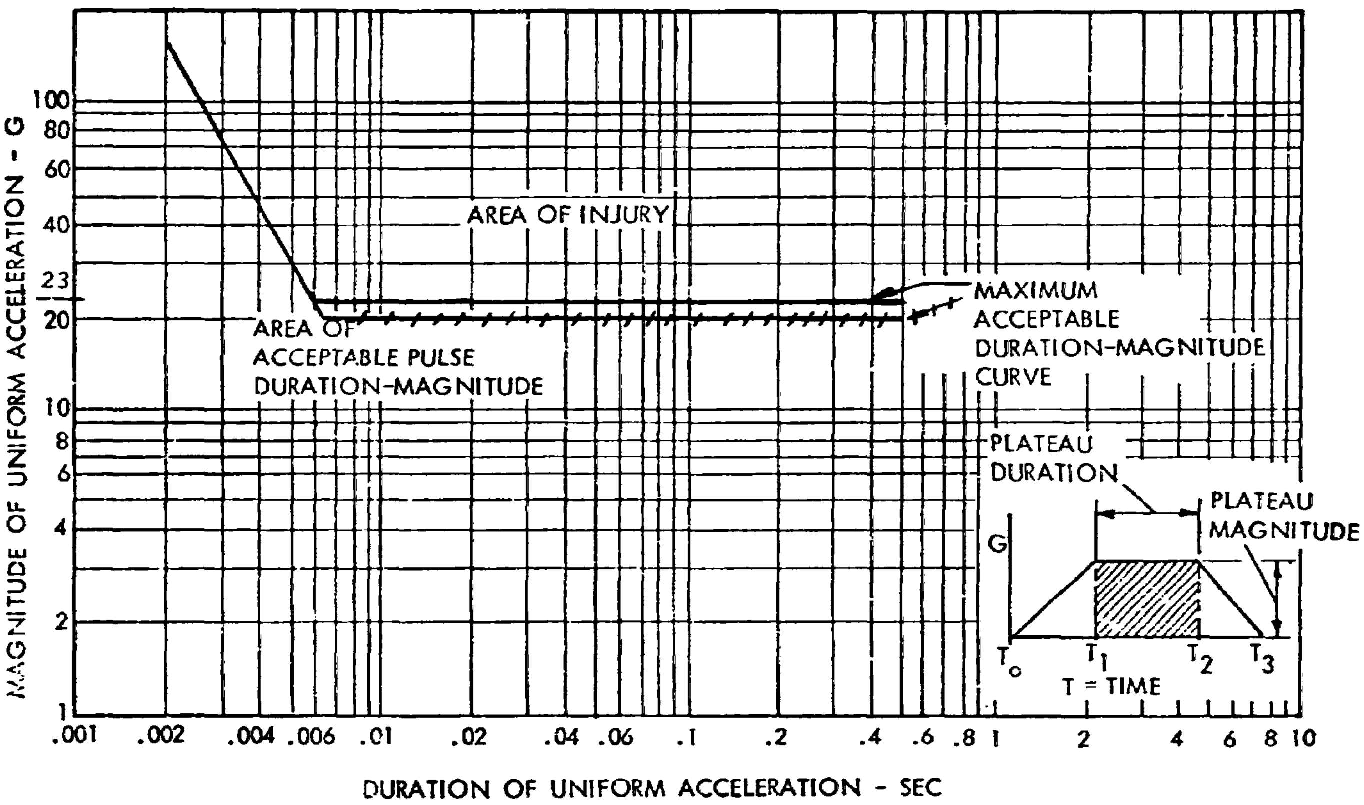
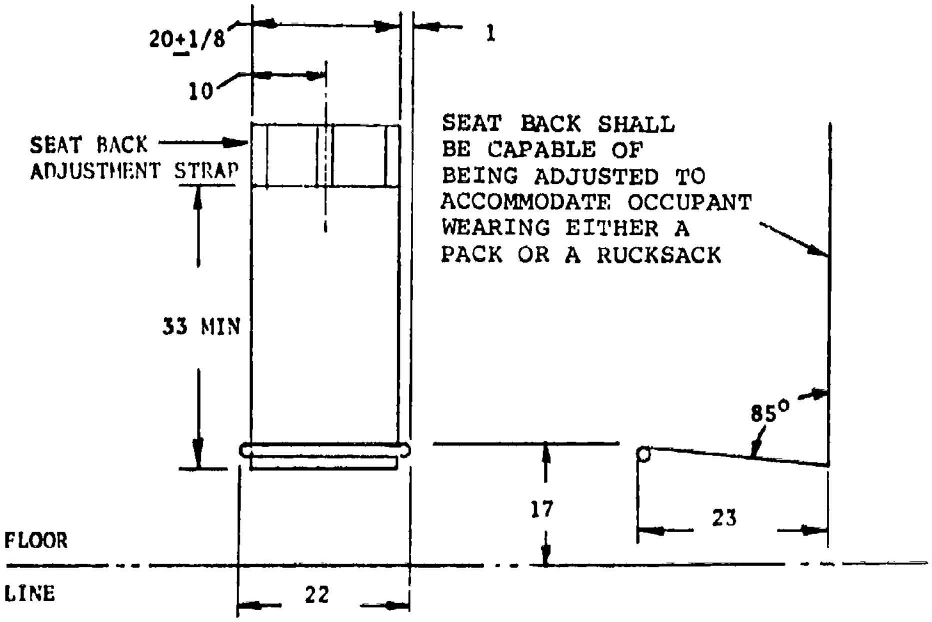


Figure 13. Maximum Acceptable Vertical Pulse Acceleration and Duration Values.



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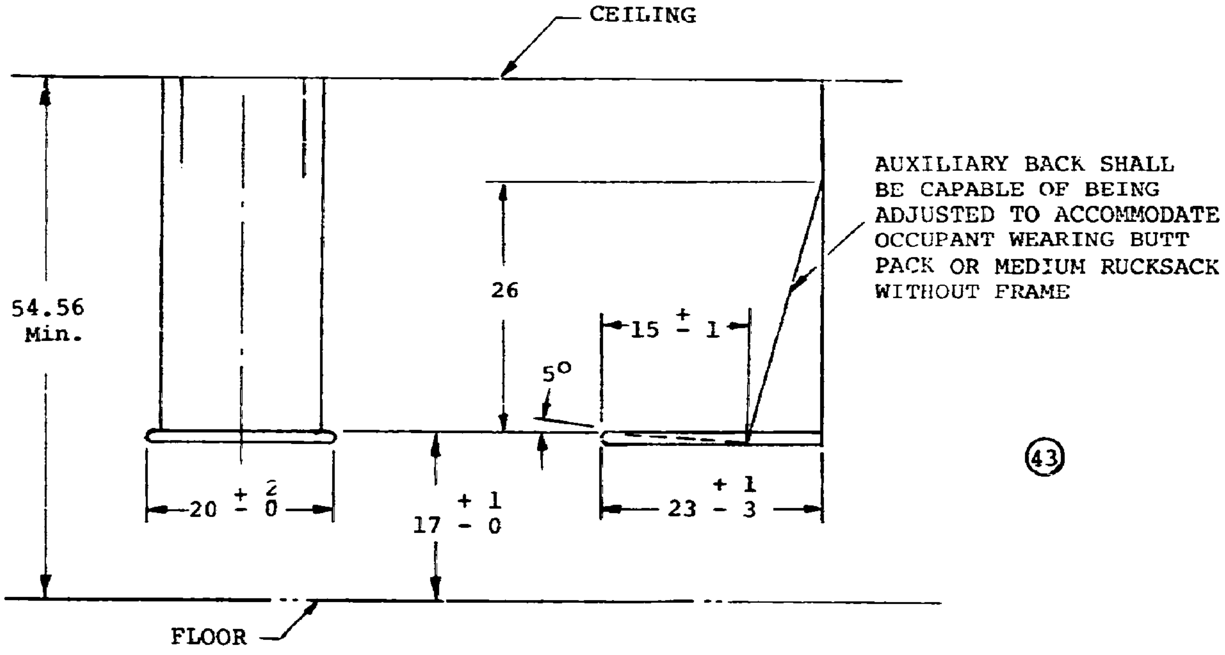
<u>NOTE:</u> ALL DIMENSIONS IN INCHES

~~Figure 1A. Seat Dimensions.~~



NOTE: ALL DIMENSIONS IN INCHES

Figure 14. Seat Dimensions.

RATIONALE FOR SPECIFICATION CHANGES

1 Quick-disconnect specified is of inadequate strength for crashworthy troop seats.

2 Punctuation and grammar corrected.

3 Statement clarification.

4 Seat cushions are not necessary for troop seats and are detrimental to crashworthiness.

5 Added preference for common seat orientation to minimize injuries due to handheld equipment during a crash.

6 Statement clarified and times revised as the times given are for conventional wall-mounted seats with minimum leg connections. The time allowed does not take into account the type of seat (one- to four-man) or the number of seats in the aircraft. A large aircraft may require more than 2 minutes for one man to stow all seats, and seats stowed against the ceiling will require more time than stowage against the sides.

7 Clarification as to what constitutes cargo compartment.

8 Clarification to remove the impression that seat fabric should be drum tight. Drum-tight fabric decreases comfort and increases loading on the seat pan frame. Spreaders under seat fabric are associated only with conventional troop seats.

9 Quick-disconnect in accordance with MIL-A-21165 will not withstand crashworthy troop seat loads.

10 Reference to seat legs removed, as crashworthy troop seats may not necessarily have legs.

11 Clarification of seat mounting priority to emphasize that seats should not have energy attenuators in series (above and below the seat), as they will not stroke simultaneously.

12 Removed self-retracting lap belt requirement, as retracting lap belts are not necessary for sliding across seats or for rapid egress. Reels also add weight and cost and require excessive space. Paragraph reference number corrected. Independent shoulder strap retraction and extension required.

13 50th percentile data included with 95th percentile data (6.3.2).

14 Higher longitudinal deformation is acceptable for troop seats due to more clearance available than for cockpit seats, and troop seats need more due to their flexibility.

15 Allowance of up to 60 percent reduction of crash impulse permitted by this paragraph is excessive due to low efficiency of aircraft structural crushing acting as an energy attenuator.

16 Seats designed for 14.5G vertical stroking load cannot be subjected to higher loads unless stops are provided at a point before the seat pan contacts the floor.

17 Twelve-inch vertical seat stroke is inadequate for troop seats due to the wider range of troop and equipment weights and ceiling deformation for ceiling-suspended seats.

18 Alternate restraint configuration provided for side-facing seats.

19 Loops in restraint harness will snag troop equipment.

20 Lap belts must be accessible for fastening, and lap belt anchors require flexible stand-ups to facilitate donning lap belt.

21 Percentage of webbing elongation cannot be determined when given in inches due to the variable strap lengths. Strap loads revised per stress analysis. Tables 1 and 2 combined.

22 Revised to clarify lateral loading on lap belt anchor.

23 Shoulder strap extension required to facilitate donning while wearing combat packs.

24 Two inches inadequate for neck clearance.

25 Single shoulder strap retractor deleted because single shoulder strap reel cannot retract double shoulder strap ends to the top of the seat back.

26 Shoulder harness reel requirements added.

27 Paragraph number corrected.

28 Survey selected, lift lever requirement added, and requirement for ejector feature added to buckle.

29 Requirements of Table II combined with Table I and various width webbings standardized.

30 Seat weight limits increased to be compatible with actual designs.

31 Placard data added.

32 Mockup requirement added.

33 Latest anthropometric data referenced.

34 Combat equipment and weights updated.

35 Test on seats without vertical guides unjustifiably complicated by sequenced load application.

36 Vertical energy attenuators determine maximum load that can be applied in predominantly vertical load application.

37 Curvilinear deformation curve used to accommodate high elongation cables for lateral energy attenuation.

38 Acceptable and unacceptable note corrected.

39 Maximum acceleration added.

40 Restraint figure updated with additional requirements.

41 Diagonal shoulder strap restraint figure added.

42 Figure 13 revised to agree with Figure 3 and with TR 71-22 and MIL-S-58095.

43 Limitation dimensions and tolerances added to Figure 14.

CRASH SURVIVAL DESIGN GUIDE CHANGE RECOMMENDATIONS

Modifications were recommended to USAAMRDL TR 71-22, "Crash Survival Design Guide". The affected paragraphs of TR 71-22 have been reproduced, and the recommended changes are noted by crosshatching (////) portions deleted and underlining (____) portions added.

3.3.2.1 The same percentile range of occupant sizes should be considered for troop 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 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 seat to accommodate the full range of equipment which can be carried by troops. A subsistence load weighs over 90 pounds and would be carried in a large rucksack with a Lincloe carrying frame. The depth of such equipment is 17 inches and cannot be accommodated within a reasonable seat depth. Such equipment will be removed and placed on the floor. Seat design should be limited to accommodations for the size and weight range of troops without equipment, to troops with combat assault equipment. The typical weights of seated troops in aircraft are: ①

	95th Percentile (lb)	
Soldier	~~192.0~~	202.0
Clothing	~~3.2~~	3.0
Boots	4.0	
~~Protective Vest~~	~~8.5~~	
Helmet	3.0	
~~Equipment~~	~~27.3~~	
~~Field Pack with Sleeping Bag~~ Combat Assault Pack and Equipment Not Including Rifle	~~17.2~~	30.3
	~~255.2~~	242.3

②

	5th Percentile (lb)	
Man	~~124.0~~	126.3
Clothing	2.6	
Boots	4.0	
Helmet	3.0	
	~~133.6~~	135.9

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

(Place this Title under Cockpit Seats)

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

(Revise Figure, Extending Controlled Deformations from 6 to 10 inches)

3.3.4 LATERAL STRENGTH AND DEFORMATION REQUIREMENTS

The lateral load and deformation requirements for forward- and aft-facing 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. Controlled deformation for side-facing seats may be increased from the 4 inches shown to 10 inches. ④

Figure 3-24. Lateral Seat Load and Deformation Requirements for Forward- or Aft-Facing Seats in All Types of Army Aircraft (95th Percentile Accident). ④

Figure 3-24. (Revise Base Curve to Curvilinear Shape) ⑤

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. ⑥

TABLE 3-II. SEAT DESIGN AND STATIC TEST REQUIREMENTS

Test Ref No.	Loading Direction With Respect to Fuselage Floor	Load Required	Deformation Requirements[a]
1	Forward	See Figure 3-23	See Figure 3-23
2	Aftward	12G Minimum	No Requirement
3	Lateral[b]	See Figure 3-24	See Figure 3-24
4	Downward/		
	Crew Seat	14.5 $\pm$ 1.0G[d,e]	See Paragraph 3.3.3.1
	Troop Seat	14.5 $\mp$ 1.0G[d]	
5	Upward	8G Minimum	No Requirement
6	Forward[c,f]	See Figure 3-23[c]	See Figure 3-23
	Downward/		
Com-bined	Crew Seat	14.5 $\pm$ 2.0G	
	Troop Seat	14.5 $\mp$ 2.0G	Same as Test 4
	Lateral[f]	9G Minimum	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-absorbing 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/ on seats employing vertical slide tubes or guides. ⑧

RATIONALE FOR CHANGES TO TR 71-22

1 To limit the range of equipment for which troop seats should be designed. The large rucksack with Lincloe 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 not applicable to side-facing seats due to lower lateral human tolerance. Figure 3-23 deflection requirements not applicable to troop seats due to higher troop equipment weight range and low weight of troop seats.

4 Lateral deformation curve Figure 3-24 not applicable to side-facing seats due to lower lateral human tolerance.

5 Base curve shown in Figure 3-24 not achievable with light tension yielding energy attenuators suitable to light troop seats.

6 Design for loads considerably above the load-limited loads on lightweight troop seats imposes a severe weight penalty.

7 Vertical static load requirements considerably above the load-limited load on all seats are 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 any unnecessary test.

REFERENCES

1. Turnbow, J. W., et al, CRASH INJURY EVALUATION, Aviation Crash Injury Research, Phoenix, Arizona, TCREC Technical Report 62-79, U.S. Army Transportation Research Command, Fort Eustis, Virginia, November 1962.

2. Turnbow, J. W., et al, CRASH INJURY EVALUATION, DYNAMIC TEST OF AN EXPERIMENTAL TROOP SEAT INSTALLATION IN AN H-21 HELICOPTER, Aviation Safety Engineering and Research, Phoenix, Arizona, TRECOM Technical Report 62-62, U.S. Army Transportation Research Command, Fort Eustis, Virginia, November 1963.

3. Weinberg, L.W.T., CRASHWORTHINESS EVALUATION OF AN ENERGY-ABSORPTION EXPERIMENTAL TROOP SEAT CONCEPT, Aviation Safety Engineering and Research, Phoenix, Arizona, USATRECOM Technical Report 65-6, U.S. Army Transportation Research Command, Fort Eustis, Virginia, February 1965.

4. Turnbow, J. W., et al, CRASH SURVIVAL DESIGN GUIDE Aviation Safety Engineering and Research, Phoenix, Arizona, USAAVLABS Technical Report 67-22, U.S. Army Aviation Materiel Laboratories, Fort Eustis, Virginia, December 1967.

5. Turnbow, J. W., et al, CRASH INJURY EVALUATION, DYNAMIC TEST OF AN EXPERIMENTAL TROOP SEAT INSTALLATION IN AN H-21 HELICOPTER, Aviation Safety Engineering and Research, Phoenix, Arizona, TRECOM Technical Report 63-62, U.S. Army Transportation Research Command, Fort Eustis, Virginia, November 1963.

6. Weinberg, L.W.T., CRASHWORTHINESS EVALUATION OF AN ENERGY-ABSORPTION EXPERIMENTAL TROOP SEAT CONCEPT, Aviation Safety Engineering and Research, Phoenix, Arizona, USATRECOM Technical Report 65-6, U.S. Army Transportation Research Command, Fort Eustis, Virginia, February 1965.

7. Reilly, M. J., ENERGY ATTENUATING TROOP SEAT DEVELOPMENT, The Boeing Company, Vertol Division, Report NADC-AC-7105 with Addendum NADC-73121-40, U.S. Naval Air Development Center, Aerospace Crew Equipment Department, Johnsville, Warminster, Pa., May 1971.

8. PROPOSAL FOR A FORWARD OR REARWARD-FACED CABLE-SUPPORTED, "LOAD-LIMITED" TROOP SEAT FOR UTTAS, USABAAR Technical Report 72-5, Applied Research Division, Technical Research and Application Department, U.S. Army Board for Aviation Accident Research, Fort Rucker, Ala., December 1971.

9. Haley, J. L., Jr., PERSONNEL RESTRAINT SYSTEMS STUDY BASIC CONCEPTS, Aviation Crash Injury Research, Phoenix, Arizona, TCREC Technical Report 62-94, U.S. Army Transportation Research Command, Fort Eustis, Virginia, 23604, December, 1962.

10. Kourouklis, G., et al, THE DESIGN, DEVELOPMENT, AND TESTING OF AN AIRCREW RESTRAINT SYSTEM FOR ARMY AIRCRAFT, Dynamic Science, Phoenix, Arizona, USAAMRDL Technical Report 72-26, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, 23604, June 1972.

11. Phillips, N. S., et al, A STATISTICAL EVALUATION OF THE INJURY POTENTIAL OF A "SQUARE WAVE" ENERGY ABSORBER, Beta Industries, Inc., Dayton, Ohio, USAAMRDL Technical Report 72-9, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, 23604, June 1972.

12. Brinkley, J.W., DEVELOPMENT OF AEROSPACE ESCAPE SYSTEMS, Air University Review, Vol XIX (95), 34-49, July-August 1968.

13. Weinberg, C. J., U.S. AIR FORCE EXPLORATORY DEVELOPMENT IN IMPACT INJURY PREDICTION AND PROTECTION, Proceedings of the 8th Annual Survival and Flight Equipment Association Symposium, 28 September 1970.

14. DeStefano, L.A., DYNAMIC RESPONSE INDEX MODULATION FOR PERSONNEL ESCAPE SYSTEMS, Memorandum Report No. M71-23-1, for Munitions Development and Engineering Directorate, Frankford Arsenal, Philadelphia, Pennsylvania, November 1971.

15. Snyder, R.G., et al, PATHOLOGY OF TRAUMA ATTRIBUTED TO RESTRAINT SYSTEM IN CRASH IMPACTS, Document No. A68-38085, August 1968 Aerospace Medicine, Vol. 39, P812-829, Supported by Federal Aviation Administration Research. Oklahoma City, Oklahoma.

16. DeHaven, H. T., et al, AIRCRAFT SAFETY BELTS: THEIR INJURY EFFECT ON THE HUMAN BODY, Crash Injury Research of Cornell University Medical College, 1953.

17. Haley, J.L., CRASH INJURY EVALUATION - PERSONNEL RESTRAINT SYSTEMS STUDY, CH-47 VERTOL CHINOOK, Aviation Safety Engineering and Research, Phoenix, Arizona, TRECOM Technical Report 64-4, U.S. Army Transportation Research Command, Fort Eustis, Virginia, April 1964.

18. Stapp, J.P. VOLUNTARY HUMAN TOLERANCE LEVELS, CRASH INJURY AND CRASH PROTECTION (E.S. Gurdjian, W.A. Lange, L.M. Patrick, and L.M. Thomas, Eds.), Springfield, Illinois, Charles C. Thomas 1970, PP 308-349.

19. Kourouklis, G., et al, THE DESIGN, DEVELOPMENT, AND TESTING OF AN AIRCREW RESTRAINT SYSTEM FOR ARMY AIRCRAFT, USAAMRDL Technical Report 72-26, Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia, June 1972, AD746631.

20. Snyder, R.G., et al, SEAT BELT INJURIES IN IMPACT, The Prevention of Highway Injury, Highway Safety Research Institute, The University of Michigan, 1967. (See also Federal Aviation Administration, Civil Aeromedical Institute, Cami report).

21. Armstrong, R.W., et al, TESTING PROGRAMS AND RESEARCH ON RESTRAINT SYSTEMS, SAE-690247, Occupant Restraint Systems Section, Office of Vehicle Systems Research National Bureau of Standards.

22. Fish, J., and Wright, R.H., THE SEAT BELT SYNDROME - DOES IT EXIST?, J. Trauma, 5:746-750, 1965.

23. DuBois, E.F., SAFETY BELTS ARE NOT DANGEROUS, British Medical Journal 2:605, 1952.

24. Bastiaanse, J.C., and Boiromon, A.A., STATISTICAL STUDY EFFECTIVENESS (OF) SEAT BELTS, Rapport Rai-Tno, Instituut Voor Wegtransport Middelen., Netherlands, 1966.

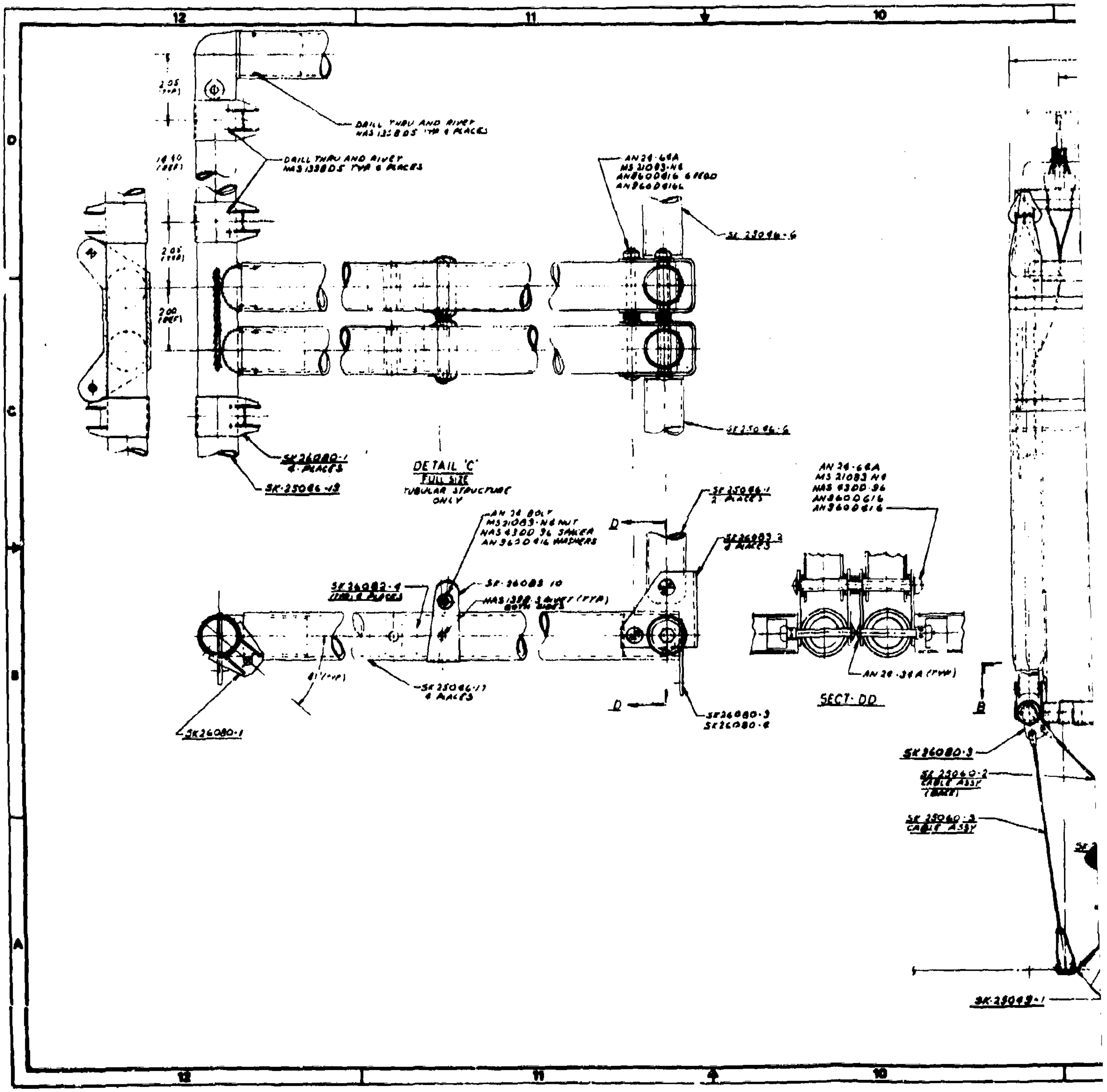
25. Young, J.W., A FUNCTIONAL COMPARISON DECOMPRESSION OF BASIC RESTRAINT SYSTEM, Document No. N67-39865 for Office of Aviation Medicine, Department of Transportation, Federal Aviation Administration, June 1967.

APPENDIX A

DETAIL DESIGN DRAWINGS

TYPE I AND TYPE II, CLASSES A, B, AND C CRASHWORTHY SEATS

These drawings are for single and double seats (Type I and Type II) and show configurations for forward-facing, aft-facing, and side-facing seats (Class A, B, and C).


