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PERFORMANCE EVALUATION OF PARA-COMMANDER MARK I PERSONNEL PARACHUTE

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1st Lieutenant, USAF
Project Engineer

TECHNICAL REPORT No. 66-16
JUNE 1966

AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

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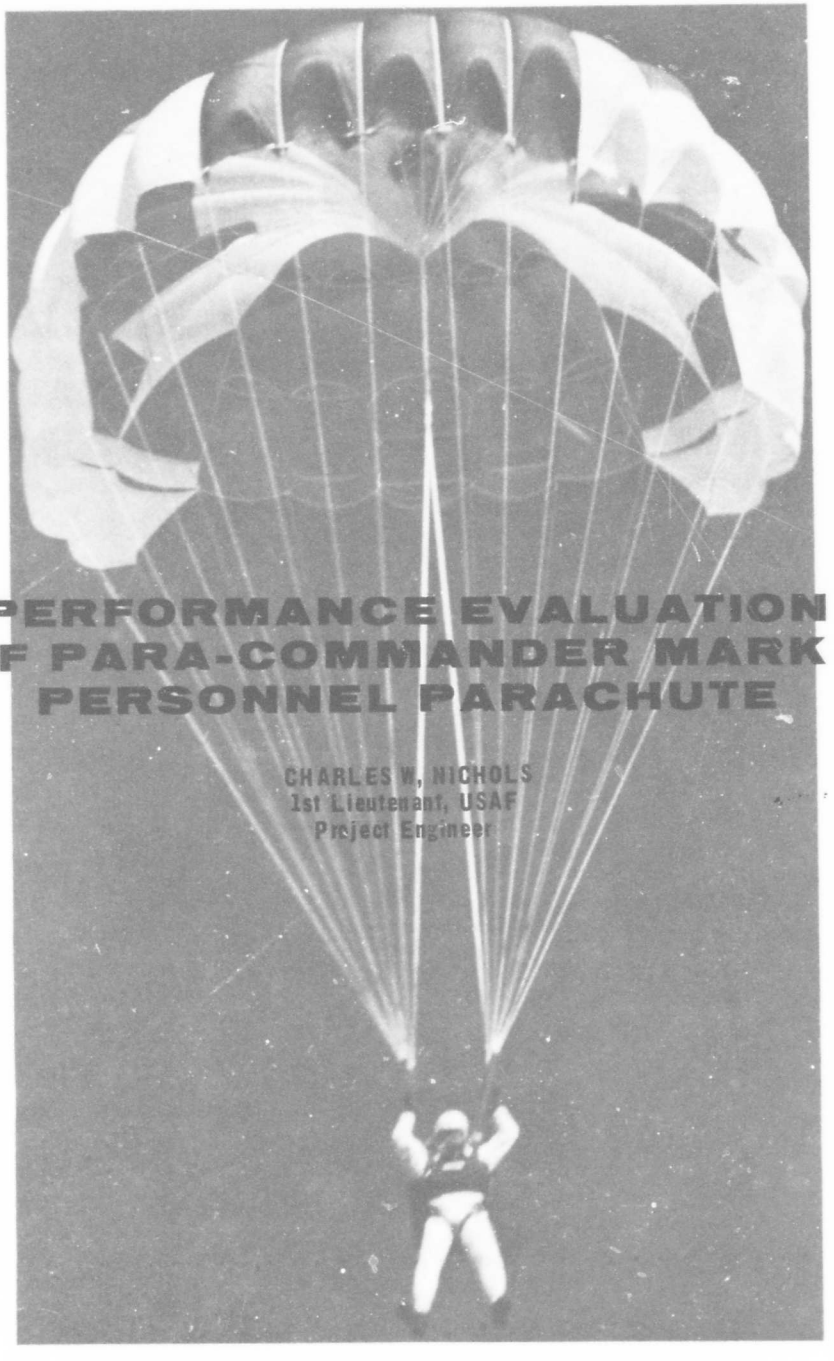

PERFORMANCE EVALUATION OF PARA-COMMANDER MARK I PERSONNEL PARACHUTE

CHARLES W. NICHOLS
1st Lieutenant, USAF
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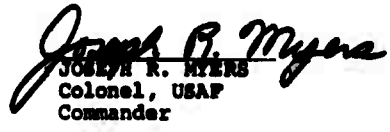
ABSTRACT

The Pioneer Para-Commander Mark I 24-foot diameter parachute manufactured by the Pioneer Parachute Company, Manchester, Connecticut, was tested. A total of 246 tests was made using a B-66, a C-130, a C-47, and an H-21 aircraft. Launch velocities varied from minimum (near-zero) to 225 KCAS and launch pressure altitudes ranged from 1000 to 35 000 feet. Articulated and torso dummies weighing 283 pounds (gross weight) were used for 82 dummy drop tests. Test parachutists weighing from 181 to 241 pounds (gross weight) made 164 live jumps. Parachute opening times, fall distances between launch and full open, rates of descent, opening forces, glide ratios, turn times, and live-jump reliability data were obtained. The test item was determined to be safe for Air Force use when used by qualified and experienced free-fall parachutists. Recommendations are made for modifications, packing procedures, and live jump procedures. It is also recommended that launch altitude should not be less than 1000 feet above ground level with a 1 second delay to pack opening, nor should the parachute be deployed above 150 KCAS at 1000 feet pressure altitude. It is recommended that additional dummy tests be conducted to determine maximum safe opening velocities above 1000 feet altitude.

This technical report has been reviewed and is approved.



JOSEPH R. MYERS
Colonel, USAF
Commander

Table of Contents

LIST OF ILLUSTRATIONS

GLOSSARY

Glide Ratio	Ratio of horizontal distance to vertical distance in a given time interval.
Bank Angle	Acute angle, in degrees, off vertical induced by the parachutist during turns.
Turn Time	The time, in seconds, required for the parachutist to complete a 360 degree turn.
Stable Prone	The body is facing downward, legs spread, arms extended to the side, and head back.
Minor Damage	Small tears, burns, or frayed control line.
Major Damage	Extensive damage that prevented full inflation of the canopy.

INTRODUCTION

AUTHORITY

Testing was requested by Systems Engineering Group (SEG) in a letter dated 20 November 1964, subject, "Pioneer Parachute Co. Para-Commander Mark I Parachute, Evaluation of." The test program was originally documented under "South Shores," Project No. 1352 and assigned AFSC priority 04F. In accordance with a message from SEG (SEMHP 735ZB), dated 22 March 1965, which cancelled the "South Shores" project, the test program was redocumented as Project No. 1559 and assigned AFSC Priority 04P. This report completes the test program which was identified locally as LIC 8508 and titled "Para-Commander Mark I Parachute Evaluation."

PURPOSE

The objective of the program was to evaluate the performance of the Pioneer Para-Commander Mark I Parachute.

SCOPE

The tests were conducted to determine parachute opening times, fall distances from launch and full open, rates of descent, opening forces, glide ratios, turn time, and live jump reliability. Eighty-two tests were made using torso and articulated dummies weighing 250 pounds (283-pound gross weight). The dummies were launched at airspeeds ranging from near-zero (minimum) to 225 KCAS and at pressure altitudes of 1000 to 35 000 feet. One hundred sixty-four live jumps were made by test parachutists weighing from 181 to 241 pounds (gross weight). These jumps were made at 60 and 110 KCAS and at pressure altitudes ranging from 8000 to 20 000 feet. A summary of the test conditions is shown in table I.

TABLE I

SUMMARY OF TEST CONDITIONS AND PURPOSE OF DUMMY DROP AND LIVE JUMP TESTS USING PARA-COMMANDER MK I PARACHUTES

Number of tests	Launch CAS (kt)	Launch pressure altitude (ft)	Type of aircraft	Purpose of tests
			Torso dummy drop tests	
40	110	1000	C-130	To evaluate performance under twisted line conditions in accordance with USAF Specification Bulletin No. 505, par. 2.3.1.2.
8	Near-Zero	do	H-21	To evaluate performance under low altitude conditions in accordance with USAF Specificat on Bulletin No. 505, par. 2.3.1.4.1.
3	40	do	do	To determine minimum safe opening altitude.
3	70	do	do	do
4	110	do	C-130	To determine maximum reliable launch speed.
4	130	do	do	do
4	150	do	do	do
4	170	do	do	do
8	200, 210, 225	do	B-66	do
			Articulated dummy drop tests	
1	110	15,000	C-130	To obtain opening forces at 10,000-ft. pressure altitude.
1	110	25,000	do	To obtain opening forces at 20,000-ft. pressure altitude.
2	110 & 150	35,000	C-130 & B-66	To obtain opening forces at 30,000-ft. pressure altitude.
			Live jump tests	
164	60 & 110	8000 to 20,000	H-21, C-47, C-130	To deter[illegible] live jump reliability, turn times, opening times, rates of descent, bank angle.

TEST ITEM

The item tested was the Pioneer Para-Commander Mark I, 24-foot diameter parachute manufactured commercially by the Pioneer Parachute Company, Manchester, Conn. (figure 1). Twenty-four 550-pound (break strength) nylon suspension lines (MIL-C-5040) extend from the canopy skirt to four connector links mounted on the four risers. A control line with a toggle attached to the lower end is secured to the inner side of each of the two front risers. The upper ends of the control lines are connected to the stabilizer panels (figure 2) located on opposite sides of the canopy. The control lines are used by the parachutist to induce and control the rate and direction of turns made during descent. Two 1500-pound (break strength, MIL-W-5625) tubular nylon lines are attached to connector links which are mounted on the two rear risers. These two lines extend upward and are joined to form the center line which is attached to the apex of the canopy (figure 3). Canopies were constructed of nylon taffeta[1] except for a small area located at the apex of the canopy where 1.1 ounces type I rip-stop MIL-C-7020 nylon was used (figure 2). Pocket bands were located at the skirt on the front of the canopy only at six suspension lines. The canopy was contained in a launching sleeve (figure 3). Twenty-four complete assemblies (canopies and Pioneer Parachute Co. P-9B packs modified to include F-1B automatic parachute ripcord releases) were furnished by Tactical Air Command (TAC) (figures 4 and 5). Eight assemblies were used for the dummy drop tests and sixteen were used for the live jump tests. Four sets of risers were modified to include strain-gage links (5000-pound capacity) to measure opening forces (figure 6). Five harnesses also were modified by installing loops which were sewn onto the right main webbing to house the rubber hose from the standard type MD-1 bail-out bottle. The CRU-8/P oxygen connector also was added (figure 7). The F-1B automatic parachute rip-cord release arming cable housing was attached as shown in figure 8.

[1] Pioneer Parachute Company, Inc., Material Control Specification E. I. 4132 specifies 2.0 to 2.25 ounces per square yard.

