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DESIGN, DEVELOPMENT AND QUALIFICATION TESTING OF THE U. S. NAVY NES-21A PARACHUTE ASSEMBLY

Jon T. Matsuo

Naval Aerospace Recovery Facility

Prepared for:

Naval Air Systems Command

July 1974

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This report covers the design, development, and the U. S. Navy Service Qualification Program conducted on the NES-21A personnel parachute assembly. The NES-21A assembly was designed by personnel of the NAVAERORECOVFAC (Naval Aerospace Recovery Facility) for use in ejection seats of U.S. Navy T-33B and QT-33A aircraft. The NES-21A design objective was to provide a retrofitable replacement for the existing NS-3 personnel parachute assembly which

would operate with a decreased opening time. This factor would improve aircrew survivability in the low speed, zero altitude operational envelope. This improvement was accomplished principally by the incorporation of a 40-inch diameter internal pilot chute and main canopy PDVL (Pull Down Vent Lines).

The qualification testing program was based on MIL-STD-858, "Testing Standard for Personnel Parachutes". Because the NES-21A parachute assembly is identical in many respects to the existing NS-3 parachute assembly, many testing requirements were satisfied by virtue of its high content of similiar, previously qualified components.

The NES-21A parachute assembly will perform satisfactorily as presently designed, in the QT-33A or T-33B aircraft (with T-33B Airframe Change No. 187 incorporated) at 90 KTAS (Knots True Airspeed) and above, for ground level and higher altitude ejections.

TECHNICAL REPORT NO. 1-74

U.S. NAVAL AEROSPACE RECOVERY FACILITY
El Centro, California

DESIGN, DEVELOPMENT AND QUALIFICATION TESTING OF THE U.S. NAVY NES-21A PARACHUTE ASSEMBLY

by

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July 1974

ABSTRACT

This report covers the design, development, and the U.S. Navy Service Qualification Program conducted on the NES-21A personnel parachute assembly. The NES-21A assembly was designed by personnel of the NAVAERORECOVFAC (Naval Aerospace Recovery Facility) for use in ejection seats of U.S. Navy T-33B and QT-33A aircraft. The NES-21A design objective was to provide a retrofitable replacement for the existing NS-3 personnel parachute assembly which would operate with a decreased opening time. This factor would improve aircrew survivability in the low speed, zero altitude operational envelope. This improvement was accomplished principally by the incorporation of a 40-inch diameter internal pilot chute and main canopy PDVL (Pull Down Vent Line).

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GLOSSARY OF TERMS

Airspeed at Pack Open	The airspeed (wind corrected) of the dummy as as determined from the cinetheodolite data at the time the parachute pack opens.
Altitude Loss	The vertical distance the dummy travels during a given interval.
Deployment Time	The time interval between pack open and line stretch.
Dynamic Pressure	One-half of the product of the air density and the square of the airspeed.
Full Open	The first moment that the canopy attains a full hemispherical shape.
Gross Weight	The total weight of the torso dummy and parachute assembly.
Line Stretch	The moment when the suspension lines are initially observed to be fully extended after quarter-bag separation.
Opening Force	The maximum total force applied to the parachute risers during inflation of the canopy.
Opening Time	The time interval between parachute pack open and canopy full open.
Pack Open	The first instant that the parachute pack flaps are observed to open, or first instant pilot chute is seen.
Snatch Force	The total first peak force imposed on the risers due to the sudden acceleration of the canopy mass at line stretch.

INTRODUCTION

Background. The NAVAERORECOVFAC was directed by Naval Air Systems Command to conduct a design and qualification program to update the present T-33B aircraft ejection seat egress system, in order to improve the low speed/altitude egress performance. The design objective was to improve survivability within an ejection envelope of 90 KTAS and zero altitude AGL (Above Ground Level); and 400 KTAS and 3,000-ft. altitude MSL (Mean Sea Level).

Principal features of the proposed improvement are: Multi-stage drogue parachute designed to provide improved seat/man stabilization and deceleration; 40-inch internal pilot chute, and PDVL (Pull Down Vent Line) to decrease the deployment and development times respectively, of the main parachute.

Purpose. Purpose of the report is to present design and qualification performance data resulting from testing of the NES-21A parachute assembly. The NES-21A was designed as a low cost, retrofitable parachute which would improve the operational envelope of the T-33 aircraft ejection system, as compared to the existing NS-3 parachute assembly.

DESCRIPTION OF EQUIPMENT TESTED

General. The NES-21A (Figure 1) evolved from, and thus is similar to the latest configuration of the NS-3 parachute assembly currently used in the T-33 series aircraft; both assemblies make use of several identical components.

1. The NES-21A assembly P/N 693AS103, -1 (regular), -2 (oversize), differs from the NS-3 P/N 264AS100-1 (regular) and 264AS109-1 (oversize) in the following details:

a. 30-in. pilot chute is replaced with a 40-in. pilot chute (P/N 693AS106-1) (see Figure 2).

b. PDVL (P/N 693AS107-1) is added to the main canopy (see Figure 3).

c. Container (P/N 693AS104-1) (see Figures 4 and 5) is similar to the NS-3 container (P/N 264AS101-1) but incorporates two additional stow loops to accomodate the re-routed arming cable-hook assembly and housing of the