12
11
10
D
C
B
A
2.05 (TYP)
14.40 (REF)
2.05 (TYP)
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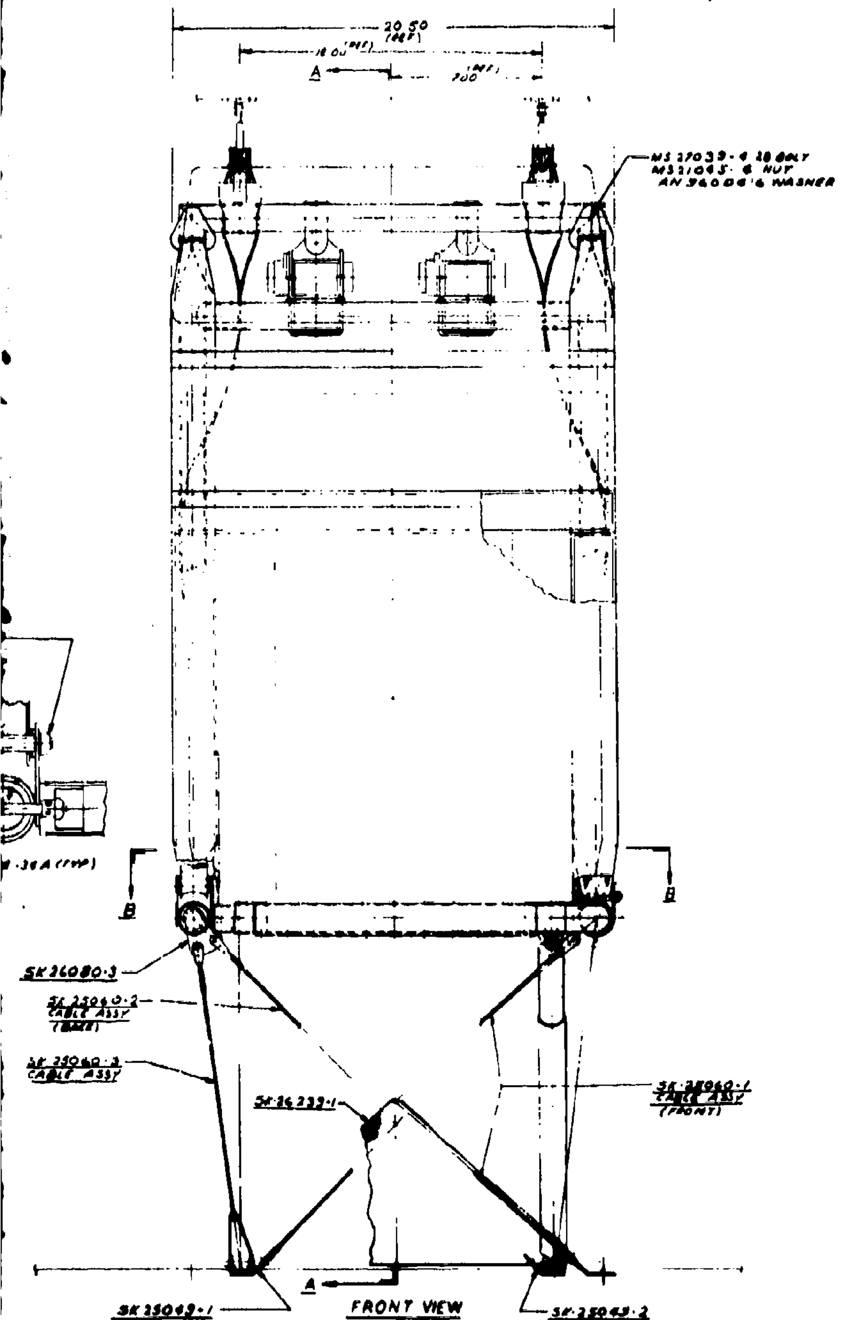
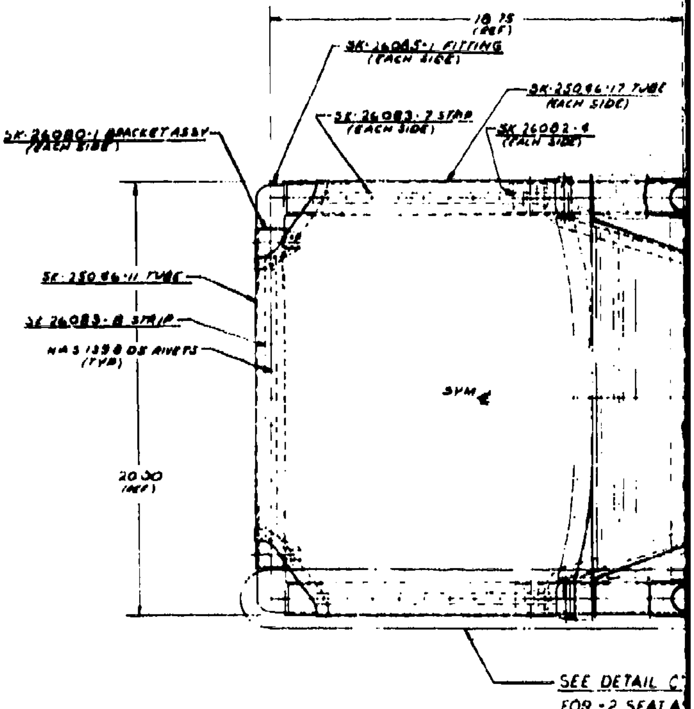
DRILL THRU AND RIVET NAS 1338 DS TYP 6 PLACES
DRILL THRU AND RIVET NAS 1338 DS TYP 6 PLACES
AN 24-64A
MS 21083-N6
AN960D616 6 REQD
AN960D616L
SK 25096-6
SK 25096-6
SK26080-1 4 PLACES
SK-25086-13
DETAIL 'C'
FULL SIZE
TUBULAR STRUCTURE ONLY
AN 24 BOLT
MS21083-N6 NUT
NAS 43DD 36 SPACER
AN 960 D 416 WASHERS
SK 25086-1 2 PLACES
SK26083-2 2 PLACES
AN 24-64A
MS 21083 N6
NAS 43DD 36
AN960D616
AN960D616
D
D
SK26082-4 (TYP) 6 PLACES
SK 26083 10
NAS 1398 RIVET (TYP) BOTH SIDES
81° (TYP)
SK 25086-17 4 PLACES
SK26080-1
SK26080-3
SK26080-4
AN 24-34A (TYP)
SECT-DD
B
SK26080-3
SK 25060-2 CABLE ASSY (BARE)
SK 25060-3 CABLE ASSY
SK 25049-1

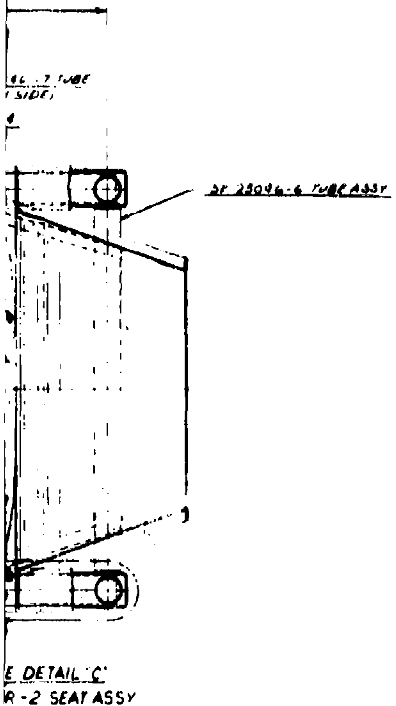


FRONT VIEW
-1 SEAT ASSY

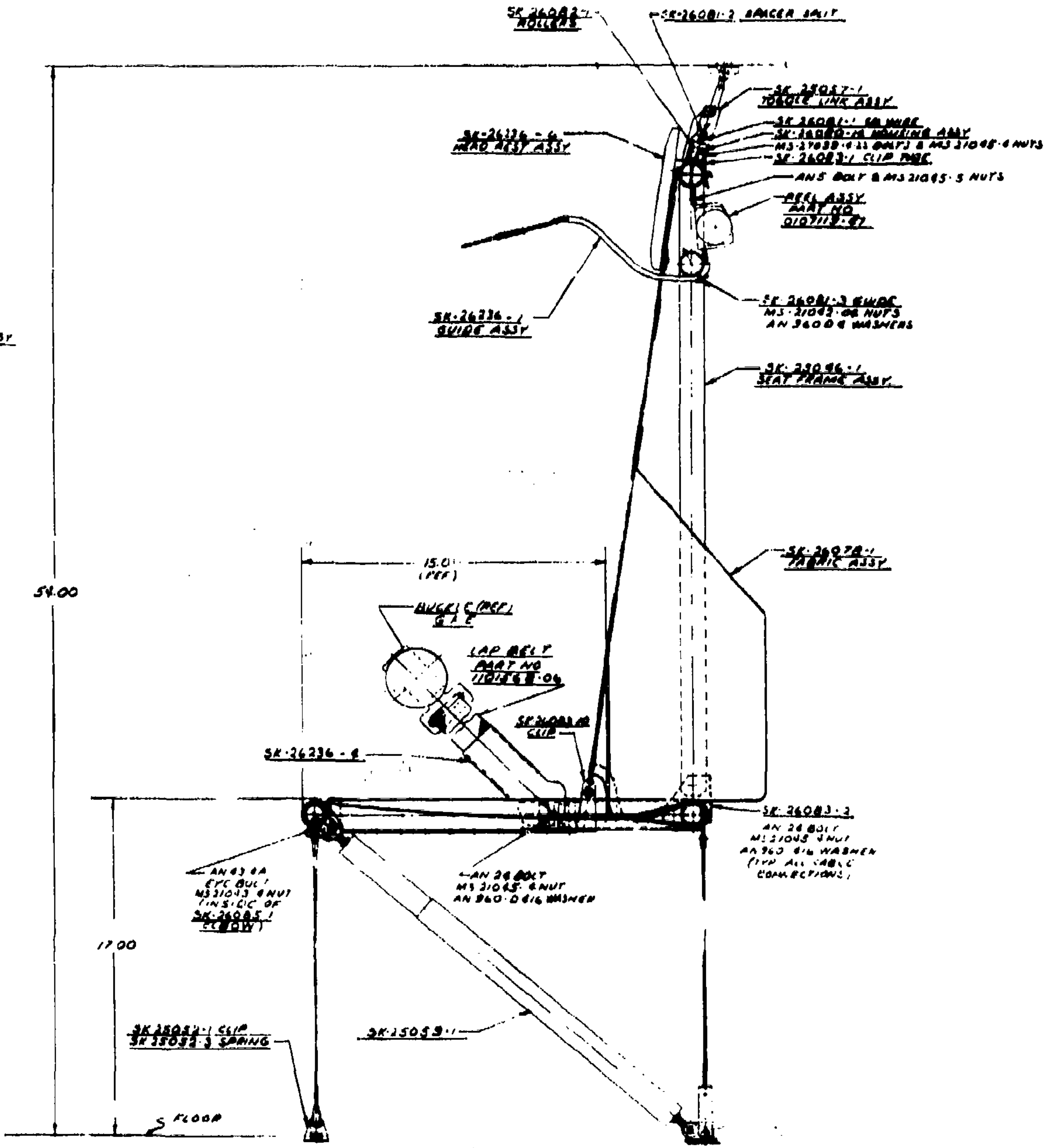


VIEW BB
PLAN VIEW
← FWD
ROTATED 90°

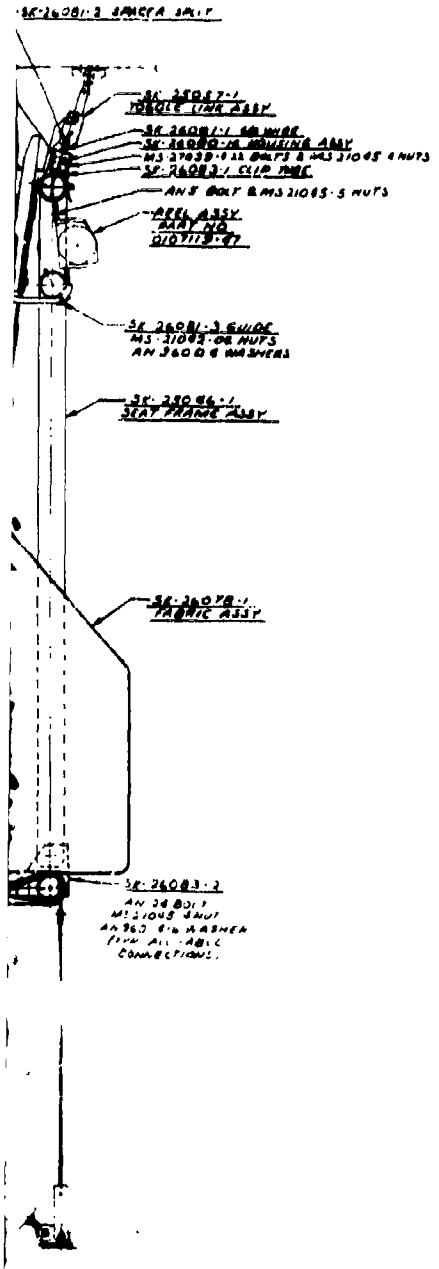
NOTE:



E DETAIL 'C'
R-2 SEAT ASSY



SECT AA
SIDE VIEW
←FWD



NOTES

⟨1⟩ -2 SEAT ASSY IS SAME AS -1 SEAT ASSY EXCEPT TWO SEATS ARE JOINED TOGETHER AS SHOWN IN DETAIL 'C'

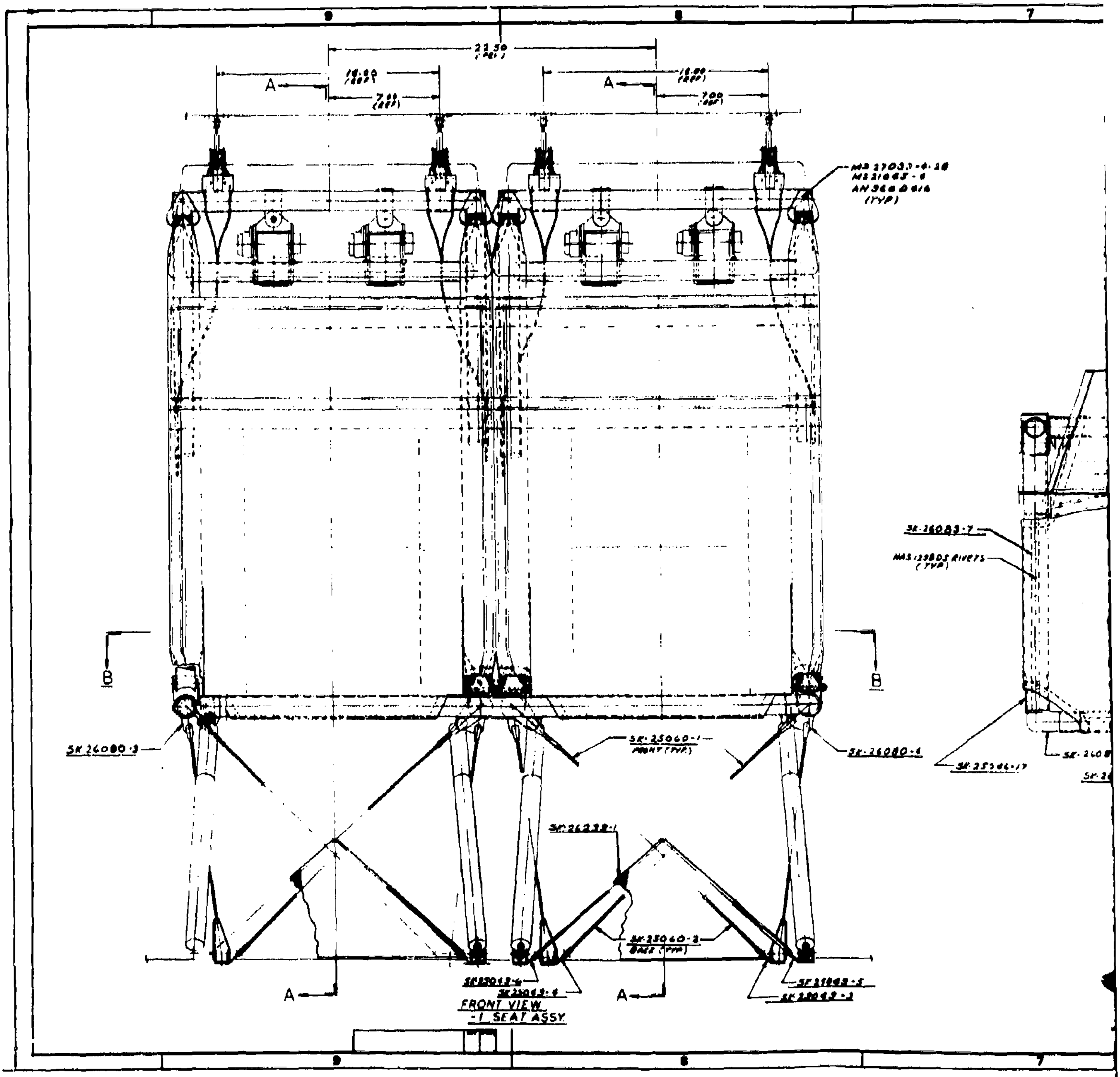
	2	1	SK-26239-1	[illegible]	
	4	2	SK-25053-1	ATTENUATOR ASSY	
	4	2	010719-97	REEL ASSY	PACIFIC SCIENTIFIC CO OR EQUIV
	2	1	110156B-06	LAP BELT ASSY	PACIFIC SCIENTIFIC CO OR EQUIV
	4	2	SK-26236-1	GUIDE ASSY	
	2	1	SK-26236-6	HEAD REST ASSY	
	4	2	SK-26236-4	BOOT	
	4	2	SK-26083-10	CLIP	
	4	2	SK 26081-5	GUIDE	
	4	2	SK 26081-2	SPACER SPLIT	
	4	2	SK-26081-1	WIRE - 4/A	
	8	4	SK-26082-1	ROLLER	
	4	2	SK-26082-4	PLUG	
	4	2	SK 26083-7	STRIP	
	2	1	SK-26083-8	STRIP	
	4	2	SK-26083-2	HINGE FITTING	
	4	2	SK-26083-1	CLIP TUBE	
	4	2	SK 25046-17	TUBE	
	4	2	SK-26080-16	HOUSING ASSY	
	2	1	SK-26080-4	LUG ASSY	
	2	1	SK-26080-3	LUG ASSY	
	4	2	SK-26080-1	BRACKET ASSY	
	2	2	SK-26085-1	ELBOW	
	1		SK-25046-13	TUBE ASSY	
		1	SK-25046-11	TUBE	
	2	1	SK-25046-6	TUBE ASSY	
	2	1	SK-25046-1	SEAT FRAME ASSY	
	4	2	SK-25052-3	SPRING	
	4	2	SK-25052-1	CLIP	
	2	1	SK-25049-2	QUICK DISCONNECT ASSY	
	2	1	SK-25049-1	QUICK DISCONNECT ASSY	
	4	2	SK-25060-3	CABLE ASSY	
	4	2	SK-25060-2	CABLE ASSY	
	4	2	SK-25060-1	CABLE ASSY	
	4	2	SK-25057-1	TOGGLE LINK ASSY	
	2	1	SK-26078-1	FABRIC ASSY	
	☒		SK-26075-2	SEAT ASSY	⟨1⟩
		☒	SK-26075-1	SEAT ASSY	
	-2	-1			

J.A.

CRASHWORTHY TROOP SEAT
TYPE I AND TYPE II
CLASS A

J

SK 26075



FRONT VIEW
-1 SEAT ASSY

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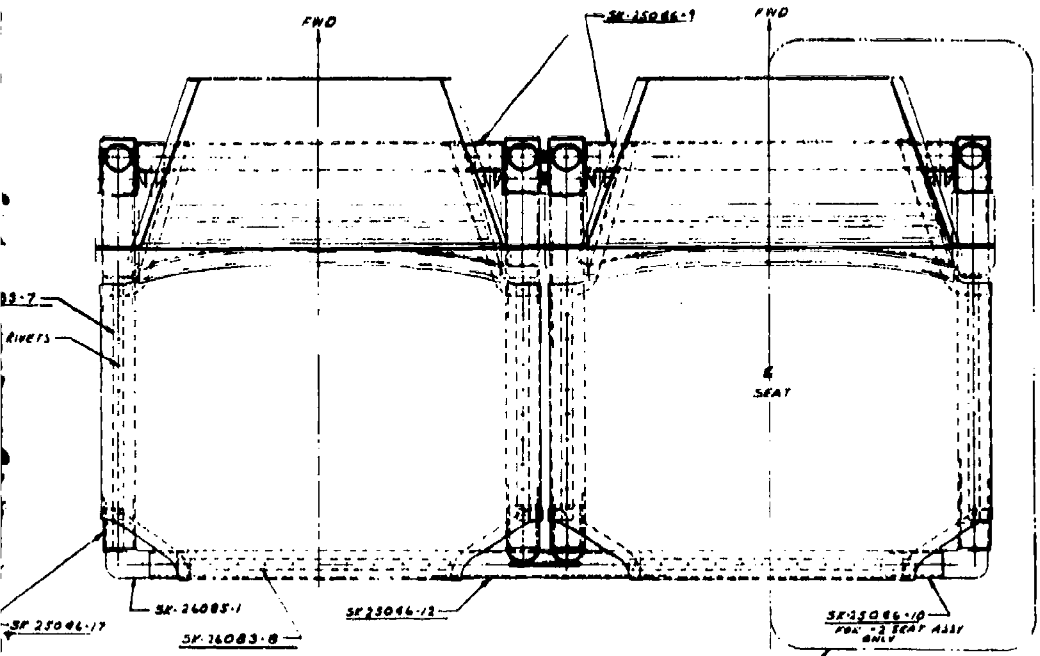
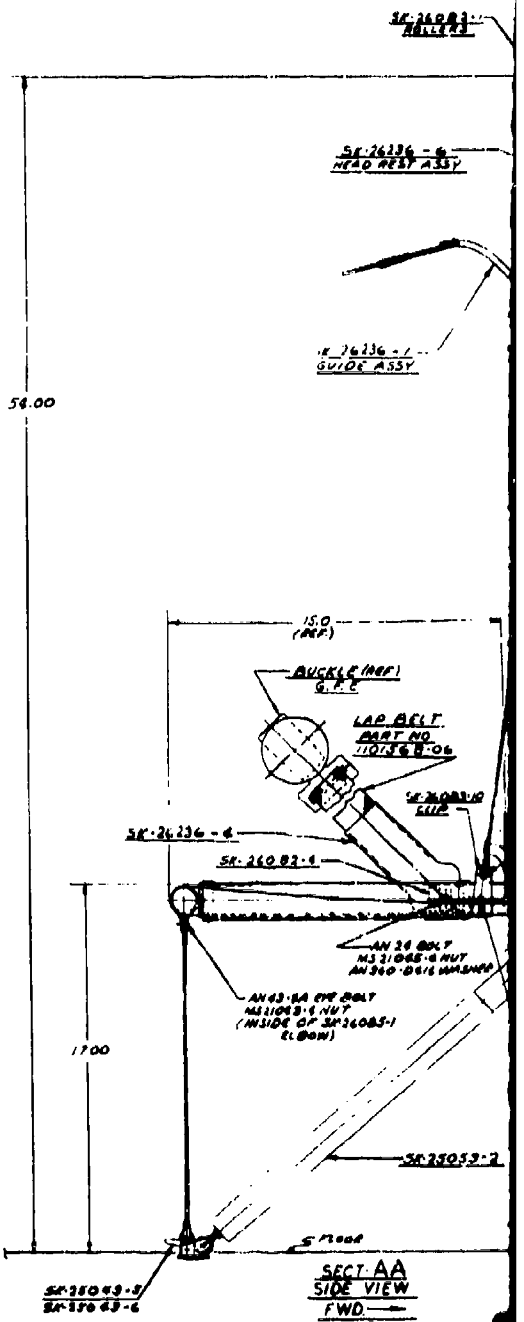
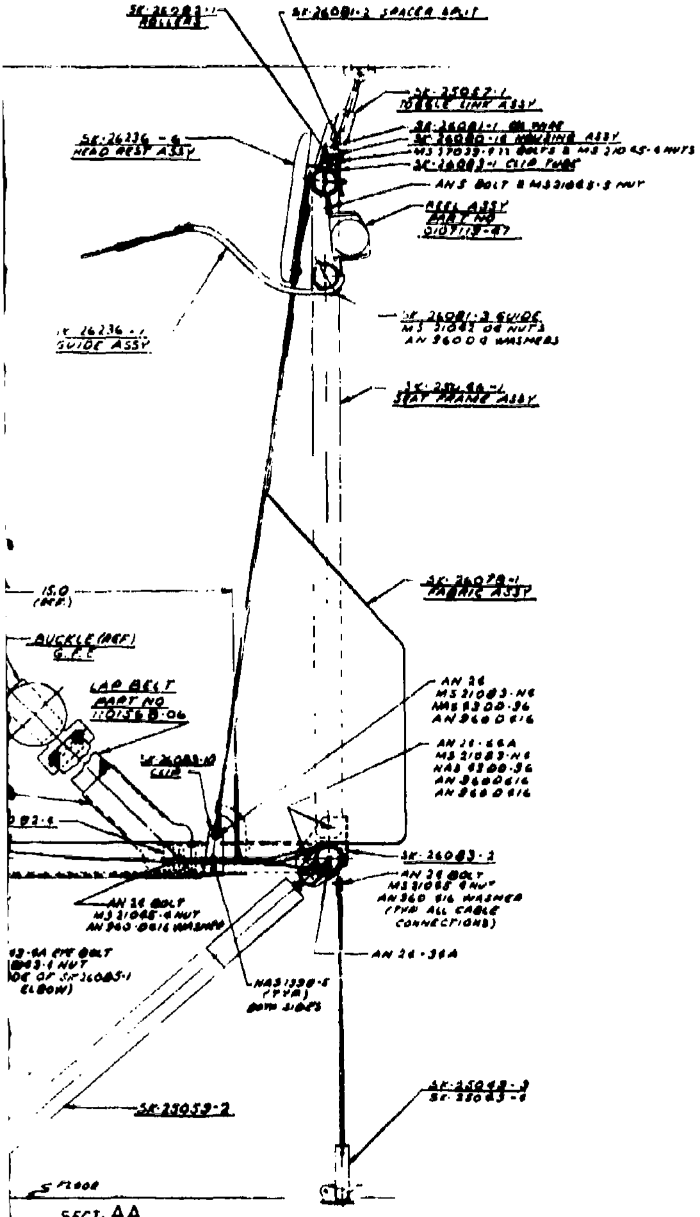


VIEW BB
PLAN VIEW



SECT AA
SIDE VIEW
FWD.
(TYP)



SECT AA
SIDE VIEW
FWD →
(TYP)