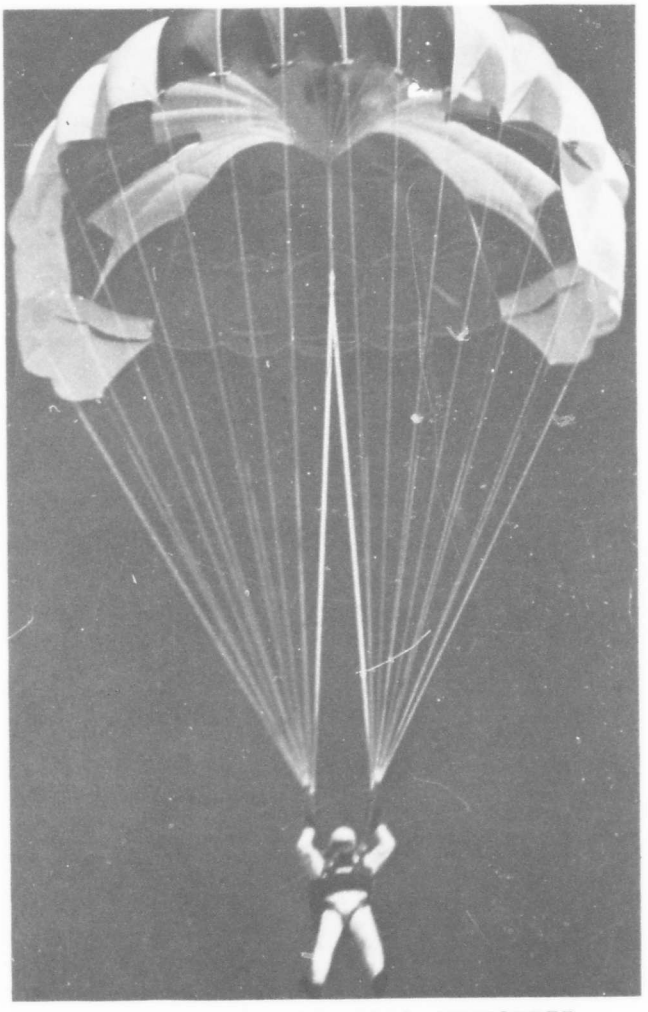


Figure 1 THE PIONEER PARA–COMMANDER MARK I PARACHUTE

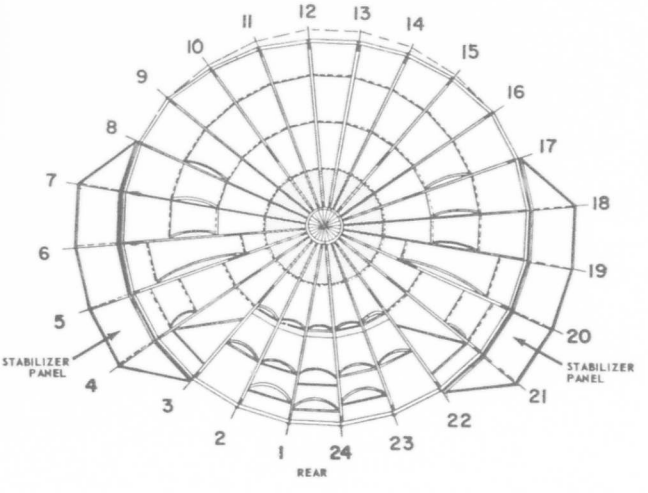


Figure 2 PLAN VIEW OF PIONEER PARA–COMMANDER MARK I PARACHUTE CANOPY. APEX (DARK AREA) IS CONSTRUCTED OF 1.1 OZ. TYPE I RIPSTOP NYLON. BALANCE OF CANOPY IS 2.0 TO 2.25 OZ. NYLON TAFFETA.

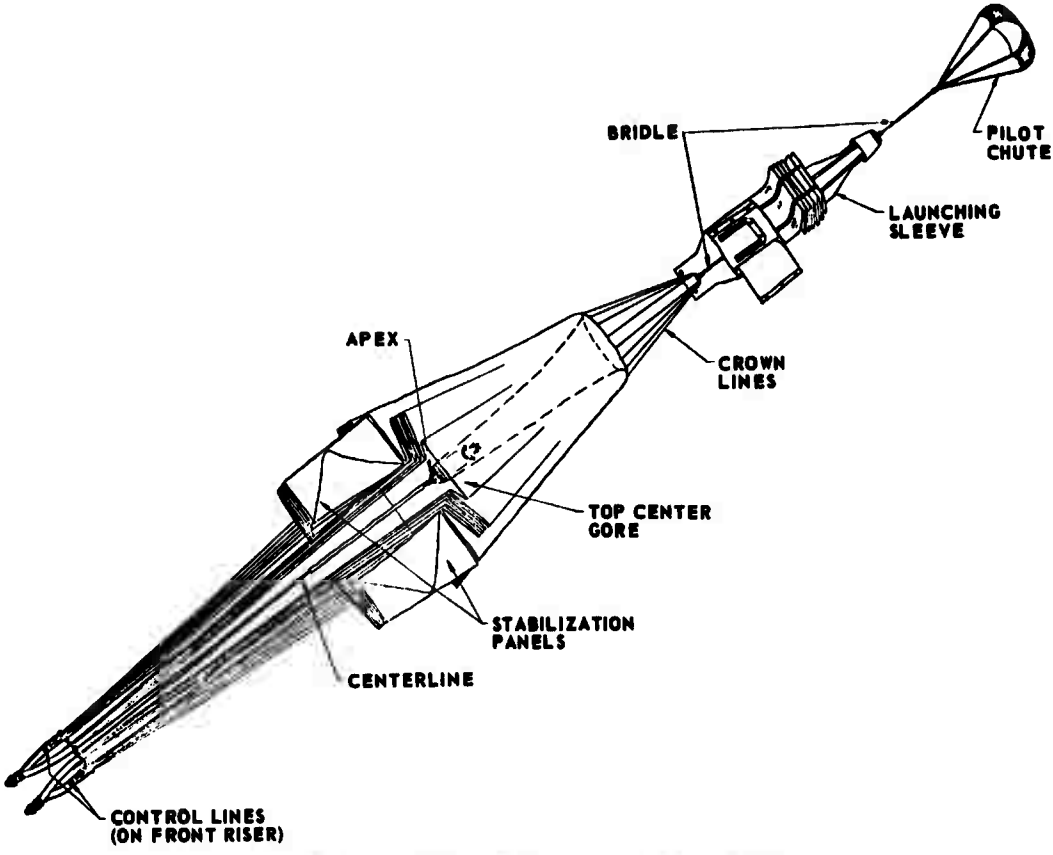


Figure 3 VIEW OF PIONEER PARA-COMMANDER MK I PARACHUTE CANOPY PRIOR TO INSTALLATION IN THE LAUNCHING SLEEVE.

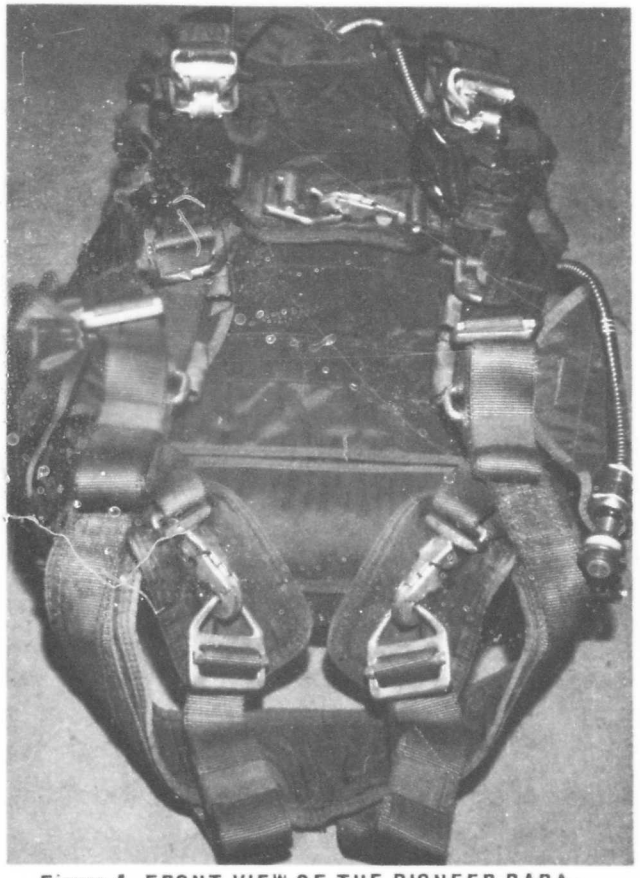


Figure 4 FRONT VIEW OF THE PIONEER PARA-COMMANDER MARK I PARACHUTE ASSEMBLY.

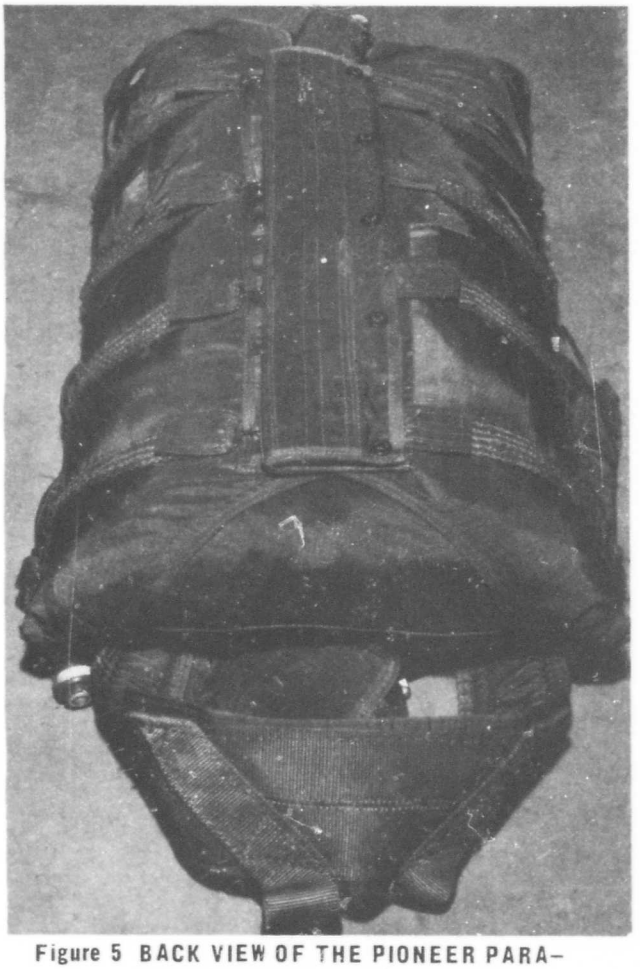


Figure 5 BACK VIEW OF THE PIONEER PARA-COMMANDER MARK I PARACHUTE ASSEMBLY.

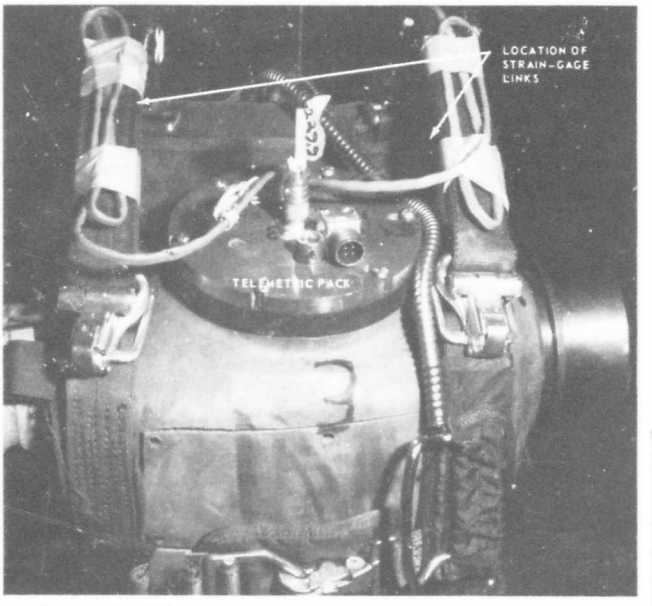


Figure 6 TORSO DUMMY EQUIPPED WITH PARA-COMMANDER MARK I PARACHUTE ASSEMBLY SHOWING LOCATION OF TELEMETRIC EQUIPMENT AND STRAIN-GAGE LINKS

Figure 7 PIONEER PARA-COMMANDER MARK I PARACHUTE ASSEMBLY SHOWING MODIFIED HARNESS.

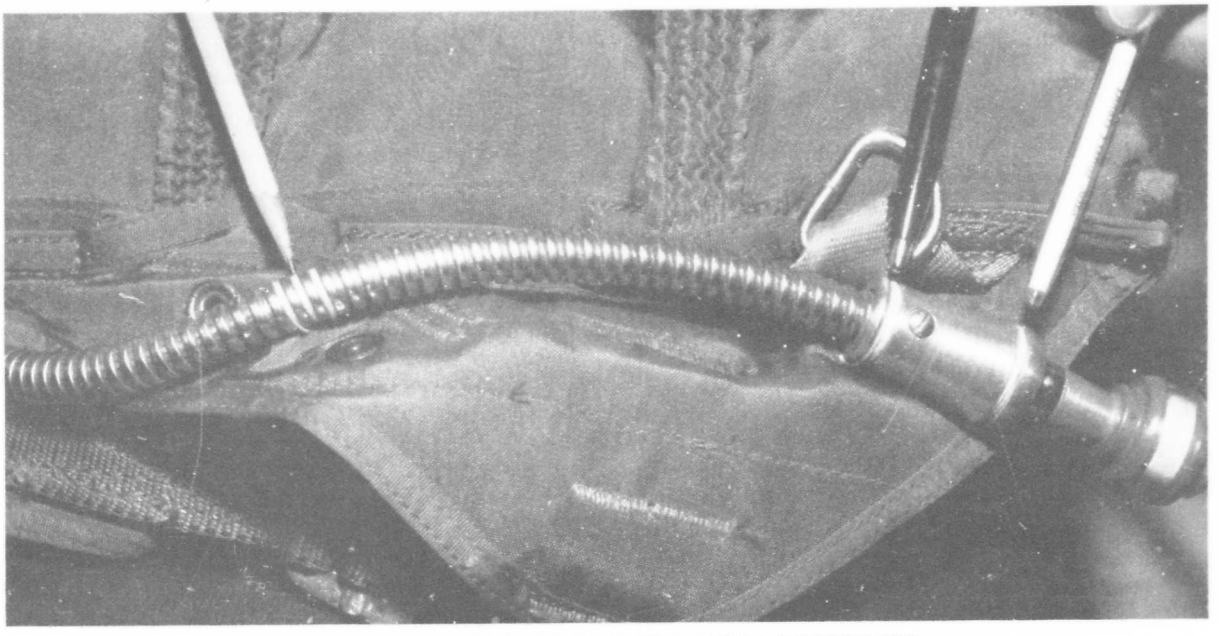


Figure 8 PIONEER PARA-COMMANDER MARK I PARACHUTE SHOWING F-1B AUTOMATIC PARACHUTE RIPCORD RELEASE ARMING CABLE HOUSING SECURED TO PACK WITH No. 5 CORD.

