How To Select An Emergency Parachute

by Manley C. Butler, Jr. Copyright © 1991

INTRODUCTION

This document is intended to supplement the Butler Parachute Systems, Inc. catalog and price list as additional information to help you select an emergency parachute for your particular application. Although we have made every effort to anticipate your questions and provide answers for them, we realize that some answers might not be here. In that case, please feel free to call us to discuss your particular application.

NOTE: In the following discussion, our catalog and price list, the term "gross weight" means your body weight plus your clothes, the parachute itself, and any other equipment you might be carrying with you when you jump out of the airplane.

Because our primary products are emergency parachute systems, we are very conservative in our recommendations of the appropriate equipment for a particular conditions. We consider your height (to determine harness/pack sizing), your gross weight (to determine canopy size for rate-of-descent), your aircraft type and its performance envelope (to determine equipment strength requirements), and your aircraft seating arrangements (to determine the configuration needed). Consequently, we generally recommend larger and more rugged equipment than our competitors (most of whom specialize in skydiving equipment).

FAA APPROVAL OF PARACHUTES

Aircraft "appliances" (nearly anything except engine, propeller or airframe) are usually approved (or "authorized") under the FAA's Technical Standard Order (TSO) process. As is customary with changes in TSO standards, items approved for production under a previous standard may still be produced, and used, after the new standard in enacted, unless there is an FAA ruling to the contrary (as may well happen with some transponders over the next few years).

Emergency parachutes (as well as skydiving reserve canopies and harnesses) are classed as appliances and must be approved by the FAA under TSO C23. Most emergency parachute equipment in use today is approved under TSO C23b, which was first issued in 1949 and referenced National Aerospace Standard (NAS) 804 as its performance standard.

C23b allowed for certification under Standard and Low-Speed Categories. A Standard Category Parachute has no legal operating limits on gross weight or deployment speed. Of course, there are physical limits to any parachute and most manufacturers placard their products with reasonable limits. Also note that there is no such thing as a "High Speed" parachute—although Standard Category is sometimes referred to as such. The "Low Speed" Category is legally limited to use in aircraft under 150 mph but still has no legal limit on weight. Because the performance testing standards in C23b were so loose, some canopy manufacturers took advantage of the latitude to produce extremely lightweight reserve parachute canopies for the skydiving market. As a result, some canopies on the market may be inadequate for use in emergency parachute systems.

TSO C23c, which references Society of Automotive Engineers (SAE) Standard 8015A, was issued in 1984 and tightened the performance testing standards significantly. Since then only a few round parachutes have been approved under C23, although many high performance gliding parachutes have been approved. C23c uses Categories A, B and C (C is strongest) and requires that the parachute by placarded with weight and airspeed limits. The minimum qualification that should be considered for use in an emergency parachute is Category B, which is limited to a deployment airspeed of 150 KIAS at a gross weight of 254 lb. However, some parachutes are placarded by the manufacturer at lower recommended weights and/or airspeeds in order to limit the opening shock or to provide a more appropriate rate of descent.

A problem not forseen by the SAE S-17 Committee that wrote the performance standard for C23c is that a surprosing number of individuals can have a gross weight in excess of 254 lb. and therefore be over the legal limit of the parachute system. As a result of this and several other problems with the performance standard, the FAA, in 1988, directed the SAE S-17 Committee to begin studies on revising the performance standards in SAE 8015A. Many changes have been made in the document, including a system that will allow the manufacturer of a parachute to select the maximum operating weight and speed for a product (with certain minimums, of course) and then test the product to those conditions plus a safety factor. The opening time and rate of descent requirements have also been redefined and are keyed to the maximum operating weight. There will be no upper limits on maximum operation weight or maximum operating speed for certification—only the requirement that the parachute system must be tested to the stated maximum allowable conditions (plus the safety factor). As of this writing (July 1991) it appears that the revised document has nearly passed through the committee and will soon be ready for submittal to the FAA. It appears that it will be enacted sometime during 1991-92.