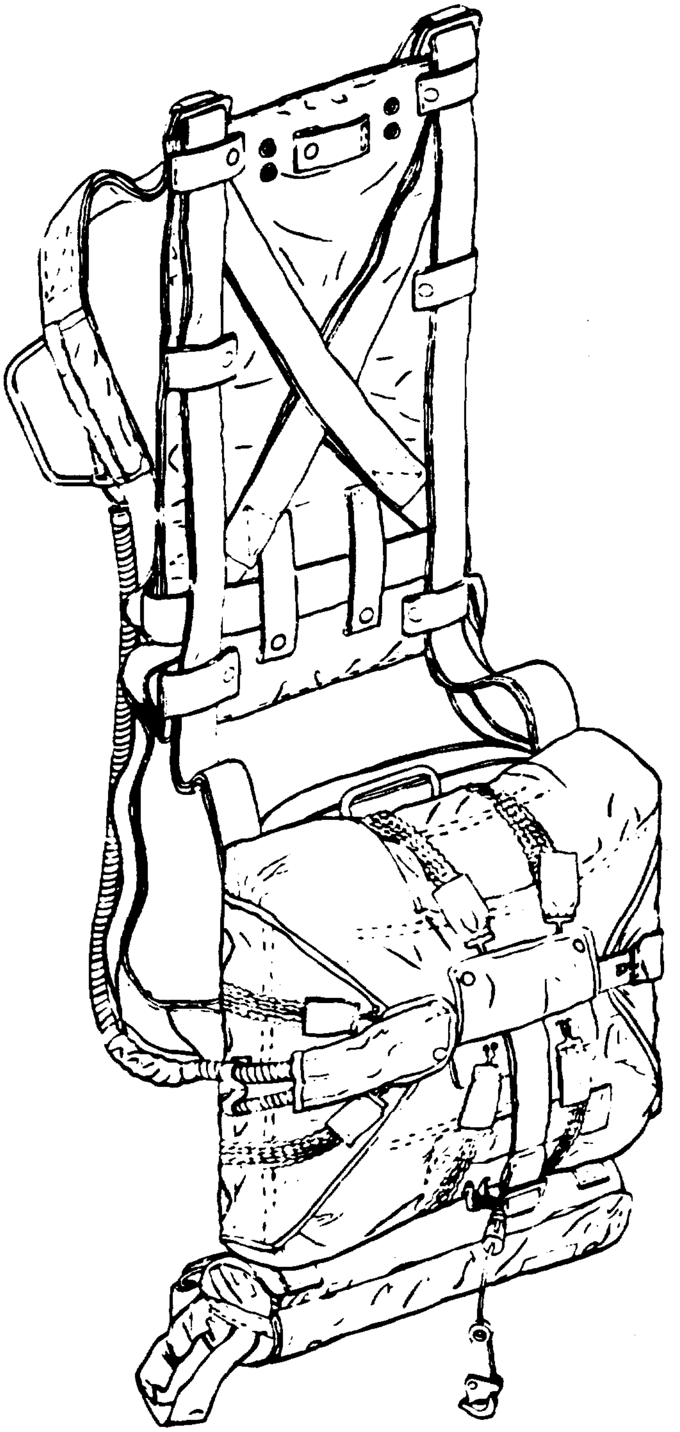


FIGURE NO. 1. NES-21A PERSONNEL PARACHUTE ASSEMBLY

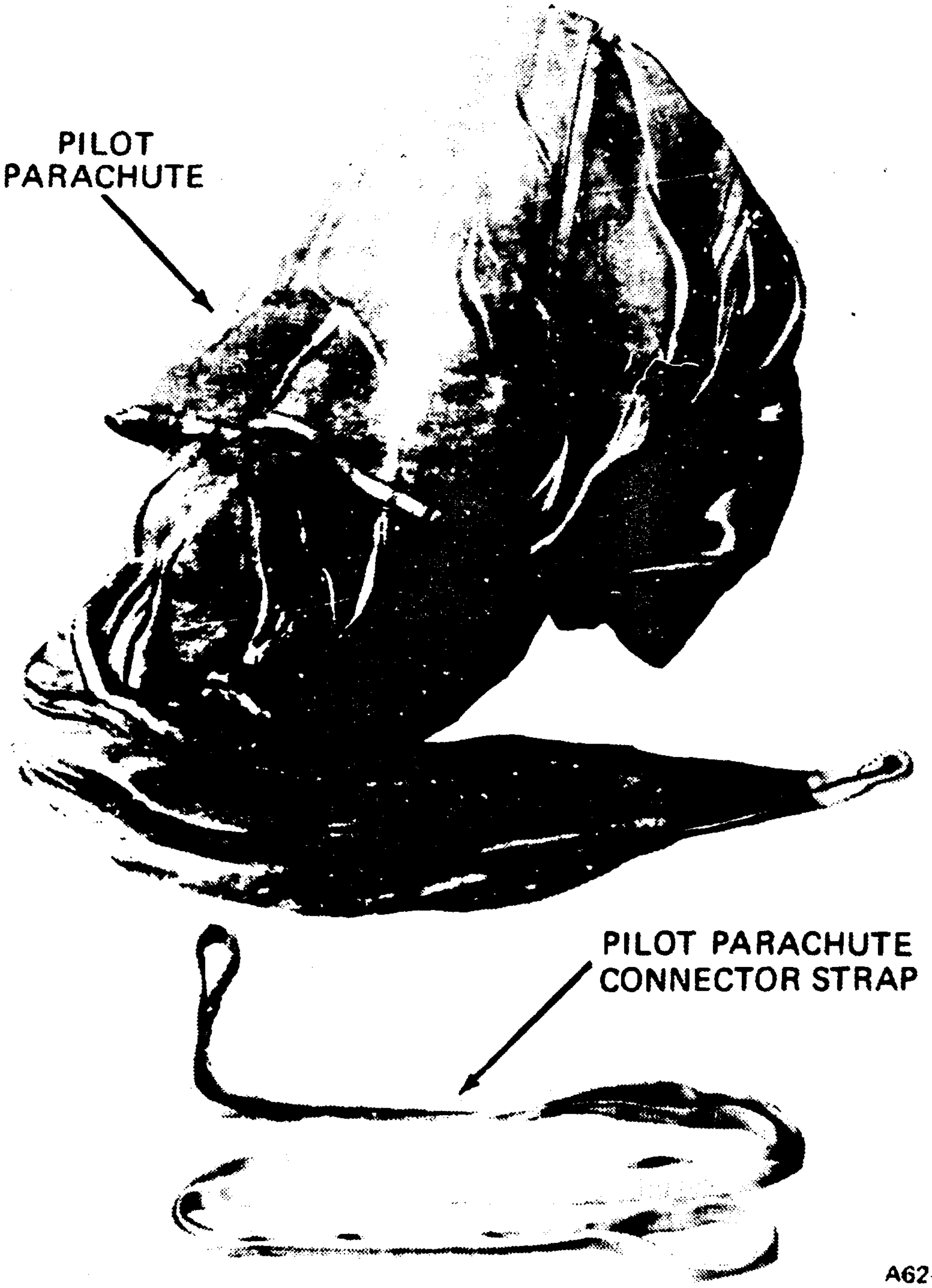


FIGURE NO. 2. PILOT PARACHUTE AND CONNECTOR STRAP ASSEMBLY

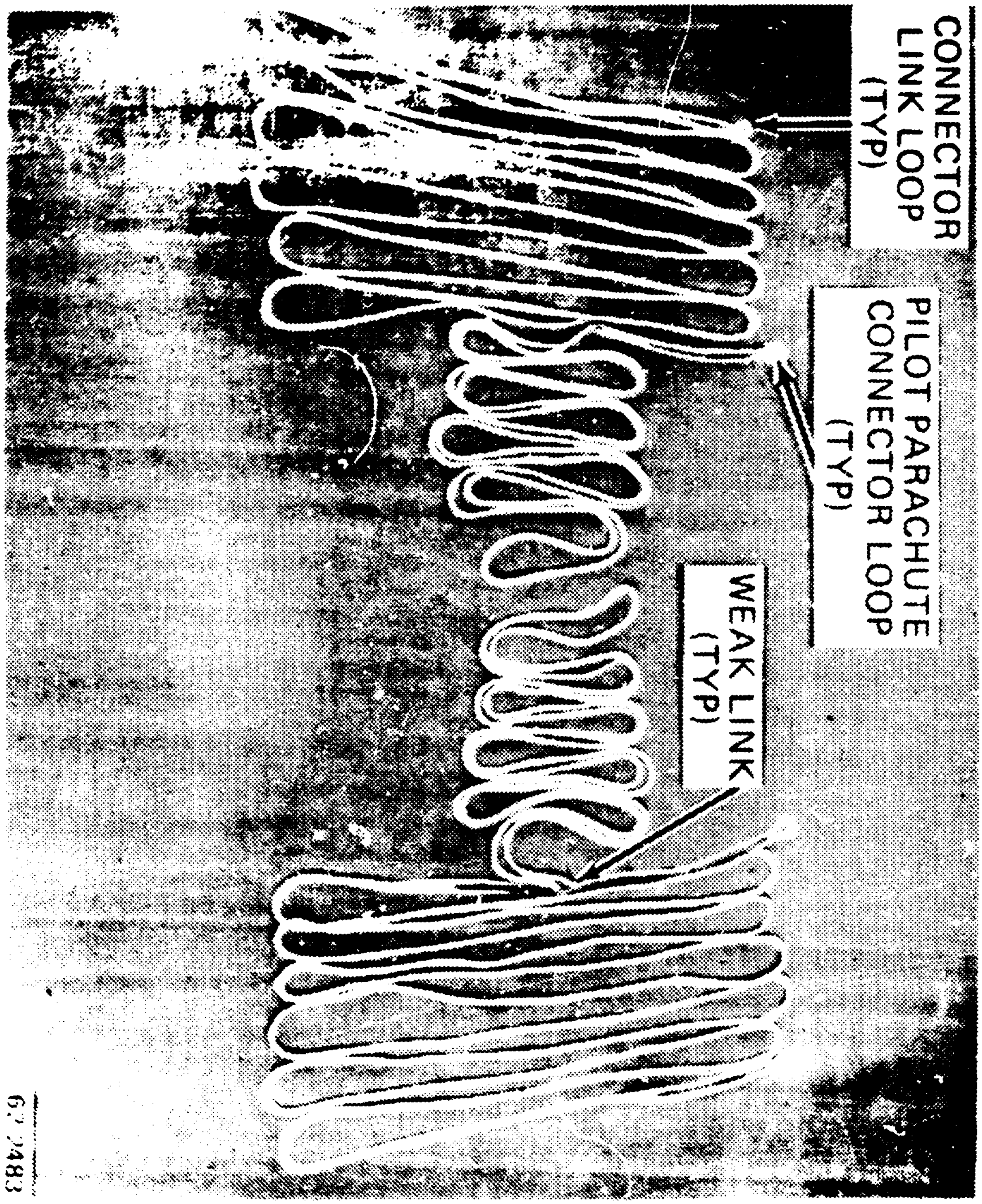


FIGURE NO. 3. PULL DOWN VENT LINES

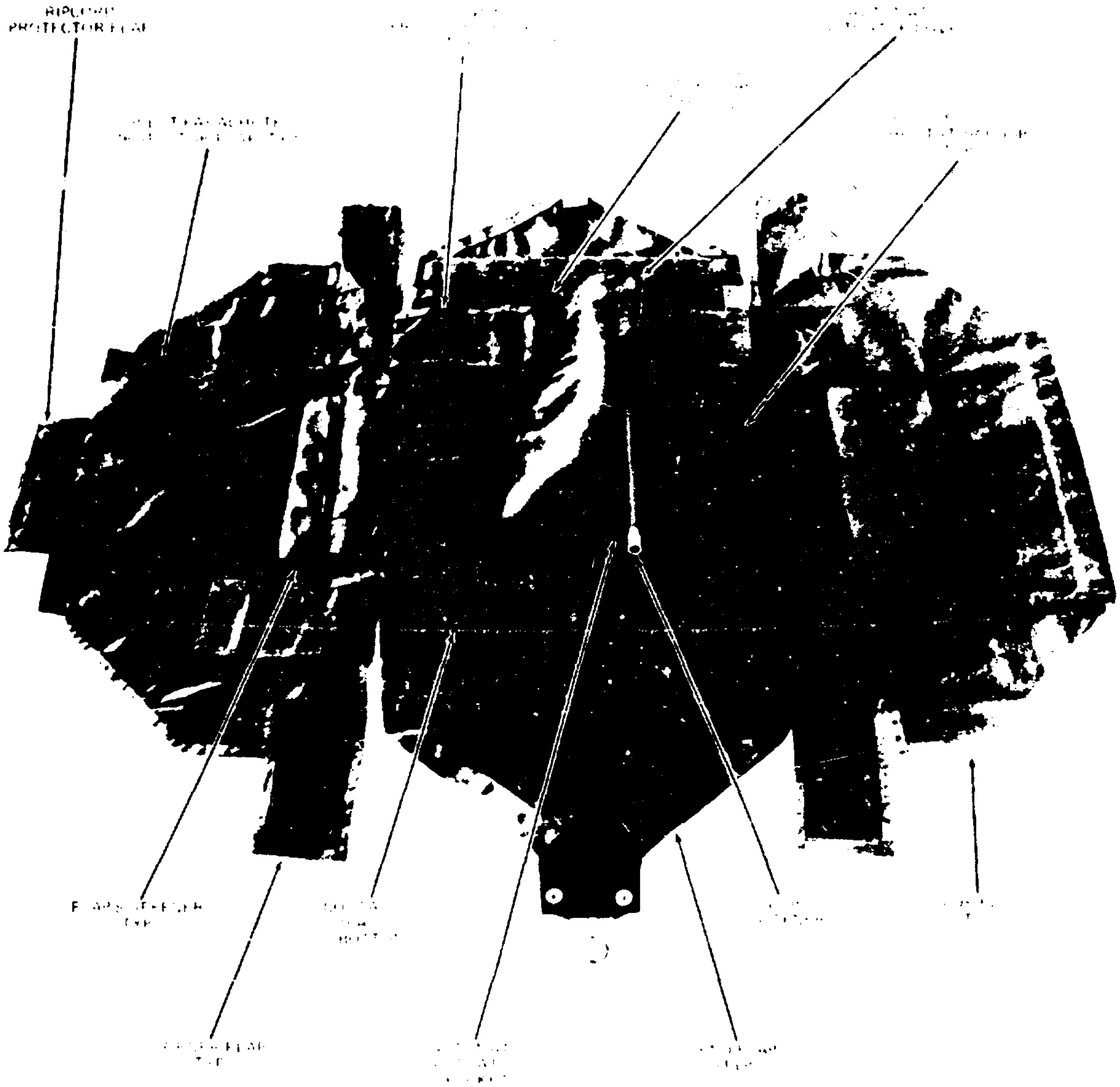


FIGURE NO. 4. NES-21A CONTAINER ASSEMBLY (INSIDE)

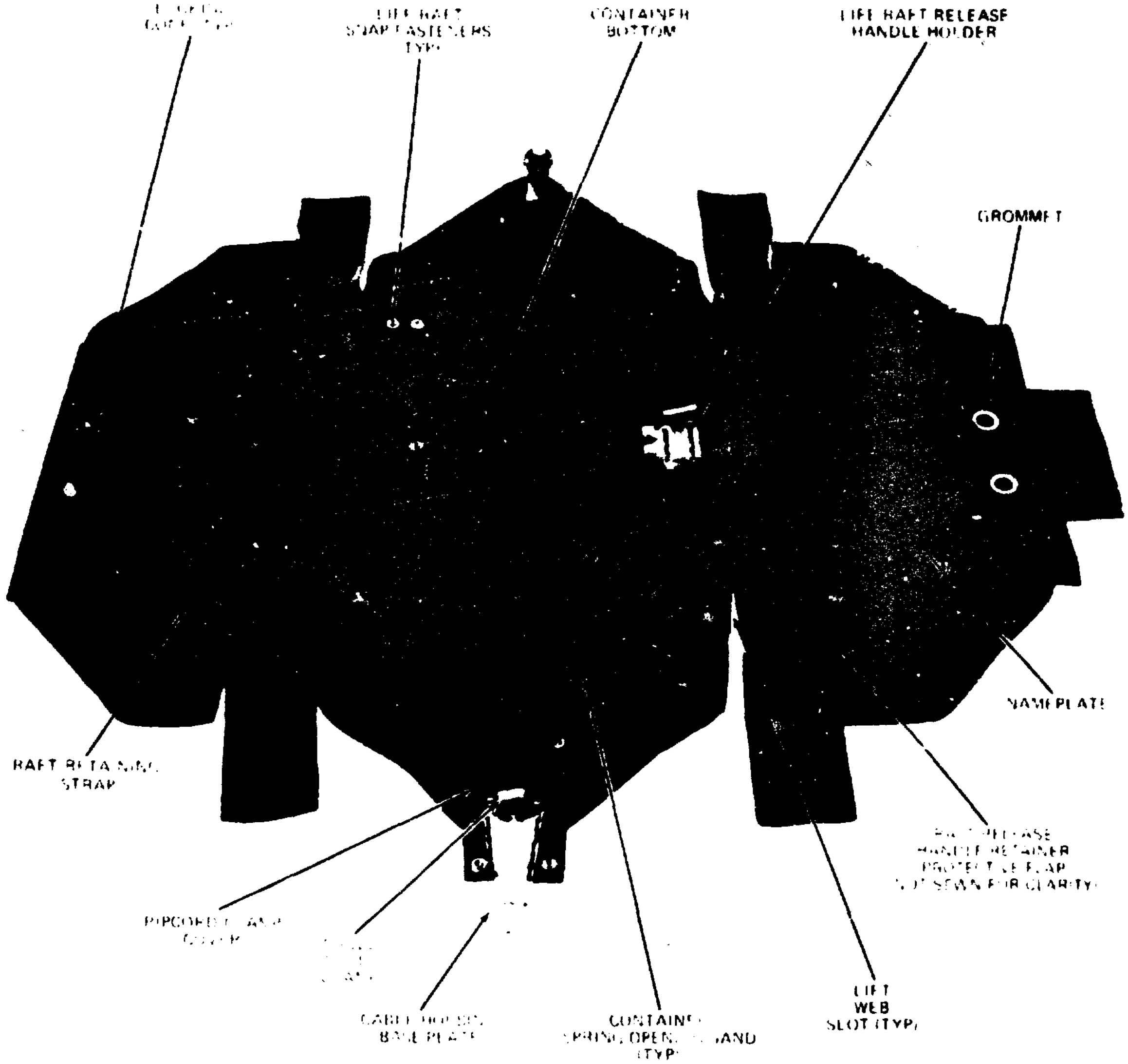


FIGURE NO. 5. NES-21A CONTAINER ASSEMBLY (OUTSIDE) automatic parachute actuator (see Figure 6) to permit a more direct pull using a floor-mounted attachment point, and one pack opening band (P/N MS70105-3) is added.

2. The NES-21A uses the following items which are identical to components of the NS-3 parachute assembly:

a. Harness (see Figure 7)

b. Back cushion, seat pan, life raft and emergency oxygen (see Figure 8).

3. The NES-21A zero delay lanyard subsystem differs from the current zero delay lanyard and incorporates the following advantages per ACC (Aircrew Systems Change) No. 181:

a. Eliminates the requirement for manual hookup at take-off with subsequent unhooking after take-off and hookup during landing. The NES-21A is engaged at all times thus unburdening the pilot and minimizing the human error factor.

b. Eliminates an approximate 300- to 400-lb. side load on the seat during ejection. It also places the lanyard/aircraft attachment along the longitudinal center line of the aircraft and seat, thus reducing the actuation force from 300-400 pounds to 10-20 pounds. The reduction in pull force improves ejection performance by eliminating eccentric loading that exists with ACC No. 181 configuration. The actuation force (retardation force on the seat) is reduced to a value where it has no significant effect on escape performance.

4. The procedure for stowing canopy suspension lines in the parachute container for the NES-21A differed from the NS-3 in order to accommodate the PDVL used to assist parachute deployment.

Scope of Tests. The NES-21A was developed and tested concurrently with the T-33B ejection seat drogue parachute program.

In accordance with MIL-STD-858, "Testing Standard For Personnel Parachutes", the following standard methods for developmental and qualification testing of man-carrying parachute assemblies were waived either entirely or partially on the basis that:

a. It is not a new concept (T101, T102, T103, T104, T105 and T107); and

b. Its similarity with qualified equipment (T106, T108, T109, T110, T111 and T112 considering parachute assemblies NS-3, NES-8B with PDVL and LW-3B with 40-in. pilot chute).