TEST EQUIPMENT

Launch Aircraft:

C-130, B-66, and H-21 aircraft were used to launch the dummies. The live jump tests were made from H-21, C-47, and C-130 aircraft.

Test Loads:

Torso and articulated dummies weighing 250 pounds (283-pound gross weight) were used as the test loads. All live jumps were made by test parachutists.

Launch Devices:

The following special equipment was used to launch the dummies:

1. An aluminum-covered sheet of plywood 4 by 8 feet was used to launch the test dummies from the ramp of the C-130 aircraft.
2. A compartmented rack placed in the bomb bay of a B-66 aircraft was used to launch dummies individually.

Photographic Equipment:

The following camera equipment was used:

1. Five Askania cinetheodolite cameras were used to obtain space positioning data.
2. One Contraves cinetheodolite camera was used to determine event times.
3. Sixteen-millimeter cameras were used for all ground-to-air, plane-to-air, and air-to-air motion picture coverage. Color film was was used at exposure rates of 50, 128, and 200 frames

per second. Still photographs were taken with a Speedgraphic camera. Parachutist-to-parachutist still photographs were taken using a head-mounted 35mm camera.

Parachutist Equipment:

All test parachutists wore coveralls or flight suits, jump boots, flight gloves, plastic goggles, and a 24-foot D_o Personnel, Chest, Reserve Parachute, P/N 56C6090 (figure 9). A panel containing an altimeter, stopwatch and hook knife was mounted on the reserve parachute pack. For live jumps made from 20 000 feet pressure altitude, the test parachutists wore HGU-2A/P helmets and MBU-3 oxygen masks. All other live jumps were made using commercial-type helmets.

Figure 9 TEST PARACHUTIST PREPARED FOR LIVE JUMP WEARING PIONEER PARA-COMMANDER MARK I PARACHUTE ASSEMBLY WITH RESERVE

Telemetric (TM) Equipment:

Telemetric equipment was used in conjunction with two main riser strain-gage links to obtain individual riser forces during parachute deployment and opening.

Permeability Measurement Equipment:

Permeability measurements were made of both the nylon taffeta and the 1.1-ounce canopy material using a Frazier permeability measuring machine (figure 10).

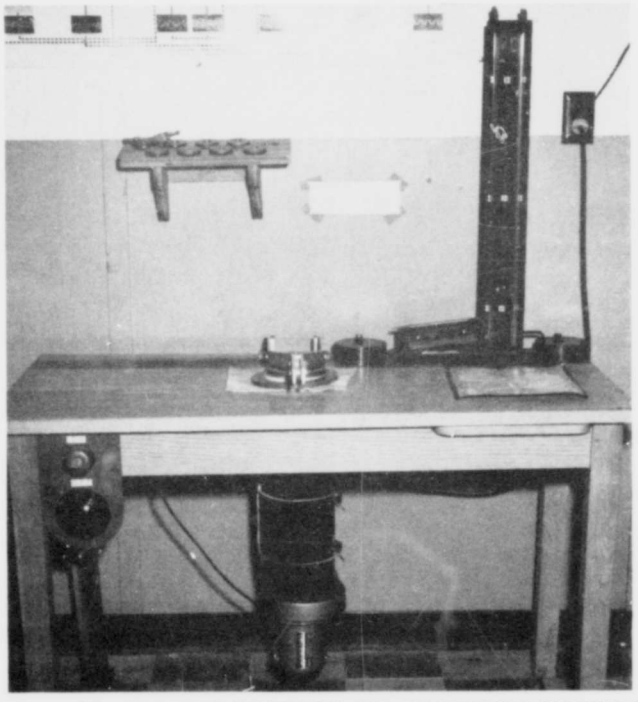


Figure 10 FRAZIER ERMEABILITY MEASURING MACHINE USED FOR TESTS OF PIONEER PARA-COMMANDER MARK I PARACHUTE CANOPY MATERIALS

■ TEST PROCEDURES

The permeability of the canopy material was obtained by calculating the volume (in cubic feet) of air passing through 1 square foot of canopy material per minute with a 1/2-inch water pressure differential between the two sides of the material. Permeability measurements were discontinued after four tests on each of four canopies, two tests on each of two canopies, and one test on each of 18 canopies had been made in order to expedite the test program.

All parachutes (except for the twisted line tests) were packed in accordance with procedures outlined in the Pioneer Parachute Co. booklet titled "Introduction and Packing Instructions for the Pioneer Para-Commander, Mark I," dated 24 July 1964, and amended 23 December 1964. Parachutes used for twisted line tests (figures 11 through 13) were packed in accordance with USAF Specification Bulletin No. 505, paragraph 2.3.1.2.

For the twisted line tests the packs were opened by a 15-foot static line attached to the C-130 aircraft. The static line was rigged to break one turn of No. 5 cord which permitted the pack to open. For all other tests the packs were opened by an F-1B automatic parachute ripcord release set for various altitudes and time delays.

Dummies launched at 110 to 150 KCAS were from the rear ramp of a C-130 aircraft. The aft end of the launch board was attached by two cables to the aft end of the aircraft ramp. The dummy was placed in a chest down, base aft position on the launch board. When the forward end of the board was lifted, the dummy slid off. The F-1B automatic parachute ripcord release was actuated manually as the dummy left the aircraft. For tests made at 170 KCAS, the dummies were launched from the side door of a C-130 aircraft. The dummies were placed in an upright position approximately 6 inches inboard from the door and then were pushed out chest first.

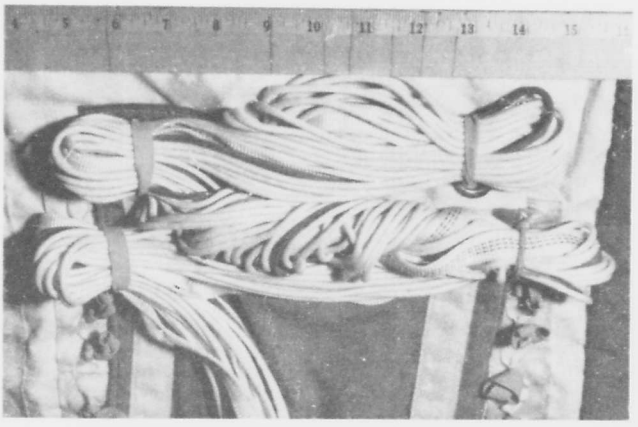


Figure 11 PROCEDURE USED TO STOW SUSPENSION LINES OF PIONEER PARA-COMMANDER MARK I PARACHUTE FOR TWISTED LINE DUMMY DROP TESTS

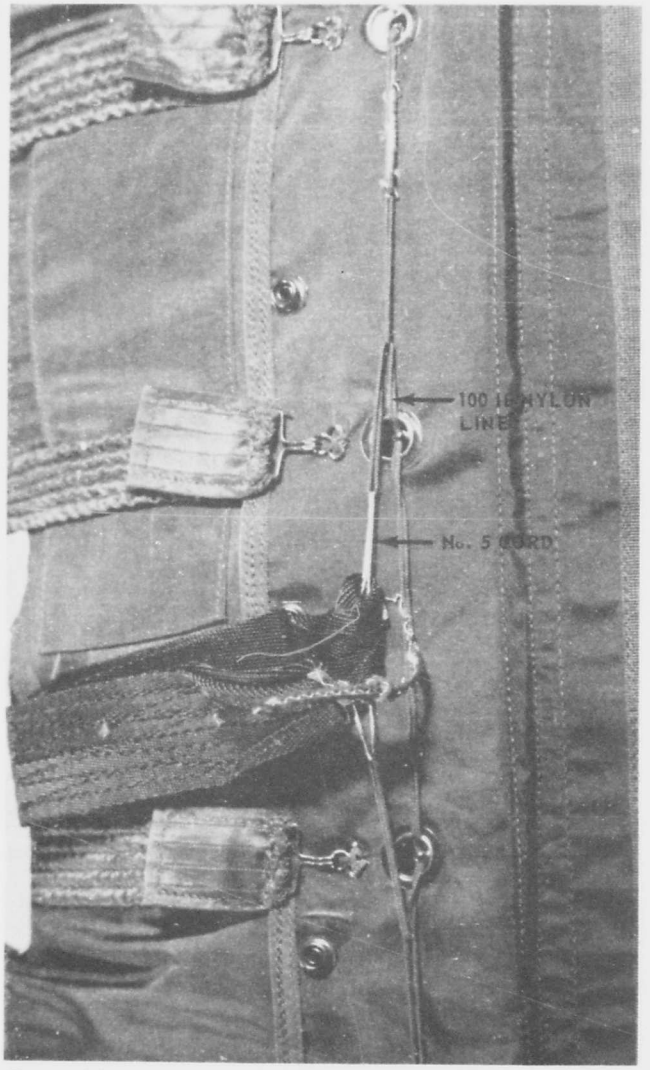


Figure 12 METHOD USED TO SECURE PIONEER PARA-COMMANDER MARK I PARACHUTE PACK WITH 100-lb NYLON LINE AND ONE TURN OF No. 5 CORD FOR TWISTED LINE DUMMY DROP TESTS

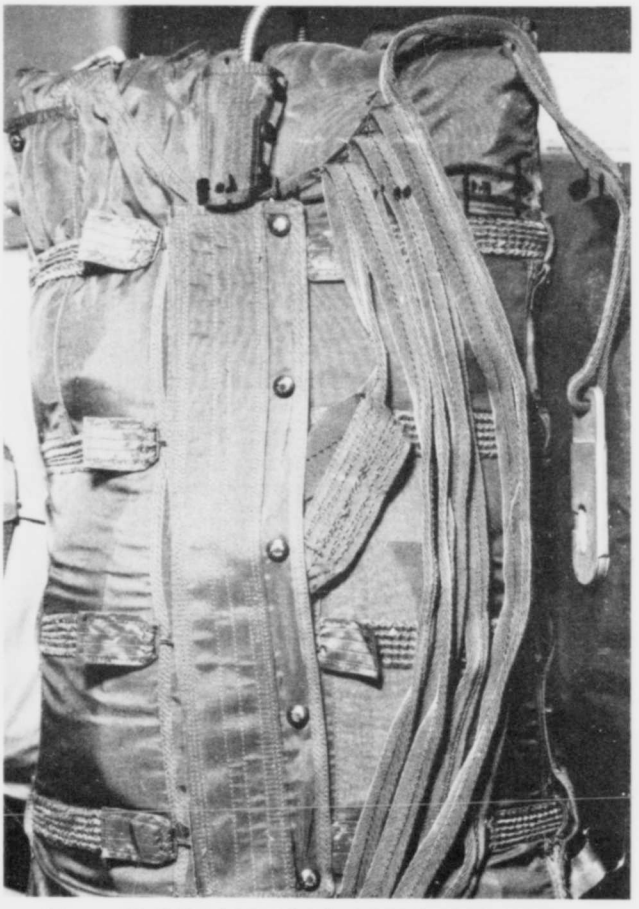


Figure 13 PIONEER PARA-COMMANDER MARK I PARACHUTE ASSEMBLY SHOWING PACK CLOSED AND STATIC-LINE ATTACHED FOR TWISTED LINE DUMMY DROP TESTS

Dummies launched from an H-21 helicopter were placed in an upright position approximately 6 inches inboard from the door and then were pushed out chest first. The F-1B automatic parachute ripcord release was actuated manually as the dummy left the helicopter.

