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TECHNICAL REPORT

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HUMAN FACTORS REQUIREMENTS FOR THE DESIGN OF HELICOPTER  
AIRCREWMEN'S SEAT AND GROIN PROTECTIVE UNITS

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FOREWORD

The ever-increasing ground combat role of helicopters requires that particular attention be devoted to the man-machine interface between the aircraft and the operating crew. This report summarizes the major human factors requirements to be considered in the design of rigidly armored protective seat and groin units for crew chiefs and door gunners of UH-1 series helicopters. Quantitative design criteria are specified to provide further assistance to designers.



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## ABSTRACT

The most important human factors requirements for the design of rigidly armored seat and groin protective units for the seated helicopter aircrewmembers are discussed. Included are requirements for preventing interference with mission performance, reducing fatigue and providing a compatible, safe and somewhat comfortable working environment for the fully-equipped aircrewman. Quantitative design criteria for dimensions, contours, cushioning and location of the seat and groin protective units are specified.

## Human Factors Requirements for the Design of Helicopter Aircrewmen's Seat and Groin Protective Units

### 1. Objectives:

a. The principal objective of this report is to summarize the most important human factors requirements for the design of rigidly armored protective seat units for the buttocks and crotch regions of the seated helicopter aircrewman. These human factors requirements have been developed from the primary in-flight missions of crew chiefs and door gunners of UH-1 B and D model helicopters; they may not be applicable to other crew positions or aircraft. In order of relative importance, the major human factors requirements are:

- (1) preventing interference with performance of the crewman's primary mission.
- (2) preventing safety hazards.
- (3) reducing fatigue.
- (4) providing compatibility between the seat unit and clothing or other equipment worn by the crewman.
- (5) providing as much comfort for the crewman as possible.

b. The secondary objective of this report is to present quantitative criteria which will assist the designer of protective seat units in meeting the above human factors requirements. These design criteria include:

- (1) dimensions and contour of the sitting surface.
- (2) characteristics and dimensions of cushioning and covering materials.
- (3) location of the seat unit and its supporting structure within the aircraft.
- (4) clearances of the seat unit and its occupant from aircraft structure.

### 2. Human Factors Requirements:

a. Preventing interference with performance of primary mission: The primary mission of both the crew chief and the door gunner of a UH-1 B or D model helicopter is to defend the flanks and belly of the aircraft with fire from the M-60 machine guns mounted in the door openings of the cargo compartment. The two crewmen sit on the most outboard of the troop seats, with the crew chief on the left and the door gunner on the right. Each crewman faces out the door on his side of the cargo compartment, but turned slightly forward so that he can search for possible targets. When

a target to the flank is detected, the crewman fires at it and must begin to swivel aftward in his seat to prevent the gun from being thrown off target by the relative motion of the aircraft. When the crewman detects and attempts to engage a target beneath the aircraft, he is forced to rise to a half-squatting position and lean out the door against the pull of his safety restraint. Any design for a protective seat unit must permit these body movements so that the weapon may be fired straight down, forward, laterally and aft.

b. Preventing safety hazards:

The seat unit must be designed with as few safety hazards as possible. This is particularly true of possible crash hazards.

(1) The seat unit must not interfere with the proper operation of the crewman's safety restraint under routine and emergency flight conditions.

(2) The seat unit must permit rapid exit from the aircraft. No projections which might entangle the crewman's clothing or equipment can be incorporated.

(3) The seat unit must be well secured to aircraft structure.

(4) All sharp corners, edges and projections must be rounded and padded. All straps, laces and buckles must be secured to prevent their flapping about in the slipstream.

(5) The crotch protective portion of the unit should be attached to the seat portion in such a manner that it will deflect away from the crewman when it is struck sharply.

(6) The seat unit must not swivel uncontrollably, but must permit the crewman to "steer" it by means of foot and leg pressure against the floor of the aircraft.

(7) The sitting surface and the crotch protector must have sufficient padding; to prevent the damaging effects of turbulence and vibration.

c. Reducing fatigue:

Fatigue can best be reduced by providing a well-balanced seat unit, shaped and located to permit a stable but relaxed body position for effective operation of the weapon.

(1) The sitting surface must not be so deeply contoured that it will prevent the crewman from occasionally changing his position to increase blood flow in the buttocks. The seat location with respect to aircraft structure must be conducive to postural changes.

(2) The seat must pivot easily and smoothly by means of foot and leg movements only, as shoulder and hip rotation will not only require much more effort but also reduce aiming steadiness.

d. The elimination of incompatibilities with other equipment:

(1) The seat unit should accommodate all aircrewmembers whose body dimensions range from the 5th to the 95th percentile, while they are wearing their complete combat equipment including any torso or leg armor protection, sidearms, canteens and survival kits.

(2) The seat unit must not interfere with the operation of the machine gun or the storage and loading of ammunition.

(3) The seat unit should be located where it will provide adequate clearance in all directions for the man and his equipment. Mission performance will be degraded by crowding the crewman into aircraft structure, on-board equipment or transported loads.

e. Comfort:

Subject to space, weight and cost limitations, the seat unit should be as comfortable as possible. This will not only provide a more pleasant working environment, but also reduce fatigue and its deleterious effects on aiming steadiness.

(1) The sitting surface should allow drainage of perspiration or rain water without becoming water-soaked or slippery.