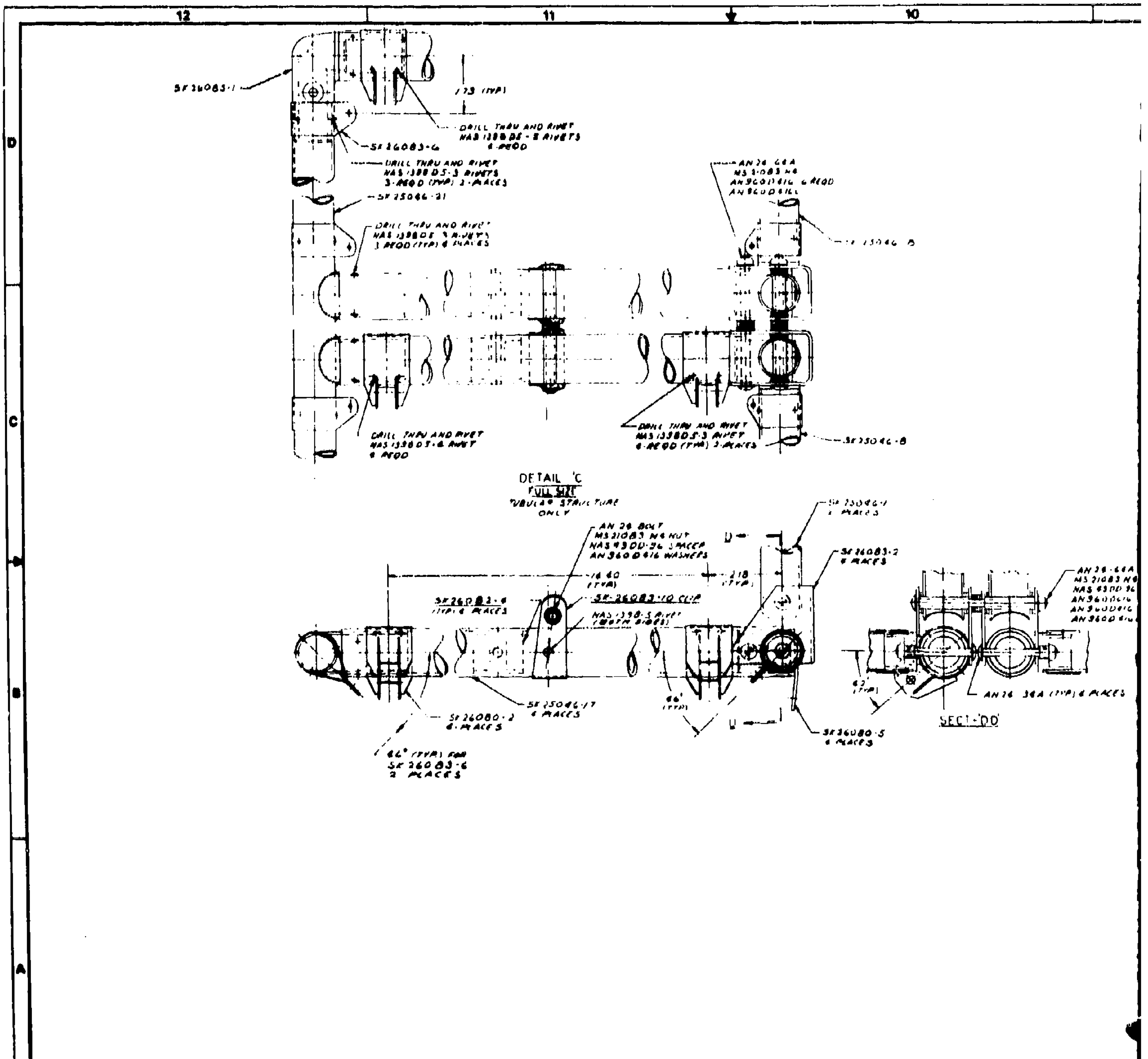
				2	4		SK-25049-6			
				2	4		SK-25049-5			
				1	2		SK-26239-1	HEEL BARRIER		
				2	4		0107119-47	REEL ASSY		PACIFIC SC OF CALIF
				1	2		1101568-06	LAP BELT ASSY		PACIFIC SCI OF CALI
				1	2		SK-26080-4	LUG ASSY		
				1	2		SK-26080-3	LUG ASSY		
				1	2		SK-25046-9	TUBE ASSY		
				2	4		SK-25059-2	ATTENUATOR ASSY		
				2	4		SK-26236-1	GUIDE ASSY		
				1	2		SK-26236-6	HEAD REST ASSY		
				2	4		SK-26236-4	BOOT		
				2	4		SK-26083-10	CLIP		
				2	4		SK-26081-3	GUIDE		
				2	4		SK-26081-2	SPACER-SPLIT		
				2	4		SK-26081-1	WIRE G/A		
				4	8		SK-26082-1	ROLLER		
				2	4		SK-26082-4	PLUG		
				2	4		SK-26083-7	STRIP		
				1	2		SK-26083-8	STRIP		
				2	4		SK-26083-2	HINGE FITTING		
				2	4		SK-26083-1	CLIP-TUBE		
				2	4		SK-25046-17	TUBE		
				1	4		SK-26080-18	HOUSING ASSY G/A		
				2	2		SK-26085-1	ELBOW		
					1		SK-25046-12	TUBE ASSY		
				2	2		SK-26083-6	CLIP-TUBE		
				1			SK-25046-10	TUBE		
				1	1		SK-25046-1	SEAT FRAME ASSY		
				2	4		SK 25049-4	QUICK DISCONNECT ASSY		
				2	4		SK 25049-3	QUICK DISCONNECT ASSY		
				2	4		SK-25060-3	CABLE ASSY		
				2	4		SK 25060-2	CABLE ASSY.		
				2	4		SK-25060-1	CABLE ASSY		
				2	4		SK 25057-1	TOGGLE LINK ASSY		
				1	2		SK-26078-1	FABRIC ASSY		
				☒			SK-26076-2	SEAT ASSY		
					☒		SK-26076-1	SEAT ASSY		
				-2	-1					

2	4	SK-25049-6		
2	4	SK-25049-5		
1	2	SK-26239-1	HEEL BARRIER	
2	4	0107113-47	REEL ASSY	PACIFIC SCIENTIFIC CO. [illegible]
1	2	1101568-06	LAP BELT ASSY	PACIFIC SCIENTIFIC CO. [illegible]
1	2	SK-26080-8	LUG ASSY	
1	2	SK-26090-3	LUG ASSY	
1	2	SK-25046-3	TUBE ASSY	
2	4	SK-25059-2	ATTENUATOR ASSY	
2	4	SK-26236-1	GUIDE ASSY	
1	2	SK-26236-6	HEAD REST ASSY	
2	4	SK-26236-9	BOOT	
2	4	SK-26083-10	CLIP	
2	4	SK-26081-3	GUIDE	
2	4	SK-26081-2	SPACER-STRIP	
2	4	SK-26081-1	WIRE 4/A	
4	8	SK-26082-1	ROLLER	
2	4	SK-26082-4	PLUG	
2	4	SK-26083-7	STRIP	
1	2	SK-26083-8	STRIP	
2	4	SK-26083-2	HINGE FITTING	
2	4	SK-26083-1	CLIP TUBE	
2	4	SK-25046-17	TUBE	
2	4	SK-26080-16	HOUSING ASSY S/A	
2	2	SK-26085-1	ELBOW	
	1	SK-25046-12	TUBE ASSY	
2	2	SK-26083-6	CLIP-TUBE	
1		SK-25046-10	TUBE	
1	2	SK-25046-1	SEAT FRAME ASSY	
2	4	SK-25049-4	QUICK DISCONNECT ASSY	
2	4	SK-25049-3	QUICK DISCONNECT ASSY	
2	4	SK-25060-3	CABLE ASSY	
2	4	SK-25060-2	CABLE ASSY	
2	4	SK-25060-1	CABLE ASSY	
2	4	SK-25057-1	TOGGLE LINK ASSY	
1	2	SK-26078-1	FABRIC ASSY	
☒		SK-26076-2	SEAT ASSY	
	☒	SK-26076-1	SEAT ASSY	
-2	-1			

CRASHWORTHY TROOP SEAT
TYPE I AND TYPE II
CLASS B

J

SK-26076



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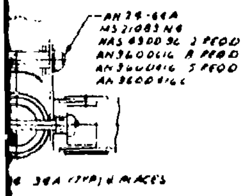
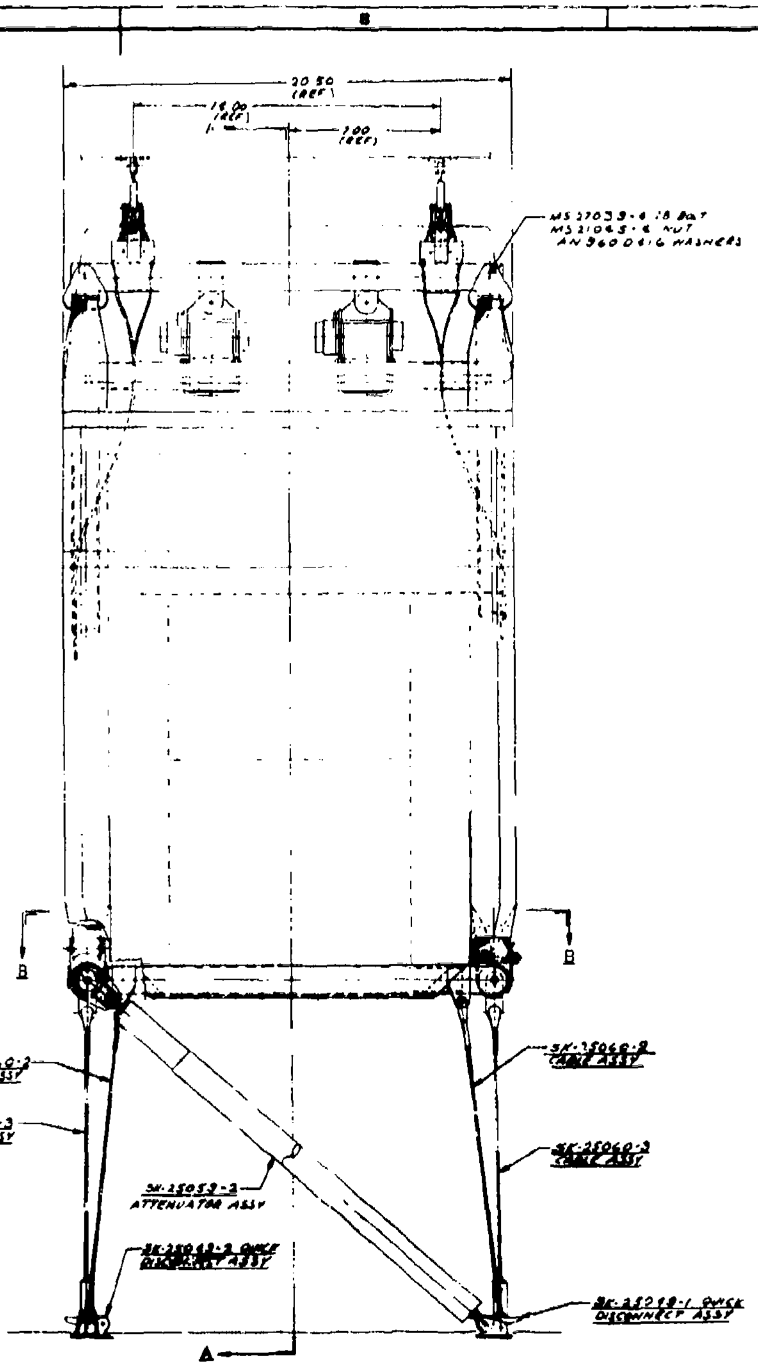
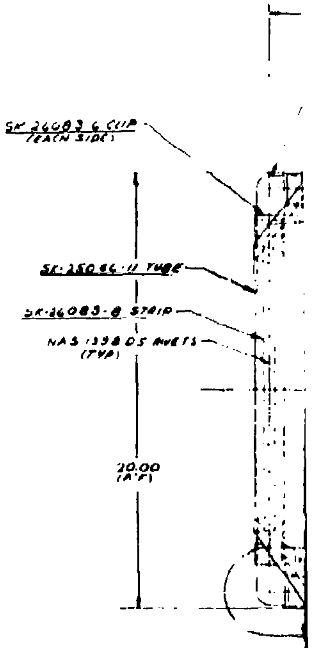
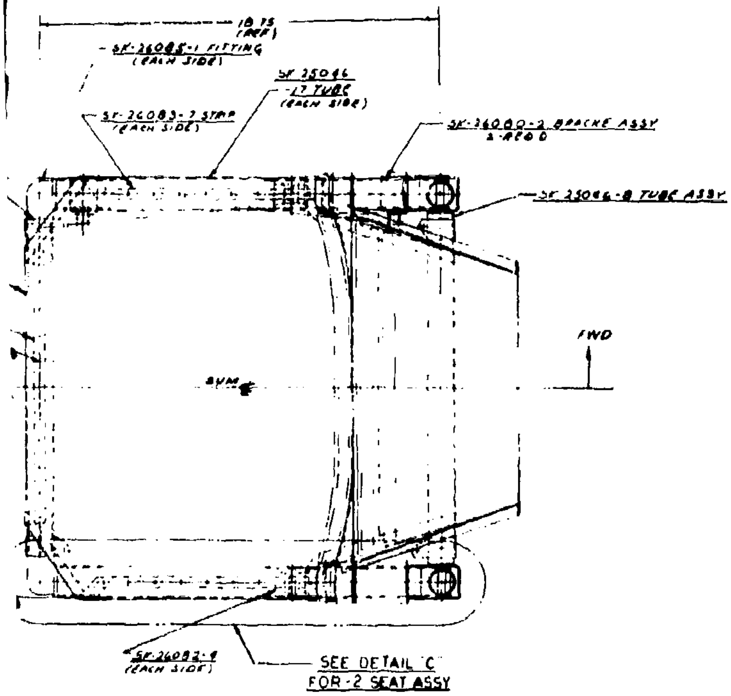


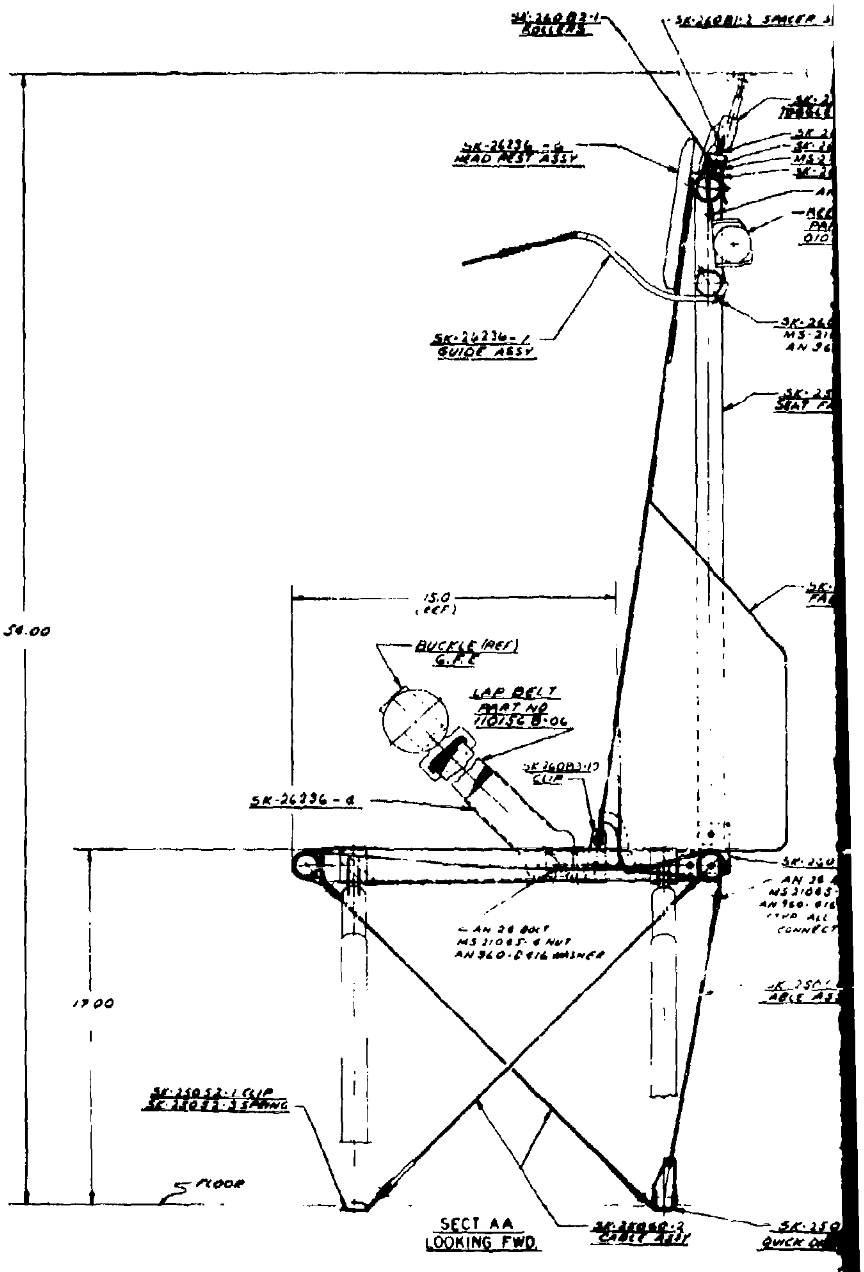


-1 SEAT ASSY
VIEW LOOKING INBD
← FWD

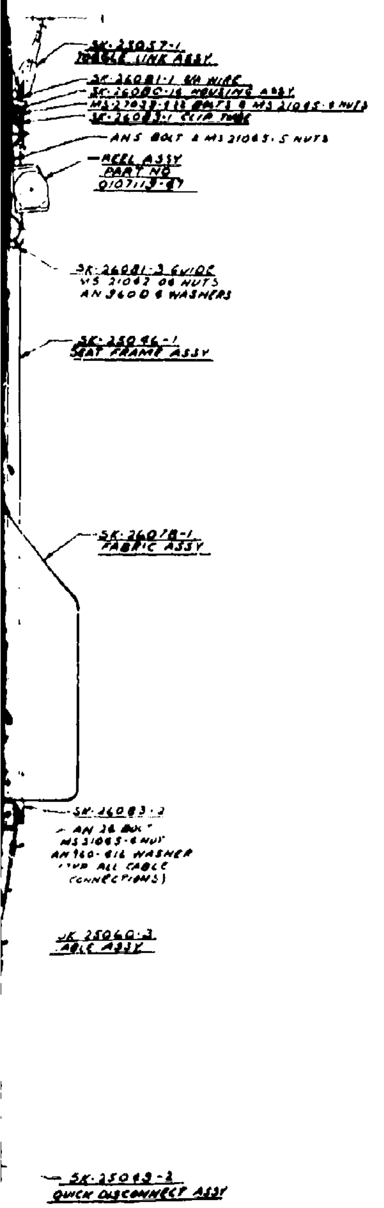




VIEW BB
PLAN VIEW
ROTATED 90°



SECT AA
LOOKING FWD

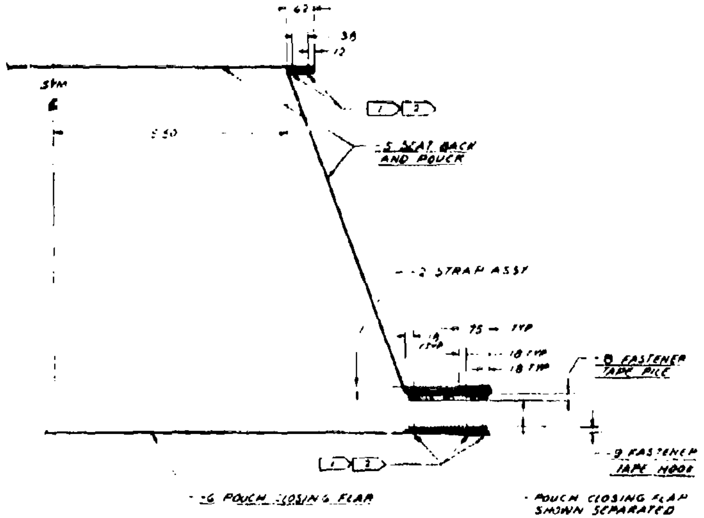


2 -2 SEAT ASSY. IS SAME AS -1 SEAT ASSY. EXCEPT TWO SEATS ARE JOINED TOGETHER AS SHOWN IN DETAIL "C"

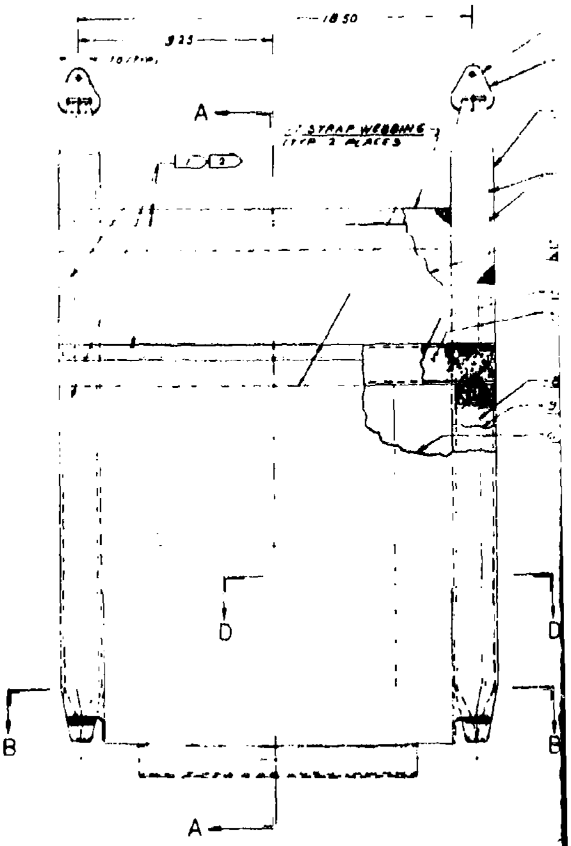
4	2	SK-25059-2	ATTENUATOR ASSY	
4	2	0107119-47	REEL ASSY	PACIFIC SCIENTIFIC CO OR EQUIV
2	1	1101568-06	LAP BELT ASSY	PACIFIC SCIENTIFIC CO OR EQUIV
4	2	SK-26236-1	GUIDE ASSY	
2	1	SK-26236-6	HEAD REST ASSY.	
4	2	SK-26236-4	BOOT	
4	2	SK-26083-10	CLIP	
4	2	SK 26081-3	GUIDE	
4	2	SK 26081-2	SPACER SPLIT	
4	2	SK-26081-1	WIRE - S/A	
8	4	SK-26082-1	ROLLER	
4	2	SK-26082-4	PLUG	
4	2	SK-26083-7	STRIP	
2	1	SK-26083-8	STRIP	
4	2	SK-26083-2	HINGE FITTING	
4	2	SK 26083-1	CLIP - TUBE	
4	2	SK-25046-17	TUBE	
4	2	SK-26080-18	HOUSING ASSY S/A	
4	2	SK-26080-5	LUG ASSY	
4	2	SK-26080-2	BRACKET ASSY	
2	2	SK-26085-1	ELBOW	
1		SK-25046-21	TUBE ASSY	
2	2	SK-26083-6	CLIP - TUBE	
	1	SK25046-11	TUBE	
2	1	SK-25046-8	TUBE ASSY	
2	1	SK 25046-1	SEAT FRAME ASSY.	
4	2	SK 25052-3	SPRING	
4	2	SK-25052-1	CLIP	
4	2	SK-25049-2	QUICK DISCONNECT ASSY.	
2	1	SK-25049-1	QUICK DISCONNECT ASSY	
4	2	SK-25060-3	CABLE ASSY	
8	4	SK-25060-2	CABLE ASSY	
4	2	SK-25057-1	TOGGLE LINK ASSY	
2	1	SK-26078-1	FABRIC ASSY	
☒		SK-26077-2	SEAT ASSY	2
	☒	SK-26077-1	SEAT ASSY	
-2	-1			

CRASHWORTHY TROOP SEAT
TYPE I AND TYPE II
CLASS C

J 77272 SK-26077



SECT DD
FULL SIZE



FRONT VIEW

SK-26078

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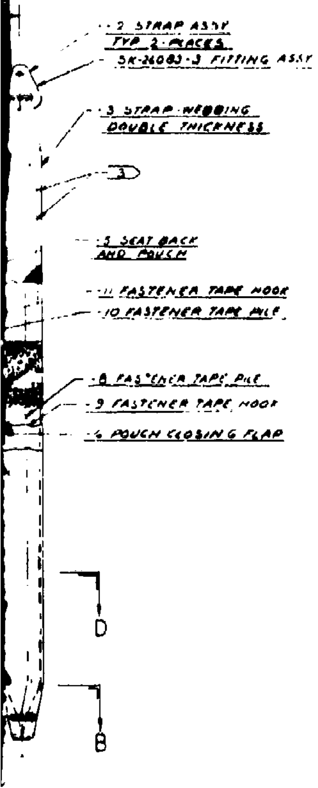
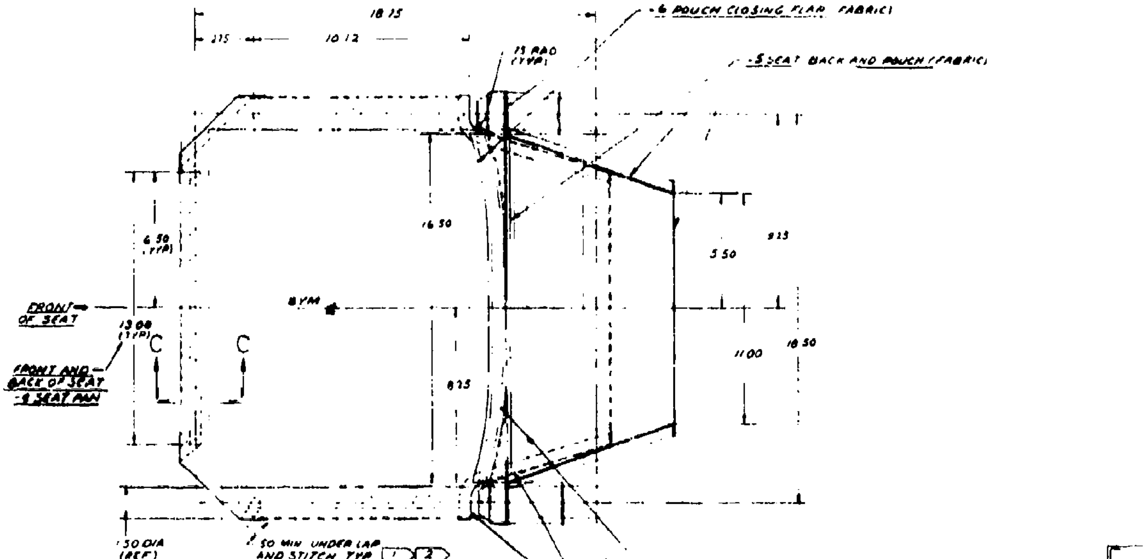
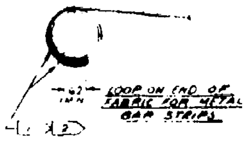
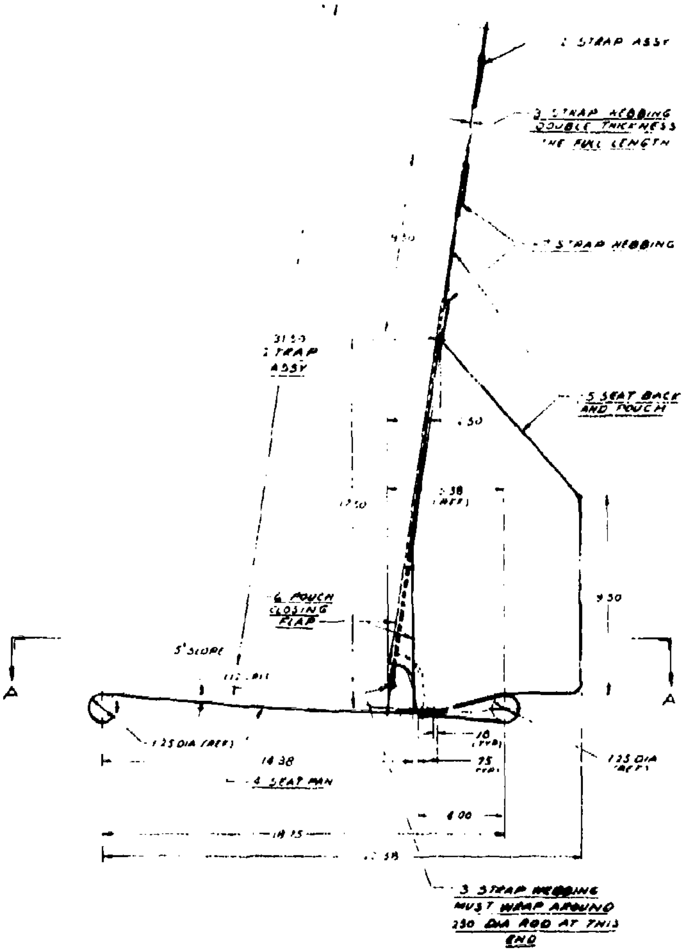




VIEW BB
PLAN VIEW
ROTATED 90°



SECT CC
TYP FOR FRONT
AND SIDES OF
-4 SEAT PAN
SCALE FULL SIZE



SECT 'AA'

NOTES

1. ALL SEWING TO BE IN ACCORDANCE WITH FEDERAL STD 751A
2. ALL SEWING THREAD SHALL BE PER FEDERAL SPEC VT 295A
3. 4½ TO 5 STITCHES PER INCH MIL-T 7807B NO 6 NYLON CORD (TYPE I OR II CLASS I SOLAS) OR EQUIVALENT

SK 26078

APPLICATION

WING TO BE IN ACCORDANCE WITH
RAL STD 751A
WING THREAD SHALL BE PER
AL SPEC V T 295A
5 STITCHES PER INCH MIL-T-7807B
NYLON CORD (TYPE I OR II CLASS 1
1) OR EQUIVALENT