A B-66 aircraft equipped with four compartments in the bomb bay was used for drop tests made above 170 KCAS. One dummy was loaded into each compartment. The dummies were launched individually in a chest down, base aft attitude during successive passes over the drop zone. A static line 8 inches long actuated the F-1B automatic parachute ripcord release as the dummies left the aircraft.

In the live jump phase of the program, the test parachutists assumed a stable prone position as they left the aircraft. The parachute packs were opened by an F-1B automatic parachute ripcord release set for 5000 feet pressure altitude and 10-second delay. Test parachutists performed various maneuvers such as turning and braking[2] after parachute opening. Turns were timed by the parachutist using a stopwatch and a reference point on the ground.

[2] Braking-Induced when the control line toggles are pulled to a level such that the canopy has no forward motion.

TEST RESULTS

The results of the permeability measurements are shown in table II. The results of twisted line, dummy drop and live jump tests are shown in tables III through VII. A summary of average rates of descent, maximum riser forces, times from pack open to full open and fall distances from launch to full open for the dummy drop tests are shown in table VIII. The relationship of aircraft launch velocity to average maximum opening force, the time from pack open to full open and the average fall distance from launch to full open are shown in figures 14 through 16. All rates of descent were corrected to ICAO standard atmosphere at sea level. During the live jump phase of the program, four control line casings were broken (figure 17) due to abrasion by the metal rings through which the control lines passed. The serial numbers of parachutes which sustained control line damage and the number of tests made before the damage occurred are shown below.

Parachute Serial No.	Number of Tests Prior to Damage
64811	7
64818	9
64824	6
64832	4

In one live jump the front of the canopy folded into the center line during deployment once but was corrected by pulling on the parachute front risers which returned the canopy to its normal configuration. There were no malfunctions of the main canopies which required use of the reserve parachute. During the dummy drop tests the canopies were not damaged when launched at calibrated airspeeds below 170 knots at 1000 feet pressure altitude. At 170 KCAS three of the four canopies tested had minor damage. During tests made at 200 KCAS, one canopy had minor damage, the front of one canopy had folded into the center line, and one other canopy, which never opened fully, had major damage. During tests made at 210 KCAS the canopies were not damaged. One of the two canopies tested at 225 KCAS had major damage and the canopy failed to open fully. The sleeves and pilot chutes broke away from all canopies during tests in which there was major canopy damage. The drop testing of dummies was terminated at 225 KCAS to prevent needless destruction of the remaining canopies. Typical examples of pack and canopy damage are shown in figures 18 through 24. Damage charts of the two canopies which sustained major damage are shown in figures 25 through 27.

Parachutists stated that the time required to made a 360-degree turn during descent ranged from 3 to 6 seconds. When only one control toggle was pulled the maximum distance (approximate length of the parachutist's arm), a 360-degree turn was completed in the minimum amount of time. When the test parachutists pulled the control line toggle its maximum length, the bank angle increased and stability decreased. When the toggles were returned to identical levels, the turn (rotation) stopped. The parachutists also reported that a more stable turn could be made by first pulling both control toggles to the level of the canopy releases, and then depressing the applicable toggle to make the turn. If the toggles were at an identical level, the canopy was very stable with less than 5 degrees oscillation.

The parachutists reported that turns began immediately upon pulling one toggle. They also

observed that they could directionally control the canopy toward a target on the ground.

The test parachutists noted that some canopies tended to turn (rotate) in one direction or the other without the control lines being used. Apparently this was caused by the center line (from the rear risers to the apex of the canopy) being tied slightly off the center of the apex which resulted in an unsymmetrical canopy.

It was noted on two different occasions during the live jump portion of the program, that the sleeve and pilot chute came through one of the vents in the canopy. This seemed to have little or no effect on canopy performance.

Test parachutists reported that the best body attitude to lessen opening shock was a "back-tracking"[3] position assumed just prior to parachute opening.

It was noted both by the project engineer and the test parachutists that landing while facing the wind was the best position due to the inherent forward speed of the Para-Commander parachute.

On all dummy tests, except drop numbers 0445, 1020, 1021, and 1023, the parachute was open fully within 500 feet of fall distance. Except for the twisted line tests, this included a 1-second delay after release from the aircraft.

[3] Back-tracking-the body is in a stable prone position with the feet lower than the head so that upon parachute opening, the forces are taken more along the length of the body and there is less whipping action.

TABLE II

RESULTS OF PERMEABILITY TESTS MADE ON PARA-COMMANDER MK I PARACHUTE CANOPY MATERIALS

Parachute aerial no.	Number of previous times dropped	Canopy material[1] permeability			Test conditions[2]
		bottom (cfm/ft^2)	center (cfm/ft^2)	top (cfm/ft^2)	
64812	0	8.1	8.1	118	S
64812	1	10.0	9.1	116	58%
64812	2	8.3	8.4	117	56%
64812	3	8.7	8.8	119	S
64817	0	10.5	9.1	107	S
64817	1	10.9	9.2	117	58%
64817	2	11.3	9.4	105	52%
64817	3	10.7	9.4	106	S
64821	0	13.5	10.9	111	S
64821	1	15.3	10.7	113	58%
64821	2	14.2	11.3	111	56%
64821	3	13.9	11.5	113	S
64827	0	8.6	8.0	117	S
64827	1	9.0	8.5	114	58%
64827	2	8.6	8.8	116	52%
64827	3	8.7	9.6	122	S
64822	0	8.3	8.0	113	S
64822	1	14.1	9.1	111	S
64833	0	9.0	8.0	118	S
64833	1	9.0	8.2	115	S
64809	0	12.7	11.6	114	S
64810	0	8.4	8.6	111	S
64811	0	8.1	11.0	120	S
64813	0	9.8	8.3	111	S
64814	0	8.8	9.3	123	S
64815	0	10.3	9.1	118	S
64816	0	8.1	8.1	113	62%
64818	0	7.9	9.1	116	S
64819	0	10.4	7.5	113	52%
64823	0	10.1	12.9	126	S
64824	0	12.2	11.4	111	S
64825	0	12.8	11.4	108	S
64826	0	9.4	10.0	125	52%
64828	0	13.0	10.7	109	S
64829	0	12.0	9.2	107	S
64830	0	7.8	7.9	112	S
64831	0	8.8	9.2	117	S
64832	0	9.6	9.0	127	S

[1] Bottom and center sections constructed of nylon taffeta. Top sections constructed of 1.1 oz. nylon.

[2] Letter "S" indicates standard test conditions (70 ± 2°F and relative humidity 65% ±2). Percentage figures indicate relative humidity at time of test. Ambient temperature was approximately 70°F.

TABLE III

RESULTS OF TWISTED LINE TESTS[1] USING 250-LB. TORSO DUMMIES EQUIPPED WITH PARA-COMMANDER MK I PARACHUTES LAUNCHED FROM A C-130 AIRCRAFT AT 110 KCAS AND 1000 FT. PRESSURE ALTITUDE

Drop No.	Time				Average glide ratio[2]	Fall Distance		Rate of descent
	Launch to pack open (sec)	Launch to full open (sec)	Launch to equilibrium[3] (sec)	Pack open to equilibrium[3] (sec)		Launch to full open (ft)	Launch to equilibrium (ft)	(ft/sec)
0053	1.0	4.9	8.0	7.0	1.21	191	260	17.3
0054	1.0	4.1	5.4	4.4	1.10	195	240	18.9
0055	1.1	4.1	5.0	3.9	1.25	195	220	17.0
0056	0.8	3.9	6.2	5.4	0.99	210	290	16.9
0057	0.8	6.1	9.0	8.2	1.16	272	330	19.5
0058	0.7	3.5	6.0	5.3	0.93	161	180	19.9
0059	0.8	5.4	5.6	4.8	1.09	256	260	18.2
0060	0.5	3.6	4.4	3.9	1.01	139	210	19.1
0087	0.6	4.9	5.6	5.0	1.18	225	220	19.3
0088	0.7	3.2	5.6	4.9	1.15	142	220	18.7
0089	0.7	4.6	6.2	5.5	1.19	213	270	17.7
0090	0.7	3.0	3.6	2.9	0.73	120	130	18.8
0091	0.6	4.0	7.0	6.4	1.59	169	260	18.3
0092	1.1	5.6	8.4	7.3	1.33	302	370	18.4
0093	0.8	3.2	6.0	5.2	1.12	130	210	17.0
0094	0.7	4.2	5.4	4.7	1.20	174	210	17.7
0114	0.7	5.1	7.6	6.9	1.45	227	310	17.6
0115	0.7	2.6	3.2	2.5	1.31	106	120	16.9
0136	0.7	4.6	5.8	5.1	1.16	208	240	15.5
0137	0.8	3.7	5.0	4.2	1.08	151	190	18.2
0138	0.7	5.0	6.0	5.3	1.10	210	240	17.3
0139	0.6	5.8	7.0	6.4	1.19	206	240	18.2
0140	0.8	3.5	5.0	4.2	1.08	161	200	15.6
014'	0.5	3.9	6.0	5.5	1.16	189	260	17.1
0249	0.7	4.1	5.0	4.3	1.23	169	190	17.0
0250	1.0	3.4	6.0	5.0	1.23	152	230	13.9
0251	0.7	3.6	7.0	6.3	1.34	193	300	16.6
0252	0.7	3.3	6.0	5.3	1.19	145	240	15.9
0253	0.9	3.6	4.4	3.5	1.24	138	160	20.4
0254	0.7	6.9	8.2	6.5	0.70	343	380	16.8
0255	0.7	5.9	7.0	6.3	0.77	248	270	17.1
0256	0.6	4.8	5.8	5.2	1.60	177	200	13.7
0333	0.8	3.1	4.0	3.2	1.21	125	140	17.2
0334	1.2	3.8	6.0	4.8	1.18	168	230	17.2
0335	0.7	3.3	5.6	4.9	1.23	92	150	17.0
0336	0.9	3.6	5.2	4.3	1.17	133	190	17.4
0337	1.0	4.2	5.0	4.0	1.51	185	210	17.6
0338	0.8	4.2	7.0	6.2	1.47	185	280	17.6
0339	0.1	4.0	7.8	7.7	0.75	187	300	17.2
0340	1.3	5.5	6.0	5.7	0.67	236	250	17.6

[1] Made in accordance with USAF Specification Bulletin No. 505 par. 2.3.1.2

[2] Average for approximately the final 300 feet of descent. Average for all dummy drop tests was 1.16. The range was from 0.64 to 2.41. This may have been due to inaccuracy of the wind corrections.

[3] Time at which the first minimum rate of descent is reached after parachute full open.

TABLE IV

RESULTS OF LOW ALTITUDE (1000 FT.) TESTS[1] USING 250-LB. TORSO DUMMIES EQUIPPED WITH PARA-COMMANDER MK I PARACHUTES LAUNCHED FROM AN H-21 HELICOPTER AT NEAR ZERO AIRSPEED

Drop No.	Time				Fall Distance		Average glide ratio[4]	Maximum Riser Forces[2]			Rate of descent
	Launch to pack open (sec)	Launch to full open (sec)	Launch to equilibrium[3] (sec)	Pack open to equilibrium[3] (sec)	Launch to full open (ft)	Launch to equilibrium[3] (ft)		Left (lb)	Right (lb)	Total (lb)	(ft/sec)
0112	0.7	4.2	6.5	5.8	278	330	1.06	1075	700	1775	17.7
0113	1.2	4.6	5.0	3.8	289	310	1.54	800	650	1400	17.8
0164	1.0	4.2	do	4.0	267	290	1.15	775	600	1350	17.6
0165	1.2	6.1	8.0	6.8	417	470	1.07	675	420	1075	18.9
0271	2.0	4.8	6.6	4.6	322	390	1.03	700	500	1200	17.5
0272	1.6	5.6	do	5.0	389	420	1.73	750	600	1300	18.4
0273	do	5.4	6.0	4.4	448	470	1.56	1000	650	1600	18.7
0274	do	5.8	7.3	4.9	496	510	1.46	(5)	1125	(5)	18.0

[1] Made in accordance with USAF Specification Bulletin No. 505, par. 2.3.1.4.1.

[2] The riser forces are the maximum recorded, but not necessarily at the same instant. The total force is the maximum instantaneous sum of the riser forces.

[3] Time at which the first minimum rate of descent is reached after parachute full open.