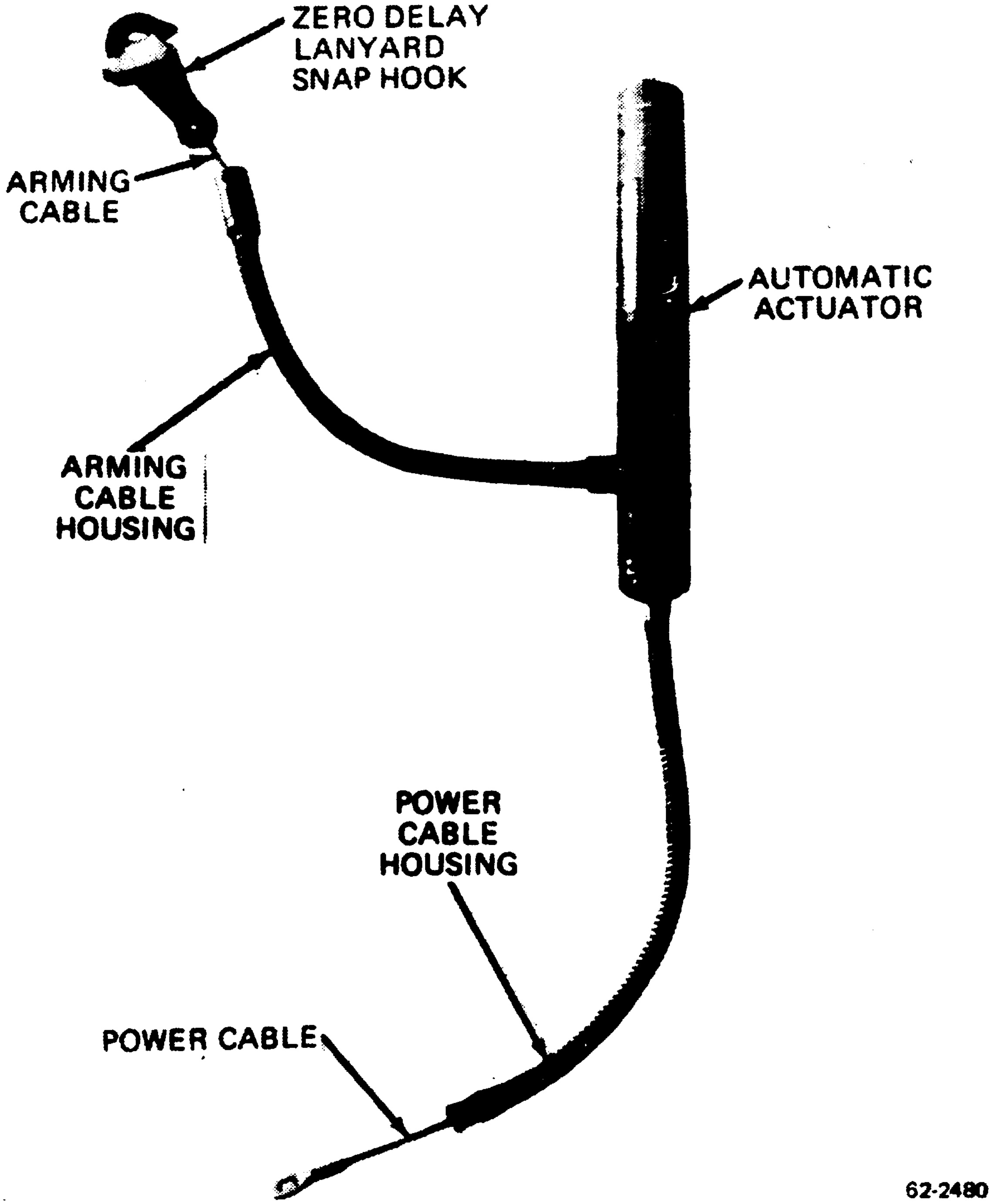


FIGURE NO. 6. MODEL 7000 AUTOMATIC PARACHUTE ACTUATOR

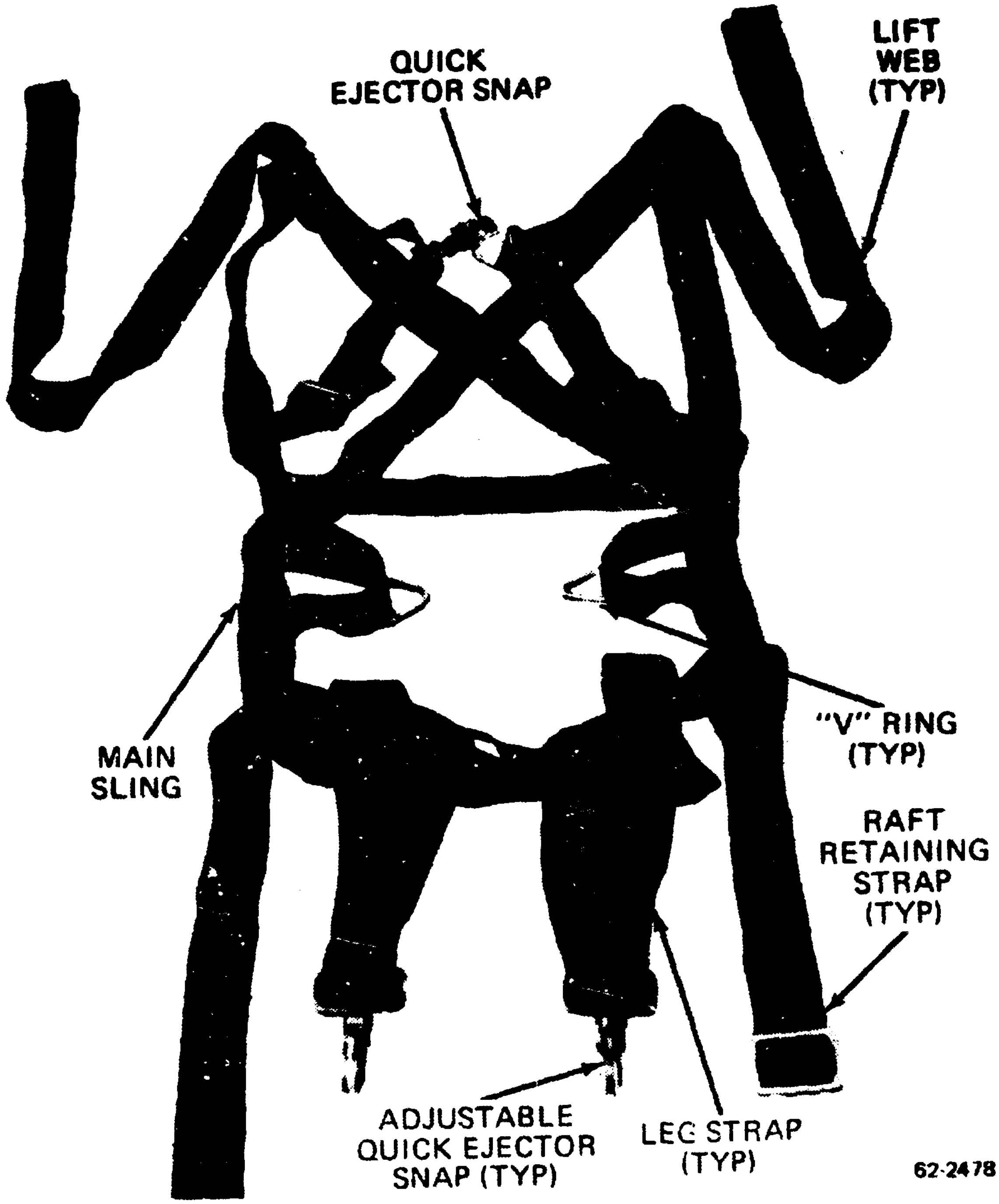
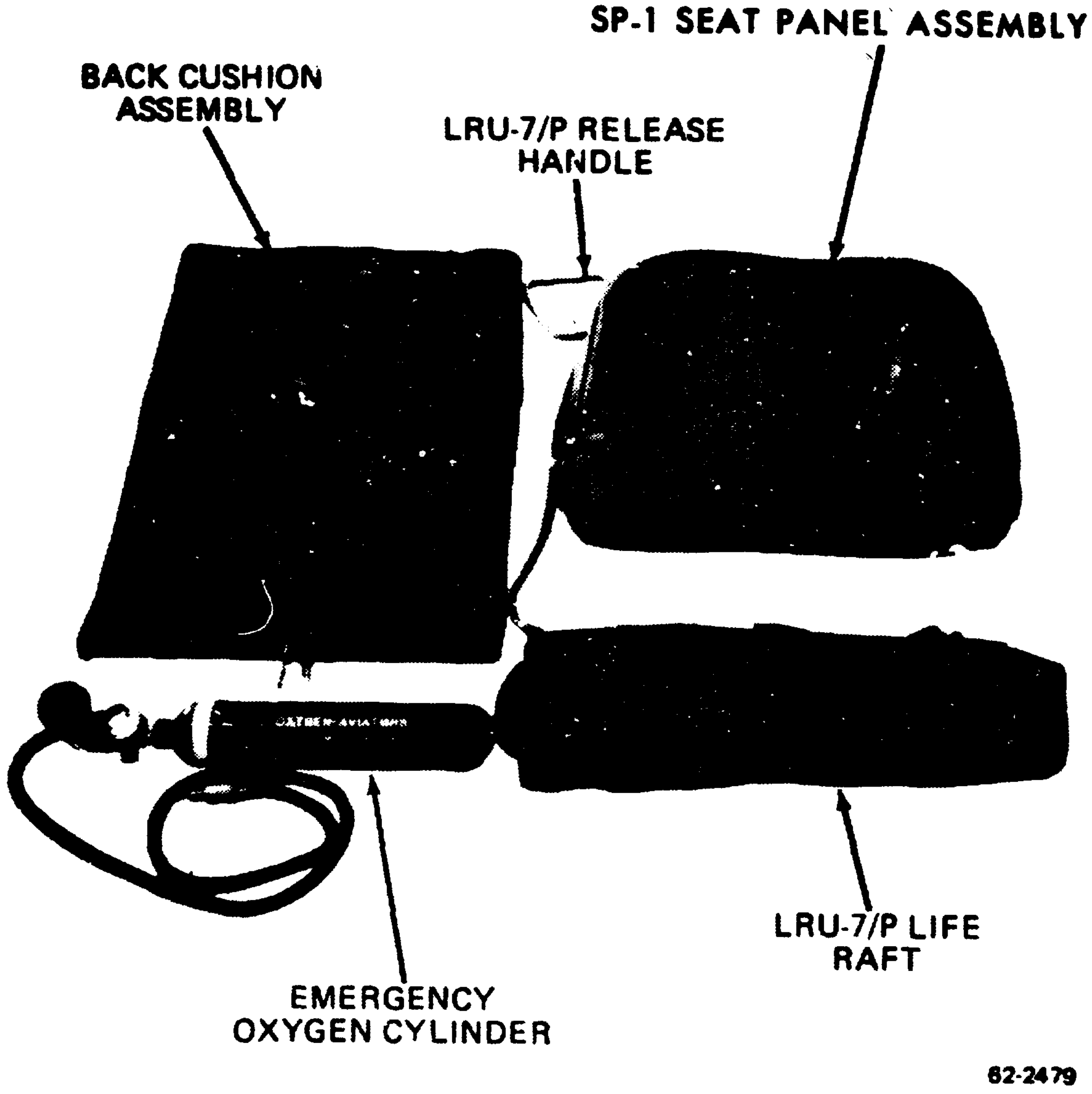


FIGURE NO. 7. NES-21A PARACHUTE HARNESS ASSEMBLY



'IGURE NO. 8. BACK CUSHION, SEAT PAN ASSEMBLY, LRU-7/P LIFE RAFT AND EMERGENCY OXYGEN CYLINDER

Qualification was based on the results of the following tests to demonstrate the suitability of the 40-in. pilot chute, addition of the PDVL and the redesigned container:

a. Aircraft ground level and airborne ejection seat system tests were conducted for qualification testing of the proposed T-33B ejection seat improvement program of which the NES-21A is a major component. Five preliminary truck-launched ejection seat system tests were conducted to develop and evaluate systems effectiveness and test procedures. Seventeen airborne ejection seat system tests (11 with drogue chute subsystem and 6 without) were conducted to evaluate seat-man collision and overall performance effectiveness. The airborne ejection seat system tests were made from the rear seat of a Navy TF9J aircraft at speeds from 90 to 400 KIAS (Knots Indicated Airspeed) and altitudes ranging from zero feet AGL to 3,000-ft. MSL.

b. Airdrop tests using torso dummies were conducted for design evaluation, airblast integrity, performance evaluation, and qualification testing of the NES-21A. Fourteen torso dummy airdrop tests were made using Navy NU1B, C-47 and A-3B aircraft. All tests were conducted using main riser strain gage links to obtain individual riser forces during parachute deployment and development. Launch speed varied from 90 to 170 KIAS with all drops being made at 3,000-ft. MSL and a gross weight of 263 (±) 5 pounds.

c. Twelve live jump tests were conducted to man-rate the NES-21A parachute assembly. All live jumps were made from the Navy NU1B and C-47 aircraft at 6,000-ft. MSL altitude, and at speeds of 44 to 90 KIAS.