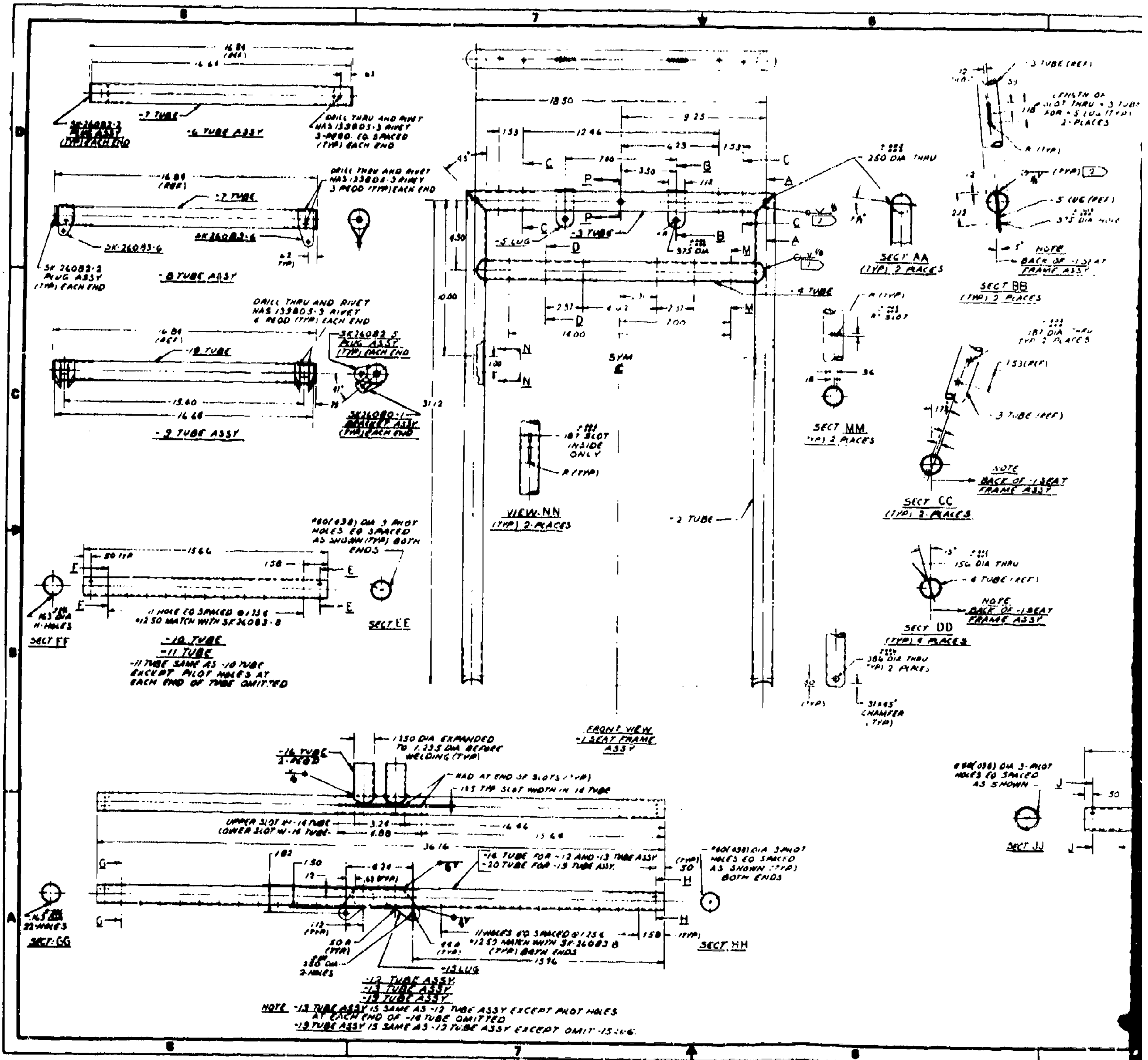
1			SK-26083-3	FITTING ASSY	
	1		-11	FASTENER TAPE HOOK	1.00 WIDE x 3.75 LG MIL-F-21840 TYPE II [illegible] COLOR SLATE GREY
	1		-10	FASTENER TAPE PILE	[illegible] COLOR SLATE GREY
	2		-9	FASTENER TAPE HOOK	[illegible] COLOR SLATE GREY
	2		-8	FASTENER TAPE PILE	[illegible] COLOR SLATE GREY
	2		-7	STRAP WEBBING	[illegible] POLYESTER WEBBING
	1		-6	POUCH CLOSING FLAP	[illegible] FABRIC MIL-C-7219 TYPE III COLOR LIGHT GREY
	1		-5	SEAT BACK AND POUCH	[illegible] FABRIC MIL-C-7219 TYPE III COLOR LIGHT GREY
	1		-4	SEAT PAN	[illegible] COLOR LIGHT GREY
1			-3	STRAP WEBBING	[illegible] POLYESTER WEBBING
☒	2		-2	STRAP ASSY.	
	☒		-1	ASSEMBLY	
	-2	-1			

APPLICATION	
-1	[illegible]
-1	[illegible]
-1	[illegible]

PHILADELPHIA, PENNSYLVANIA

CRASHWORTHY TROOP
SEAT
FABRIC ASSY & DETAIL

J 77272 SK 26078



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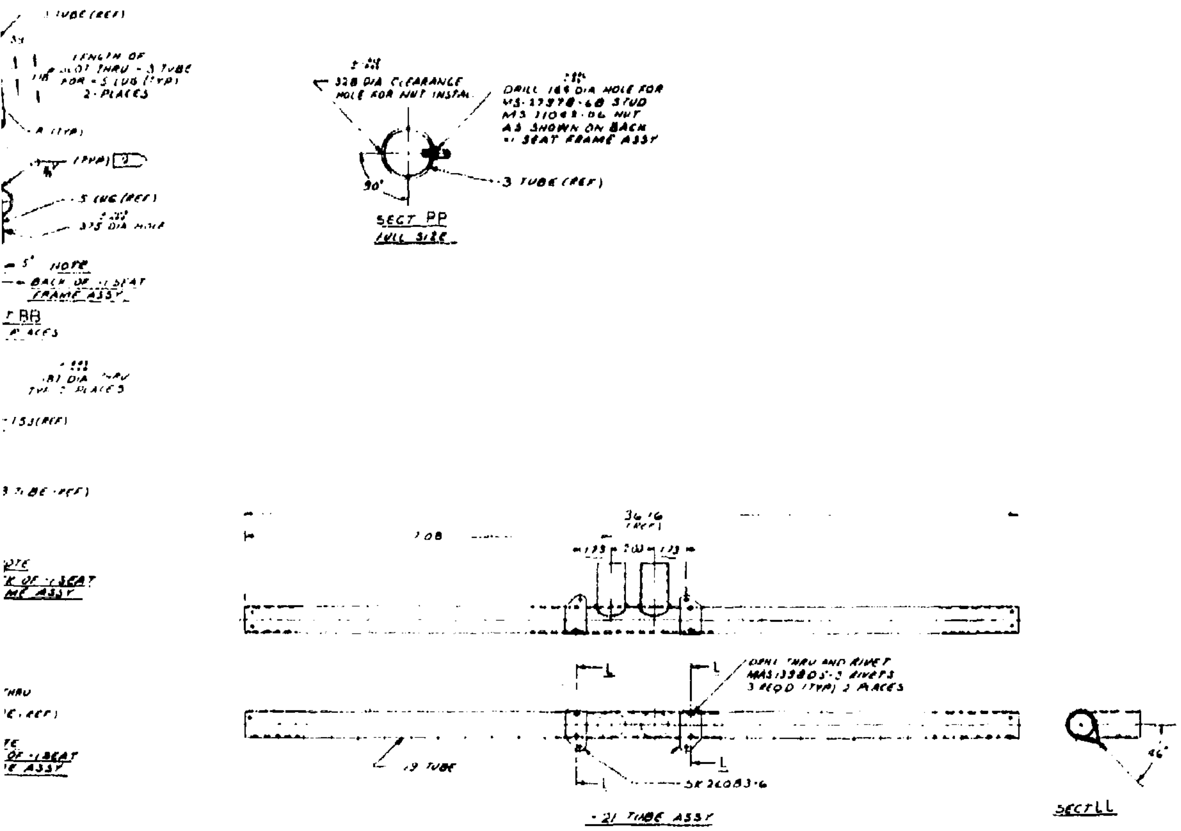
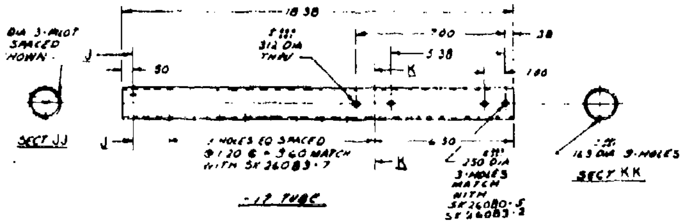




-21	SK26077-2				
-17	[illegible]				
-13	[illegible]				
-12	[illegible]				
-11	[illegible]				
-10	[illegible]				
-9	[illegible]				
-8	[illegible]				
-6	[illegible]				
-1	[illegible]				

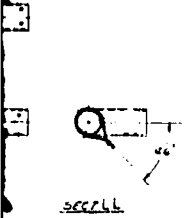
APPLICATION

NOTES

1 [illegible]

2 WELD PER MIL W-8604 WITH 4043 AL FILLER WIRE

3 BREAK ALL SHARP EDGES AND CORNERS



SECT L-L

-21	-19	-13	-12	-9	-8	-6	-1				
							1	MS-21042-06	NUT		
							1	MS-27378-68	STUD		
				2				SK26080-1	BRACKET ASSY		
					2	2		SK26082-2	PLUG ASSY		
				2				SK26082-5	PLUG ASSY		
2					1			SK26083-6	CLIP TUBE		
					1			SK26083-9	CLIP TUBE		
6				8	6	6		NAS-1398D5-3	RIVET BLIND		
☒								SK25046-21	TUBE ASSY		
	1							-20	TUBE	[illegible] AL ALY TUBING 6061-T6 WW-T-700/6	
1	☒							-19	TUBE ASSY	2	42
				1				-18	TUBE	[illegible] AL ALY TUBING 2024-T3 WW-T-700/3	
								-17	TUBE	[illegible] AL ALY TUBING 2024-T3 WW-T-700/3	
	2	2	2					-16	TUBE	[illegible] AL ALY TUBING 6061-T6 WW-T-700/6	
		1	1					-15	LUG	[illegible] 6061-T6 AL ALY SHEET QQ-A-250/11	
		1	1					-14	TUBE	[illegible] AL ALY TUBING 6061-T6 WW-T-700/6	
		☒						-13	TUBE ASSY	2	42
			☒					-12	TUBE ASSY	2	42
								-11	TUBE	[illegible] AL ALY TUBING 2024-T3 WW-T-700/3	
								-10	TUBE	[illegible] AL ALY TUBING 2024-T3 WW-T-700/3	
				☒				-9	TUBE ASSY		
					☒			-8	TUBE ASSY		
					1	1		-7	TUBE	[illegible] AL ALY TUBING 2024-T3 WW-T-700/3	
						☒		-6	TUBE ASSY		
							2	-5	LUG	[illegible] 6061-T6 AL ALY SHEET QQ-A-250/11	
							1	-4	TUBE	[illegible] AL ALY TUBING 6061-T6 WW-T-700/6	
							1	-3	TUBE	[illegible] AL ALY TUBING 6061-T6 WW-T-700/6	
							2	-2	TUBE	[illegible] AL ALY TUBING 6061-T6 WW-T-700/6	
							☒	SK25046-1	SEAT FRAME ASSY	2	42

-21	[illegible]		
-19	[illegible]		
-13	[illegible]		
-12	[illegible]		
-11	[illegible]		
-10	[illegible]		
-9	[illegible]		
-8	[illegible]		
-6	[illegible]		
-1	[illegible]		

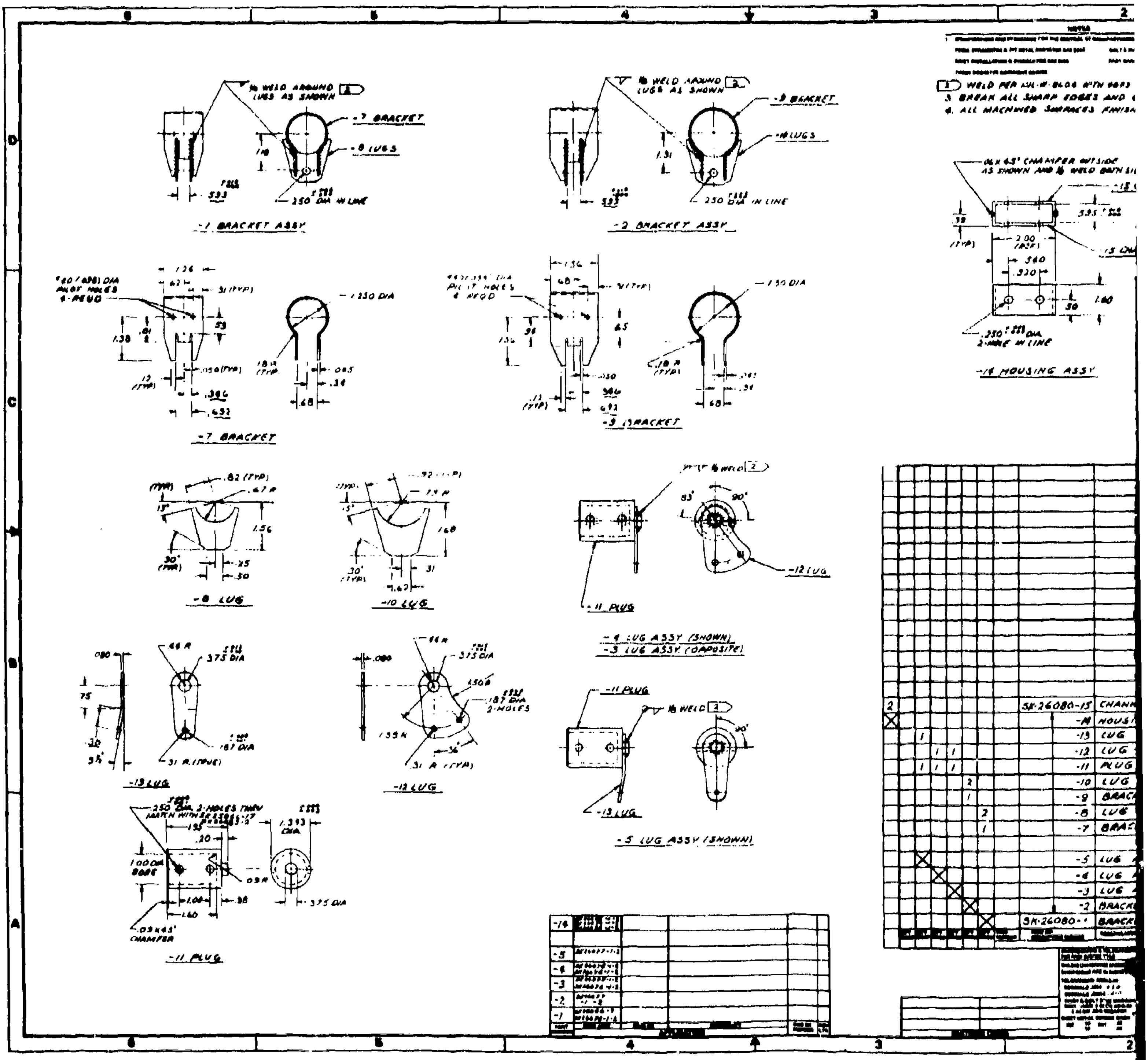
J A

M J REILLY

DETAILS
CRASHWORTHY
TROOP SEAT

J

SK-250 46



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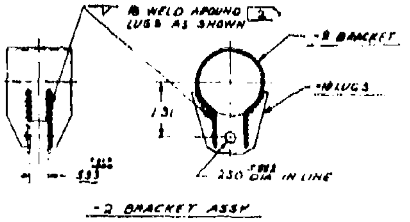
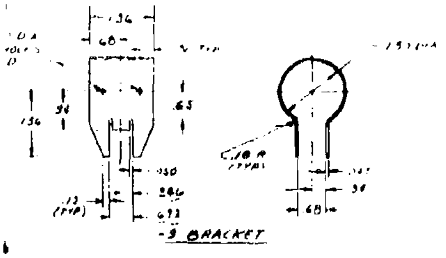
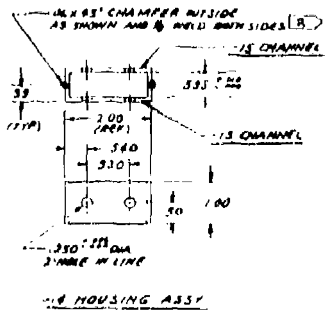
3 WELD PER MIL-W-8604 WITH 4043 ALUM FILLER WIRE
5. BREAK ALL SHARP EDGES AND CORNERS
4. ALL MACHINED SURFACES FINISH 125



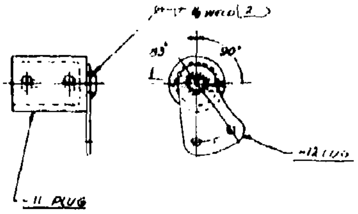
-2 BRACKET ASSY



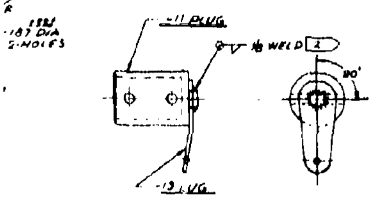
-9 BRACKET



-14 HOUSING ASSY



-4 LUG ASSY (SHOWN)
-3 LUG ASSY (OPPOSITE)



-5 LUG ASSY (SHOWN)

2								SK-26080-15	CHANNEL	MAKE FROM [illegible] [illegible] QQ-A-[illegible]	
☒								-14	HOUSING ASSY		
		1						-13	LUG	.380 X 1.00 X 2.31 16 6061-T6 AL ALY. SHEET QQ-A-[illegible]	
			1	1				-12	LUG	.090 X 1.88 X 2.30 16 6061-T6 AL ALY SHEET QQ-A-[illegible]	
		1	1	1				-11	PLUG	[illegible] 6061-T6 AL ALY BAR QQ-A-225/8	
					2			-10	LUG	[illegible] 6061-T6 AL ALY SHEET QQ-A-[illegible]	
					1			-9	BRACKET	[illegible] 6061-T6 AL ALY SHEET QQ-A-[illegible]	
						2		8	LUG	[illegible] 6061-T6 AL ALY SHEET QQ-A-[illegible]	
						1		-7	BRACKET	[illegible] 6061-T6 AL ALY SHEET QQ-A-[illegible]	
		☒						-5	LUG ASSY.		42
			☒					-4	LUG ASSY.		42
				☒				-3	LUG ASSY		42
					☒			-2	BRACKET ASSY.		42
						☒		SK-26080-1	BRACKET ASSY.		42

PARTS LIST

-14	[illegible]
-5	AF16077-1-2
-4	[illegible]
-3	[illegible]
-2	AF16077 -1 -2
-1	[illegible]

APPLICATION

D. [illegible]
J R
H. J. [illegible]

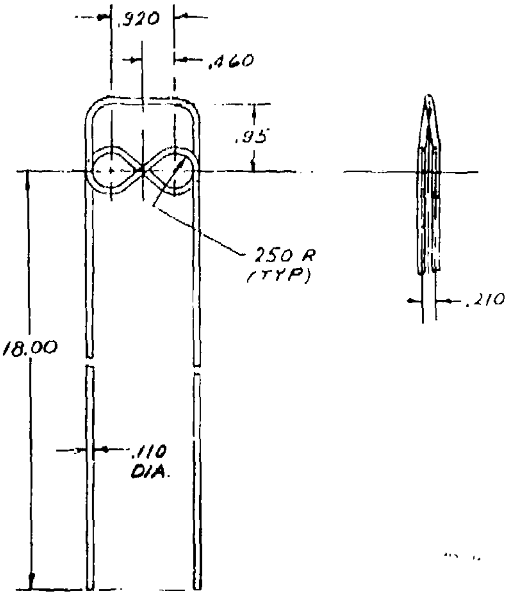
DETAILS
CRASHWORTHY
TROOP SEAT

J SK-26080

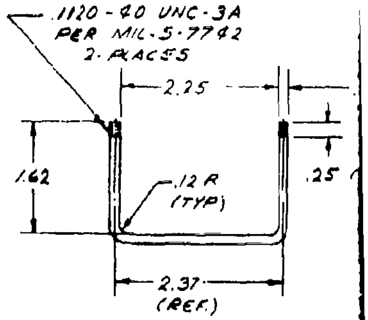
NOTES

1. [illegible]

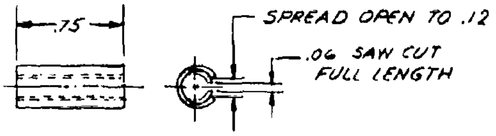
2. BREAK ALL SHARP



-1 WIRE E/A



-3 GUIDE



-2 SPACER-SPLIT

MAKE FROM .250 O.D TUBING

SCALE 2/1

QTY REQD	QTY REQD	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	
			SK-26081-3	G
			SK26081-2	S
			SK26081-1	W

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY	REV LTR
-3	SK26075-1-2 SK26076-1-2 SK26077-1-2			
-2	SK26075-1-2 SK26075-1-2 SK26077-1-2			
-1	SK26075-1-2 SK26076-1-2 SK26077-1-2			
	APPLICATION			

FASTENER CODES

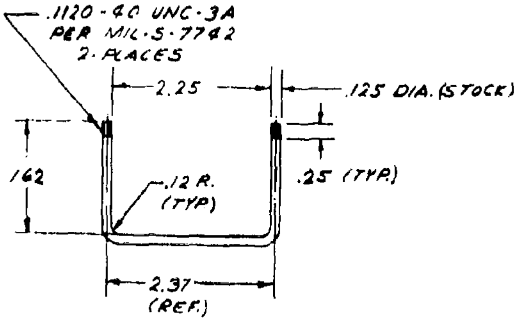
[illegible]

NOTES

1. SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS AS APPLICABLE: [illegible] PART MARKING FOR BAC [illegible] BOLT & NUT INSTALLATION FOR BAC [illegible] RIVET INSTALLATION & SYMBOLS FOR BAC [illegible]

2. BREAK ALL SHARP EDGES AND CORNERS.

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



-3 GUIDE

			SK-26081-3	GUIDE	.125 DIA. X 5.50 LG 4130 STL. ROD MIL-S-6758	150				
			SK-26081-2	SPACER-SPLIT	.250 O.D. X .049 WALL X .80 LG 5052-0 AL ALY. TUBING WW-T-700/4	35				
			SK-26081-1	WIRE - E/A	.110 DIA. X 46.0 LG MUSIC WIRE SPRING STL. QQ-W-470	NONE				
QTY REQD	QTY REQD	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION		FINISH		CALC / ACT UNIT WT	REV LTR

PARTS LIST

BOEING VERTOL COMPANY
A DIVISION OF THE BOEING COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

DRAWN	D. D'AMICO	4/6/73
CHK	J.R	
ENGR	M. J REILLY	4/10/74

DETAILS
CRASHWORTHY
TROOP SEAT

SIZE	CODE IDENT NO.	
D	77272	SK-26081

SCALE FULL-SIZE

SH 1 OF 1

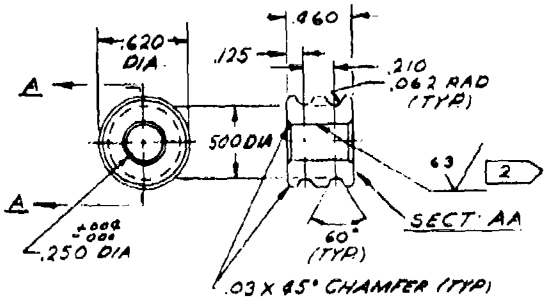
FASTENER CODES

NOTES

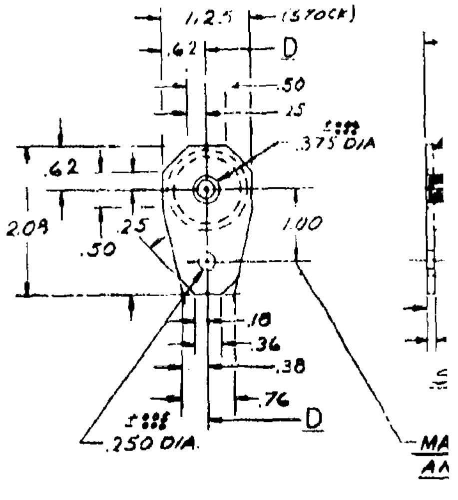
[illegible]

2. ALL MACHINED SU

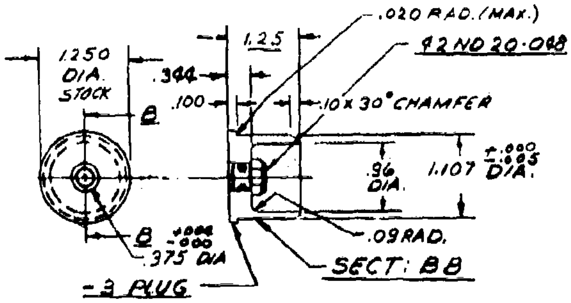
3. BREAK ALL SH:RP



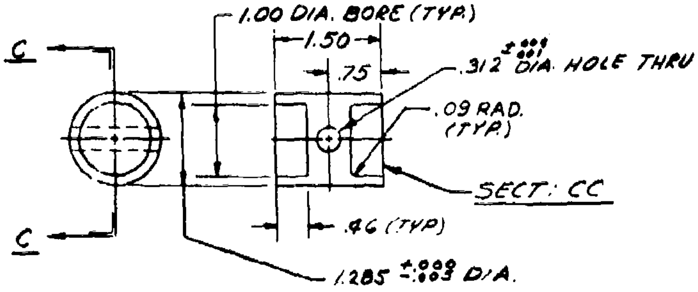
-1 ROLLER
SCALE 2/1



-5 PLUG ASSY



-2 PLUG ASSY



-4 PLUG

1	1		42ND20-048	NU
1			SK-26082-6	PL
X			SK-26082-5	PL
			SK-26082-4	PL
	1		SK-26082-3	PL
	X		SK-26082-2	PL
			SK-26082-1	RO
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

TOLERANCES ANGLES ±
.010
.010

-5	SK25066-9			
-4	[illegible]			
-2	SK25066-6 SK25066-8			
-1	[illegible]			
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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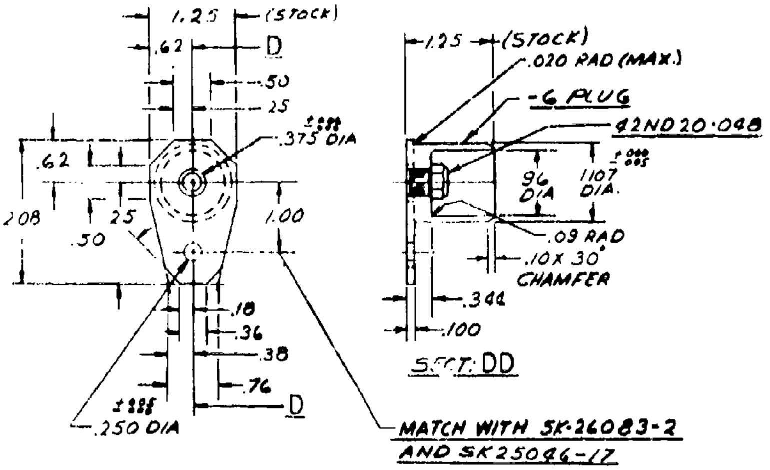
NOTES

1. [illegible]

2. ALL MACHINED SURFACES FINISH 125 √ EXCEPT AS NOTED

3. BREAK ALL SHARP EDGES AND CORNERS.



-5 PLUG ASSY.