[4] Average from approximately the final 300 feet of descent. Overall average for dummy drop tests was 1.16.

[5] Suspension lines on left riser deployed under base plate. Data not obtained.

TABLE V

RESULTS OF DROP TESTS USING 250-LB. TORSO DUMMIES EQUIPPED WITH PARA-COMMANDER MK I PARACHUTES LAUNCHED AT 1000-FT. PRESSURE ALTITUDE

Drop No.	Time				Fall Distance		Average glide ratio[3]	Maximum Riser Forces[1]			Rate of descent
	Launch to pack open	Launch to full open	Launch to equilibrium[2]	Pack open to equilibrium[2]	Launch to full open	Launch to equilibrium[2]		Left	Right	Total	
	(sec)	(sec)	(sec)	(sec)	(ft)	(ft)		(lb)	(lb)	(lb)	(ft/sec)
H-21 helicopter -- 60 KCAS											
0341	1.4	4.1	6.0	4.6	238	270	0.64	660	775	1260	14.7
0342	1.7	4.6	do	4.3	263	290	0.70	(4)	(4)	(4)	17.4
0343	1.6	3.8	5.6	4.0	226	300	1.28	725	900	1625	16.8
H-21 helicopter -- 70 KCAS											
0344	1.3	3.7	4.6	3.3	215	230	1.11	800	1125	1925	19.9
0345	1.1	3.2	6.0	4.9	171	260	1.09	750	1225	1975	16.5
0346	1.4	4.2	7.0	5.6	225	310	0.64	600	650	1260	19.7
C-130 aircraft -- 110 KCAS											
0412	1.3	3.1	6.0	4.7	124	200	0.97	1380	1600	2980	17.5
0413	0.9	2.9	3.6	2.7	103	120	0.95	1150	910	2030	19.3
0414	0.8	2.6	5.4	4.6	105	200	1.31	1300	1800	3100	17.5
0415	do	3.1	5.0	4.2	127	180	0.95	1135	1300	2435	17.3
C-130 aircraft -- 130 KCAS											
0416	0.4	1.9	4.4	4.0	53	140	1.33	2250	1800	4050	16.9
0417	0.8	2.2	do	3.6	79	150	1.34	1350	1350	2775	16.6
0418	do	3.7	7.0	5.0	189	290	1.23	1300	1260	2560	18.8
0419	0.4	2.0	5.7	5.3	78	200	1.17	1025	1000	1925	17.2
C-130 aircraft -- 150 KCAS											
0444	0.4	1.8	4.2	3.8	44	120	1.13	1675	1800	3475	19.2
0445	[5]4.5	6.1	9.4	4.9	507	620	1.21	(4)	(4)	(4)	19.3
0446	0.4	1.7	4.0	3.6	41	110	0.89	2500	3000	5500	16.1
0447	0.3	1.9	do	3.7	39	do	1.29	1210	1150	2360	17.9
C-130 aircraft -- 170 KCAS											
[6]0513	0.7	2.0	3.2	2.5	69	100	1.03	(4)	1125	(4)	16.8
0514	0.5	do	5.0	4.5	54	140	1.30	1875	2265	4140	15.8
[6]0515	0.9	2.1	6.0	5.1	70	200	0.78	1775	2900	4200	21.7
[6]0516	0.8	1.8	4.0	3.2	63	130	1.19	3000	2550	5550	16.5
B-66 aircraft -- 200 KCAS											
1018	0.9	[7]3.3	6.0	5.1	187	200	1.03	2000	(4)	(4)	18.5
[8]1019	1.1	3.6	do	3.7	126	do	1.29	(4)	(4)	(4)	17.2
[8]1020	1.0	--	--	--	--	--	--	2600	2650	4050	32.7
1021	do	(9)	(9)	(9)	(9)	(9)	--	2425	2500	4925	42.3
B-66 aircraft -- 210 KCAS											
1024	0.8	2.2	6.6	5.8	93	240	0.94	1775	2175	3775	20.8
1025	0.9	2.1	2.5	1.6	92	110	0.78	2325	2525	4850	[10]25.0
B-66 aircraft -- 225 KCAS											
1022	0.6	1.9	3.8	3.2	45	80	--	2525	1905	4430	18.4
[8]1023	1.0	--	--	--	--	--	--	3300	3075	6375	104.0

[1] The riser forces are the maximum recorded, but not necessarily at the same instant. The total force is the maximum instantaneous sum of the riser forces.
[2] Time at which the first minimum rate of descent is reached after parachute full open.
[3] Average from approximately the final 300 ft. of descent. Overall average for dummy drop tests was 1.16.
[4] Data not obtained.
[5] Cause of the delay could not be determined.
[6] Minor damage to canopy.
[7] Canopy opened in stages causing the long opening time.
[8] Major damage to canopy.
[9] Canopy did not open fully because the front half folded into the centerline.
[10] Canopy was deformed for unknown reasons causing the high rate of descent.

TABLE VI

RESULTS OF HIGH ALTITUDE TESTS USING 250-LB. ARTICULATED DUMMIES EQUIPPED WITH PARA-COMMANDER MK I PARACHUTES

Drop No.	Launch pressure altitude (ft)	Launch velocity (kt)	Altitude above mean sea level at pack open (ft)	Velocity at pack open (ft/sec)	Maximum Riser Forces [1] Left (lb)	Right (lb)	Total (lb)	Average glide ratio[2]	Rate of descent (ft/sec)
				C-130 aircraft					
0439	15,000	110	10,570	206	1220	2050	3270	1.20	16.9
0448	25,000	do	20,410	248	1750	2750	4300	1.15	15.1
0504	35,000	do	29,450	309	(3)	(3)	(3)	1.49	16.7
				B-66 aircraft					
0663	35,000	150	(4)	(4)	1850	2600	4450	2.41	13.0

[1] The riser forces are the maximum recorded, but not necessarily at the same instant. The total force is the maximum instantaneous sum of the riser forces.

[2] Average from approximately the final 300 ft. of descent. Overall average for dummy drop tests was 1.16.

[3] Data were not obtained.

[4] Cinetheodolite data were not obtained until 50 seconds after launch.

TABLE VII

RESULTS OF LIVE JUMP TESTS[1] MADE USING PARA-COMMANDER MK I PARACHUTES

Drop No.	Gross weight of parachutist	Maximum bank angle	Time			Fall Distance	Rate of descent[3]
			Launch to pack open	Launch to pack open	Interval between pack open and full open[2]	Pack open to full open	
	(lb)	(deg)	(sec)	(sec)	(sec)	(ft)	(ft/sec)
H-21 helicopter -- 8000 ft. pressure altitude -- 60 KCAS							
0597	221	44	25.2	27.4	2.2	340	14.0
0872	219	do	23.0	25.7	2.7	290	17.5
0893	220	do	22.7	25.4	do	330	11.2
0898	221	49	20.2	22.6	2.4	360	16.7
0990	231	44	22.4	24.6	2.2	420	18.1
0995	do	do	24.6	27.5	2.9	450	19.2
1000	210	45	23.3	26.1	2.8	320	17.5
1098	181	49	26.1	31.7	5.6	750	11.0
1104	231	41	24.8	27.6	2.8	400	19.0
1175	do	44	25.7	28.4	2.7	290	16.3
1176	214	42	24.2	27.0	2.8	440	15.6
1177	220	44	22.9	24.9	2.0	300	16.4
1179	231	43	25.1	25.1	do	320	23.0
1109	214	do	22.6	25.3	2.7	270	14.2
1190	226	45	24.0	25.9	1.9	300	17.9
1195	do	do	24.4	26.2	1.8	330	21.2
0703	220	36	25.4	28.1	2.7	390	16.3
0821	do	47	24.5	28.3	3.8	360	14.2
H-21 helicopter -- 10,000 ft. pressure altitude -- 60 KCAS							
0691	225	43	26.7	26.9	3.2	590	13.4
0693	231	38	34.8	36.9	2.1	240	14.6
0695	230	45	37.2	39.1	1.9	180	13.5
0697	235	44	33.6	36.1	2.5	440	16.8
0701	235	41	34.1	36.0	1.9	170	16.3
1005	220	42	36.5	39.2	2.7	420	15.0
C-130 aircraft -- 12,500 ft. pressure altitude -- 110 KCAS							
0602	232	44	46.9	48.9	2.0	240	14.1
0607	223	36	48.7	50.8	2.1	do	14.9
0699	235	43	49.6	52.8	3.2	380	14.0
0867	237	46	48.1	51.1	3.0	360	13.6
1093	221	40	49.7	51.8	2.1	230	13.7
1185	231	39	52.4	53.9	1.5	220	15.2
1240	208	46	49.5	52.1	2.6	340	15.6
C-130 aircraft -- 20,000 ft. pressure altitude -- 110 KCAS							
0985	244	45	86.7	91.6	4.9	420	15.1

[1] Data were accumulated on 19.5 percent of total number of live jumps made to furnish a sample and expedite completion of the program.
[2] Average time between pack open and full open was 2.6 seconds.
3 Average rate of descent was 15.7 feet per second.

TABLE VIII

SUMMARY OF AVERAGE RATES OF DESCENT, MAXIMUM RISER FORCES, TIMES FROM PACK OPEN TO FULL OPEN, AND FALL DISTANCES FROM LAUNCH TO FULL OPEN FOR DUMMY DROP TESTS MADE AT 1000 FT. PRESSURE ALTITUDE

Number of tests averaged	Launch velocity CAS (kt)	Rate of descent (ft/sec)	Maximum force on both risers (lb)	Time from pack open to full open (sec)	Fall distance from launch to full open (ft)
		H-21 helicopter			
8	Near-zero	18.0	1385	3.0	358
3	40	16.3	1442	2.6	242
3	70	18.7	1720	2.4	203
		C-130 aircraft			
40	110	17.5	(1)	3.5	185
4	do	17.9	2636	1.9	114
4	130	17.3	2827	1.5	99
4	150	18.1	3778	1.4	41
4	170	17.7	4630	1.2	64
		B-66 aircraft			
4	200	27.6	4487	4.5	157
2	210	22.9	4312	1.3	92
1	225	18.4	5402	do	45

[1] Twisted line tests; opening forces not measured.

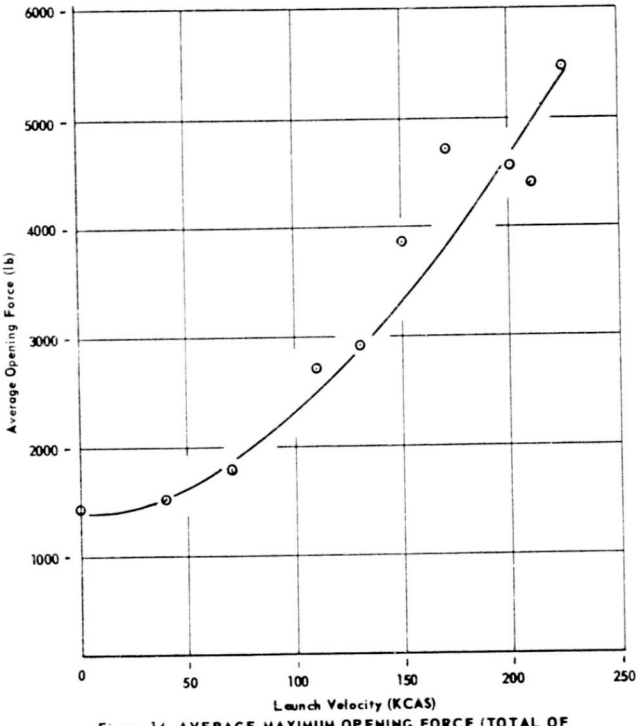


Figure 14 AVERAGE MAXIMUM OPENING FORCE (TOTAL OF BOTH RISERS) WITH F-1B AUTOMATIC PARACHUTE RIPCORD RELEASE SET FOR 1-SECOND DELAY vs LAUNCH VELOCITY. PIONEER PARA-COMMANDER MARK I PARACHUTES TESTED AT 1000 ft PRESSURE ALTITUDE

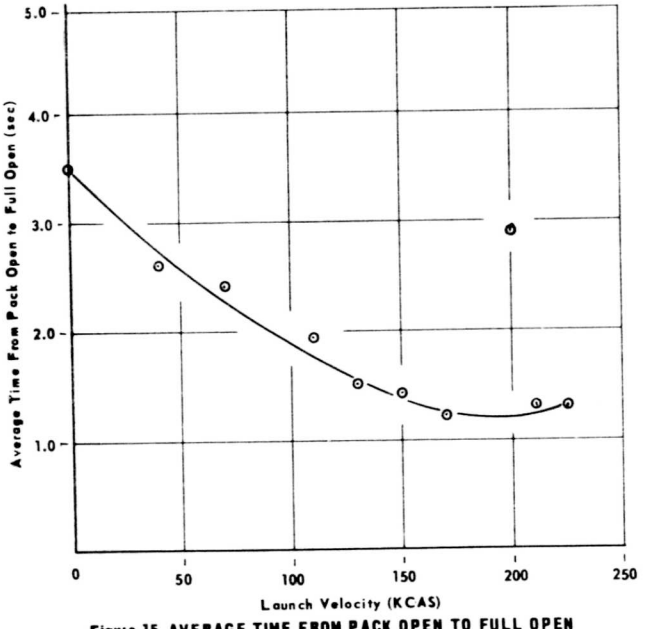


Figure 15 AVERAGE TIME FROM PACK OPEN TO FULL OPEN vs LAUNCH VELOCITY. PIONEER PARA-COMMANDER MARK I PARACHUTES TESTED AT 1000 ft PRESSURE ALTITUDE.