(2) The surface covering should be an effective thermal insulator, as the seat unit will be exposed to intense solar radiation. If the covering is a poor insulator (such as the vinyl upholstery commonly used in automobiles), annoying leg and buttock irritation may result when the crewman first sits down.

(3) The seat unit should provide an adjustable back rest for the lumbar region of the spine, analagous to that of a well-designed typist's chair. No single addition could do more to reduce fatigue, although the weight penalty to the aircraft could be quite severe.

3. Design Criteria:

a. Dimensions of the protective seat unit:

In order to accommodate and protect the 95th percentile aircrewman, yet not hinder the 5th percentile aircrewman, the dimensions of the seat unit should be as follows (values derived from pertinent U.S. military anthropometric surveys, with suitable allowances for clothing):

(1) Seat width: 17 inches, measured 3 inches back from the intersection of the crotch protector and the sitting surface.

(2) Seat depth: 12 inches at centerline.

(3) Minimum width of crotch protector:  $3\frac{1}{2}$ -inches, measured 2 inches above the compressed sitting surface.

(4) Maximum width of crotch protector:  $7\frac{3}{8}$  inches, measured  $6\frac{3}{4}$  inches above the compressed sitting surface.

(5) Vertical height of crotch protector:  $7\frac{1}{8}$  inches above the compressed sitting surface measured along the centerline.

b. Contour of the sitting surface:

Damon and Stoudt<sup>(1)</sup> recommend a completely flat seat pan, which will allow occasional changes of posture. To prevent the crewman's sliding off the flat sitting surface under turbulent flight conditions, the side and back edges should be curved upward one inch.

c. Contour of crotch protector:

The crotch protector should have a slight forward curvature in the genital region. One inch forward curvature at a height of three inches above the compressed sitting surface appears to be adequate from anatomical considerations, although the exact curvature must be determined empirically. To further protect the crewman when he slides forward during a crash, the crotch protector should be hinged to deflect forward level with or below the seat pan. There must be a positive stop to prevent the crotch protector from moving to the rear in the event of a projectile hit.

d. Edge finish:

All edges should be smoothly rounded to  $3/8$ -inch minimum radius and covered.

e. Seat cushioning:

(1) Damon and Stoudt<sup>(1)</sup> recommend a minimum of one inch cushioning under the ischial tuberosities to allow adequate blood circulation in the buttocks.

(2) Bondurant<sup>(2)</sup> recommends a maximum cushion thickness of 3 inches to prevent amplification of accelerations which cause compression fractures of the spine.

(3) Whittenberger<sup>(3)</sup> recommends a 3.5-inch thick cushion of poly-ether urethane foam of 2.1 - 2.5 pounds per cubic foot density as the best compromise between comfort and resistance to "bottoming".



(4) Whittenberger further recommends the equivalent of Goodyear C-25 hard polyether foam based on this material's uniform compressability, compression set and hysteresis characteristic. The 25% deflection load rating is 46 pounds per 50 square inches, while the 50% deflection load rating is 72.0 pounds. Hysteresis reduces these load ratings by approximately 20 percent.

(5) A 3-inch thick cushion compressed to fit in a 2½-inch thick cover appears optimum, if the heavier density material (2.5 lb. cu. ft.) is used. The cushion should cover the entire sitting surface, including the rolled side and back edges.

f. Covering materials:

(1) The standard heavyweight ballistic nylon fabric appears to offer the desired surface characteristics of water drainage, non-absorbency and thermal insulation without being excessively slippery. A water impermeable layer is required beneath the cover, however, to prevent the foam from absorbing rain-water and perspiration.

(2) The ballistic nylon fabric also appears suitable for covering the crotch protector.

g. Location of seat unit and supporting structure:

As the seat unit and its supporting structure will most probably be added to the existing troop seat, the locations specified should be used only as guidelines to be followed whenever possible.

(1) Location forward of bulkhead: Under ideal conditions, the seat pivot should be located midway in the door opening to provide maximum horizontal traverse for the machine gun. If a close approximation to the ideal location is not possible, the seat pivot should be located a minimum of 11.5 inches forward of the bulkhead to provide clearance for swivelling and not less than 29 inches behind the rear wall of the cockpit to provide knee room plus three inches clearance for lower leg armor.

(2) Location from edge of door: The back of the seat, when turned to face out the door, should be a minimum of 28.0 inches from the edge of the door sill to allow the seat to be pivoted by foot and leg pressure alone. No part of the seat/groin unit should be located any closer to the door opening than one inch.

(3) Height above the floor: The present troop seat is located 41 inches above the floor of the cargo compartment. This location provides a clearance of 41 inches. If the seat/groin unit is located at the

present troop seat level or higher, the percentile clothed and helmeted sitting heights accommodated will be as tabulated below:

<u>Height of Sitting Surface above floor</u>	<u>Percentile Erect Sitting Height Accommodated</u>	<u>Percentile Slumped Sitting Height Accommodated*</u>
15	95	99.8
16	81	90.0
17	56	75
18	29	79

\*Based on 1 3/4-inch slump.

b. Clearance from structure:

If any of the above location criteria cannot be met, the seat unit must be located such that it and the 95th percentile combat clothed and equipped aircrewman and his weapon remain at least one-half inch from all aircraft structure. Consideration must also be given to the possible relocation of on-board equipment, and the revision of present loading plans in order to insure adequate clearances for the seat/groin unit and its occupant.

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Design	8					
Seat armor	9					
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