THRU

1	1		42ND20-048	NUT-SPLINE	ELASTIC STOP NUT CORP. UNION, NEW JERSEY.						
1			SK-26082-6	PLUG	1.25 X 1.25 X 2.18 LG 2024-T4 AL. ALY. SQ. BAR QQ-A-225/6						
X			SK-26082-5	PLUG ASSY.							
			SK-26082-4	PLUG	1.375 DIA. X 1.625 LG 2024-T4 AL. ALY. RD. BAR QQ-A-225/6						
	1		SK-26082-3	PLUG	1.250 DIA. X 1.125 LG. 2024-T4 AL. ALY. RD. BAR QQ-A-225/6						
	X		SK-26082-2	PLUG ASSY.							
			SK26082-1	ROLLER	.625 DIA. X .60 LG. 4130 STL. RD. BAR MIL-S-6758	150					
QTY REQD	QTY REQD	[illegible]	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

PARTS LIST

TOLERANCES: DECIMALS .030, .010

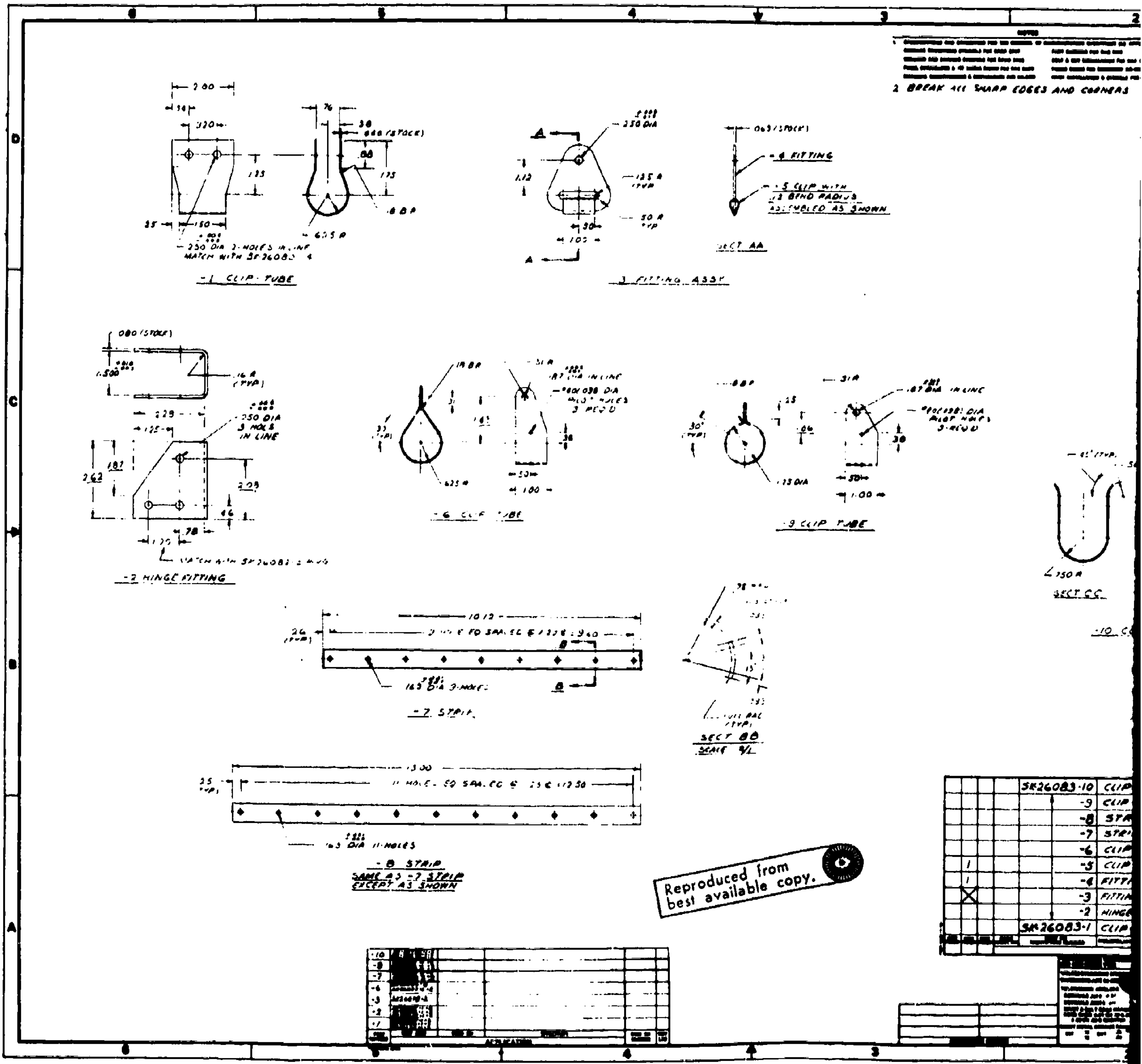
	D.O'AMICO	4/4/73
	J R	
	M. J. REILLY	4/10/73

BOEING VERTOL COMPANY
PHILADELPHIA, PENNSYLVANIA 19142

DETAILS
CRASHWORTHY
TROOP SEAT

D 77272 SK-26082

SCALE FULL



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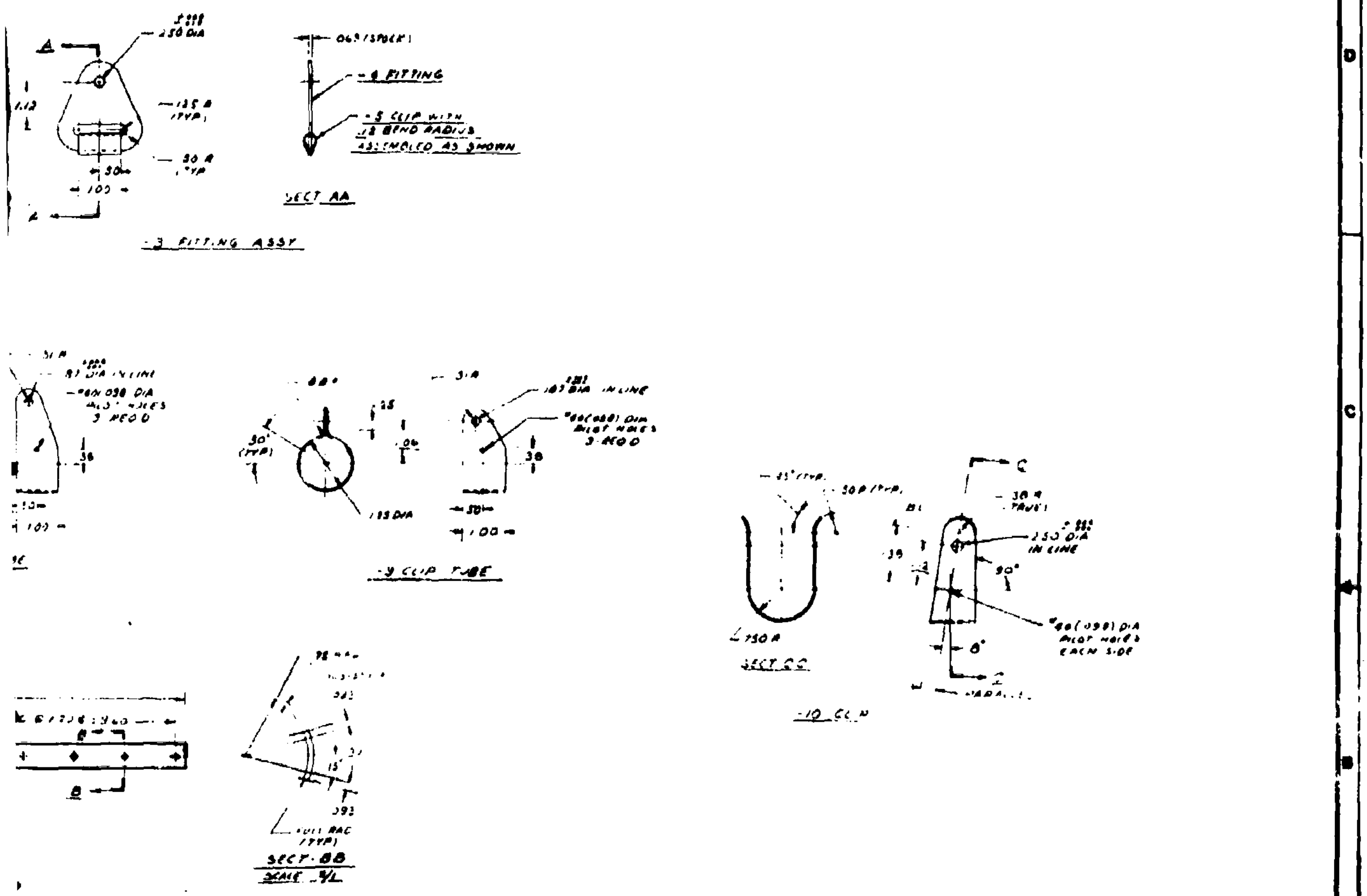
NOTES

1. [illegible]

2. BREAK ALL SHARP EDGES AND CORNERS



	SK26083-10	CLIP	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	59
	-9	CLIP-TUBE	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	59
	-8	STRIP	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	53
	-7	STRIP	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	59
	-6	CLIP-TUBE	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	53
1	-5	CLIP	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	59
1	-4	FITTING	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	59
X	-3	FITTING ASSY.			
	-2	HINGE FITTING	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	59
	SK26083-1	CLIP-TUBE	[illegible] AL ALY SHEET	[illegible] QQ-A-[illegible]	53

DETAILS
CRASHWORTHY
TROOP SEAT

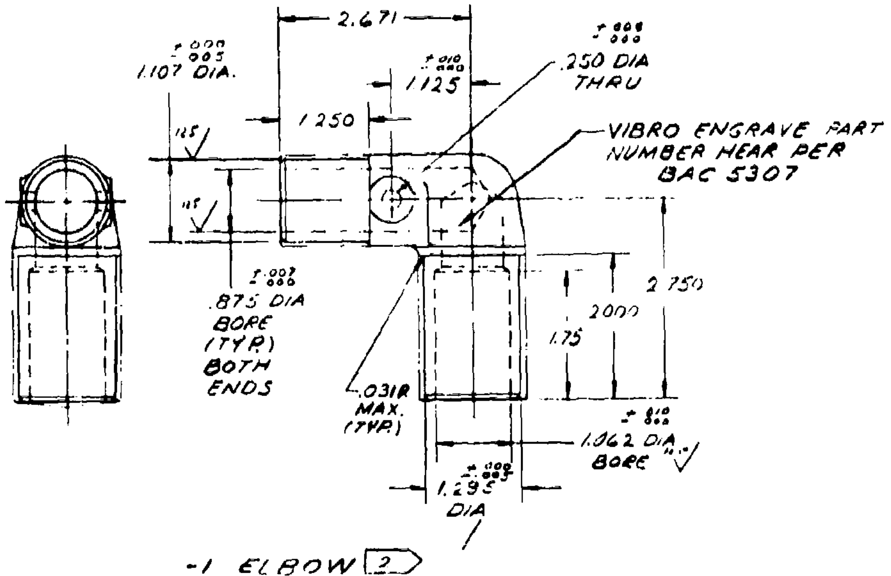
J 77272 SK26083

NOTES

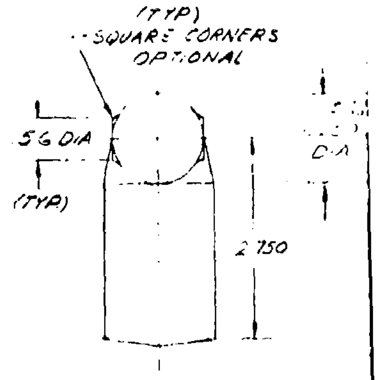
1 [illegible]

2 ALL MACHINED S

3 AS FORGED SUR
EQUIVALENT



-1 ELBOW 2



-2 DIE

			-2	
			SK-26085-1	

-/	SK26075 -/ -2			
-/	SK26076 -/ -2			
-/	SK26077 -/ -2			

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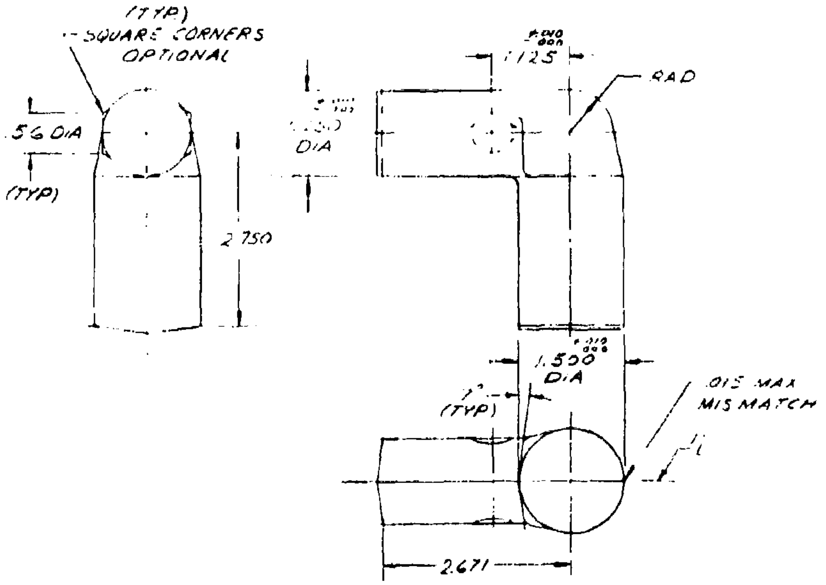
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NOTES

1 SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):
SURFACE ROUGHNESS SYMBOLS PER BACD [illegible] — PART MARKING PER BAC [illegible]
WELDING AND BRAZING SYMBOLS PER BACD [illegible] — BOLT & NUT INSTALLATION PER BAC [illegible]
FORM STRAIGHTEN & FIT METAL PARTS PER BAC [illegible] — FINISH CODES FOR DOCUMENT [illegible]
MATERIAL SUBSTITUTIONS & EQUIVALENTS PER [illegible] — RIVET INSTALLATION & SYMBOLS PER BAC [illegible]

2 ALL MACHINED SURFACES FINISH 125√

3 AS FORGED SURFACES 250√ USUALL EQUIVALENT TO.



-2 DIE FORGING 3

QTY REQD	QTY REQD	CODE IDENT NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION	WT	FINISH				REV LTR
			-2	ELBOW DIE FORGING	AL ALY 2014-T6 FORGING QQ-A-367 COMP 2014 TEMP T6	65					
			SK-26085-1	ELBOW	MAKE FROM -2						

PARTS LIST

DIMENSIONING & TOLERANCING PER ANSI Y14.5
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
DECIMALS .XX ± [illegible]
DECIMALS .XXX ± [illegible]
[illegible]

FASTENER CODES

DATA REVIEW

CONTRACT NUMBER

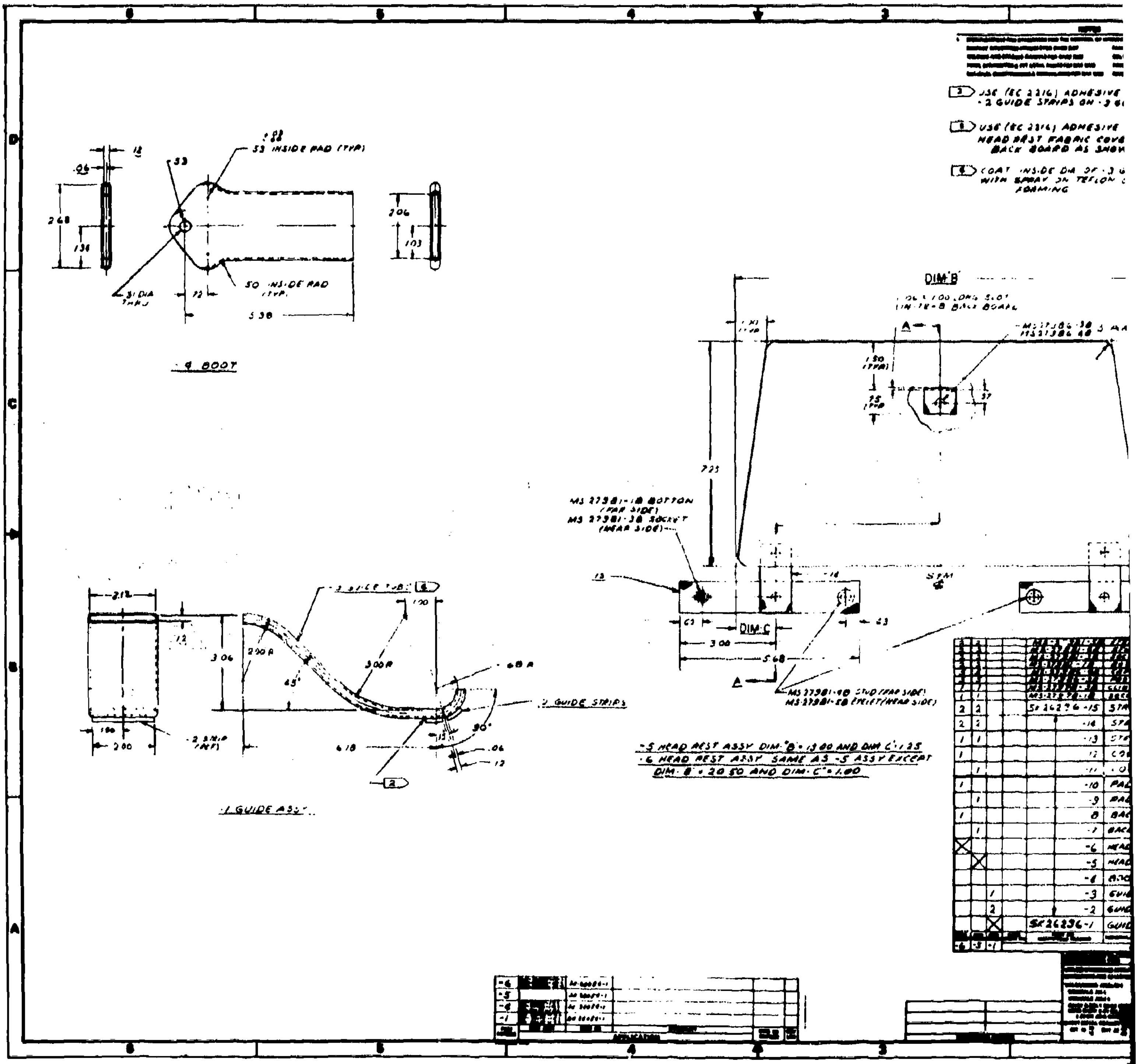
DR	D DAMICO	11/4/73
CHK	J R	
ENGR	J REILLY	4/10/74

PROJECT APPROVAL

BOEING VERTOL COMPANY
PHILADELPHIA PENNSYLVANIA 19142

ELBOW DETAIL
CRASHWORTHY
TROOP SEAT

D 77272 SK-26085



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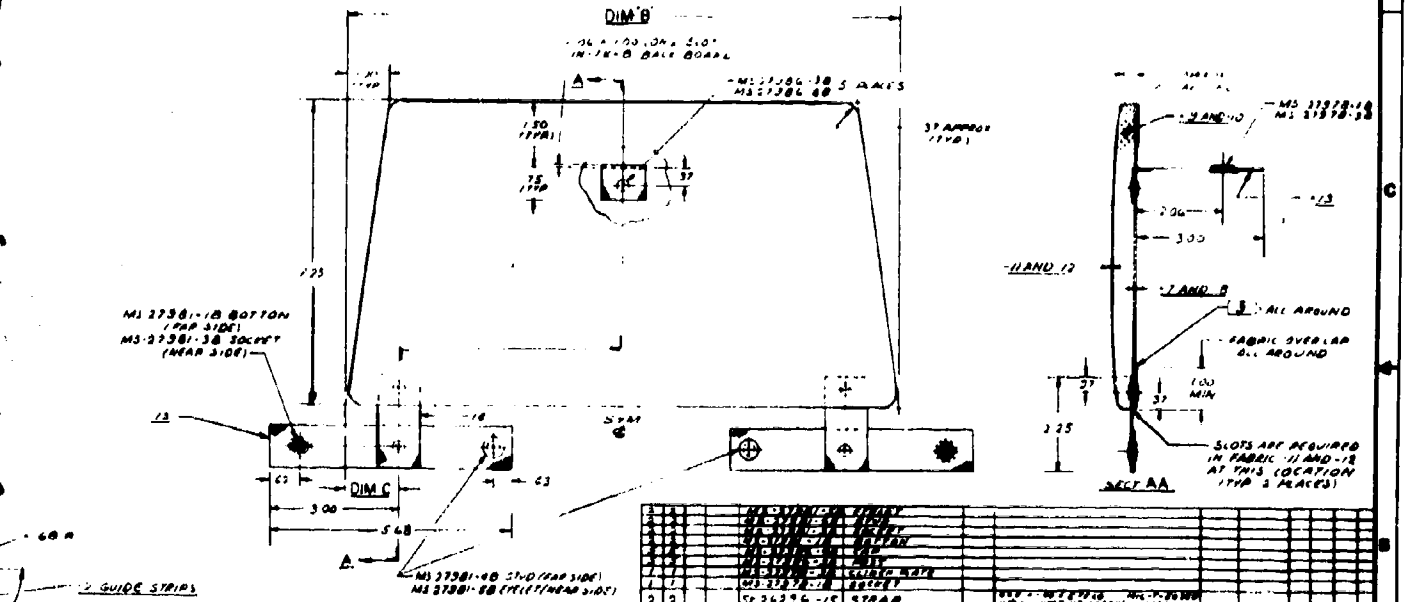
2 USE (EC 2216) ADHESIVE TO BOND -2 GUIDE STRIPS ON -3 GUIDE TUBE

3 USE (EC 2216) ADHESIVE TO BOND HEAD REST FABRIC COVER TO BACK BOARD AS SHOWN

4 COAT INSIDE DIA OF -3 GUIDE TUBE WITH SPRAY ON TEFLON BEFORE FORMING



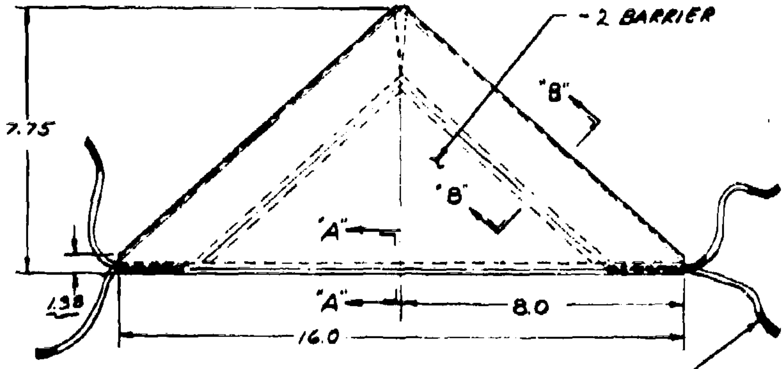
-5 HEAD REST ASSY DIM 'B' = 13.80 AND DIM 'C' = 1.25
-6 HEAD REST ASSY SAME AS -5 ASSY EXCEPT DIM 'B' = 20.50 AND DIM 'C' = 1.60

-6	-5	-1			
[illegible]	[illegible]		MS 27981-[illegible]	[illegible]	
[illegible]	[illegible]		MS 27981-[illegible]	[illegible]	
[illegible]	[illegible]		MS 27981-[illegible]	EYELET	
[illegible]	[illegible]		MS 27981-[illegible]	BUTTON	
[illegible]	[illegible]		MS 27981-[illegible]	CAP	
[illegible]	[illegible]		MS 27981-[illegible]	POST	
1	1		MS 27978-[illegible]	CLINCH PLATE	
1	1		MS 27978-18	SOCKET	
2	2		SK 26236-15	STRAP	[illegible] MIL-T-[illegible] NYLON WEBBING (GREY) TYPE [illegible]
2	2		-14	STRAP	[illegible] MIL-T-[illegible] NYLON WEBBING (GREY) TYPE [illegible]
1	1		-13	STRAP	[illegible] MIL-T-[illegible] NYLON WEBBING (GREY) TYPE [illegible]
1			-12	COVER	[illegible] FABRIC MIL-C-[illegible] TYPE [illegible] COLOR LIGHT GREY
	1		-11	COVER	[illegible] FABRIC MIL-C-[illegible] TYPE [illegible] COLOR LIGHT GREY
1			-10	PADDING	[illegible] ENSOLITE FOAM
	1		-9	PADDING	[illegible] ENSOLITE FOAM
1			-8	BACK BOARD	[illegible]
	1		-7	BACK BOARD	[illegible]
X			-6	HEAD REST ASSY	
	X		-5	HEAD REST ASSY	
			-4	BOOT	[illegible]
		1	-3	GUIDE TUBE	[illegible]
		2	-2	GUIDE STRIP	[illegible]
		X	SK 26236-1	GUIDE ASSY	

DETAILS
CRASHWORTHY
TROOP SEAT

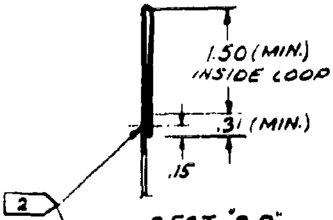
J
SK 26236

2 SEWING PER FEDE
THREAD PER FEDE
4 ½ TO 5 STITCHES
NO. 6 NYLON COR
50 LBS) OR

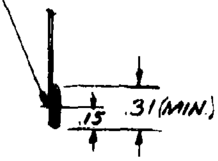


-1 HEEL BARRIER

-3 TIE DOWN CORDS APPROX 5.0 LONG. TWO ON EACH END AS SHOWN



SECT "BB"
SCALE FULL



SECT "AA"
SCALE 3/1

	4		SK-26239 -3	CO
	1		SK-26239 -2	BA
	☒		SK-26239-1	HE
	-1			

-1	SK-26075-102			
-1	SK-26076-102			

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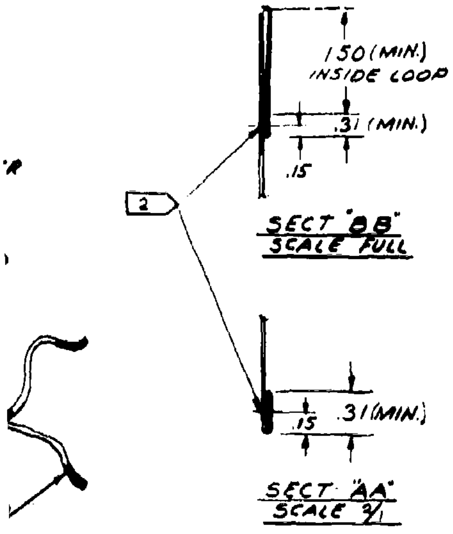
NOTES

1 [illegible]

2 SEWING PER FEDERAL STD. 751A
THREAD PER FEDERAL SPEC V-T-295A
4 1/2 TO 5 STITCHES PER INCH MIL-T-7807B
NO. 6 NYLON CORD (TYPE I OR II CLASS 1
50 LBS) OR EQUIVALENT.



SECT "BB"
SCALE FULL

SECT "AA"
SCALE 2/1

3 TIE DOWN
CORDS APPROX
5.0 LONG. TWO
ON EACH END
AS SHOWN

	QTY REQD		PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION
	4		SK-26239 -3	CORD	250 WIDE X 6.00 LG COTTON TAPE CLASS I SPEC DDD-T-86
	1		SK-26239 -2	BARRIER	12.00 X 18.00 LG FABRIC MIL-C-7219 TYPE III COLOR LIGHT GREY
	☒		SK-26239-1	HEEL BARRIER ASSY	
	-1				

PARTS LIST

DR	D D'AMICO	4/11/78
CHK	JR	
ENGR	J REILLY	4/11/78

BOEING VERTOL COMPANY
PHILADELPHIA PENNSYLVANIA 19142

DETAIL
HEEL BARRIER
CRASHWORTHY TROOP SEAT

D 77272 SK-26239

SCALE NONE

TYPE I AND TYPE II, CLASSES A AND B TESTWORTHY/MOCKUP SEATS

These drawings are for single and double seats (Type I and Type II) and show configurations for forward-facing and aft-facing seats. These seat design drawings are modifications of the previous seat drawings. Modifications of the idealized configurations were required to adapt the seat for installation in the Boeing UTTAS aircraft mockup.