METHODS OF TEST

Data Acquisition and Reduction.

1. Space Positioning. Askania and Contraves cinetheodolite cameras were used on all tests (except the five ground level runway ejection seat system tests) to obtain event times, altitude losses, airspeeds, rates of descent and dynamic pressures. The data were corrected to compensate for surface winds and standard National Advisory Committee for Aeronautics day conditions.

A Bowen Model 6 acceleration camera operated at 60 f.p.s. (frames per second) was used on the five ground level runway ejection seat system tests to obtain event times and altitude data.

2. Telemetric Equipment. TM (Telemetric Equipment) was used in conjunction with main riser strain gage links to obtain left- and right-hand riser forces during parachute deployment and opening for the torso dummy tests. Total riser force time histories were obtained by electronic summation of left- and right-hand riser forces.

3. Photographic Equipment. 16mm cameras were used on all tests for ground-to-air, plane-to-air, and air-to-air motion picture coverage. Color film was exposed at rates of 50, 64, 100, 128 and 200 f.p.s. and still photographs were taken to document rigging and damage using a press-type camera.

TEST METHODS AND PROCEDURES

Ejection Seat System Tests.

1. Test Equipment. The NES-21A was tested in its operational environment as a component part of a proposed modified T-33B aircraft ejection seat egress system. The seat modifications primarily consisted of the addition of:

a. A rocket catapult

b. An automatic 0.5-second delay seat-man separation system

c. Seat bucket filler blocks

d. A seat drogue parachute system (except on six tests where no drogue chute was used for comparative purposes); and

e. A center floor attach point for the automatic parachute actuator arming cable snap hook.

The tests results of the proposed modifications to the T-33B ejection seat egress system are the subject of a separate document NAVAERORECOVFAC Technical Report No. 6-74. Articulated dummies weighted either to 145 or 210 (±5) pounds, were used for all ejection seat tests of the NES-21A.

2. Test Procedure. Seventeen T-33 ejection seat system tests were conducted with the system being launched from the rear seat of a Navy F-9 aircraft. Test events/procedures were as follows:

a. At the proper time, an electrical circuit was closed and a pressure cartridge fired, which in turn actuated an M-28 gas initiator. This simultaneously fired the rocket catapult, the drogue gun assembly (except on six tests), and the one-half-second time delay M-72 gas initiator of the seat/man separator system.

b. Upward movement of the ejection seat in turn pulled the arming cable of the NES-21A automatic parachute actuator equipped with a 2-second time delay pyrotechnic cartridge.

c. Approximately 0.2 seconds after the rocket catapult had fired, the drogue gun (except on six tests) fired and deployed the drogue parachute canopy. At approximately 0.5 seconds after rocket catapult actuation, seat/man separation and rocket burnout occurred.

d. The seat and dummy free-fell separately for approximately 1.5 seconds. Approximately 2.0 seconds after first movement of the ejection seat, the automatic parachute actuator opened the NES-21A parachute container.

e. A spring-loaded, 40-inch diameter pilot chute deployed the standard 28-ft. diameter, flat circular personnel parachute canopy with standard short PDVL incorporated.

Airdrop Torso Dummy Tests.

1. Test Equipment. The test equipment consisted of a 263- (±5)-pound torso dummy with telemetric cavity and a reserve recovery parachute; the NES-21A parachute assembly which had been modified to accept main riser strain gage links and a 2-channel TM package. A NAVAERORECOVFAC-designed PDVL "daisy chain" manual release subassembly, and the standard U.S. Air Force 4-line (rear) release subassembly were incorporated during four tests (Nos. 1587, 1588, 0122 and 0123) to check structural integrity and compatibility of the release subassemblies with the NES-21A before the live jump tests were conducted.

2. Test Procedures. In tests conducted from the U-1B and C-47 aircraft, the torso dummies were launched individually from the side door. For these tests, the dummies were placed in an upright position adjacent to the door and then pushed out chest first. After exit of each dummy, the Model 7000 automatic parachute actuator of the NES-21A (2-second time delay) and the F-1B automatic reserve parachute actuator (10-second time delay) were armed simultaneously by a static line 3 feet long.

In tests conducted from the A-3 aircraft, the dummies were released individually from compartmented racks installed in the aircraft's bomb bays. The dummies were positioned in the racks with the head toward the line of flight and the parachute container facing upward. After exit of the dummy, the same procedures and equipment were used to arm the automatic parachute actuators as with tests from the U-1B and C-47 aircraft.

The TM equipment was calibrated and checked out immediately prior to each launch.

Live Jump Tests.

1. Test Equipment. Each parachutist used a NES-21A assembly and wore an underharness to which a reserve parachute assembly had been attached.

The NES-21A was modified to incorporate the PDVL daisy chain type of manual release and the standard Air Force rear suspension line release subassemblies previously tested on torso dummies. These modifications were made to alleviate any dangerous canopy oscillations and to minimize the possibility of ground impact injuries.

2. Test Procedures. Each parachutist assumed the uncontrolled airborne position - feet extended but together, head down looking toward feet, hands over reserve, elbows close to sides and torso bent slightly forward. After a time delay of 2 to 5 seconds, the NES-21A parachute assembly ripcord handle was pulled manually.

The test parachutists were instructed to descend normally during the first 1,000 feet and then to take whatever action they deemed necessary in an effort to minimize discomfort and avoid ground impact injuries. A jumper's evaluation report was submitted by all test parachutists, as a means of recording his subjective evaluation

Test Results And Discussion.

Ejection Seat System Tests. The test results and applicable remarks are shown in Table I. Figures 9 and 10 depict graphically the most pertinent data.

The runway (ground level) ejection seat test results were not plotted on Figures 9 and 10 because airspeed data required for specific events were not available. The opening time intervals (pack open to canopy first full open) were consistent with only 0.5 seconds difference between the slowest and the fastest. The altitude losses during the time intervals from pack open to canopy first full open, varied from 8 to 64 feet. The 56-foot variation in altitude loss is considered acceptable for the low altitude/low airspeed, pack open environment. The method of measurement used had an accuracy of ± 5 feet.

Figure 9 depicts the opening time interval envelope (pack open to canopy first full open) versus airspeed at pack open. The variations in opening time interval are typical for uncontrolled pilot chute deployment.

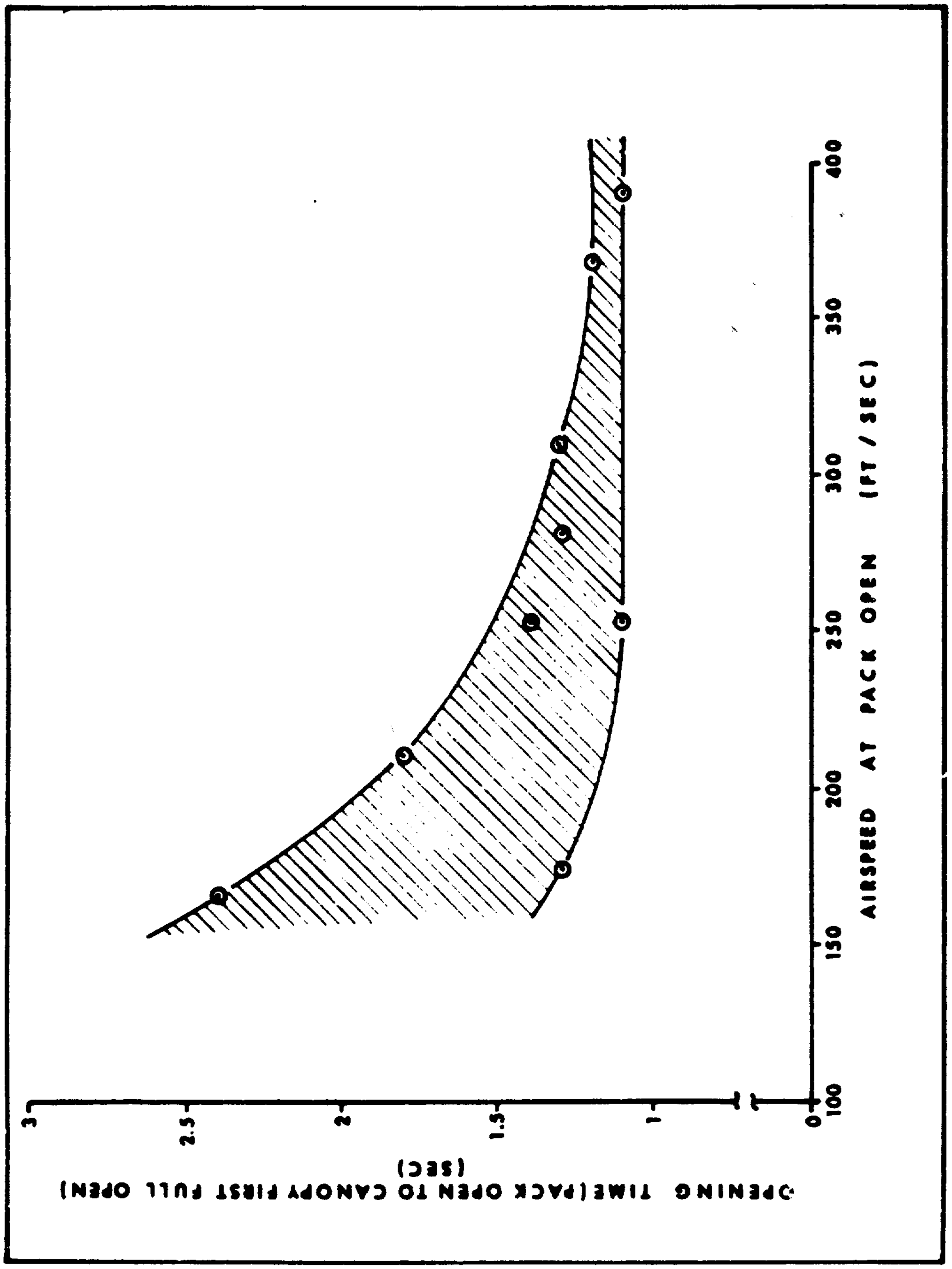


FIGURE NO. 9. EJECTED SEAT TESTS, NES-21A PARACHUTE ASSEMBLY, OPENING TIME (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN

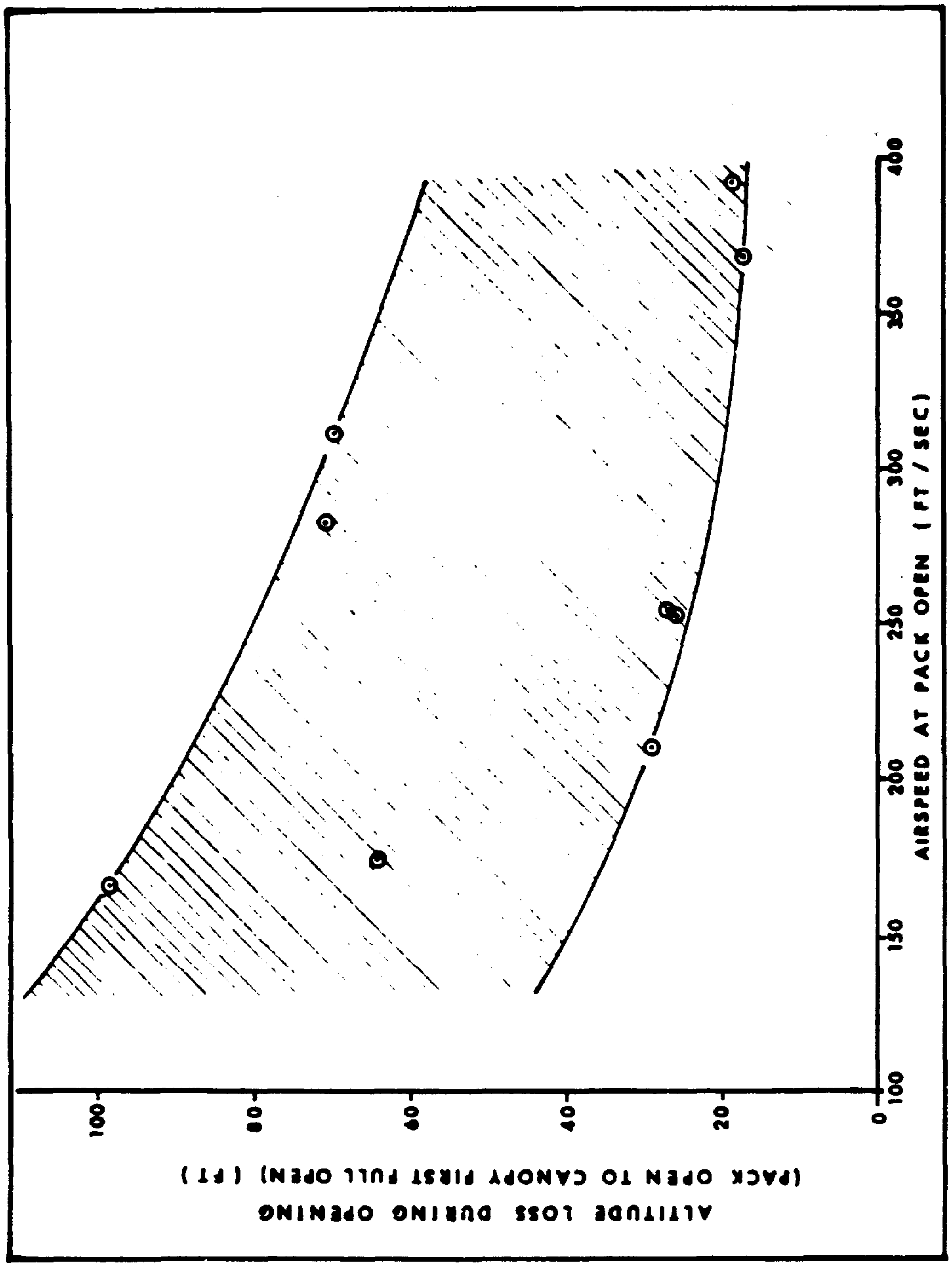


FIGURE NO. 10. EJECTED SEAT TESTS, NES-21A PARACHUTE ASSEMBLY, ALTITUDE LOSS DURING OPENING (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN

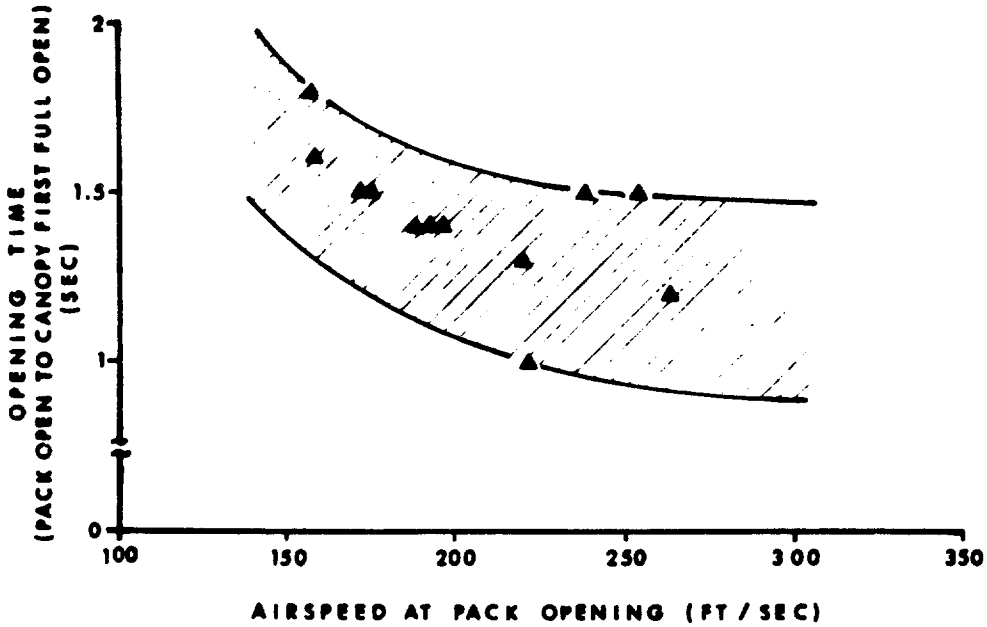


FIGURE NO. 11. TORSO DUMMY TESTS, NES-21A PARACHUTE ASSEMBLY, OPENING TIME (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN

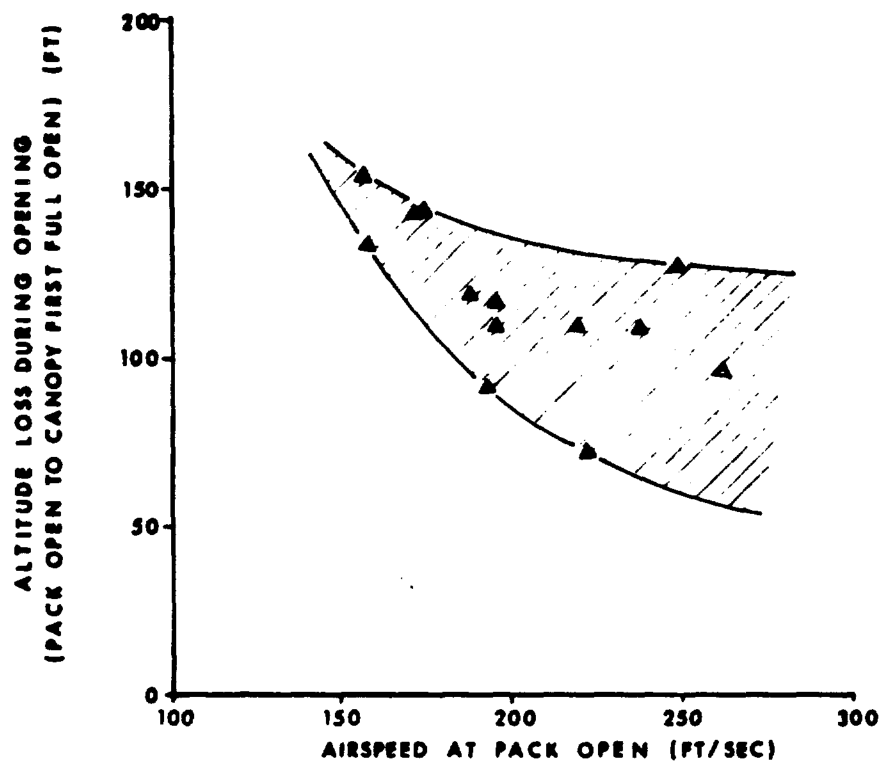


FIGURE NO. 12. TORSO DUMMY TESTS, NES-21A PARACHUTE ASSEMBLY, ALTITUDE LOSS DURING OPENING (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN