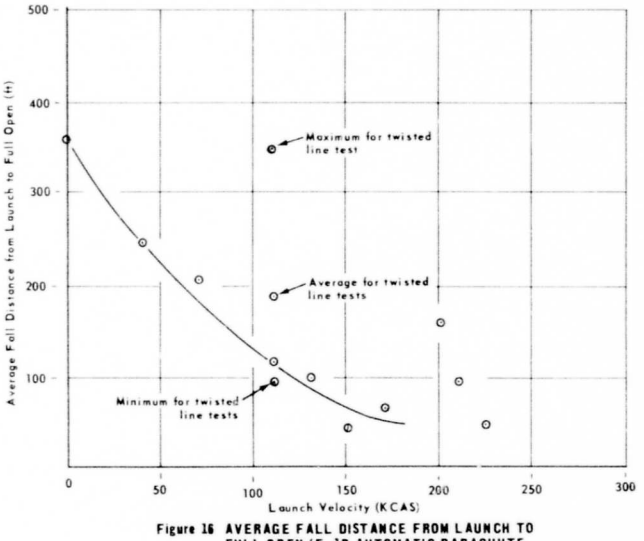


Figure 16 AVERAGE FALL DISTANCE FROM LAUNCH TO FULL OPEN (F-1B AUTOMATIC PARACHUTE RIPCORD RELEASE SET FOR 1-SECOND DELAY) vs LAUNCH VELOCITY. PIONEER PARA-COMMANDER MARK I PARACHUTES TESTED AT 1000 ft PRESSURE ALTITUDE.

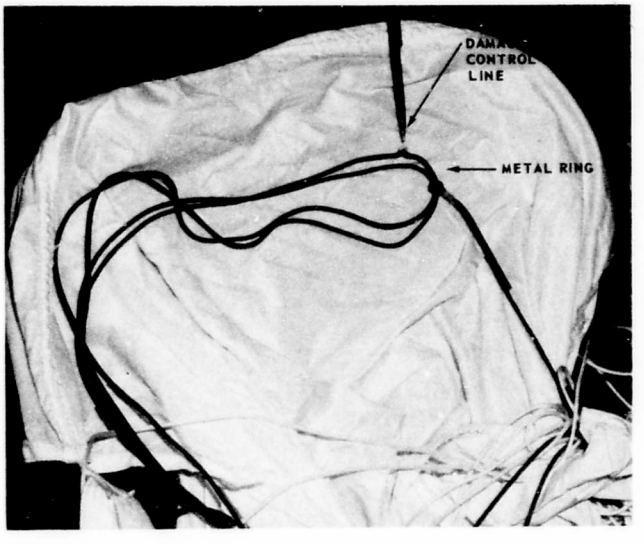


Figure 17 PIONEER PARA-COMMANDER MARK I PARACHUTE CANOPY (PARACHUTE SERIAL No. 64832) SHOWN AFTER A LIVE JUMP TEST. NOTE METAL RING AND DAMAGED CONTROL LINE

Figure 18 CANOPY OF PIONEER PARA–COMMANDER MARK I PARACHUTE SHOWING MAJOR DAMAGE AFTER DROP TEST No. 0516 MADE AT 170 KCAS AND 1000 ft PRESSURE ALTITUDE

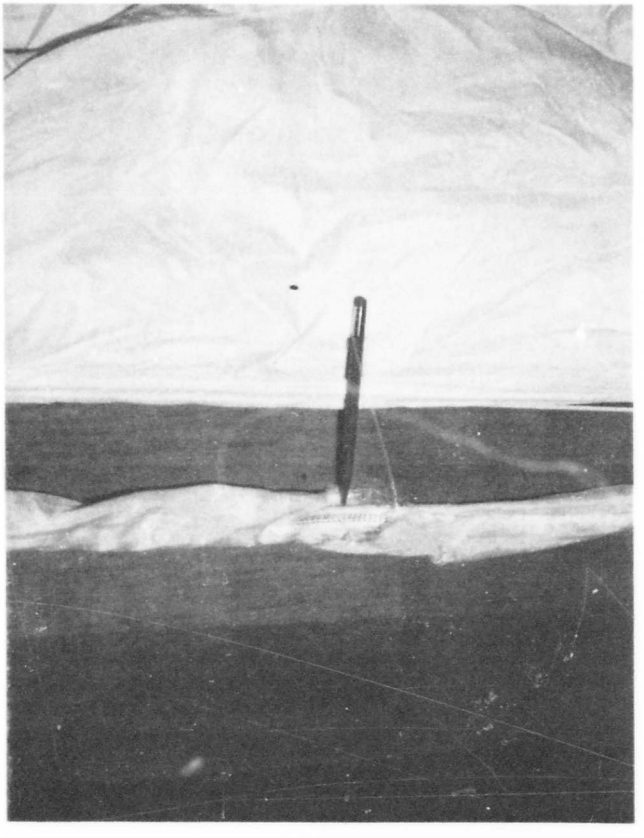


Figure 19 DAMAGED BUFFER ON CENTERLINE OF PIONEER PARACHUTE AFTER DROP TEST No. 0516 MADE AT 170 KCAS AND 1000 ft PRESSURE ALTITUDE.

Figure 20 MAJOR DAMAGE TO CANOPY OF PIONEER PARA–COMMANDER MARK I PARACHUTE AFTER DROP TEST No. 1023 MADE AT 225 KCAS AND 1000 ft PRESSURE ALTITUDE.

Figure 21 MAJOR DAMAGE TO STABILIZER PANEL OF PIONEER PARA–COMMANDER MARK I PARACHUTE CANOPY AFTER DROP TEST No. 1023 MADE AT 225 KCAS AND 1000 ft PRESSURE ALTITUDE.

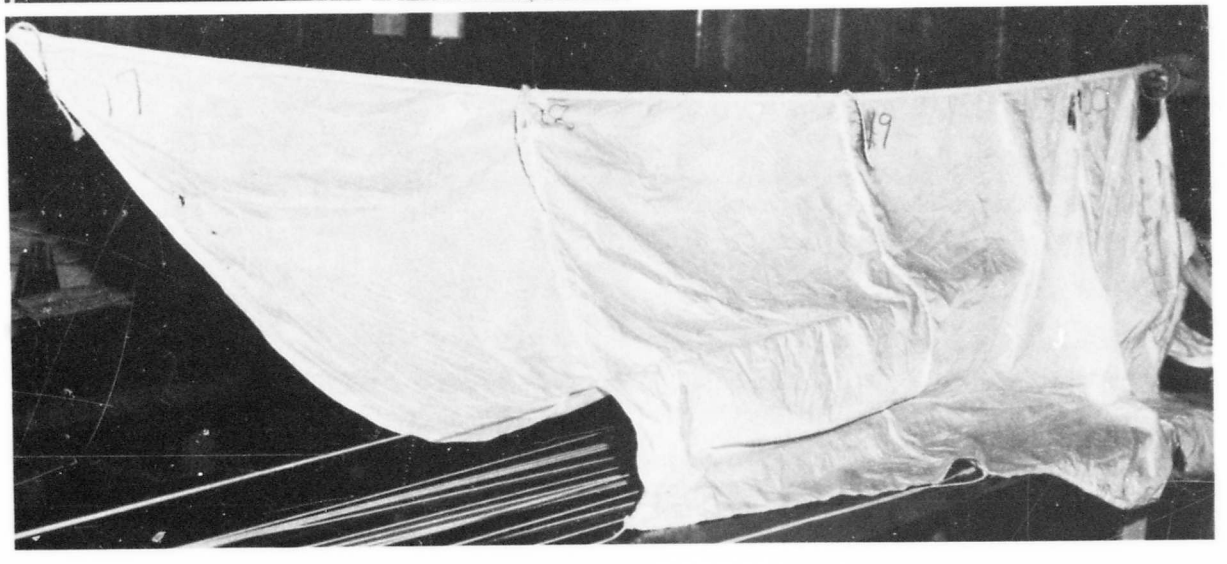


Figure 22 MAJOR DAMAGE TO PIONEER PARA-COMMANDER MARK I PARACHUTE PACK AFTER DROP TEST No. 1023 MADE AT 225 KCAS AND 1000 ft PRESSURE ALTITUDE. NOTE THE TORN FABRIC AND BROKEN MANUAL RIPCORD RELEASE HOUSING.

Figure 23 BROKEN 1500 lb (BREAK STRENGTH) TUBULAR NYLON WEBBING ON LAUNCH SLEEVE OF PIONEER PARA-COMMANDER MARK I PARACHUTE. FAILURE CAUSED LAUNCH SLEEVE TO SEPARATE FROM CANOPY DURING DROP TEST No. 1021 MADE AT 200 KCAS AND 1000 ft PRESSURE ALTITUDE.