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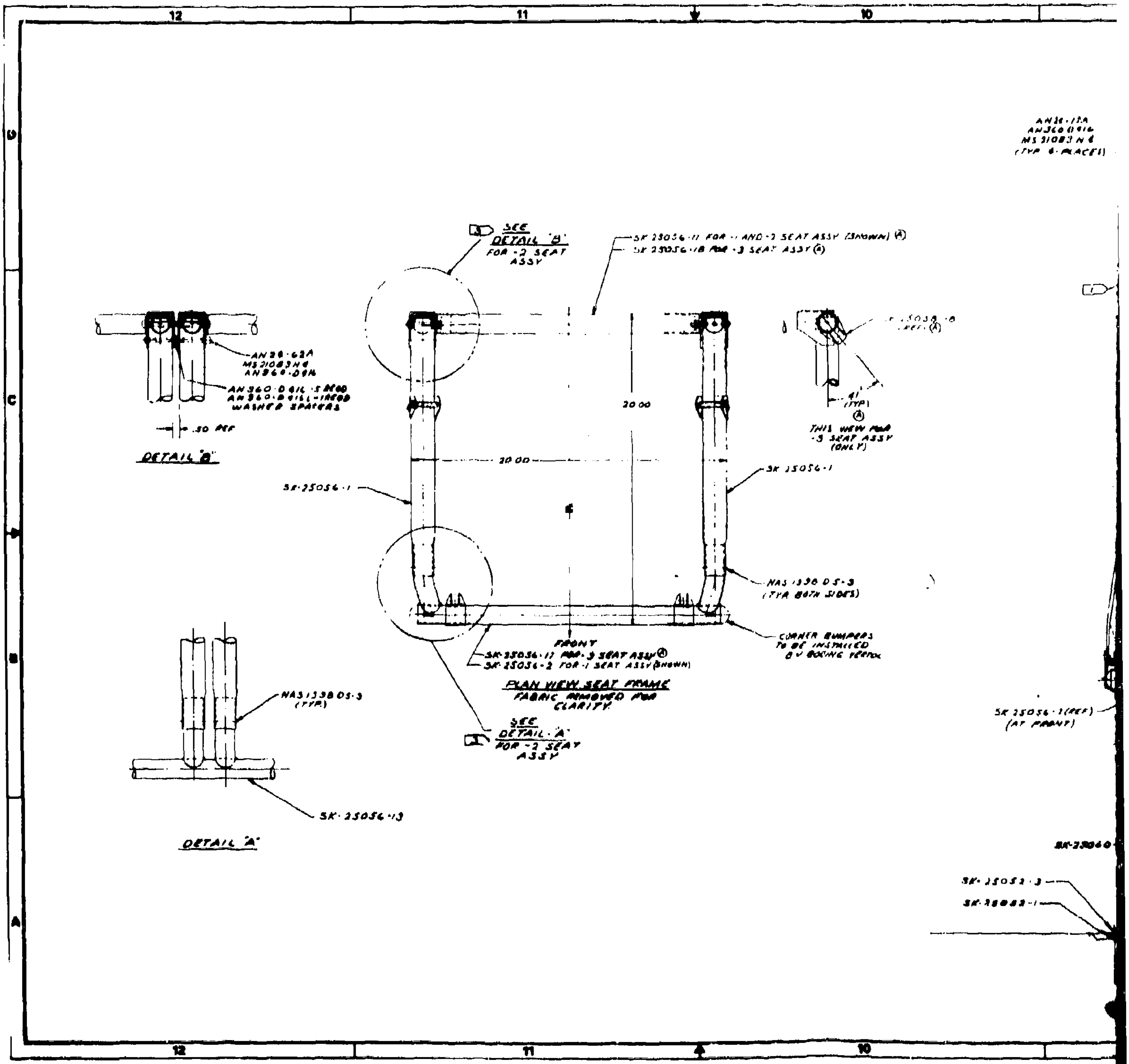

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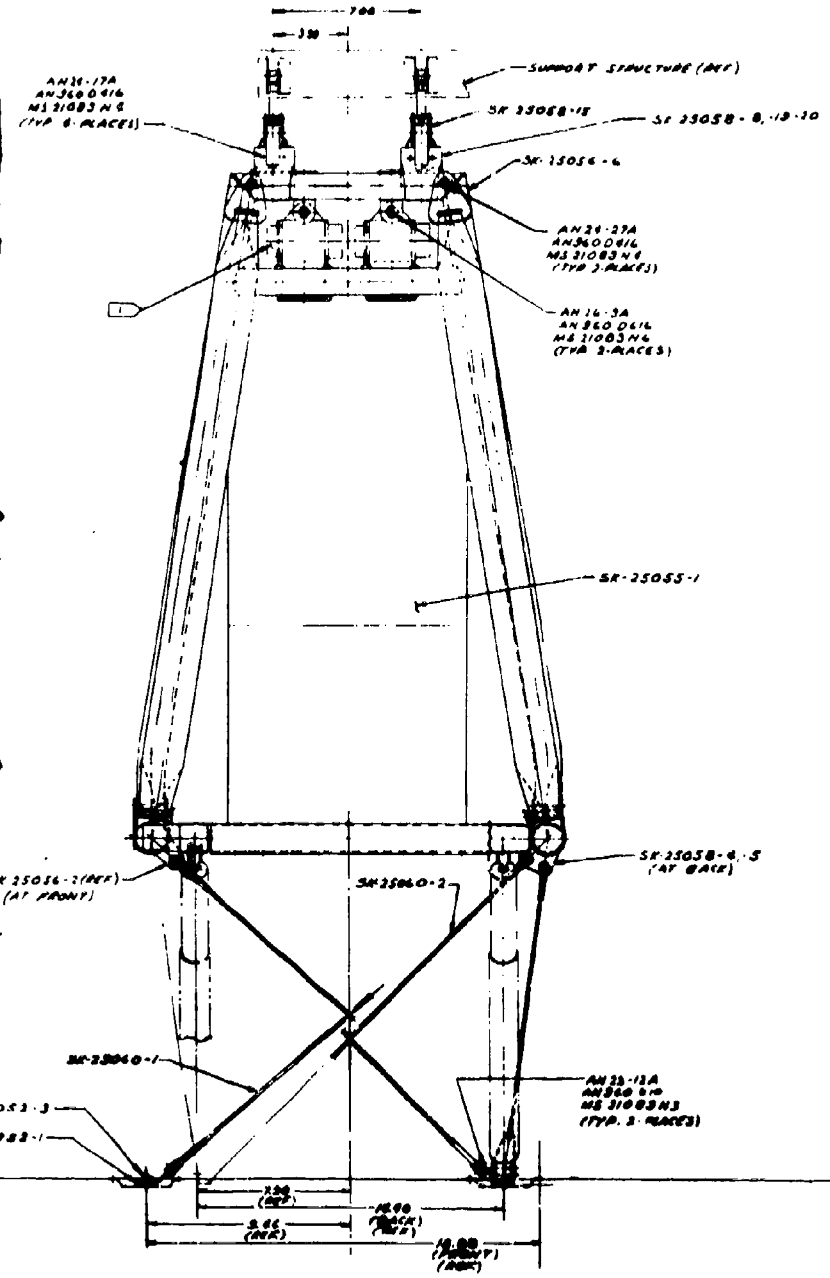
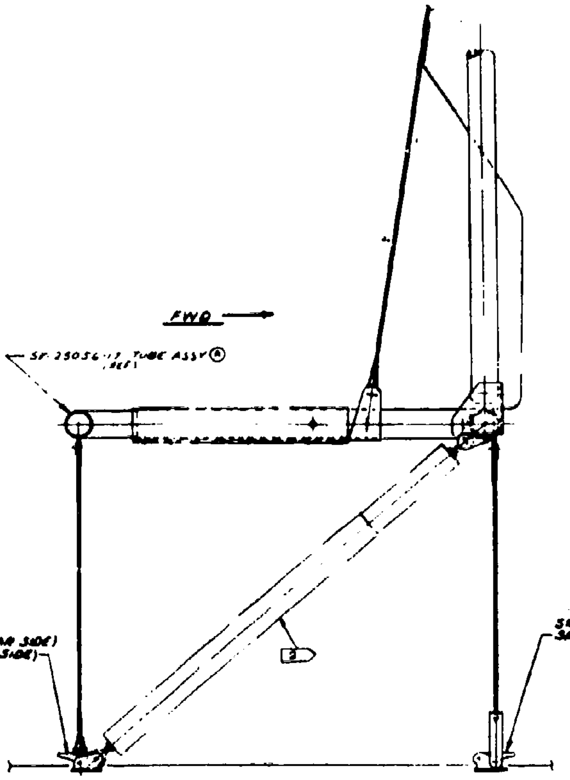
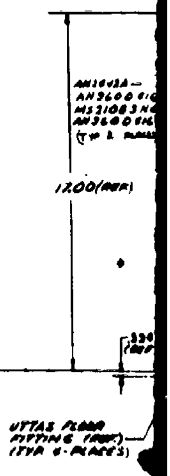
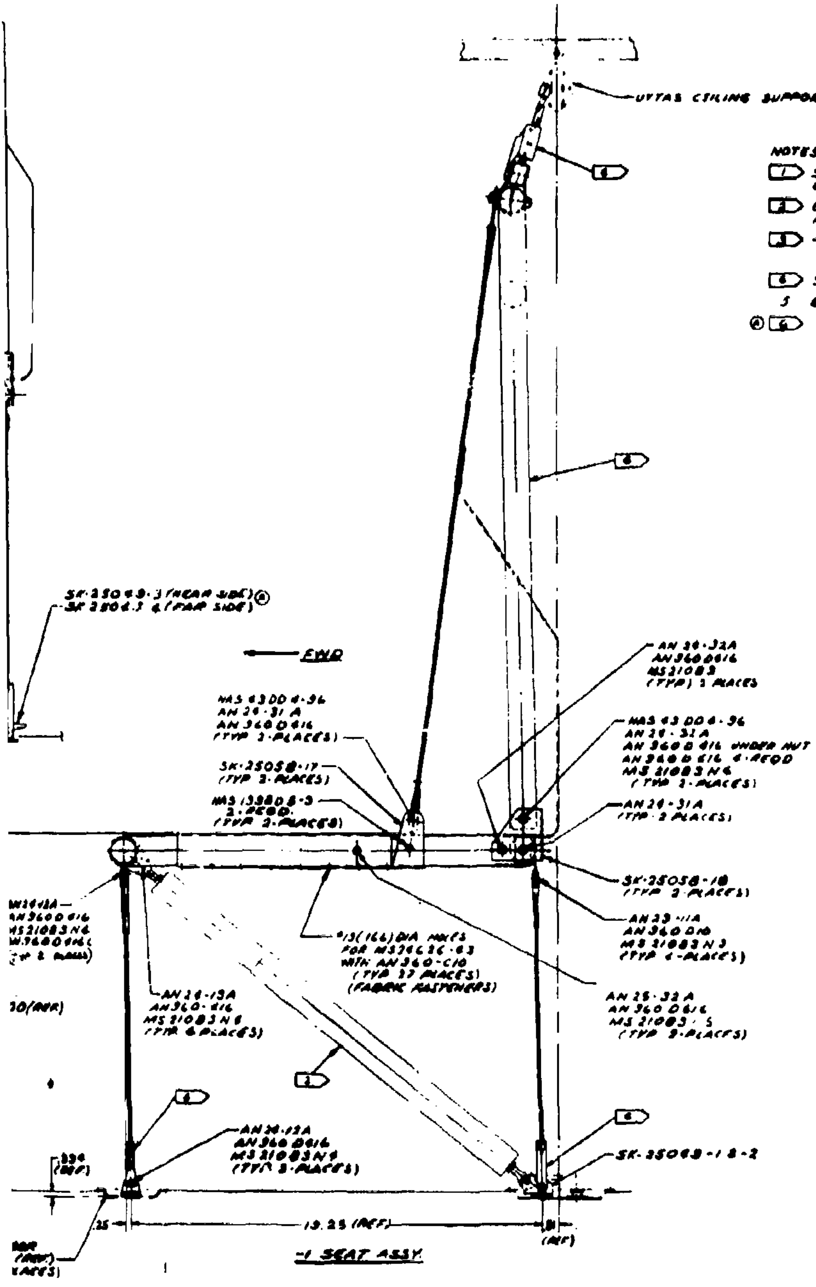

7.00
3.50
SUPPORT STRUCTURE (REF)
AN24-17A
AN960D416
MS21083N4
(TYP 6 PLACES)
SK 25058-15
SK 25058-8,-13-10
SK-25056-6
AN24-27A
AN960D416
MS21083N4
(TYP 2 PLACES)
1
AN24-3A
AN960D416
MS21083N4
(TYP 2 PLACES)
SK-25055-1
K 25056-2(REF)
(AT FRONT)
SK25060-2
SK-25058-4,-5
(AT BACK)
SK-25060-1
053-3
082-1
AN23-12A
AN960 610
MS 21083N3
(TYP. 2 PLACES)
3.90
(REF)
5.66
(REF)
12.00
(BACK)
(REF)
18.00
(FRONT)
(REF)


FWD
SK-25056-17 TUBE ASSY ⑧
(REF)
⑧ SK 25043-6 (NEAR SIDE)
SK 25043-5 (FAR SIDE)
2
SK
SK

③ -3 SEAT ASSY


AN24-12A
AN960 616
MS21083N4
AN960 616
(TYP 2 PLACES)
12.00(REF)
.330
(REF)
UTTAS FLOOR
FITTING (REF)
(TYP 6 PLACES)



-1 SEAT ASSY

NOTES

1. SHOULDER HARNESS REELS AND LAP BELT UNDER SEPARATE PURCHASE ORDER AND TO BE INSTALLED BY BOEING VERTOL.
2. ENERGY ATTENUATOR STRUTS UNDER SEPARATE PURCHASE ORDER AND TO BE INSTALLED BY BOEING VERTOL
3. -2 SEAT ASSY SAME AS -1 SEAT ASSY EXCEPT TWO SEATS ARE JOINED TOGETHER AS SHOWN IN DETAIL A & B
4. SEAT ASSY TO BE SPRAY PAINTED LIGHT GREY (DULL) BEFORE INSTALLING FABRIC.
5. BOEING VERTOL APPROVAL REQUIRED FOR ANY MATERIAL SUBSTITUTIONS
Ⓐ 6. -3 SEAT ASSY SAME AS -1 SEAT ASSY EXCEPT ENERGY ATTENUATORS STRUTS ARE ATTACHED TO BACK OF SEAT INSTEAD OF THE FRONT

TEST

REELS AND LAP BELT UNDER SEPARATE PURCHASE
STALLED BY BOEING VERTOL.

STRUTS UNDER SEPARATE PURCHASE ORDER
D BY BOEING VERTOL

E AS -1 SEAT ASSY EXCEPT TWO SEATS
THER AS SHOWN IN DETAIL A & B

AY PAINTED LIGHT GREY (DULL) BEFORE INSTALLING FABRIC.

OVAL REQUIRED FOR ANY MATERIAL SUBSITUTIONS

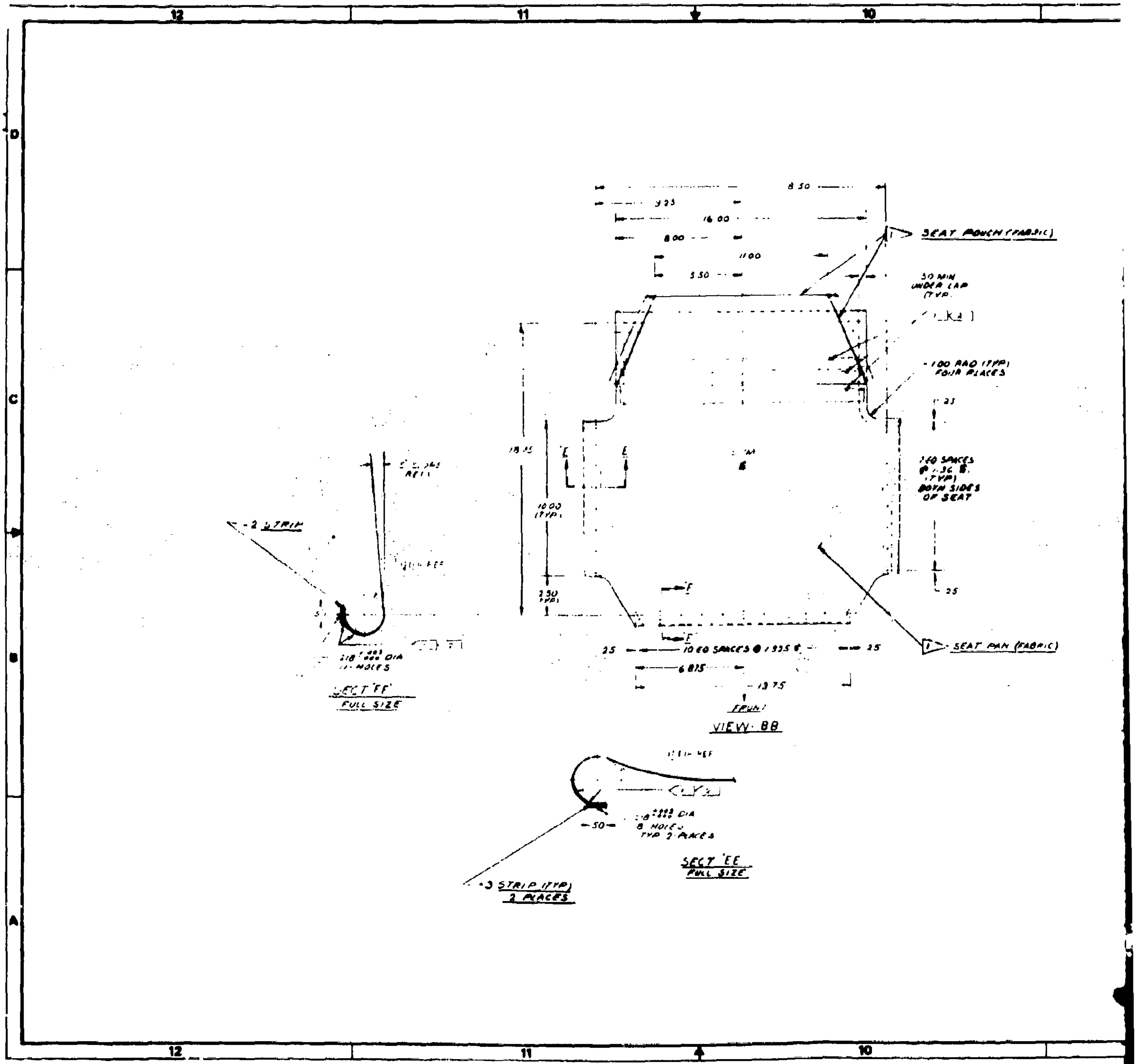
E AS -1 SEAT ASSY EXCEPT ENERGY ATTENUATORS STRUTS
BACK OF SEAT INSTEAD OF THE FRONT

-3	-2	-1			
2	4	2	AN26-3A	BOLT	
	1		AN26-62A	BOLT	
4	8	4	AN24-32A	BOLT	
2	4	2	AN26-17A	BOLT	
2	4	2	AN26-13A	BOLT	
4	8	4	AN26-12A	BOLT	
4	8	4	AN23-11A	BOLT	
4	8	4	AN26-31A	BOLT	
2	4	2	AN24-27A	BOLT	
2	4	2	[illegible]	NUT	
2	4	2	AN23-12A	BOLT	
2	4	2	AN25-22A	BOLT	
6	12	6	AN960-D416	W[illegible]ER	
22	56	22	AN960-D916	WASHER	
1	2	1	AN960-D416L	WASHER	
4	8	4	AN960-D10	WASHER	
27	54	27	AN960-C10	WASHER	
12	24	12	AN960-D10	WASHER	
2	4	2	MS21083N6	NUT	
10	20	10	MS21083N8	NUT	
8	16	8	MS21083N3	NUT	
	20	10	[illegible]	RIVET	
4	8	4	[illegible]	SPACER	
27	54	27	[illegible]	SCREW	
1			SK-25049-6	QUICK DISCONNECT	
1			SK-25049-5	QUICK DISCONNECT	
1			SK-25049-4	QUICK DISCONNECT	
1			SK-25049-3	QUICK DISCONNECT	
2	4	2	SK-25052-3	SPRING	
2	4	2	SK-25052-1	CLIP	A
1			SK-25056-18	TUBE ASSY	A
1			SK-25056-17	TUBE ASSY	A
1	2	1	SK-25053-1	FABRIC ASSY	
2	4	2	SK-25056-1	TUBE	
2	4	2	SK-25060-2	CABLE ASSY.	
2	4	2	SK-25060-1	CABLE ASSY.	
4	8	4	SK-25058-20	ROLLER	
2	4	2	SK-25058-19	SUPPORT	
	2	1	SK-25049-2	QUICK DISCONNECT	
2	4	2	SK-25058-8	HOUSING ASSY	
2	4	2	SK-25058-18	HINGE FITTING	
2	4	2	SK-25058-17	BRACKET	
	2	1	SK-25049-1	QUICK DISCONNECT	
2	4	2	SK-25058-15	TOGGLE LINK ASSY	
1	2	1	SK-25058-5	LUG ASSY	
1	2	1	SK-25058-4	LUG ASSY	
	1		SK-25056-13	TUBE ASSY.	
1	2	1	SK-25056-6	TUBE ASSY	
	2	1	SK-25056-11	TUBE ASSY.	
		1	SK-25056-2	TUBE ASSY	
X			SK-25054-3	SEAT ASSY	A
	X		SK-25054-2	SEAT ASSY	
		X	SK-25054-1	SEAT ASSY	

CRASHWORTHY TROOP
SEAT
ASSY & INSTL.

J SK-25054

-3 TEST



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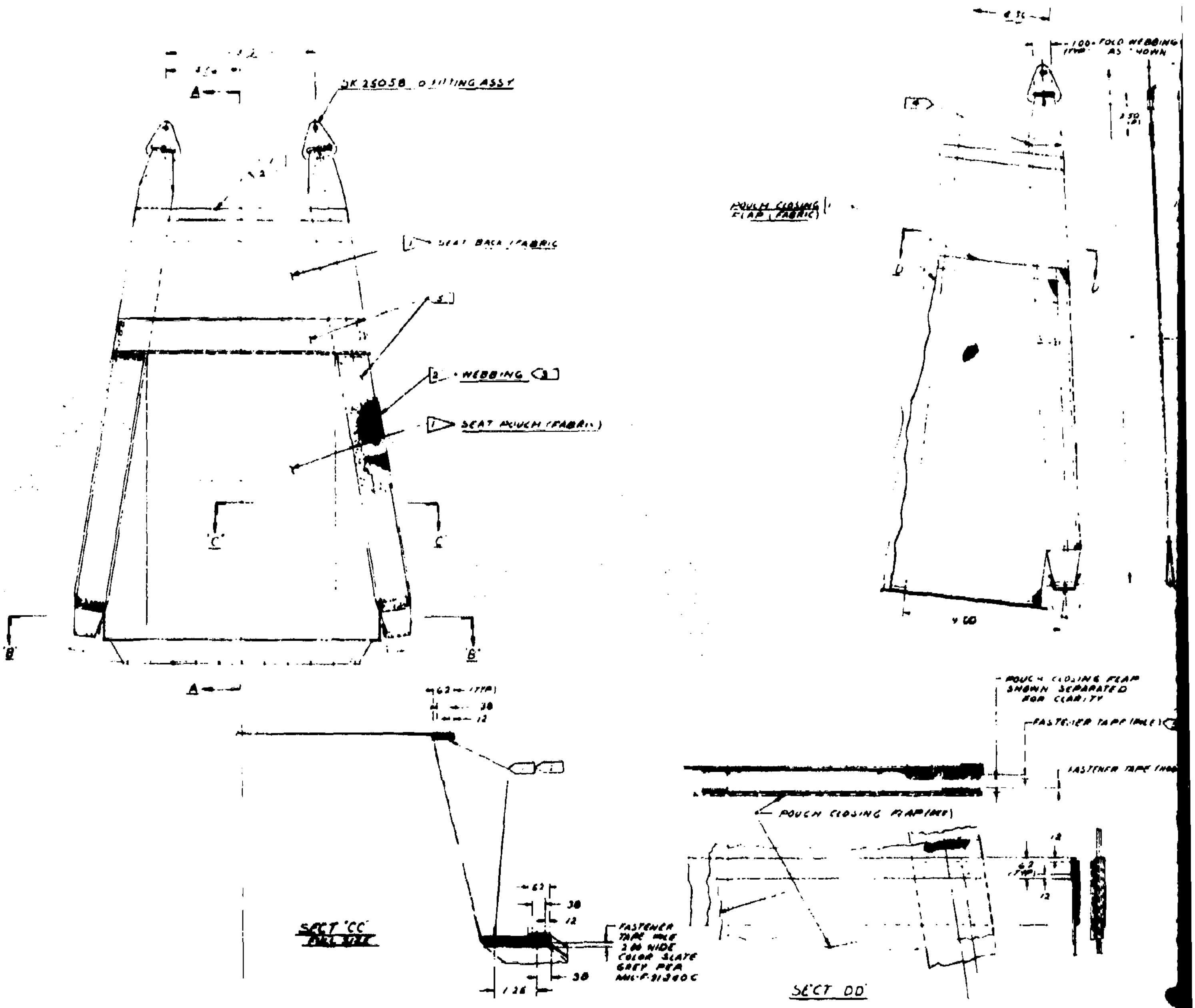
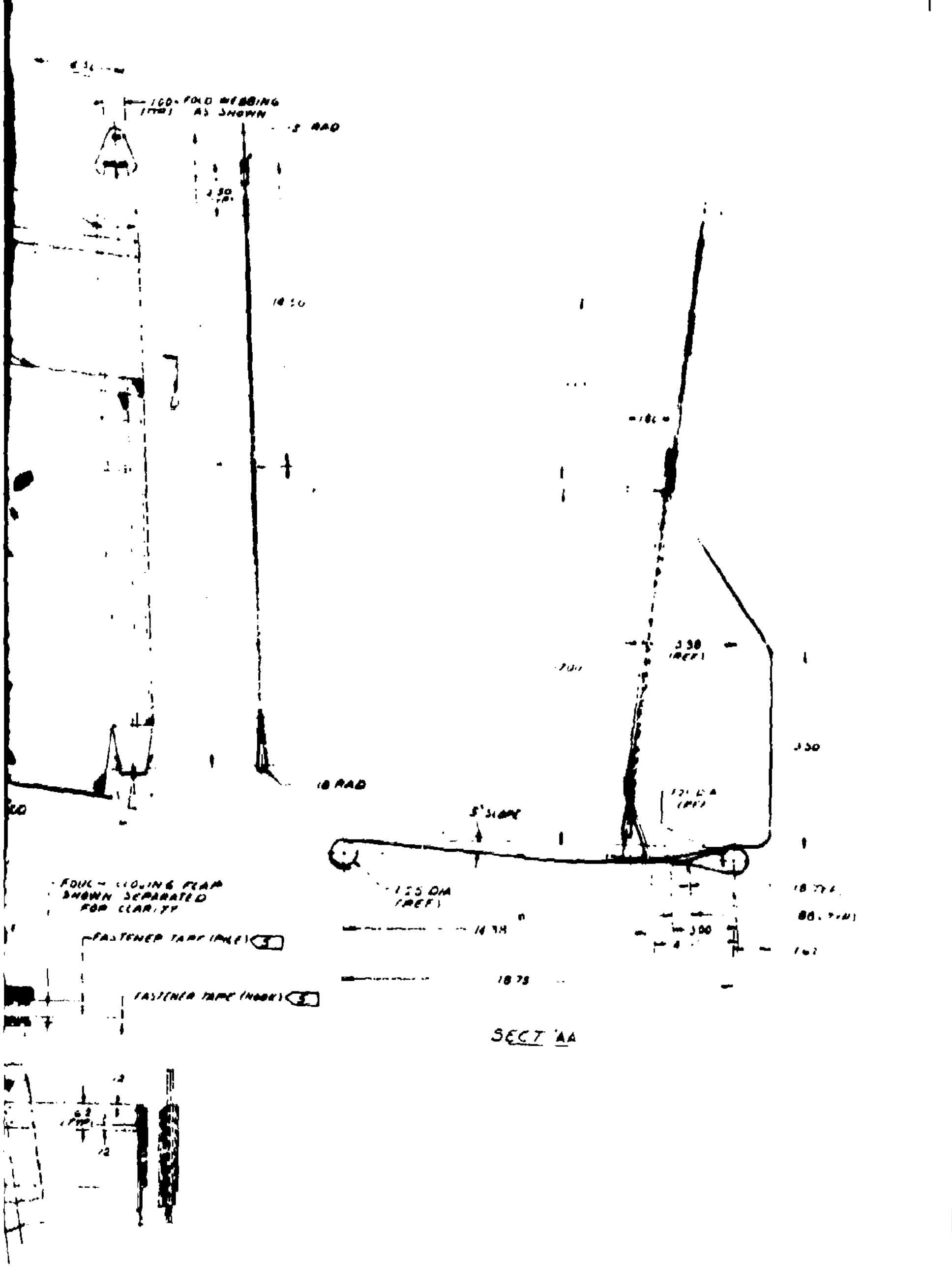
SK 25058 D FITTING ASSY
A
A
1 SEAT BACK (FABRIC
5
2 WEBBING 3
1 SEAT POUCH (FABRIC)
C
C
B
B
.62 (TYP)
.38
.12
.62
.38
.12
1.26
.38
FASTENER TAPE PILE 2.00 WIDE COLOR SLATE GREY PER MIL-F-21840C
SECT 'CC' FULL SIZE
4.50
.100 FOLD WEBBING (TYP) AS SHOWN
4
2.50
POUCH CLOSING FLAP (FABRIC)
D
D
4.00
POUCH CLOSING FLAP SHOWN SEPARATED FOR CLARITY
FASTENER TAPE (PILE)
FASTENER TAPE (HOOK
POUCH CLOSING FLAP(PILE)
.12
.62 (TYP)
.12
SECT DD
9
8
7
6