Some of the Butler Parachute Systems products that required TSO authorization, were FAA approved as follows:

BETA Back	C23b Standard Category	1979
BETA Chair	C23b Standard Category	1979
BETA Seat	C23b Standard Category	1982
BETA QAC	C23c Category B	1991
XTC-500 Canopy	C23c Category B	1991
BETA Pilot Chute	C23c Category B	1991

PARACHUTE CONTAINER TYPES

The basic container (or pack) types found in emergency parachute systems are back, seat, chair and chest. As the names imply, the type is determined by where the container (the part of the parachute assembly that houses the parachute canopy) fits on the body: i.e., a back parachute is worn on the back; a seat parachute is sat upon; a chair pack starts at the shoulders, goes down the back around the buttocks and out toward the knees; and a chest pack is worn on front and usually attached only in an actual emergency. Butler Parachute Systems manufactures many different sizes and shapes of all four types in order to accommodage the wide variety of applications that we encounter. Representative samples of each type are shown in the following photographs.

1. BETA Back Parachute (with options)

2. BETA Quick Attachable Chest (QAC)

3. BETA Seatpack (with options)

4. BETA Chairpack (standard)

PARACHUTE HARNESS TYPES

Most military type parachute harnesses are of the solid saddle type which have several pieces of webbing crossing under the buttocks to help the leg straps distribute the loads into the lower torso and hips. While it looks like a good idea, in practice the solid saddle harness really doesn't do much except add weight and bulk to the harness. And it can be extremely uncomfortable. The solid saddle also makes it harder to build a harness that will fit an acceptable range of body sizes without a large amount of adjusting hardware—exactly as found on most military harnesses.

In contrast, most modern parachute systems produced for civil use utilize the "split saddle" harness in which the leg straps are part of the main lift web of the harness but are not connected to each other across the buttocks. This makes the harness easier to fit, and much more comfortable, for a wider range of users. However, the split saddle does have one potential disadvantage when compared to the solid saddle—if one leg strap is inadvertently left unfastened (or becomes unfastened by accident), there is a much higher chance of pelvic injury with a split saddle than with a solid saddle. The answer to this potential problem is to ensure that your leg straps are properly fastened and that you have a minimal chance of accidental release.

We minimize the danger of an accidental release by utilizing the MS22044 snap (also called the B12 snap) along with an MS27765 adjustable V-ring on our leg straps. Photo 5 shows the our standard leg strap setup using these pieces.

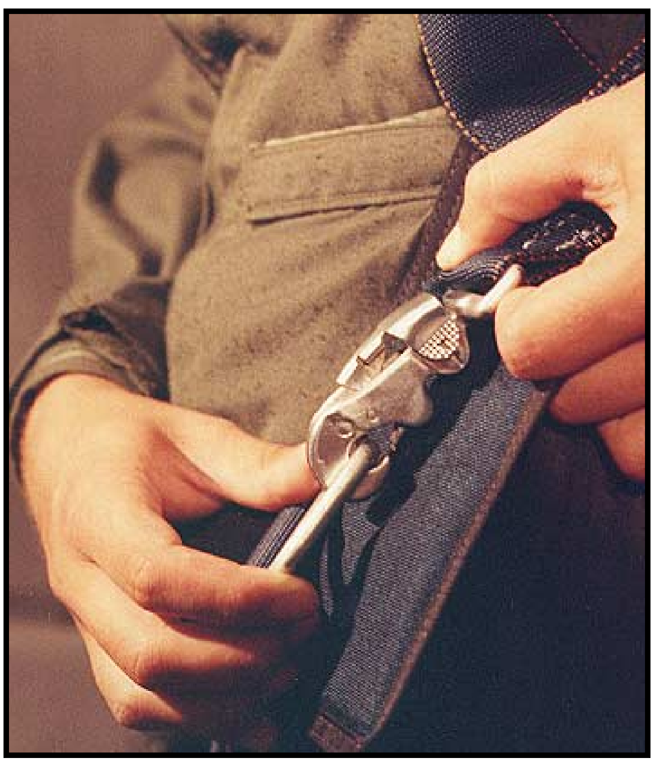
5. Standard Leg Strap w/B12 Snap & V-ring

Some harnesses use the MS22017 snap (also called the "Quick Ejector") in the same place on the leg straps. We do not use this snap because we believe that it much more likely to become accidentally unhooked than the MS22044 snap. If you look carefully at Photo 6 you will see that the ejector lever is partially open and thus very susceptible to snagging and accidental opening. We will build parachutes with this type of snap installed on special order only—and you must sign a waiver acknowledging the dangers as we see them.