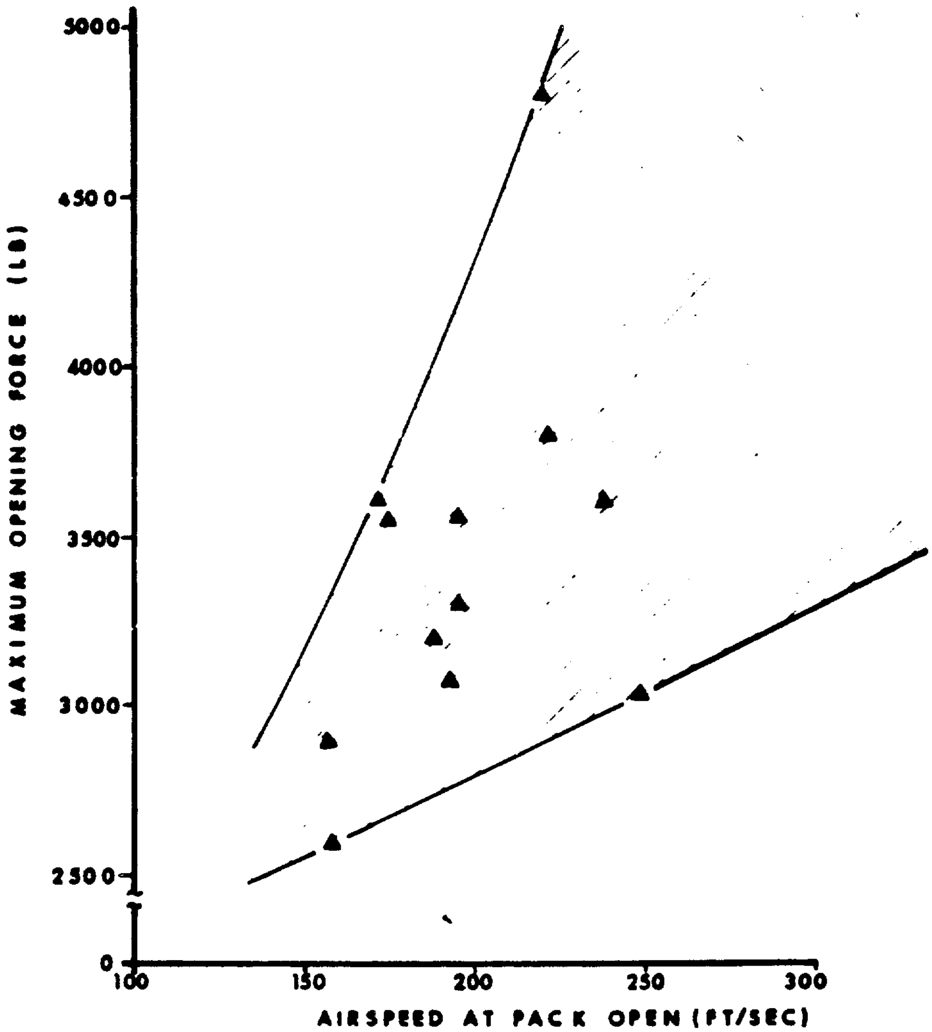


FIGURE NO. 13. TORSO DUMMY TESTS, NES-21A PARACHUTE ASSEMBLY, MAXIMUM OPENING FORCE VERSUS AIRSPEED AT PACK OPEN

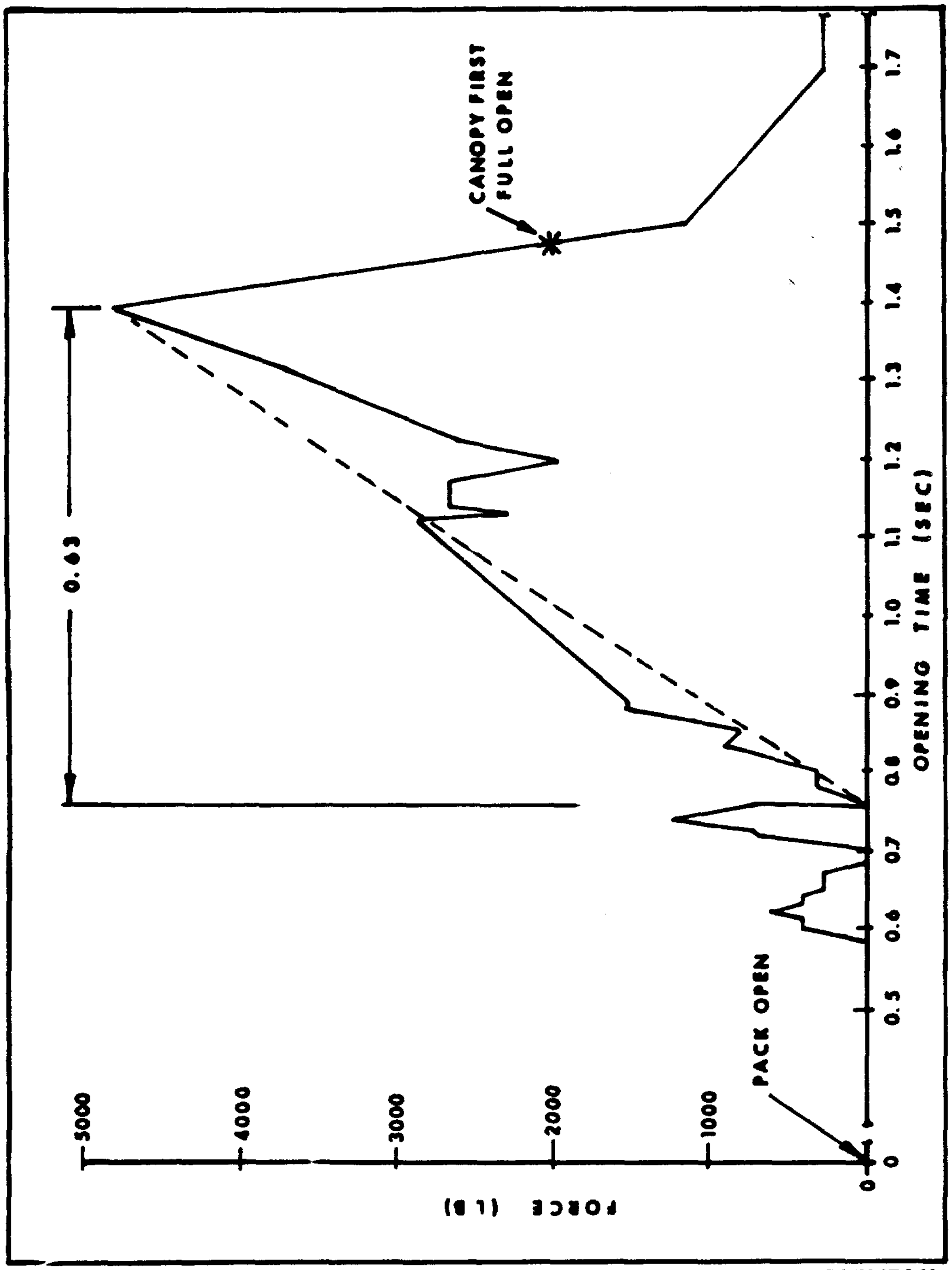


FIGURE NO. 14. TORSO DUMMY TESTS, NES-21A PARACHUTE ASSEMBLY, TYPICAL TOTAL RISER FORCE VERSUS TIME

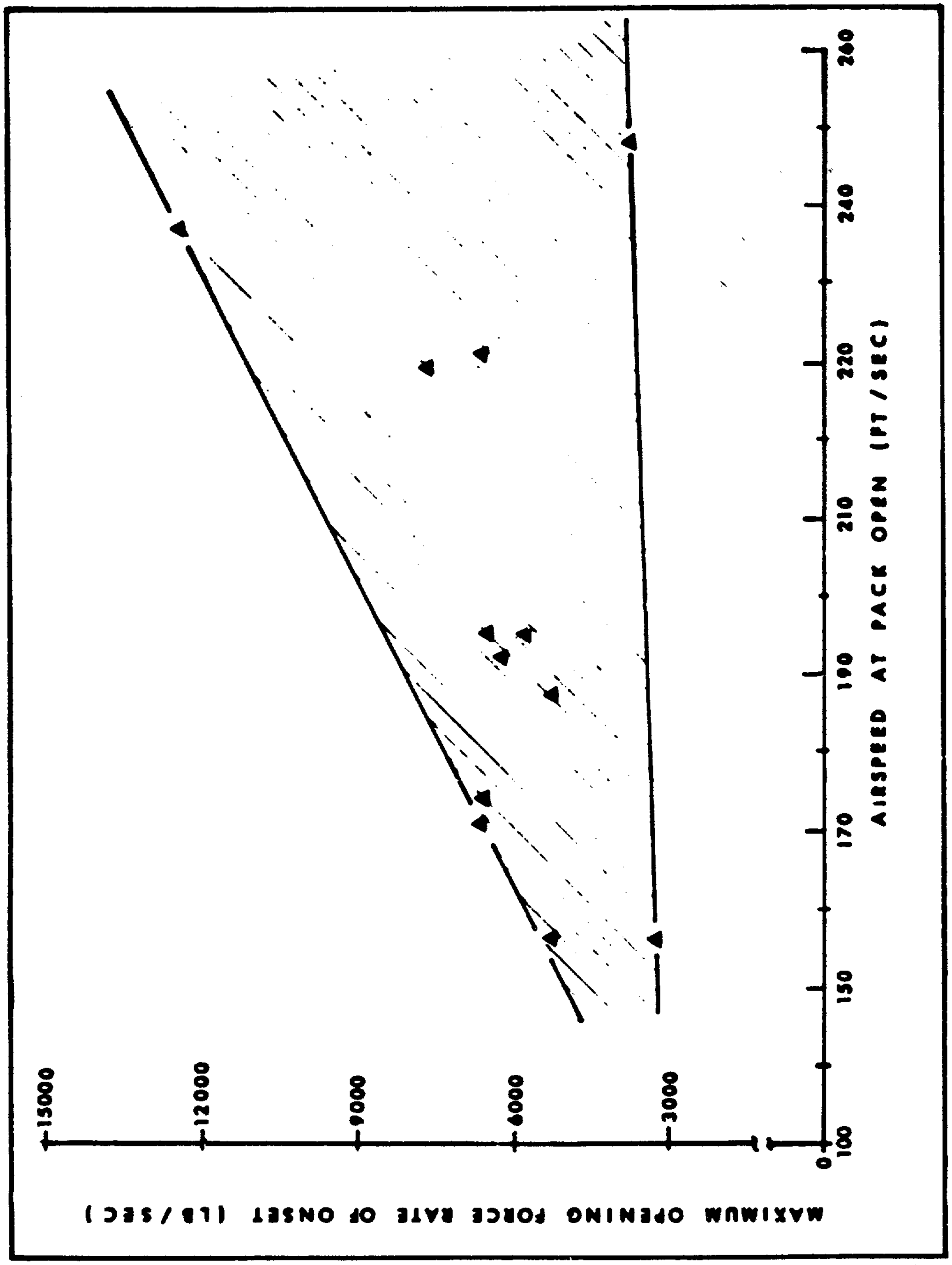


FIGURE NO. 15. TORSO DUMMY TESTS, NES-21A PARACHUTE ASSEMBLY, MAXIMUM OPENING FORCE RATE OF ONSET VERSUS AIR-SPEED AT PACK OPEN

Figure 10 depicts the altitude loss (during pack open to canopy first full open envelope) versus airspeed at pack open. The variation of 81 feet for the entire pack open airspeed range is not unusual for uncontrolled pilot chute deployment.

Torso Dummy Airdrop Tests. Test results and applicable remarks for each test are presented in Table II. Figures 11 through 15 depict, in graphic form, the pertinent data from Table II. Data from test No. 1584N were not used because of major damage to 50 percent of the parachute drag surface.

Figure 11 depicts the opening time interval envelope (pack open to canopy first full open) versus airspeed at pack open. The variations in opening time interval are considered excellent.*

Figure 12 shows the altitude loss (during pack open to canopy first full open) envelope versus airspeed at pack open. The 80-foot (maximum) variation for the entire pack open airspeed range is considered excellent.*

Figure 13 depicts the maximum opening force envelope versus airspeed at pack open measured at the parachute risers. A typical force-time history is illustrated in Figure 14. The absence of any significant snatch force is typical of uncontrolled deployment.

Figure 15 shows the opening force rate of onset envelope (pounds per second) versus airspeed at pack open. For drop test No. 1590N (Figure 14), the maximum increase in opening force was 4800 pounds during a period of 0.63 seconds for an average value of 7,620 pounds per second. Both the average maximum opening force and the average opening rate of onset of the NES-21A, when compared with the other Navy operational emergency personnel parachute assemblies (at comparable pack open airspeeds) were:

a. Approximately the same as the NES-8B or NES-14A, which utilizes the short PDVL;

b. Greater than the average maximum opening force and lower than the average opening force rate of onset of the NB-11, NES-12C, NES-15A, which utilize the spreading gun.

*The use of aerodynamically clean torso dummies tended to downgrade the significance of the relatively small variations when compared with tests in which articulated dummies were used.

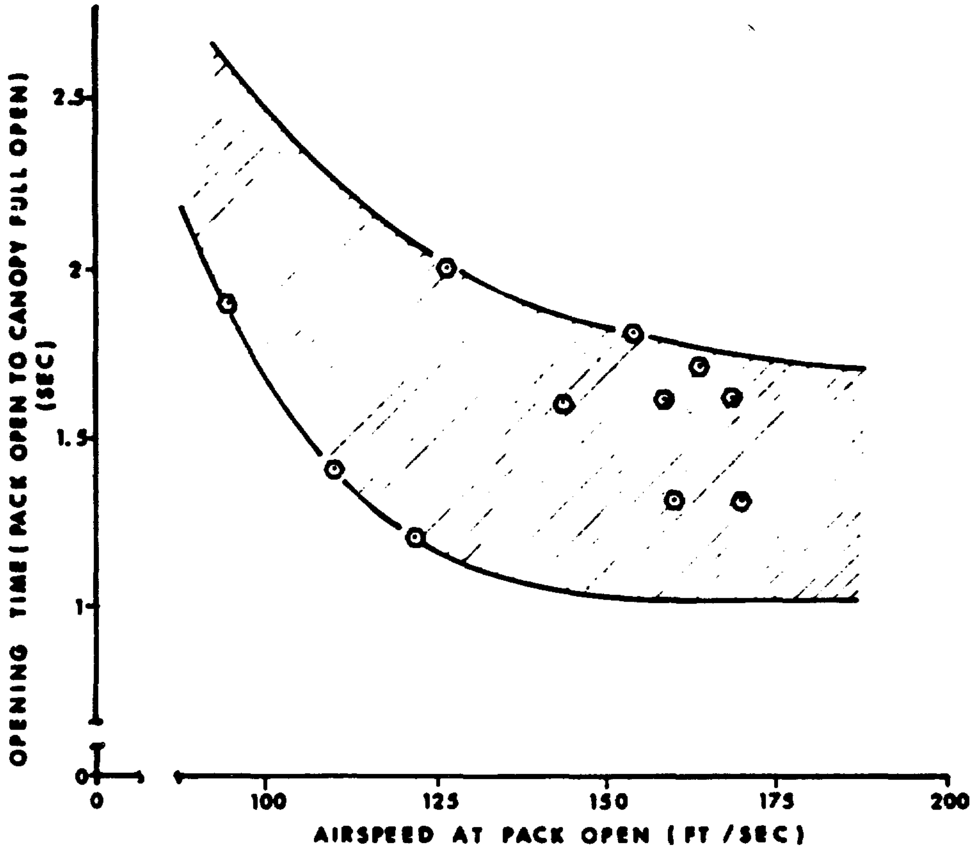


FIGURE NO. 16. LIVE JUMP TESTS, NES-21A PARACHUTE ASSEMBLY, OPENING TIME (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN

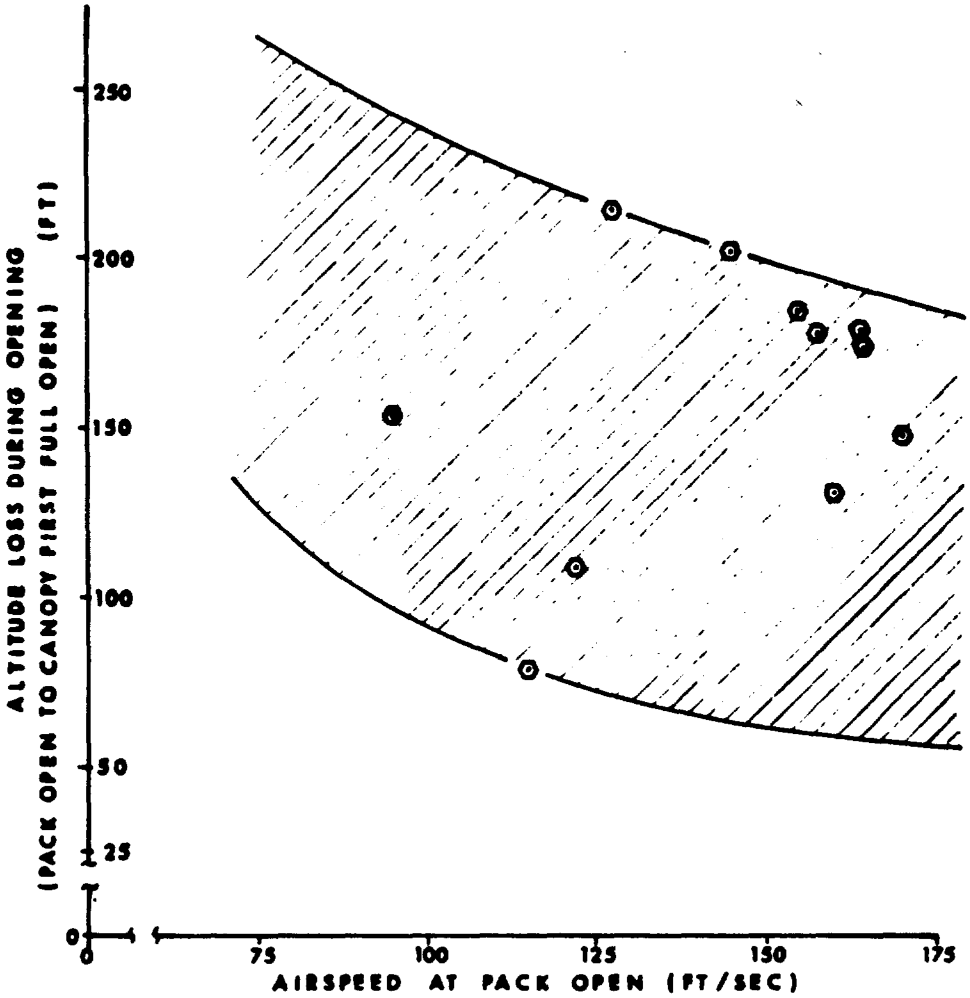


FIGURE NO. 17. LIVE JUMP TESTS, NES-21A PARACHUTE ASSEMBLY, ALTITUDE LOSS DURING OPENING (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN

Live Jump Tests. Test results and applicable remarks for each test are presented in Table III. The data from test No. 1577 were not used due to entanglement of the pilot chute with the parachutist and the main parachute canopy. Figures 16 and 17 depict graphically the pertinent data shown in Table III.

Figure 16 shows the opening time interval envelope (pack open to canopy first full open) versus airspeed at pack open. The opening time intervals varied from 1.2 to 2.0 seconds or an 0.8-second maximum variation in opening time.