SECT AA

NOTES

1. ALL STITCHING TO BE IN ACCORDANCE WITH FEDERAL STD NO 751A
2. ALL SEWING THREAD SHALL BE PER FEDERAL SPEC V-T-295A
3. POLYESTER WEBBING TO BE PROVIDED BY BOEING VERTOL
4. [illegible] TYPE I OR II CLASS [illegible] OR EQUIVALENT
5. FASTENER TAPE (PILE) 2.00 WIDE AND TYPE II (HOOK) 2.00 WIDE PER MIL-F-21840 [illegible]

2	3	STRAP ASSY WEBBING		
1	1	SEAT BACK	FABRIC [illegible]	
1	1	SEAT POUCH	FABRIC [illegible]	
1	1	SEAT PAN	FABRIC [illegible] COLOR [illegible]	
2	SK25055-3	STRIP	.063 [illegible] AL ALY	
1	SK25055-2	STRIP	.063 [illegible] AL ALY	
2	SK25058-10	FITTING ASSY WEBBING		
-1	SK25055-1	ASSEMBLY		

-1	SK25054	TEST

SECT AA

NOTES

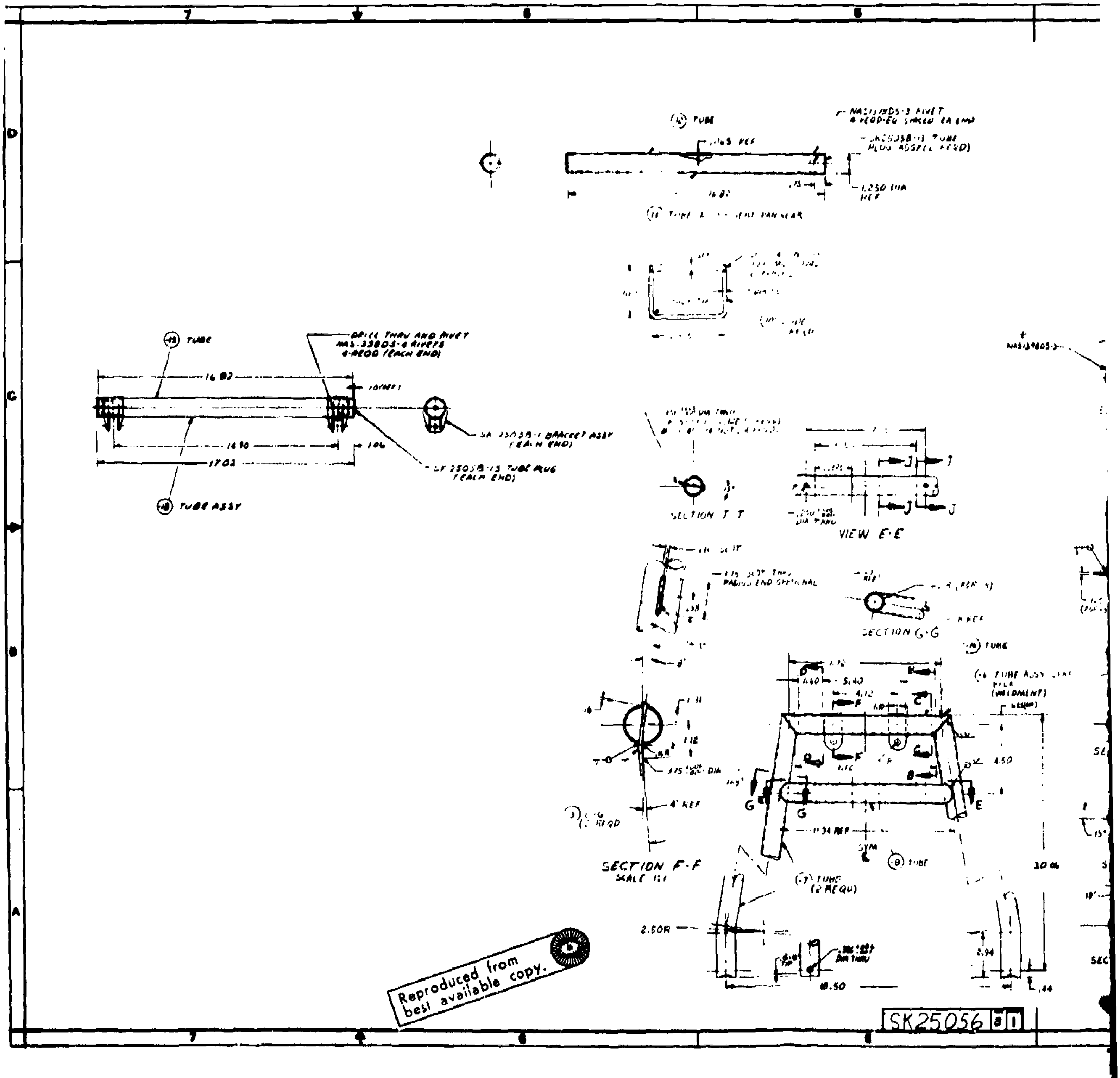
1. ALL STITCHING TO BE IN ACCORDANCE WITH FEDERAL STD NO 751A
2. ALL SEWING THREAD SHALL BE PER FEDERAL SPEC V-T-295A
3. POLYESTER WEBBING TO BE PROVIDED BY BOEING VERTOL
4. 6-8 [illegible] STITCHES PER INCH MIL-T-7807B NO 4 NYLON CORD TYPE I [illegible] CLASS I 50 LBS OR EQUIVALENT
5. FASTENER TAPE (PILE) 2.00 WIDE AND (HOOK) [illegible] 2.00 WIDE PER MIL-F-21840C [illegible] STATE SPEC

2	3	STRAP ASSY WEBBING	3
1	1	SEAT BACK	FABRIC MIL-C-7219 TYPE III COLOR LIGHT GREY
1	1	SEAT POUCH	FABRIC MIL-C-7219 TYPE III COLOR LIGHT GREY
1	1	SEAT PAN	FABRIC MIL-C-7219 TYPE III COLOR LIGHT GREY
2	SK-25055-3	STRIP	.063 × .50 × 18.18 [illegible] 2024-T3 AL ALY [illegible]
1	SK25055-2	STRIP	.063 × .50 × 13.88 [illegible] 2024-T3 AL ALY [illegible]
2	SK-25058-10	WEBBING ASSY WEBBING	
-1	SK-25055-1	ASSEMBLY	

CRASHWORTHY TROOP SEAT
FABRIC ASSY & DETAIL

J

SK-25055



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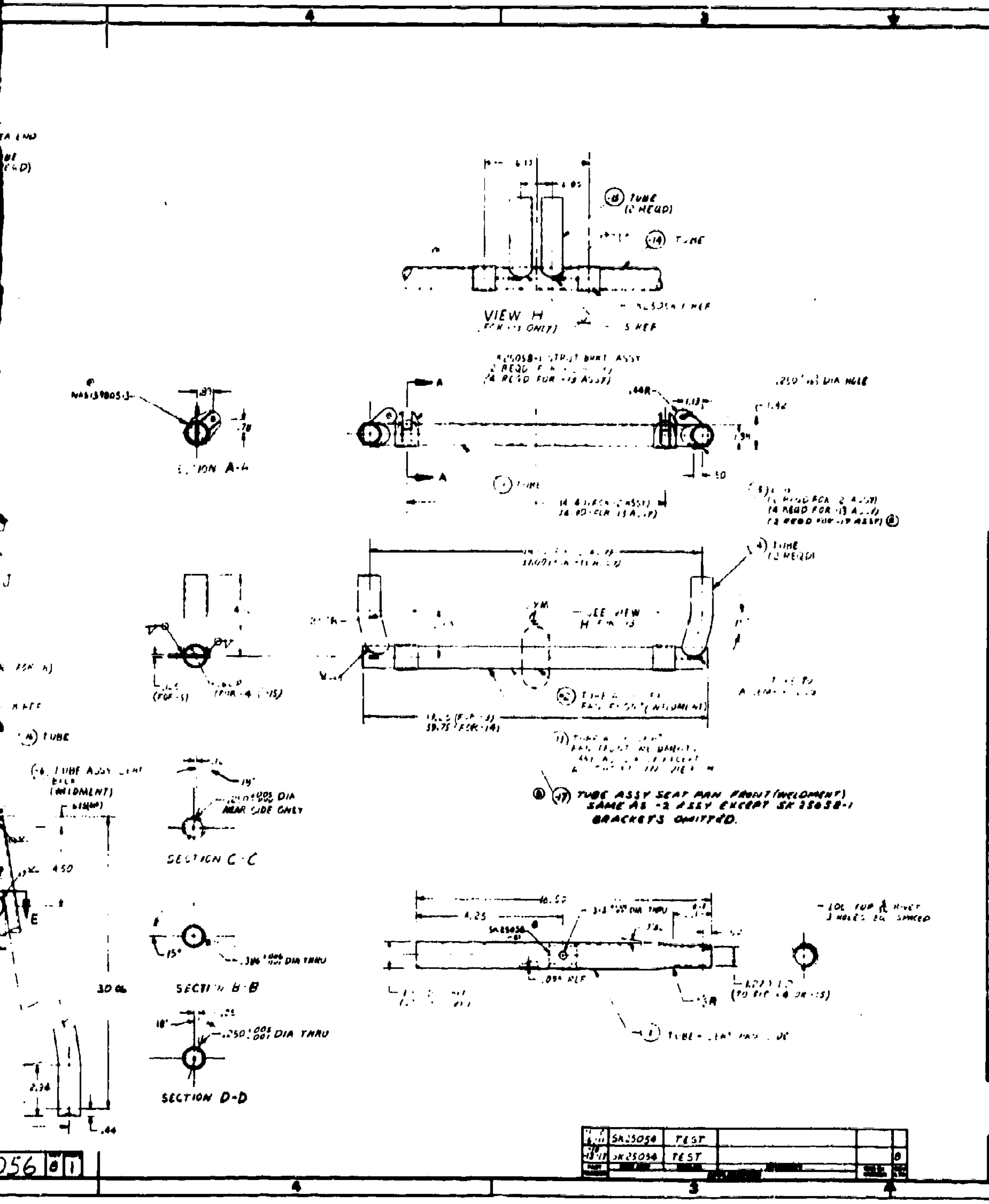
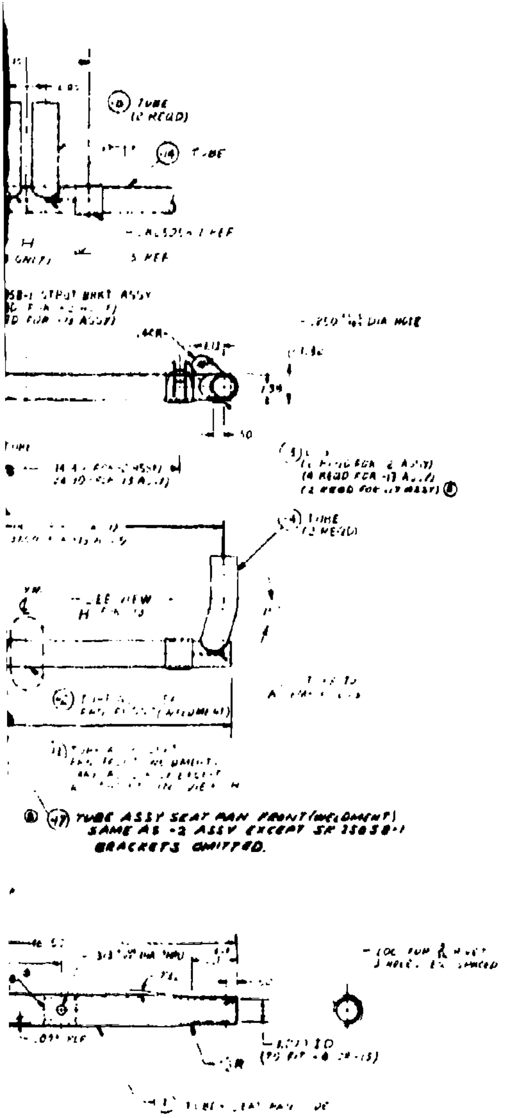
WELD PER MIL-W-8604 [illegible] UNLESS OTHERWISE SHOWN

HEAT TREAT AFTER WELDING TO [illegible] CONDITION



8							NAS1398D5-4	RIVET
		16	8		8		NAS1398D5-3	BLIND RIVET
				4			MS21045-04	NUT
X							SK25056-18	TUBE ASSY
	X						SK25056-17	TUBE ASSY
2			2				SK25058-13	TUBE PLUG [illegible]
				1			SK25056-16	TUBE
		2					SK25056-15	TUBE
		1					-14	TUBE
		X					-13	TUBE ASSY
1			1				-12	TUBE
			X				SK25056-11	TUBE ASSY
2		4			2		SK25058-1	STRUT BRKT ASS
				2			SK25056-10	GUIDE
				2			-9	LUG
				1			-8	TUBE
				2			-7	TUBE
				X			-6	TUBE ASSY
	2	4			2		-5	LUG
	2	2			2		-4	TUBE
	1				1		-3	TUBE
					X		-2	TUBE ASSY
							SK25056-1	TUBE

-18 -17	SK25054	TEST
-18 -17	SK25054	TEST



NOTES

1. [illegible]

WELD PER MIL-W-8604 WITH 4043 ALUM FILLER WIRE. WELDS ARE [illegible] UNLESS OTHERWISE SHOWN

HEAT TREAT AFTER WELDING TO -T6 CONDITION

	A	[illegible]	8 4 U	[illegible]
	B	ADDED [illegible] -17 TUBE ASSY AND -18 TUBE ASSY	[illegible]	[illegible]

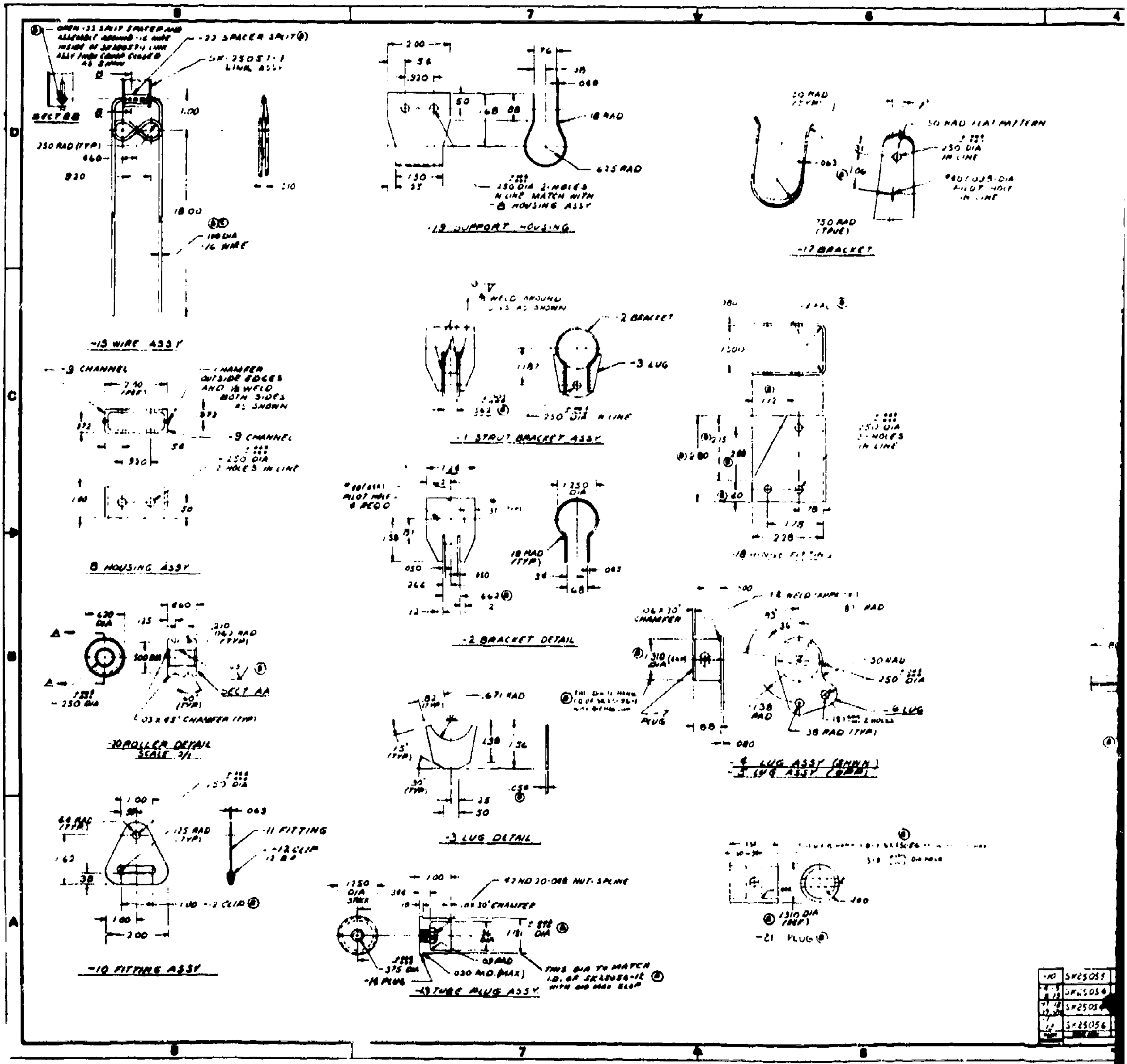
8							NAS1398DS-4	RIVET							
		16	8		8		NAS1398DS-3	BLIND RIVET							
				4			MS21045-04	NUT							
☒							SK25056-18	TUBE ASSY							
	☒						SK25056-17	TUBE ASSY		2	3				B
2			2				SK25058-11	TUBE PLUG ASSY							
				1			SK25056-16	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
		2					SK25056-15	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
		1					-14	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
		☒					-13	TUBE ASSY		2					
1			1				-12	TUBE		1.250 DIA x .065 WALL TUBING 2024-T3 WW-T-700/3					A
			☒				SK25056-11	TUBE ASSY							
2		4			2		SK25058-1	STRUT BRKT ASSY							
				2			SK25056-10	SLIDE		.125 DIA [illegible] STEEL WIRE					
				2			-9	LUG		.093 SHEET 6061-T6 QQ-A-250/11					
				1			-8	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
				2			-7	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
				☒			-6	TUBE ASSY		2	3				
	2	4			2		-5	LUG		.125 SHEET 6061-T6 QQ-A-250/11					
	2	2			2		-4	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
	1				1		-3	TUBE		1.250 DIA x .065 WALL TUBING 6061-T6 WW-T-700/6					
					☒		-2	TUBE ASSY		2	3				
							SK25056-1	TUBE		1.50 DIA x .083 WALL TUBING 2024-T3 WW-T-700/3					

	SK25056	TEST
	SK25056	TEST

DETAILS - CRASHWORTHY TROOP SEAT

J SK25056

7930



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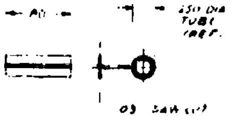
(B) 4. ALL MACHINED SURFACES FINISH $\sqrt{}$ EXCEPT AS NOTED



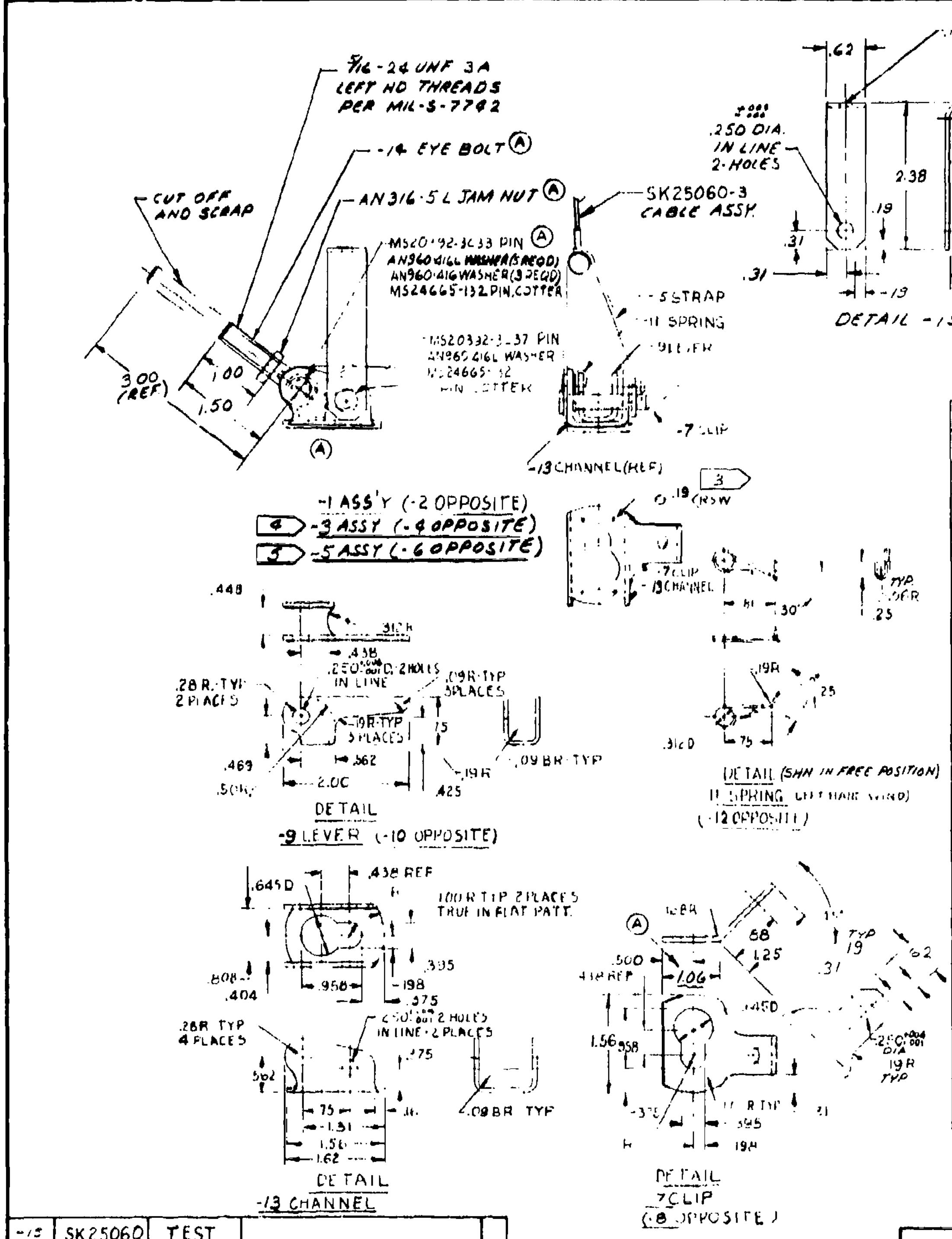
(B) -22 TUBE SPLIT

1	SK25058-22	SPACER SPLIT	[illegible] AL ALY [illegible]		B
	SK25058-21	[illegible]	[illegible]		
1	NAS1020-068	NUT SPLINE	ELASTIC STOP NUT CORP		
1	SK-25057-1	LINK ASSY			B
	SK25058-20	ROLLER	.375 DIA [illegible]		
	-19	SUPPORT	[illegible] AL ALY [illegible]		B
	-18	HINGE FITTING	[illegible] AL ALY [illegible]		B
	-17	BRACKET	[illegible] AL ALY [illegible]		B
1	-16	WIRE	.100 DIA [illegible] MUSIC WIRE [illegible]		C
-15	-15	WIRE ASSY			
1	-14	PLUG	[illegible] AL ALY [illegible]		
-13	-13	PLUG ASSY			
1	-12	CLIP	[illegible] AL ALY [illegible]		B
1	-11	FITTING	[illegible] AL ALY [illegible]		B
-10	-10	FITTING ASSY			
2	-9	CHANNEL	[illegible]		
-8	-8	HOUSING ASSY			
1 1	-7	PLUG	[illegible] AL ALY BAR [illegible]		
1 1	-6	LUG	[illegible] AL ALY [illegible]		
-5	-5	LUG ASSY			
-4	-4	LUG ASSY			
2	-3	LUG	[illegible] AL ALY [illegible]		B
1	-2	BRACKET	[illegible] AL ALY [illegible]		
-1	SK25058-1	STRUT BRACKET ASSY			

-10	SK25055	TEST
-4 -5 -13	SK25053	TEST
-10	SK25054	TEST
-1 -13	SK25056	TEST

DETAILS
CRASHWORTHY
TROOP SEAT

J SK-25058 B



1	1	2	2	2	2	MS24665-132
		1	1	1	1	MS20392-3C3
1	1			1	1	AN316-5L
1	1	1	1	1	1	MS20392-3C3
6	6			6	6	AN960-416L
3	3			3	3	AN960-416
		1	1	1	1	SK25060-3
		1	1	1	1	SK25049-
1	1			1	1	-
1	1	1	1	1	1	-
1		1		1		-
	1		1		1	-
1		1		1		-
	1		1		1	-
1		1		1		-8
	1		1		1	-7
X						-6
	X					-5
		X				-4
			X			3
				X		-2
					X	SK25099-
-6	-5	-4	-3	-2	-1	PART OR IDENTIFYING NUMBER

PART NUMBER	NEXT ASSY	USED ON	EFFECTIVITY
-15	SK25060	TEST	
-1&2 -3&4 -5&6	SK25054	TEST	

APPLICATION

FASTENER CODES

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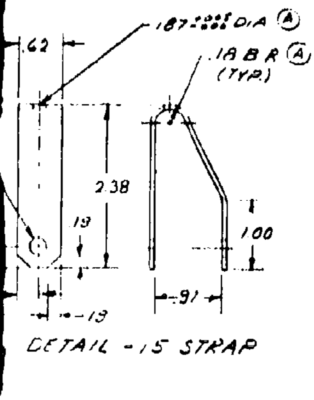
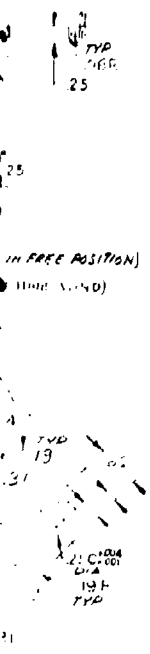


DETAIL -15 STRAP



NOTES

1 [illegible]

2 HEAT TREAT TO 150-170 KSI

3 SPOT WELD

4 -3 AND -4 SAME AS -1 AND -2 EXCEPT -14 EYE BOLT OMITTED.