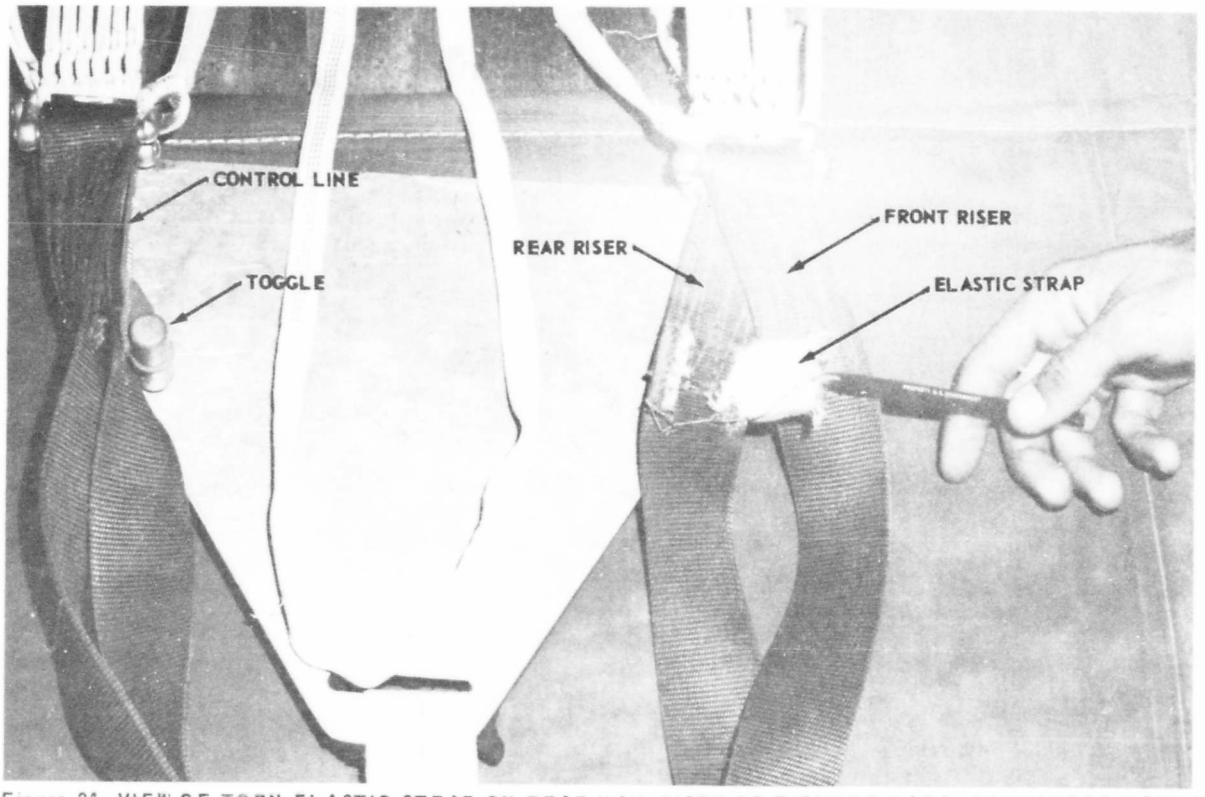
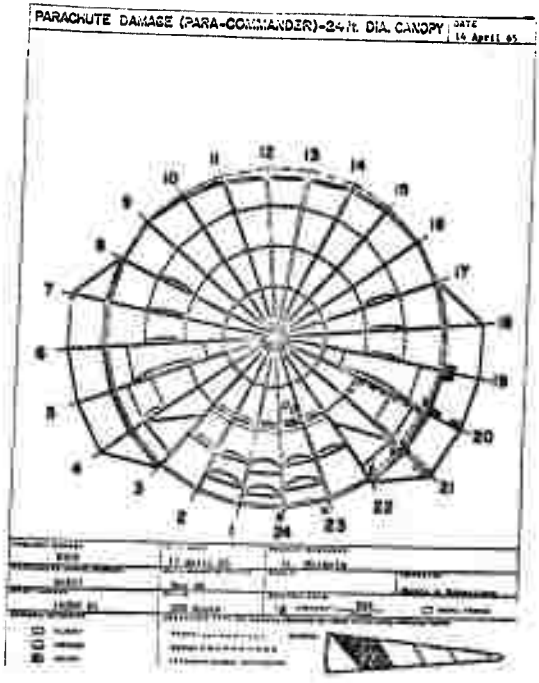
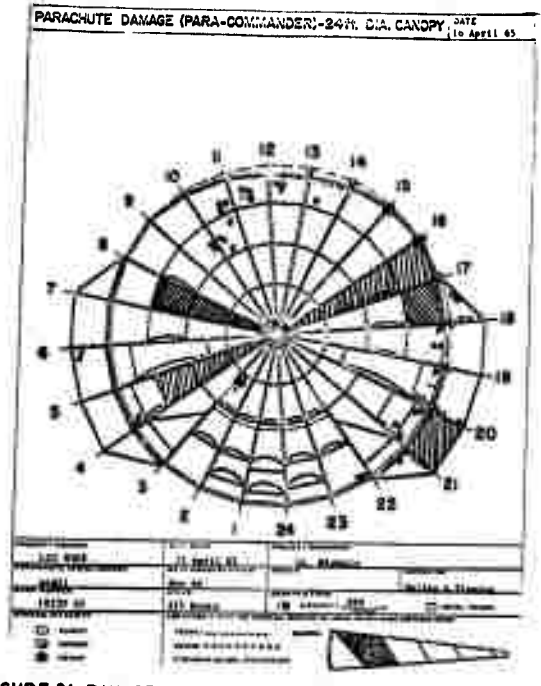


Figure 24 VIEW OF TORN ELASTIC STRAP ON REAR MAIN RISER OF PIONEER PARA-COMMANDER MARK I PARACHUTE. STRAP SECURES CONTROL LINE AND TOGGLE TO RISER AND WAS DAMAGED DURING DROP TEST No. 1023 MADE AT 225 KCAS AND 1000 ft PRESSURE ALTITUDE.



SYMBOL	REMARKS
X	DENOTES BROKEN SUSPENSION LINE
→	DENOTES BROKEN STITCHING AT SUSPENSION LINE/ CANOPY ATTACHMENT POINT.
O	DENOTES TWO 2 in HOLES IN SECTION 4 OF GORE 23.
o	DENOTES TWO SMALL HOLES IN CANOPY
NOT SHOWN	BROKEN CONTROL LINE CASING, BROKEN BRIDLE SLEEVE TORN REAR DIAGONAL STRAP KEEPER BROKEN STITCHING IN APEX AREA BROKEN SUSPENSION LINE CASINGS ONE 6 in TEAR IN TOP AREA OF APEX THREE 12 in TEARS IN SLEEVE

FIGURE 25 DAMAGE CHART OF PIONEER PARA-COMMANDER MARK I PARACHUTE CANOPY SHOWING LOCATION OF DAMAGED AREAS AFTER DROP TEST No. 1020 MADE AT 200 KCAS AND 1000 ft PRESSURE ALTITUDE.



SYMBOL	REMARKS
X	DENOTES BROKEN SUSPENSION LINE
–(B)	DENOTES BROKEN APEX BUFFER TAB
NOT SHOWN	BROKEN TOGGLE RETAINER ONE 2 in TEAR IN SLEEVE ONE ¼ in TEAR IN BOTTOM FLAP

FIGURE 26 DAMAGE CHART OF PIONEER PARA-COMMANDER MARK I PARACHUTE CANOPY SHOWING LOCATION OF DAMAGED AREAS AFTER DROP TEST No. 1023 MADE AT 225 KCAS AND 1000 ft PRESSURE ALTITUDE.

DAMAGE CHART

PARACHUTE TYPE	SERIAL NUMBER	PROJECT NUMBER	DROP NUMBER	TEST DATE
24' Para-Commander	64821	LTC 8508	10230 65	15 Apr 65

GORE	SECTION	LINE	REMARKS
		7	Stitching broken at connector link
		10	Broken at apex
		13	Broken at skirt
		14	do
		15	do
		16	Broken at apex
		17	Broken at skirt
		18	do
		19	do
		20	do
			Control line broken at toggle (right side)
			Control line casing broken (right side)
			Buffer on center line torn
			Ripcord housing broken
			Vest torn from pack
			Harness retainer broken (top)
			Both shoulder pads torn from harness
			Harness retainer stitching pulled loose (side)
			Both top end-flaps torn
			End-flap pocket torn
			Release cover torn

SIGNATURE OF INSPECTOR	INSPECTION DATE
	16 Apr 65

CONCLUSIONS

1. The data shown in figures 28 through 35 indicated that the rate of descent of the parachutist increased while turns were being made. Turns made below 100 feet above ground level may result in a higher than normal rate of descent at impact.

2. The rate of descent range (11 to 21.2 ft/sec) was well within allowable limits (25 ft/sec for a 300-pound parachutist) for personnel parachutes.[4]

3. The parachutists were able to maintain precise directional control of the canopies during descent.

4. The parachute pack was opened satisfactorily by an F-1B automatic parachute ripcord release.

5. The Para-Commander Mark I parachute met the requirements of USAF Bulletin No. 505, paragraph 2.3.1.2 (twisted line tests).

6. The glide ratios were obtained from the final 300 feet of descent on all dummy drop tests. Ratios ranged from 0.64 to 2.41 with an overall average of 1.16. The opening times from launch to full open with the F-1B automatic parachute ripcord release set for 1-second delay, ranged from an average of 5.1 seconds at near-zero launch airspeed to 1.8 seconds at 150 KCAS. Fall distances between launch and full open ranged from an average of 186 feet for the twisted line tests and 321 feet for tests made at near-zero airspeed to 41 feet at 150 KCAS. The packs were opened by a 15-foot static line for the twisted line tests; for all other tests the F-1B automatic parachute ripcord release was set for 1-second delay. Total forces (the maximum instantaneous sum of the riser forces) ranged from an average of 1386 pounds for tests made at near-zero airspeed to 3678 pounds at 150 KCAS.

[4] Technical report No. ASD-TR-61-579, Performance and Design Criteria for Deployable Aerodynamic Decelerators, page 319, paragraph 7.1.1.1 (C).

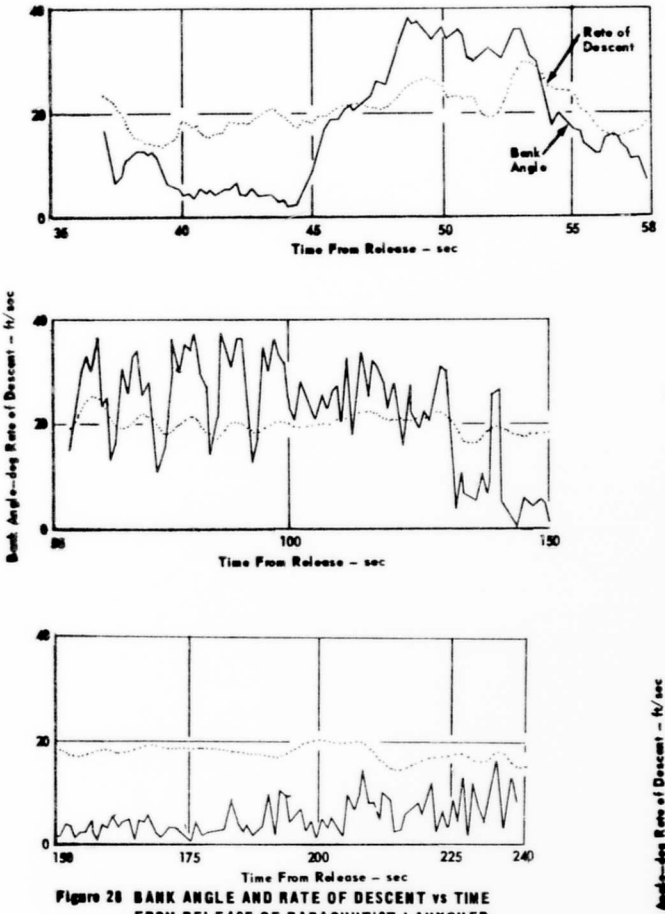


Figure 28 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 60 KCAS AND 10 000 ft PRESSURE ALTITUDE TEST No. 0693

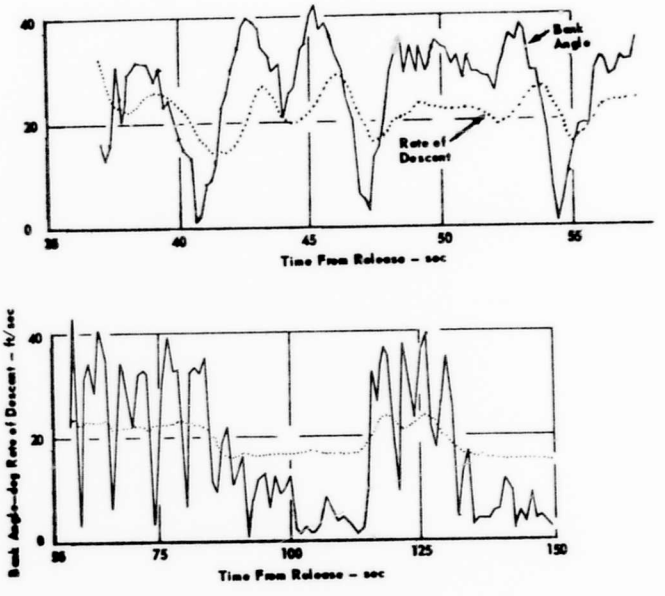
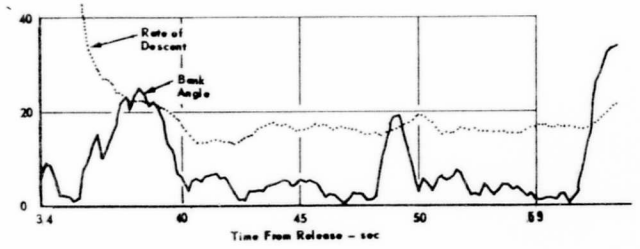
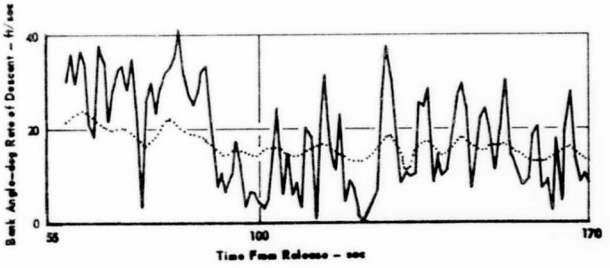


Figure 29 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 60 KCAS AND 10 900 ft PRESSURE ALTITUDE TEST No. 0697