Figure 17 shows the altitude lost during pack open to canopy first full open envelope versus airspeed at pack open. The altitude lost varied from 79 to 214 feet. The variation may be due to the body position of the accelerating parachutist (either rapid or slow acceleration) and the initial effectiveness of the pilot chute (aerodynamic interference of the parachutist).

Although there is no specific limitation as to the maximum force (opening shock) or the force rate-of-onset imposed on the crewmember during parachute deployment, it is believed that the NES-21A borders on the edge of safe, human tolerance levels of impact force in the head-to-toe axis. The test subjects who parachuted using the NES-21A objected to the extreme opening shock discomfort and the extreme oscillations induced by the (unbroken) PDVL's which can cause nausea and injuries on ground impact due to unpredictable landing attitudes. Both the opening force and the oscillation magnitude encountered by the test parachutists were higher than desired but considered acceptable since they are comparable to other Navy parachutes such as the NES-8B and NES-14A assemblies.

Test Data Comparison. As a means of evaluating the NES-21A performance data noted in Tables I, II, and III, data from previous tests of similar contemporary escape system parachute assemblies were reviewed on a comparative basis. Data from the following tests were used:

Table IV, Navy torso dummy drops of the NB-11 parachute assembly equipped with the Stencel spreading gun and a 50-inch external pilot chute.

Table V, Navy live jump tests of NB-11 parachute assembly equipped with the Stencel spreading gun but without an external pilot chute.

Table VI, Air Force Torso dummy tests using the Air Force, standard, free-type, back-style parachute assembly equipped with the Stencel spreading gun and without quarter-bag or external pilot chute. The assembly was packed in accordance with Air Force T.O. 14D1-2-81 except that the spreading gun was installed

Navy NB-7 back-style modified parachute assembly* averaged test results of 26 tests.

Figure 18 summarizes the opening time interval envelope of the NES-21A assembly (from Tables I, II, and III) compared to the comparative data contained in Tables IV, V, and VI. It is considered impracticable to obtain parachute deployment or development time intervals, when uncontrolled parachute deployment is involved, because separation of the two specific phases is not possible. The opening time interval (pack open to canopy first full open) of a parachute assembly versus pack open airspeed, was chosen as one of the primary parachute performance comparison parameters. The NES-21A and the NB-7 are considered to have uncontrolled parachute deployment and the Stencel spreading gun-equipped assembly to have controlled parachute deployment. The NES-21A had an equal or shorter opening time (pack open to canopy first full open) at all test airspeeds at pack open when compared with current Navy and Air Force parachute assemblies equipped with the Stencel spreading gun and that averaged by a Navy NB-7 parachute assembly.

Figure 19 depicts test data concerning the altitude lost during parachute pack open to canopy first full open envelope versus pack open airspeed for comparable parachute assemblies. The altitude lost during parachute opening for the NES-21A assembly equaled that for all test airspeeds at pack open, when compared with the Navy and Air Force assemblies equipped with the Stencel spreading gun and the averaged Navy NB-7 parachute assembly.

CONCLUSIONS

1. The NES-21A parachute assembly will perform satisfactorily as presently designed, in the QT-33A or T-33B aircraft (with T-33B Airframe Change No. 187 incorporated) at 90 KTAS and above, for ground level and higher altitude ejections.

2. The standard, short, single-stage PDVL does decrease the opening time (pack open to canopy first full open) of the NES-21A parachute assembly at all tested airspeeds.

3. The unbroken PDVL weak link is the cause of the very high canopy oscillations that occurred during descent.

*NAVAERORECOVFAC technical paper, "A Comparison of Parachute Opening Shock Experience By Humans and Human Analogs", by Jon O. Baldock, Donald H. Reid, John A. Buckman, Joseph E. Doerr, and John D. Whitecar, dated 1 October 1973.

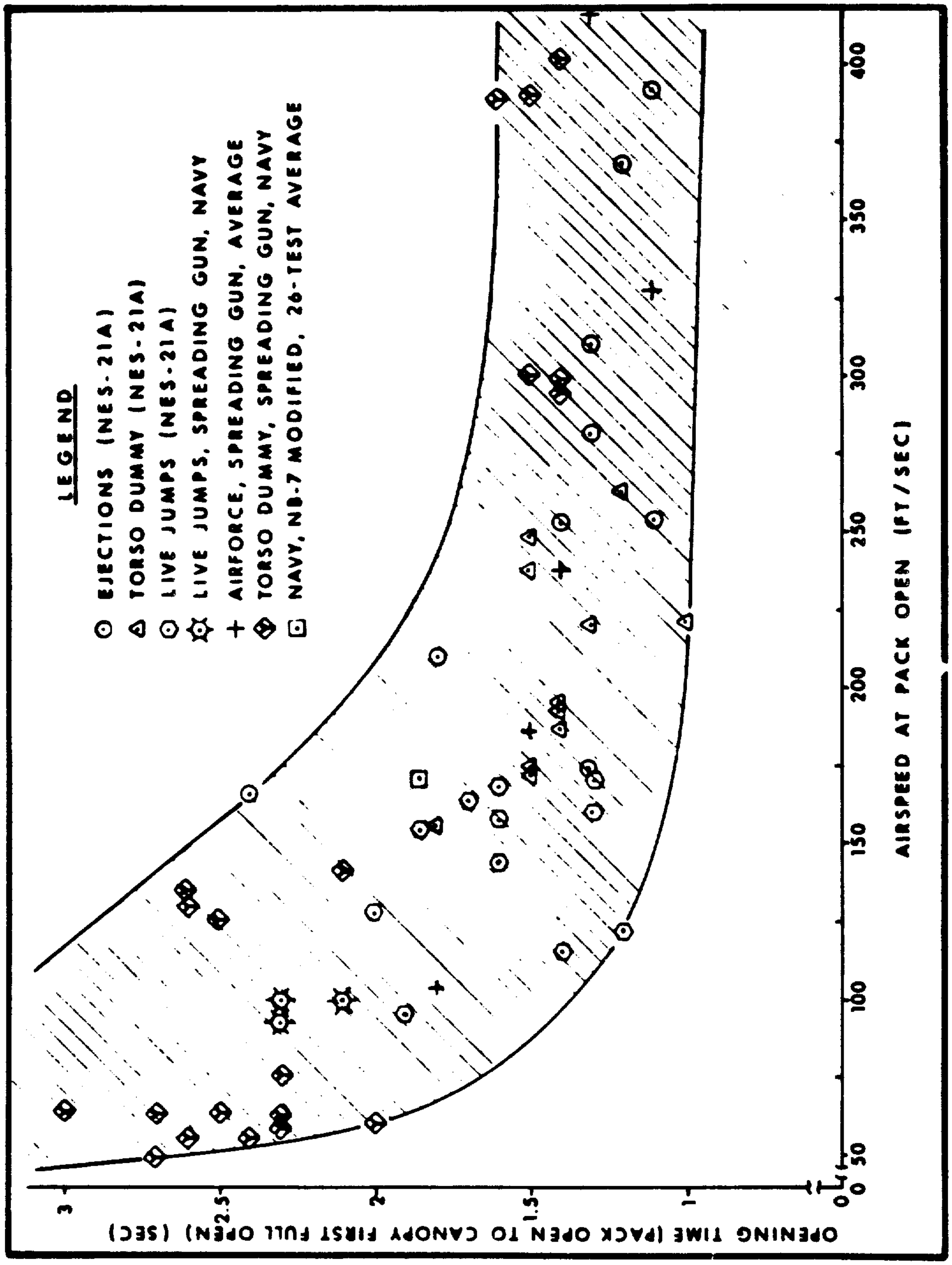


FIGURE NO. 18. COMPARISON OF OPENING TIME (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED AT PACK OPEN OF VARIOUS CURRENT ESCAPE SYSTEM PARACHUTE ASSEMBLIES

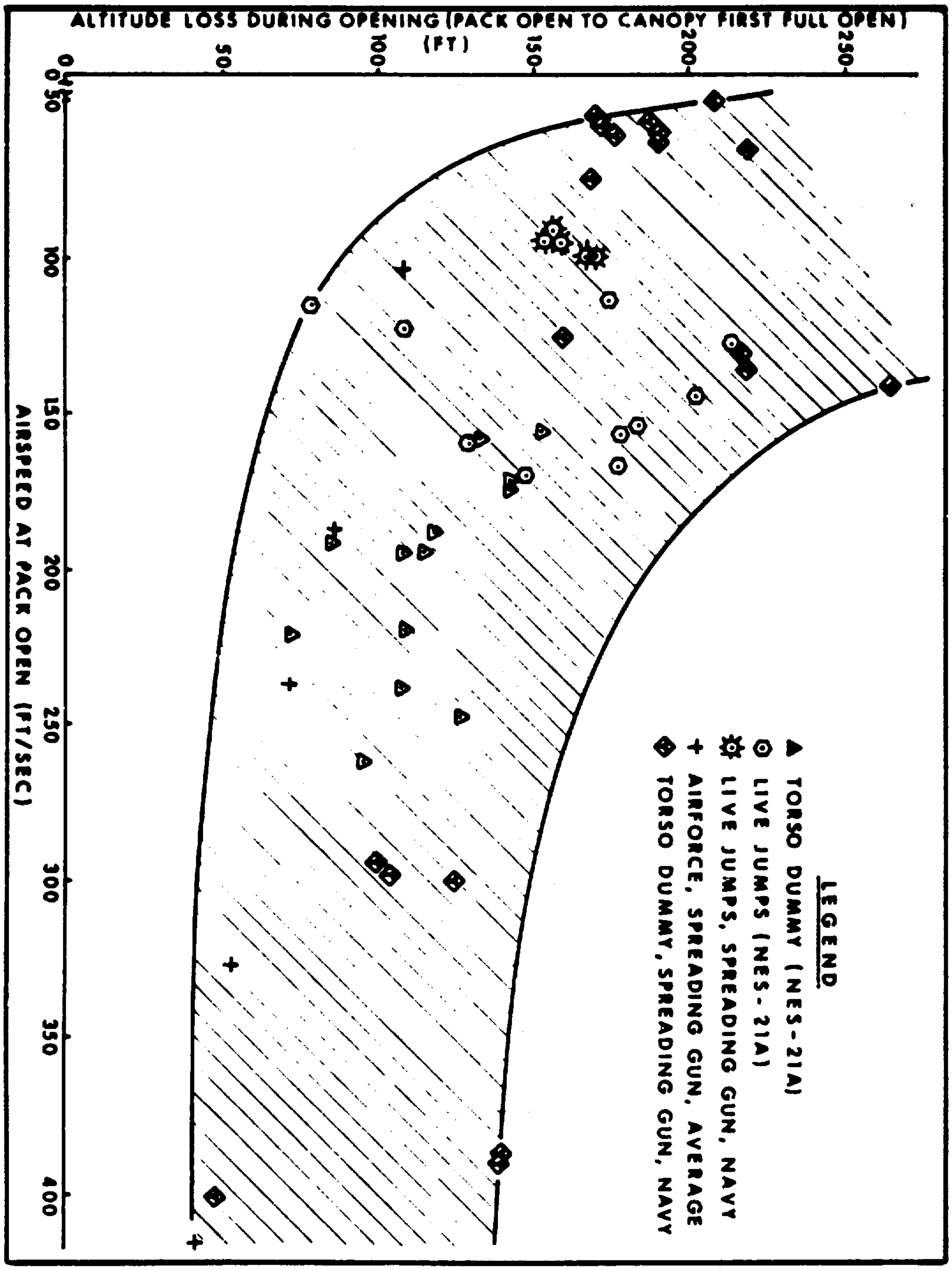


FIGURE NO. 19. COMPARISON OF ALTITUDE LOSS DURING OPENING (PACK OPEN TO CANOPY FIRST FULL OPEN) VERSUS AIRSPEED PACK OPEN OF VARIOUS CURRENT ESCAPE SYSTEM PARACHUTE ASSEMBLIES

4. The NES-21A parachute harness (unchanged from the NS-3, NB-6, NB-8) is not optimized for high opening force parachute assemblies. The lack of parachute canopy releases make this harness potentially dangerous, particularly when high wind conditions during landing increase the danger of being dragged.

RECOMMENDATIONS

1. The NES-21A parachute assembly be adopted for Fleet operational use in the T-33B and QT-33A aircraft when T-33B Airframe Change No. 187 (or equivalent) has been incorporated.

2. The standard, ›rt PDVL, common to many parachute assemblies, is acceptable but in ne ơf improvements because:

a. The weak link as designed is too strong and is the primary cause of the high opening forces encountered at all tested airspeeds; and

b. The unbroken weak link is the cause of the very high canopy oscillations that occur during descent of the NES-21A parachute assembly.

3. The NES-21A parachute assembly harness should be replaced by the standard MA-2 integrated parachute-restraint harness, for flight safety reasons as stated in paragraph 4. of CONCLUSIONS above.