5 -5 AND -6 SAME AS -1 AND -2 EXCEPT SK-25060-3 CABLE ASSY OMITTED

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	ON F/D -15 STRAP .187 +.005/-.000 DIA WAS .161 +.005/-.000 DIA AND .18 B.R WAS .16 B.R. ON F/D -7 & -8 CLIP 1.06 DIM. WAS .98 IN L/M FOR -7-8-9-10-13-15 .080 MATL THICKNESS WAS .075 ON F/D AND IN L/M ADDED -14 EYE BOLT TO -1-2 AND -5-6 ASSYS. ON F/D AND IN L/M ADDED AN316-5L JAM NUT TO -1-2 AND -5-6 ASSYS ADDED 4 AND 5	12/11/73	[illegible]

-6	-5	-4	-3	-2 QTY REQD	-1 QTY REQD	[illegible]	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION	HT TR	FINISH	[illegible]	[illegible]	REV LTR
1	1	2	2	2	2		MS24665-132	COTTER PIN						
		1	1	1	1		MS20392-3C37	PIN						
1	1			1	1		AN316-5L	JAM NUT						A
1	1	1	1	1	1		MS20392-3C33	PIN						
6	6			6	6		AN960-416L	WASHER						A
3	3			3	3		AN960-416	WASHER						A
		1	1	1	1		SK-25060-3	CABLE ASSY						
		1	1	1	1		SK-25049 -15	STRAP	.080(4130)STL.SHT.MIL-S-18729 ANNEALED	2				
1	1			1	1		-14	EYE BOLT	MAKE FROM CL-31-EB EYE BOLT CARR-LANE MANUF. CO ST. LOUIS MO.					
1	1	1	1	1	1		-13	CHANNEL	.080(4130)STL. SHT. MIL-S-18729 ANNEALED	2				A
1		1		1			-12	SPRING-(R.H)	.032 DIA.(MUSIC WIRE) QQ-W-423					
	1		1		1		-11	SPRING-(L.H.)	.032 DIA (MUSIC WIRE) QQ-W-423					
1		1		1			-10	LEVER-(R.H.)	.080(4130)STL.SHT.MIL-S-18729 ANNEALED	2				A
	1		1		1		-9	LEVER (L.H)						A
1		1		1			-8	CLIP-(R.H)						A
	1		1		1		-7	CLIP. (L.H)	.080(4130)STL. SHT. MIL-S-18729 ANNEALED	2				A
X							-6	QUICK (R.H) DISCONNECT ASSY						A
	X						-5	QUICK (L.H) DISCONNECT ASSY						A
		X					-4	QUICK (R.H) DISCONNECT ASSY						
			X				3	QUICK (L.H) DISCONNECT ASSY						
				X			-2	QUICK (R.H) DISCONNECT ASSY						
					X		SK-25049-1	QUICK (L.H) DISCONNECT ASSY						

PARTS LIST

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ± 1°
DECIMALS .XX ± .030
DECIMALS .XXX ± .010

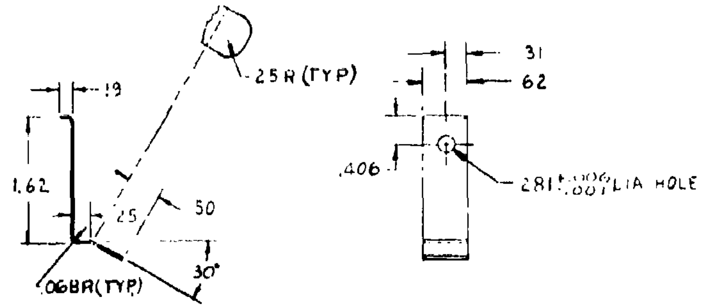
STRUCT	L.B. Hershman	8-9-73	
DRAWN	R.E. GRUENEWALD	6-22-73	
CHK		7-18-73	
ENGR	M J REILLY	7-20-73	
PROJECT APPROVAL		[illegible]	

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

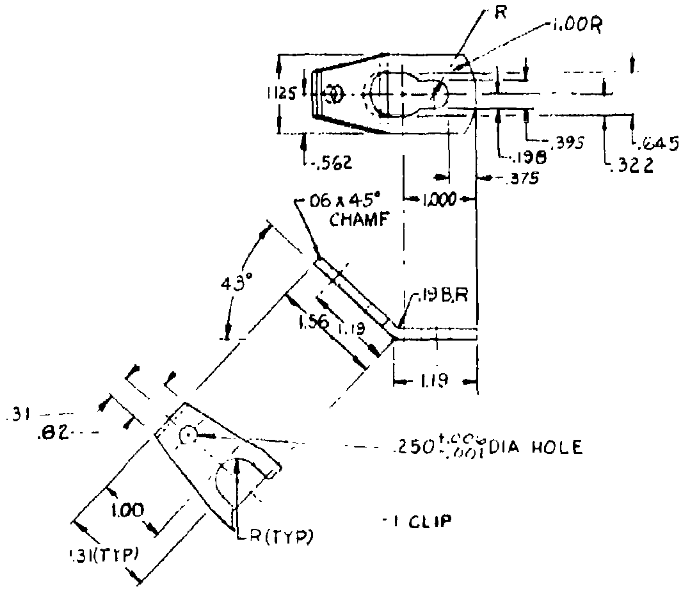
QUICK DISCONNECT ASS'Y
TROOP SEAT LEG

SIZE D
CODE IDENT NO. -
SK 25049A
SCALE FULL
SHT 1 OF 1

1 HEAT TREAT
2 HEAT TREAT



-3 SPRING - RETAINER



-1 CLIP

					-3	SP
					-1	CL
					PART OR IDENTIFYING NUMBER	
RELEASE						

APPLICATION							
NEXT ASSY	USED ON	SECT NO	SERIAL NUMBER	PART NUMBER	RELEASE COLUMN IND	DWG SH NUMBER	REV LTR
SK25054	TEST			-3			
SK25054	TEST			-1			

PART MARKING PER BAC 5307.
RIVET INST & SYMBOLS PER BAC 5004
SEE BACD 2097 FOR SURFACE ROUGHNESS
FORM, PUNCH, STRAIGHTEN & FIT
METAL PARTS PER BAC 5300
BOLT & NUT INSTALLATION PER BAC 5009
MATERIAL SUBSTITUTION &
EQUIVALENTS PER D8-0127
FOR FINISH CODE SEE DOC D8 5000

DWG ORIG BY (GROUP). CHANGE NO:

DIMENSIONING & TOL
PER MIL-STD-8
UNLESS OTHERWISE S
DIMENSIONS ARE IN
TOLERANCES ANG
XX ± .03
RIVET & BOLT ED
MARGINS ± .0
BEND RADII
± .01 ON .03 &
± .03 ON .09 A
SHEET METAL CORN
INT 16

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REVISIONS

LTR	ZONE	DESCRIPTION	DATE	APPROVE
A		IN L/M FOR -1 CLIP .160 WAS .156 THK	[illegible]	

1 HEAT TREAT TO 150-170 KSI

2 HEAT TREAT TO 180-220 KSI AFTER FORMING

31 $^{+.006}_{-.001}$ DIA HOLE

					PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	ZONE	MATERIAL AND SPECIFICATION	HT-TR	FINISH	PT-MK	REV LTR
					-3	SPRING-RETAINER		.020 (SAE 1095) MIL-S-7947	2			
					-1	CLIP		.160 (4130) STL. SHT. MIL-S-18729 ANNEALED	1			A
RELEASE					LIST OF MATERIAL							

MARKING PER BAC 5307.
INST & SYMBOLS PER BAC 5004
CD 2097 FOR SURFACE ROUGHNESS
, PUNCH, STRAIGHTEN & FIT
L PARTS PER BAC 5300
& NUT INSTALLATION PER BAC 5009
RIAL SUBSTITUTION &
VALENTS PER DB-0127
INISH CODE SEE DOC D8 5000

ORIG BY (GROUP) CHANGE NO.

DIMENSIONING & TOLERANCING PER MIL-STD-8
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
TOLERANCES ANGLES ± 1°
.XX ± .03 .XXX ± .010
RIVET & BOLT EDGE MARGINS ± .05
BEND RADII
± .01 ON .03 & .06
± .03 ON .09 & GREATER
SHEET METAL CORNER RADII
INT .16 .19 EXT .22 .25 .90

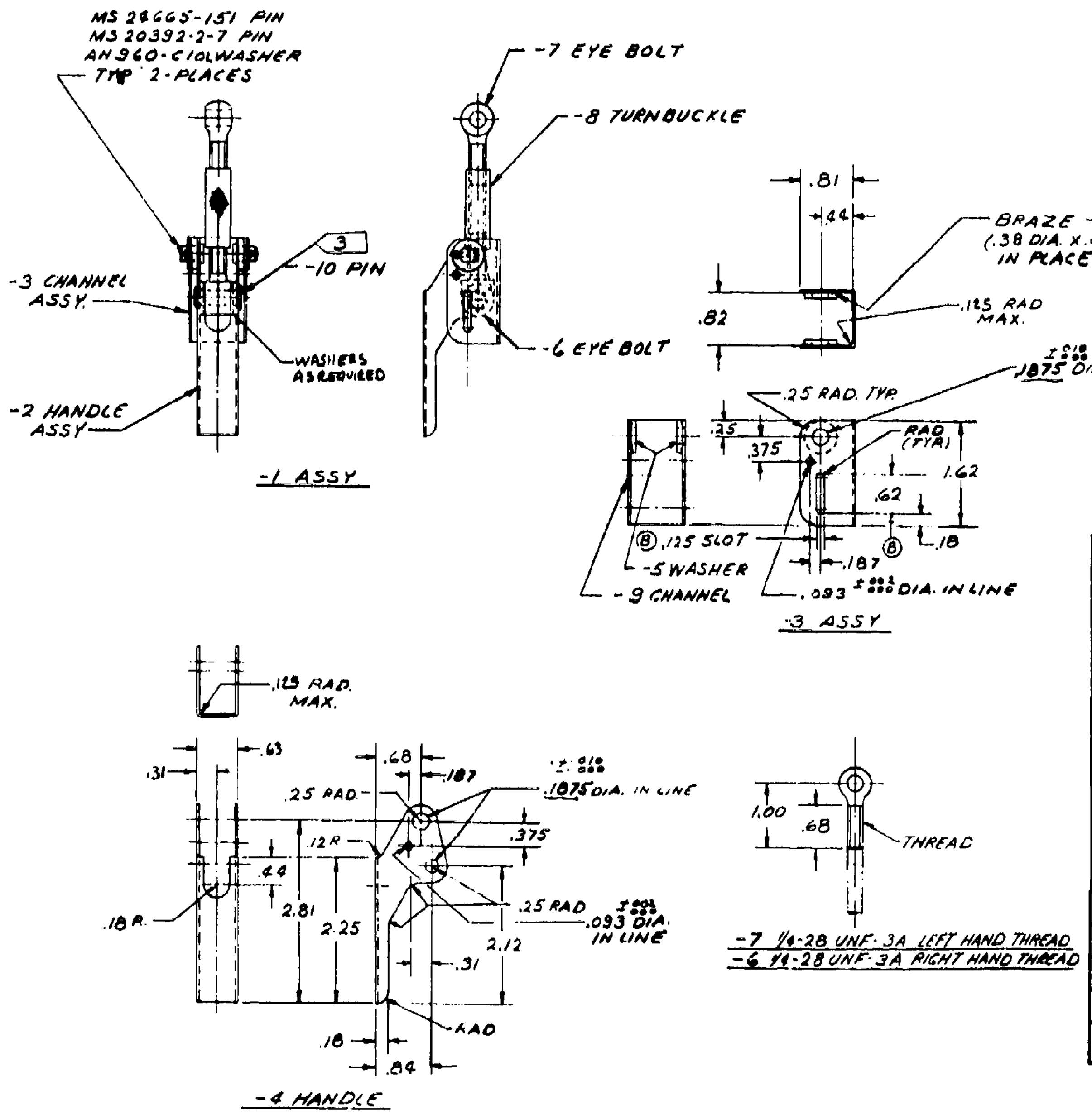
M
MATL & PROCESS
DATE

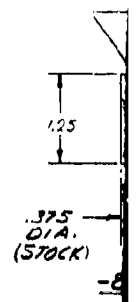
CONTR
DR R E GRUENEWALD DATE
CHK SR 7-12-73
STRUCT 7-13
WTS
GR M. J. REILLY 7-20-73
PROJ 7-20-73

THE BOEING COMPANY
VERTOL DIVISION MORTON, PENNSYLVANIA

QUICK DISCONNECT-
TROOP SEAT BRACE

SIZE D
CODE IDENT NO 77272
SK 25052A
SCALE FULL
SH 1 OF 1





NOTES.
1- BREAK A
2- ALL MA
3 NOTE:
END OF
-6 EYE

			2	AN960-10L
			2	MS24665-151
			2	MS20392-2-7
		2		AN960-C10
		2		AN960-C10L
		1		-10
	1			-9
			1	-8
			1	-7
		1		-6
	2			5
		1		-4
	☒		1	-3
		☒	1	-2
			☒	-1

-1	SK2505B	TEST		
	APPLICATION			

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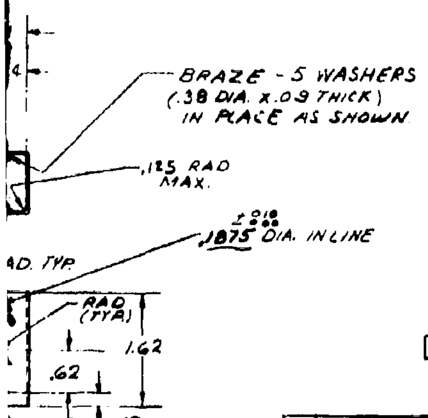
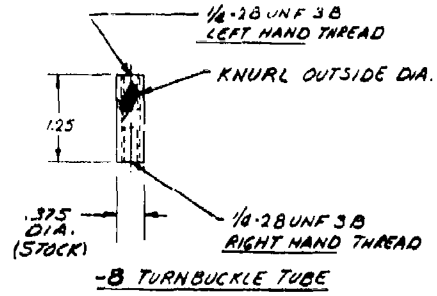
NOTES

1 SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE)

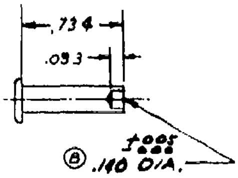
[illegible]

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	GAGE CHG -48-9 .032 TO .040	8-1-73	JR
B	ON F/D -3 ASSY CHANGED .125 DIA HOLES TO .125 WIDE x .62 LG SLOTS ON F/D -10 PIN .140 DIA HOLE WAS .119 DIA	12-18-73 D.D'AMICO	





-8 TURNBUCKLE TUBE

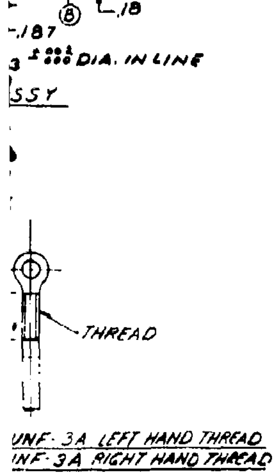


-10 PIN

SIZE 2/1

NOTES.
1. BREAK ALL SHARP EDGES AND CORNERS.
2. ALL MACHINED SURFACE FINISH 125

3 NOTE: FLARE OPEN AND PEEN LIGHTLY END OF -10 PIN AT ASSY. WITH -2 HANDLE. -6 EYE BOLT MUST ROTATE FREE WITHOUT BINDING.



QTY REQD	QTY REQD			PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION	[illegible]	[illegible]	FINISH	[illegible]	REV LTR
			2	AN960-10L	WASHER						
			2	MS24565-151	PIN						
			2	MS20392-2-7	PIN						
		2		AN960-C10	WASHER						
		2		AN960-C10L	WASHER						
		1		-10	PIN	MAKE FROM MS 20392-2C27					
	1			-9	CHANNEL	.040 x 1 5/8 x 2 3/8 LG 4130 STL SHT MIL-S-18729					A
			1	-8	TURNBUCKLE TUBE	.375 DIA x 1 3/8 LG. 4130 STL. BAR MIL-S-6758					
			1	-7	EYE BOLT LEFT HAND	MAKE FROM CL-25-EB EYE BOLT CARR LANE MANUF CO. ST. LOUIS MO.					
		1		-6	EYE BOLT RIGHT HAND	MAKE FROM CL-25-EB EYE BOLT CARR LANE MANUF CO ST. LOUIS MO.					
	2			-5	WASHER	.375 DIA. x .09 THICK 4130 STL BAR MIL-S-6758					
		1		-4	HANDLE	.040 x 2 1/4 x 3 1/8 LG. 4130 STL. SHT. MIL-S-18729					A
	X		1	-3	CHANNEL ASSY.						
		X	1	-2	HANDLE ASSY.						
			X	-1	TOGGLE LINK ASSY.						

PARTS LIST

TOLERANCES: ANGLES ±
DECIMALS .XX ± .030
DECIMALS .XXX ± .010

REVIEW & APPROVAL	
STRUCT	8-13-73

DR	D.D'AMICO	7/3/73
CHK	JR	7-16-73
ENGR	M.J. REILLY	7-20-73
PROJECT APPROVAL		7-20-73

THE BOEING COMPANY
CORPORATE OFFICES SEATTLE, WASHINGTON

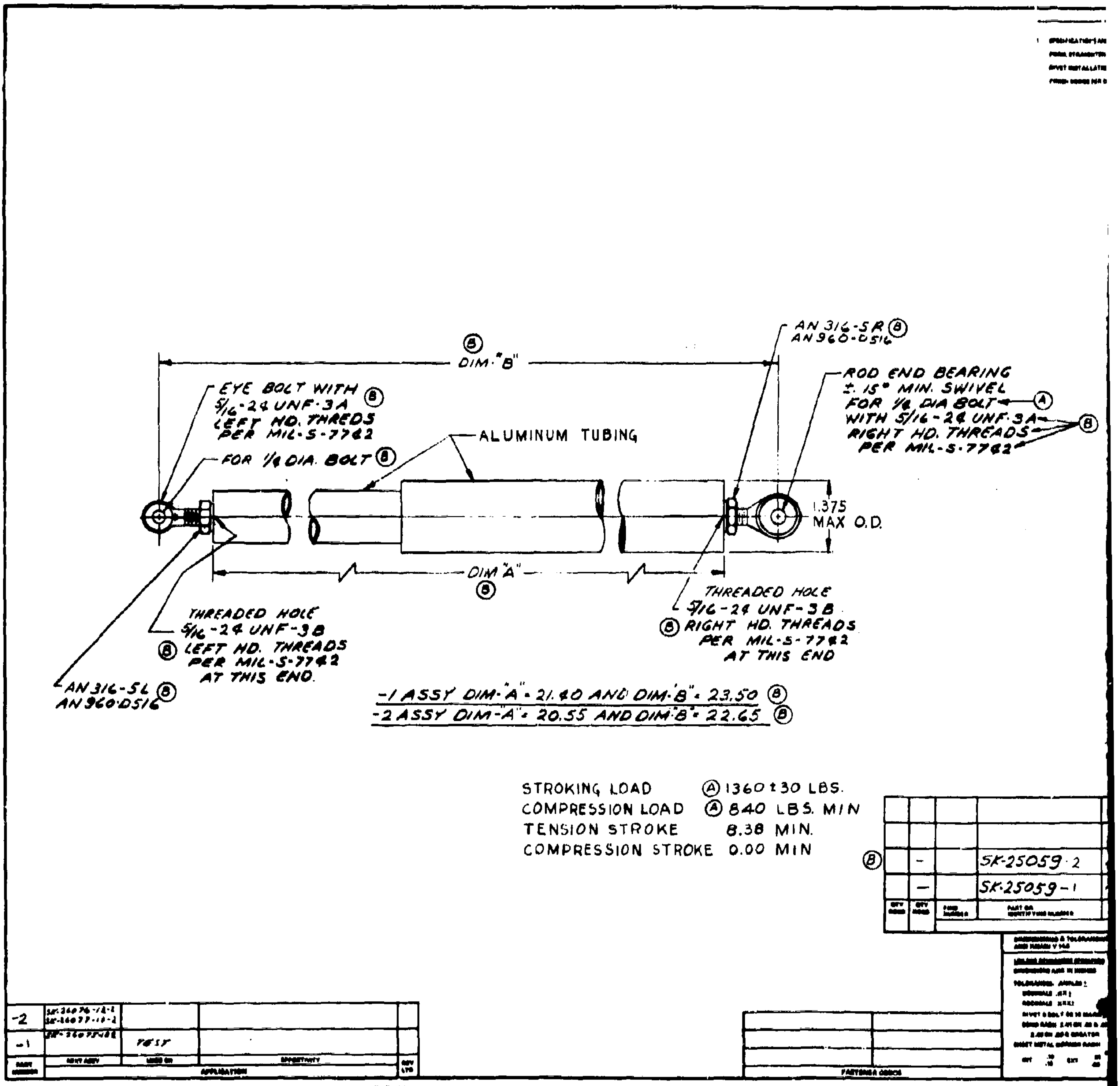
TOGGLE LINK
ASSY.
CRASHWORTHY TROOP SEAT

SIZE D

SK-25057B

SCALE FULL

FASTENER CODES



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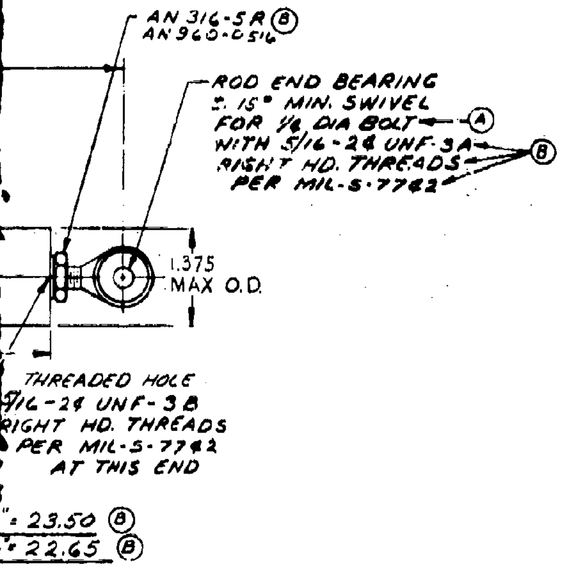
NOTES

1 SPECIFICATIONS AND STANDARDS FOR THE CONTROL OF MANUFACTURING OPERATIONS (AS APPLICABLE):

[illegible]

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	CHG FROM 1030 TO 1360 CHG FROM 840 LBS MAX TO 840 LBS MIN [illegible]	8-9-73	JR
B	REVISED DWG BY REPLACING ROD END BEARING WITH EYE BOLT AT ONE END OF ATTENUATOR AND ADDED -2 ASSY. ON P/O AND IN VM	[illegible]	JR



Ⓐ 1360 ± 30 LBS.

Ⓐ 840 LBS. MIN

8.38 MIN.

OKE 0.00 MIN

Ⓑ	–			SK-25059-2	ASSY ENERGY ATTENUATOR						
	—			SK-25059-1	ASSY ENERGY ATTENUATOR						
	QTY REQD	QTY REQD	FIND NUMBER	PART OR IDENTIFYING NUMBER	NOMENCLATURE OR DESCRIPTION	MATERIAL AND SPECIFICATION					

PARTS LIST

CHECKER	8-9-73
DRAWN AE GRUENEWALD	7-19-73
JR	7-19-73
M.J. REILLY	7-20-73
	7-20-73

FASTENER CALLOUT

THE BOEING COMPANY

ENERGY ATTENUATOR - CRASH WORTHY TROOP SEAT

D

SK 25059B

SCALE FULL

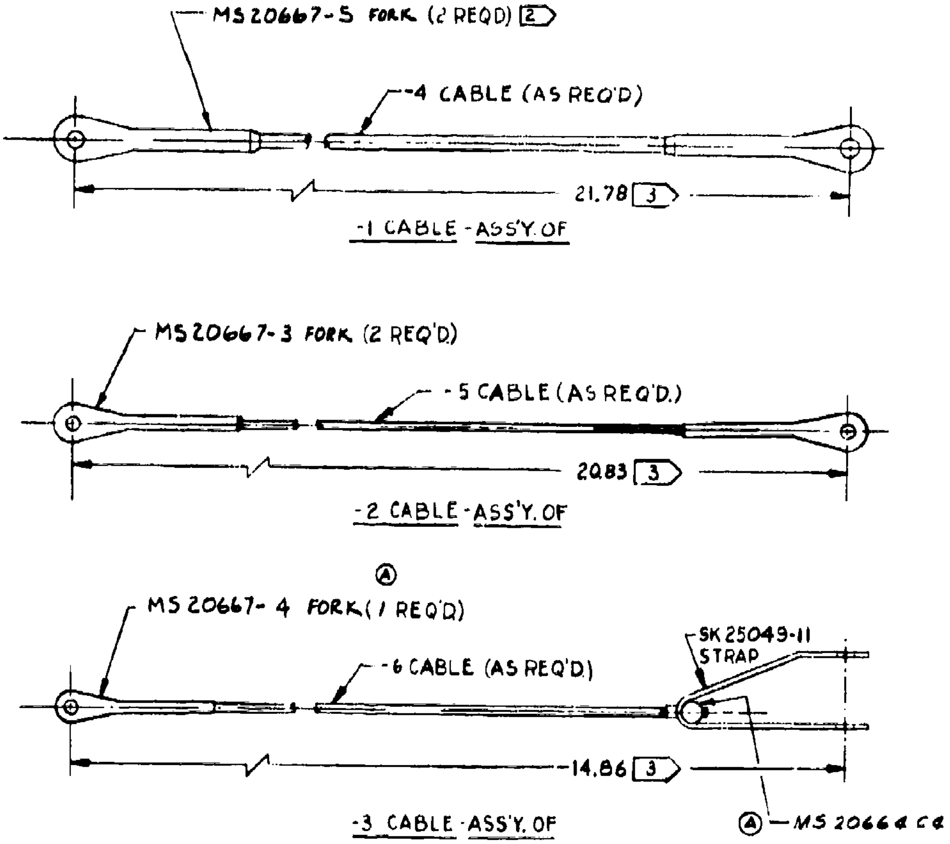
SH 1 OF 1

1 [illegible]

2 SWA
9/32 F

3 DIME
UNDE

4 -4 & -
HIGH



-1 CABLE-ASS'Y. OF

-2 CABLE-ASS'Y. OF

-3 CABLE-ASS'Y. OF

1				MS20664C4	S
1				MS20667-4	
	2			MS20667-3	
		2		MS20667-5	
1				SK25049-11	S
AS REQ'D				-6	C
	AS REQ'D			-5	C
		AS REQ'D		-4	C
—				-3	C
	—			-2	C
		—		-1	C
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
-3	-2	-1			

-3	SK25054	TEST		
-2	SK25054	TEST		
-1	SK25049	TEST		

Ⓐ

APPLICATION

.03

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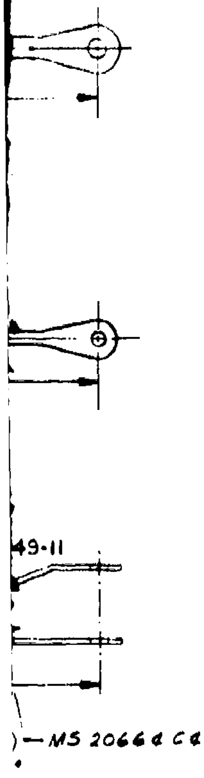
LTR	DESCRIPTION	DATE	APPROVED
A	IN L/M -6 CABLE ⅛ DIA 7x19 WAS 3/32 DIA 7x7. ON F/D -3 CABLE ADDED CALLOUT FOR MS20664C4 ON F/D AND IN L/M CHANGED CALLOUT FOR MS20664C4 NO. REQD. WAS (2) ON F/D IN N/A BLOCK N/A FOR -1 WAS SK25060	12/11/73	

2 SWAGE -4 CABLE ENDS TO FACILITATE USE OF 3/32 FORK FITTINGS.

3 DIMENSIONS ARE WITH CABLE TAUT UNDER 10# LOAD.

4 -4 & -5 CABLE SHALL BE ANNEALED TO PRODUCE HIGH ELONGATION ENERGY ATTENUATION FEATURES.



1				MS20664C4	SINGLE SHANK BALL						A
1				MS20667-4	FORK END						
	2			MS20667-3	FORK END						
		2		MS20667-5	FORK END						
1				SK25049-11	STRAP						
AS REQD				-6	CABLE	⅛ DIA. 7x19 S.S WIRE ROPE, MIL-C-5424					A
	AS REQD			-5	CABLE	3/32 DIA. 7x7 S.S WIRE ROPE, MIL-C-5424		4			
		AS REQD		-4	CABLE	3/16 DIA 7x19 S.S WIRE ROPE, MIL-C-5424		4			
—				-3	CABLE·ASS'Y. OF						
	—			-2	CABLE·ASS'Y OF						
		—		-1	CABLE·ASS'Y OF						
-3	-2	-1									

.03

R.E. GRUENEWALD 7-19-73

7-19-73

M.J. REILLY 7-20-73

7-20-73

CORPORATE OFFICES SEATTLE, WASHINGTON

CABLE ASS'YS.
CRASHWORTHY
TROOP SEAT

D

SK 25060A

FULL

1 OF 1

• U S GOVERNMENT PRINTING OFFICE, 1975 636-612/84