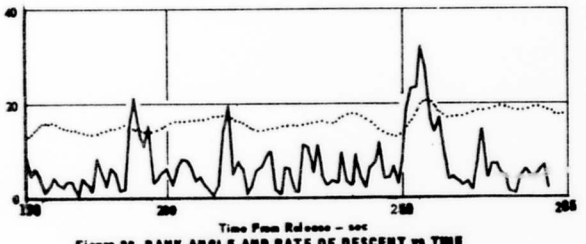
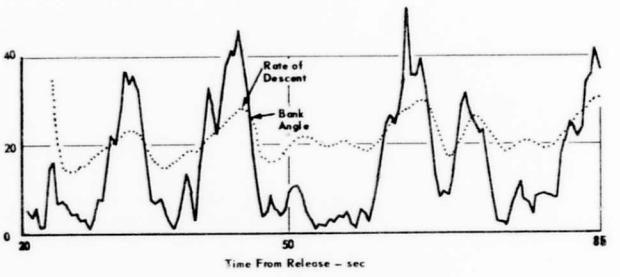
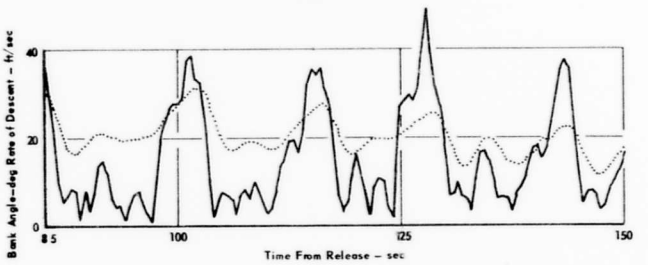


Figure 30 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 60 KCAS AND 30 000 ft PRESSURE ALTITUDE
TEST No. 0761





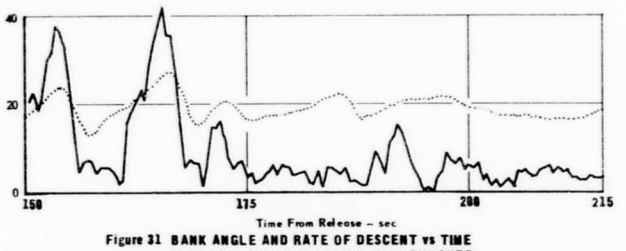


Figure 31 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 60 KCAS AND 8000 ft PRESSURE ALTITUDE
TEST No. 0898

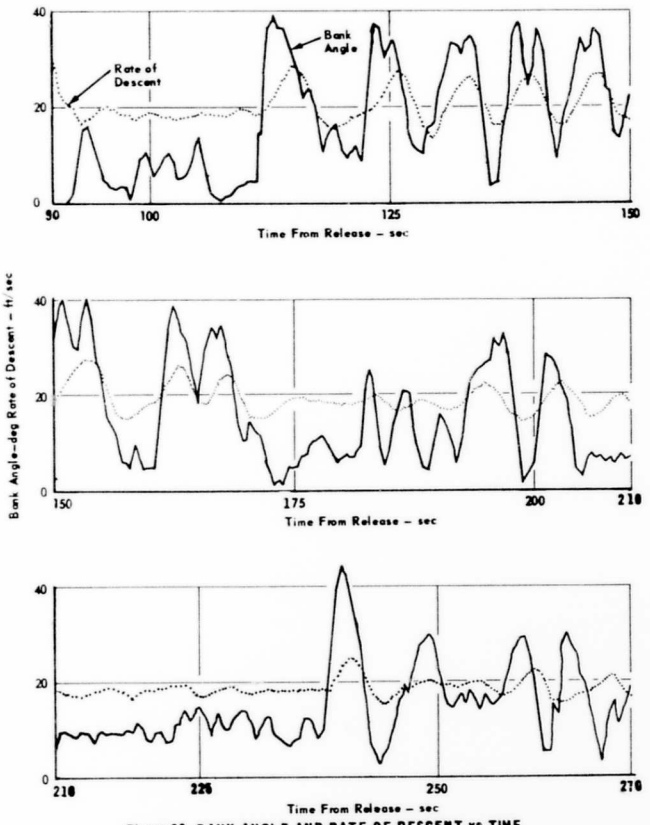


Figure 32 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 110 KCAS AND 20 000 ft PRESSURE ALTITUDE
TEST No. 0985

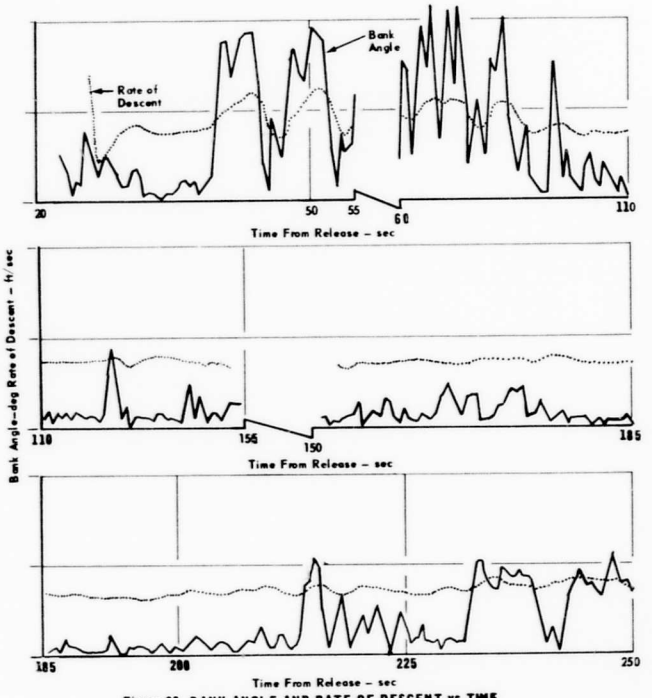


Figure 33 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 60 KCAS AND 8000 ft PRESSURE ALTITUDE
TEST No. 1177

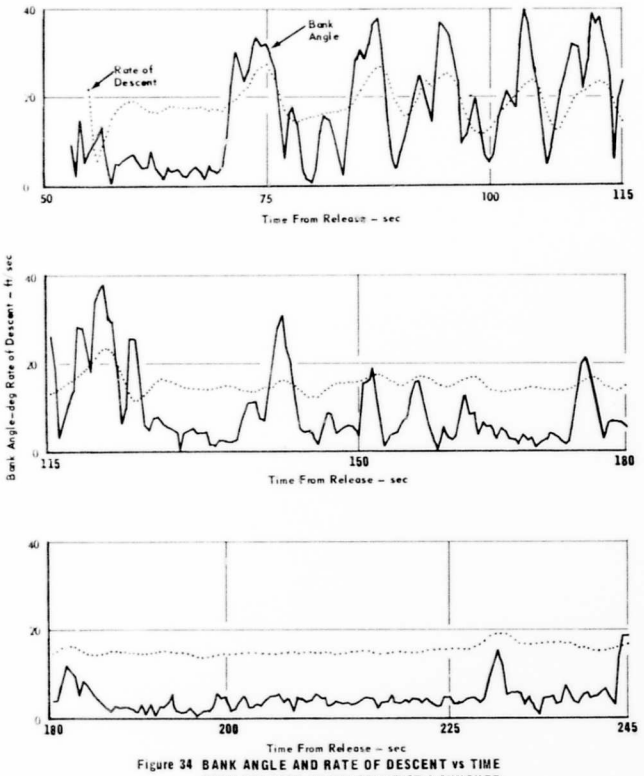


Figure 34 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 110 KCAS AND 12 500 ft PRESSURE ALTITUDE TEST No. 1185

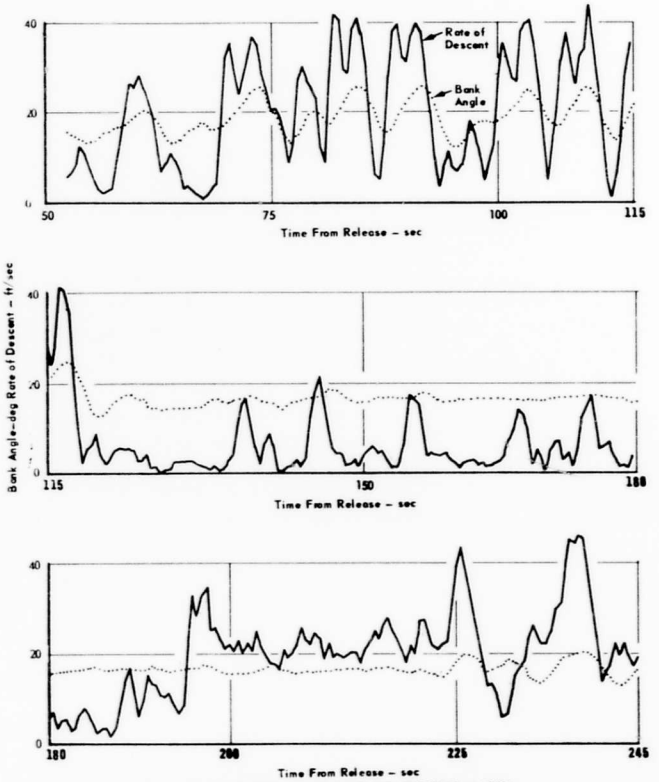


Figure 35 BANK ANGLE AND RATE OF DESCENT vs TIME FROM RELEASE OF PARACHUTIST LAUNCHED AT 110 KCAS AND 12 500 ft PRESSURE ALTITUDE TEST No. 0867

RECOMMENDATIONS

1. The metal rings through which the canopy control lines pass should be replaced by rings constructed of less abrasive material to reduce wear on the control line casings.

2. The point where the center line is attached to the apex of the canopy should be checked for exact centering as part of the packing procedure to assure proper location.

3. During free-fall the parachutist should assume a back-tracking attitude just prior to parachute opening.

4. To complete a 360-degree turn (either clockwise or counter-clockwise) in the minimum amount of time, one control line toggle should be pulled the maximum distance (approximate length of the parachutist's arm). For maximum stability during turns, both control line toggles should be pulled to the level of the canopy releases. The control line toggle on the side into which the turn is to be made should then be pulled downward below the canopy release until the desired degree of turn has been obtained.

5. Landings should be made with the parachutist facing the wind because of the inherent forward speed of the canopy.

6. No turns should be attempted when the parachutist is less than 100 feet above the ground unless absolutely necessary.

7. The Pioneer Para-Commander Mark I parachute should be used only by qualified and experienced free-fall parachutists.

8. Launch altitude should not be less than 1000 feet above ground level with a 1-second delay to pack opening until further information can be obtained.

9. Velocity at launch with a 1-second delay to pack opening should not exceed 150 KCAS at 1000 feet pressure altitude due to canopy damage sustained above that speed.

10. It is recommended that additional dummy tests be conducted to determine maximum safe opening velocities above 1000 feet altitude.

REFERENCES

1. Pioneer Parachute Company, Inc., Material Control Specification, No. E.I. 41321.

2. United States Air Force, Performance and Design Criteria for Deployable Aerodynamic Decelerators, ASD-TR-61-579, UNCLASSIFIED.

3. United States Air Force, Parachutes, Personnel, Testing Standards For, Specification Bulletin No. 505, FSC-1670, UNCLASSIFIED.

UNCLASSIFIED

Security Classification

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FTC-TR-66-16

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13. ABSTRACT

The Pioneer Para-Commander Mark I 24-ft. diameter parachute manufactured by the Pioneer Parachute Company, Manchester, Connecticut was tested. A total of 246 tests was made using a B-66, a C-130, a C-47 and an H-21 aircraft. Launch velocities varied from minimum (near-zero) to 225 KCAS and launch pressure altitudes ranged from 1000 to 35,000 ft. Articulated and torso dummies weighing 283 lb. (gross weight) were used for 82 dummy drop tests. Test parachutists weighing from 181 to 241 lb. (gross weight) made 164 live jumps. Parachute opening times, fall distances, glide ratios, turn times and live-jump reliability data were obtained. The test item was determined to be safe for Air Force use when used by qualified and experienced free-fall parachutists. Recommendations are made for modifications, packing procedures and live jump procedures. It is also recommended that launch altitude should not be less than 1000 ft. above ground level with a one-second delay to pack opening, nor should the parachute be deployed above 150 KCAS at 1000 ft. pressure altitude. It is recommended that additional dummy tests be conducted to determine maximum safe opening velocities above 1000 ft. altitude.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Personnel Parachutes						
Pre-meditated, Free Fall						
Steerable						
Para-Commander						
Opening Times						
Opening Forces						
Fall Distances from Launch to Full Open						
Rates of Descent						
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