TABLE I

TEST RESULTS OF NES-21A PARACHUTE ASSEMBLIES EJECTED FROM NAVY F-9 AIRCRAFT USING T-33 EJECTION SEAT

Test No.	Percentile Articulated Dummy (1)	Airspeed at Pack Open (ft/sec)	Dynamic Pressure at Pack Open (lb/ft)	Pack Open to Canopy First Full Open		Remarks
				Opening Time Interval (sec)	Altitude Loss (ft)	
0616N	5th			2.0	8	(2)
0617N	95th			2.4	12	(2)
0618N	5th			2.3	64	(2)
0721N	95th			1.9	28	(2)
0208N	5th	391	153.6	1.1	19	
0885N	5th	281	80.0	1.3	71	
0949N	95th	310	96.9	1.3	70	
0950N	5th	252	66.8	1.4	26	
1079N	95th	254	69.5	1.1	27	
1232N	5th	166	28.7	2.4	99	(3)
1269N	95th	210	45.7	1.8	29	
1270N	5th	174	31.4	1.3	64	
1323N	95th	368	139.6	1.2	18	
1433N	95th			1.5		(4)

(1) 5th%: 145 lbs; 95th %: 210 lbs.
(2) 90 KIAS, on-the-deck ejection, T-33 ejection seat assy; no space positioning data.
(3) Definite hesitation noted when approx. 50% of drag surface was deployed.
(4) Space positioning cameras tracked seat only; pack open and full open times obtained by 16mm high speed cameras.

TABLE II

RESULTS OF AERIAL DROP TESTS OF NES-21A PARACHUTE ASSEMBLIES LAUNCHED AT 3000-FT ALTITUDE WITH 263-LB GROSS WEIGHT TORSO DUMMY

Drop No.	Airspeed At Pack Open (ft/sec)	Altitude Loss From Pack Open To Canopy First Full Open (ft)	Pack Open To Canopy First Full Open (sec)	Maximum Opening Force (lb)	Maximum Opening Force Rate of Onset (lb/sec)	Remarks
1580	195	109	1.4	3560	6470	
1581	195	116	1.4	3300	5690	
1582	192	86	1.4	3070	6140	
1583	187	118	1.4	3200	5180	
1584	274	242	2.9			(1)
1585	262	96	1.2			(2)
1586	237	108	1.5	3600	12380	(3)
1587	248	126	1.5	3040	3700	(4)(5)
0122	157	133	1.6	2600	3250	(5)
0123	156	152	1.8	2900	5370	(5)
1588	171	143	1.5	3600	6670	(5)
1589	174	143	1.5	3550	6640	
1590	219	109	1.3	4800	7620	
1591	221	72	1.0	3800	6600	

(1) Major damage to 50% of drag surface; PDVL broken at weak link; TM failed; data not used.
(2) PDVL broken at weak link; TM failed.
(3) PDVL broken at lark's head knot; suspension lines 7 & 8 broken 16 inches above connector links.
(4) Major damage to drag surface.
(5) No visual damage or deployment interference from the PDVL daisy chain manual release or standard Air Force 4-line (rear) release subassemblies.

TABLE III
RESULTS OF LIVE JUMP TESTS USING NES-21A PARACHUTE ASSEMBLIES AT LAUNCH ALTITUDE OF 6,000-FEET

Test No.	Gross Weight (lb)	Exit Air-speed (ft/sec)	Pack Open Air-speed (ft/sec)	Body Position to Pack Open	Pack Open To Canopy First Full Open (sec)	Altitude Lost From Pack Open To Canopy First Full Open (ft)	Opening Shock	Oscillation (1)	Remarks
1568	185	144	167	Face up	1.6	177	Mild	M	(3)(4)
1569	205	137	157	Face up	1.6	178	Very Hard	VH	(3)(4)
1570	200	66	95	On Side	1.9	154	Mild	M	(3)(4)
1571	190	132	122	On Side	1.2	109	Mild	VH	(3)
1572	220	121	115	Face up	1.4	79	Very Hard	VH	(3)
1573	190	160	164	On Side	1.7	174	Very Hard	VH	(3)(4)
1574	230	211	170	Face up	1.3	148	Very Hard	VH	(3)
1575	190	171	154	Face up	1.8	184	Very Hard	VH	(3)(4)
1576	230	170	160	Face Down	1.3	130	Very Hard	VH	(3)(4)
1577	200	86	100	Head Down	-	-	Very Hard	-	(2)(3)
1578	190	72	144	Head Down	1.6	202	Very Hard	M	(4)
1579	180	74	127	Head Down	2.0	214	Hard	S	(4)

(1) Oscillation (degrees): Slight 0-15, Moderate 15-30 and Very High 30-45.
(2) Pilot chute and main parachute canopy became entangled with legs of parachutists and with reserve ripcord handle during deployment; complete inversion occurred with major damage to main parachute canopy; data not used.
(3) Released PDVL.
(4) Released/cut 4 rear suspension lines.

Note: M = Moderate; VH = Very High; S = Slight.

In all tests, the PDVL remained intact.

TABLE IV

RESULTS OF NAVY AERIAL DROP TESTS OF PARACHUTE ASSEMBLIES EQUIPPED WITH STENCEL SPREADING GUNS, LAUNCHED AT 2000-FT. ALTITUDE, BALLISTIC MODE, 270-LB. GROSS WEIGHT

Drop No.	Spreading Gun Config. No.	Airspeed		Dynamic Pressure		Deployment (Pack Open To Line Stretch)		Development (Line Stretch To Full Open)		Opening (Pack Open To Full Open)		Opening Force (Maximum Force During Opening Sequence)
		Pack Open (ft/sec)	Line Stretch (ft/sec)	Pack Open (lb/ft²)	Line Stretch (lb/ft²)	Time Interval (sec)	Altitude Loss (ft)	Time Interval (sec)	Altitude Loss (ft)	Time Interval (sec)	Altitude Loss (ft)	(lbs)
1135	I	50	94	3	10	2.09	167	0.60	40	2.69	207	-
1127	I	55	84	4	8	1.74	135	0.61	35	2.35	170	-
1134	I	56	90	4	8	1.83	146	0.72	41	2.55	187	-
1136	I	58	88	4	9	1.48	116	0.86	56	2.34	172	-
1128	I	60	96	4	11	1.41	134	0.61	51	2.02	185	-
1129	I	62	92	5	10	1.64	136	0.67	40	2.31	176	-
1133	I	63	94	4	10	1.61	136	0.84	54	2.45	190	-
0687	III	63	79	4	7	1.68	130	1.02	60	2.70	190	-
1131	I	65	83	4	8	2.16	176	0.82	43	2.98	219	-
1130	I	65	93	5	10	1.55	-	0.78	-	2.33	-	-
0685	III	76	81	6	7	1.34	115	0.92	53	2.27	168	-
1132	I	78	74	7	6	0.44	33	0.76	38	1.20	071	-
1568	I	126	111	14.9	12.3	1.55	65	0.96	95	2.50	160	1300
1566	I	131	122	16.3	14.1	1.63	110	0.95	106	2.58	216	-
1565	I	136	120	17.6	14.1	2.00	54	0.64	164	2.64	218	-
1567	I	142	117	19.2	13.1	1.37	83	0.76	182	2.13	265	1700
1443	I	260	215	72.0	59.0	0.20	13	0.76	94	.96	107	4300
1329	I	294	248	98.8	94.0	0.75	59	0.69	41	1.43	100	-
1330	I	298	225	99.1	51.6	0.79	49	0.61	55	1.40	104	4050
1442	I	300	265	106.0	72.0	0.61	44	0.84	81	1.45	125	3950
1373	I	370	290	143.0	93.0	0.63	25	2.21	75	2.84	100	-
1375	I	388	300	166.0	86.0	0.68	58	0.93	92	1.61	140	-
1374	I	390	288	173.0	92.0	0.88	60	0.65	80	1.53	140	5600
2199	III	401	332	186.0	118.0	0.46	17	0.98	31	1.44	048	-

Note: Test data from all drops except Nos. 1130, 1132, 1443 and 1373 were used in Figures 18 and 19; high speed drop tests data not used. **Data from Naval Aerospace Recovery Facility Technical Report No. 6-69.**

(1) Configuration I was original spreader gun. Configuration II was basically identical except that the firing lanyard sleeve was lengthened to 10 feet to eliminate premature firing. In configuration III, firing mechanism was reconfigured by providing a positive ball locking mechanism to prevent slug release prior to pulling the firing pin. Also, a stainless steel shear band vice an aluminum band was used. This configuration also incorporated a firing lanyard stow pocket in the sleeve for stowing 18 inches of firing lanyard.

(2) Opening time data plotted to nearest tenth of a second.

TABLE V

RESULTS OF NAVY LIVE JUMP TESTS FROM 5000 FT. ALTITUDE WITH STENCEL SPREADING GUN, BALLISTIC MODE, 3-SEC. DELAY, LESS EXTERNAL PILOT CHUTE

Drop No.	Spreading Gun Configuration Number	Airspeed		Deployment (Pack Open To Line Stretch		Development (Line Stretch To Full Open		Opening (Pack Open To Full Open	
		Pack Open (ft/sec)	Line Stretch (ft/sec)	Time Interval (sec)	Altitude Loss (ft)	Time Interval (sec)	Altitude Loss (ft)	Time Interval (sec)	Altitude Loss (ft)
0259	III	92	92	.87	72	1.40	84	2.26	156
0257	III	96	99	.90	59	1.03	98	1.93	157
0256	III	100	97	.87	86	1.23	81	2.10	167
0258	III	100	99	.77	64	1.50	105	2.27	169

Note: Data reproduced from Naval Aerospace Recovery Facility's Technical Report No. 6-69.

(1) See Table V for spreading gun configuration description.

(2) Opening time data plotted to nearest tenth of a second.

TABLE VI

(1) AVERAGE TEST RESULTS (ALL CONFIGURATIONS) OF U.S. AIR FORCE AERIAL DROP TESTS USING STENCEL SPREADING GUN

Launch Speed (CAS)	Spreading Gun Condition	Airspeed		Dynamic Pressure		Deployment (Pack Open To Line Stretch)			Development (Line Stretch To Full Open)			Opening (Pack Open To Full Open)			Forces		No. of Tests Averaged
		Pack Open	Line Stretch	Pack Open	Line Stretch	Time Interval	Flight Path Distance	Altitude Loss	Time Interval	Flight Path Distance	Altitude Loss	Time Interval	Flight Path Distance	Altitude Loss	Snatch	Opening Shock	
(kt)		(ft/sec)	(ft/sec)	(lb/ft^2)	(lb/ft^2)	(sec)	(ft)	(ft)	(sec)	(ft)	(ft)	(sec)	(ft)	(ft)	(lb)	(lb)	
0	Live	61	89	4	9	1.68	139	123	0.77	47	52	(3) 2.45	186	175	-	-	11
0	Dummy	57	97	4	10	1.80	136	127	1.41	103	92	3.21	239	218	-	-	12
55	Live	104	102	12	12	1.11	117	66	0.73	51	43	1.84	168	109	690	1,975	5
55	Dummy	108	114	13	15	1.31	146	94	1.17	90	76	2.48	236	170	-	-	5
110	Live	187	158	39	28	0.78	137	50	0.70	66	36	1.48	203	86	1,540	2,600	5
110	Dummy	184	166	38	30	0.82	145	49	0.98	102	56	1.80	247	105	950	1,950	5
150	Live	238	190	63	43	0.67	153	37	0.70	81	35	1.37	234	72	2,485	3,485	5
150	Dummy	240	205	65	47	0.64	145	36	0.83	96	40	1.47	241	76	-	-	5
205	Live	327	259	119	75	0.46	133	23	0.68	100	29	1.14	233	52	3,050	4,580	5
205	Dummy	346	259	134	76	0.55	160	28	0.73	110	28	1.28	270	56	-	-	4
270	Live	417	341	196	133	0.41	146	15	0.85	145	27	1.26	291	42	4,405	4,840	7
270	Dummy	423	343	200	135	0.43	161	20	0.80	146	32	1.24	307	52	-	-	5
325	Live	440	344	232	141	0.35	130	14	0.73	135	23	1.08	265	37	5,300	5,460	6
325	Dummy	449	362	251	160	0.32	124	12	1.04	150	27	1.36	274	39	5,150	5,050	1
350	Live	478	397	294	188	0.31	132	13	1.25	211	40	1.56	343	53	-	-	4
(2) 400	Live	524	441	340	286	0.29	130	13	1.63	288	58	1.92	418	71	-	-	5
110	Live	183	159	38	29	0.76	130	46	1.09	103	54	1.85	233	100	-		10
(3) 110	Dummy	184	170	38	32	0.95	170	61	1.53	153	89	2.48	323	150	-	-	10

(1) Reproduced from Air Force Flight Test Center Technical Report No. 69-18.
(2) Twisted line tests.
(3) Opening time data plotted to nearest tenth of a second.