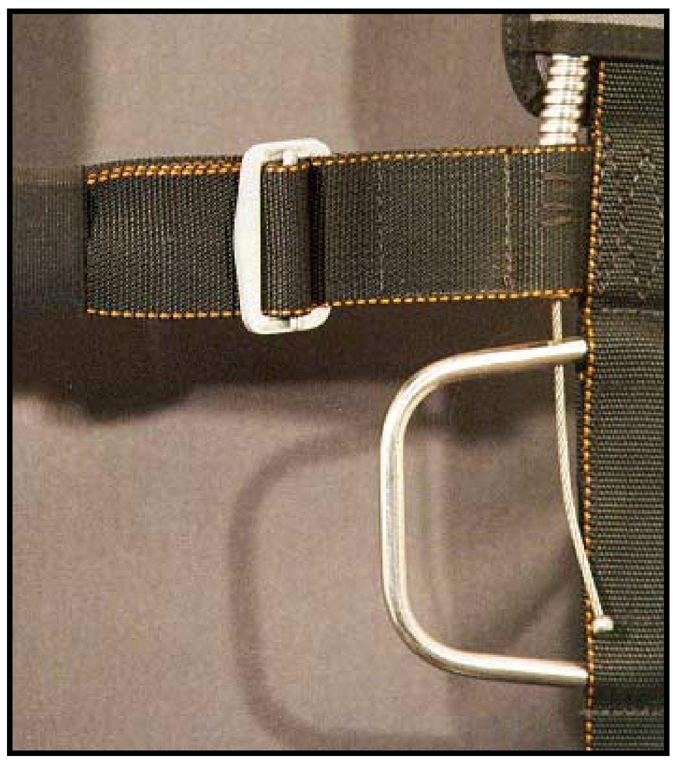
Chest Strap Configuration

Our standard chest strap configuration for back, seat and chair parachutes is shown in Photo 7. We use a lightweight, low-profile adjuster (MS70101) here because the restraint system shoulder straps will typically pass over this area and sometimes force the chest strap hardware into your breastbone.

However, for those that want it, a B12 Snap with an adjustable V-ring (like the leg strap hardware) is available as an option on most parachute systems. A quick ejector snap with adjustable V-ring is also available as an option.



6. Optional Leg Strap w/Quick Ejector & V-ring



7. Standard Chest Strap Configuration

PARACHUTE & AIRCRAFT COMPATIBILITY

You could theoretically fit almost any parachute into almost any aircraft if you tried hard enough and were willing to put up with the results. However, in general, we believe that the pilot and crew should wear the type of parachute the aircraft designer had in mind when he built the aircraft. If you do try some other type of chute, you will most likely be unhappy with your seating arrangement. Of course, if some overriding circumstance precludes the use of the intended parachute, then we can help you work around whatever difficulties may occur as a result.

With each different type of pack, there are numerous variations in size and shape. The appropriate choice of size and shape is dictated by the aircraft seat size, shape and layout and the user's size (which has a bearing on the canopy selected—see below). There are an infinite number of possible combinations of plane and pilot, so this discussion is meant only as a general introduction to the subject of fitting a parachute to a user and aircraft.

For instance, in an aircraft with a highly reclined seating position ***and*** with a smoothly curved transition from the back panel of the seat onto the bottom panel (many sailplanes and some home built aircraft), a moderately long (in relation to the user's sitting height) backpack (or chairpack) parachute that is thickest at the top and tapers to nearly nothing at the waist is usually the best shape because it avoids a large, unsupported air gap at the base of the spine. However, remember that in a highly reclined seat, anything placed behind the shoulders will raise the head toward the canopy. If, on the other hand, (still in a reclined seating position) the seat back panel meets the seat bottom panel at a well defined break (with an angle of less than 140^o or so), then a relatively short backpack that is thin behind the shoulders and thickest just above the waist may be the best choice. In this case the backpack must be short enough to fit snugly against the back panel at the top (without pushing the shoulder restraint straps up out of the way) and at the bottom (without buckling and creating a lump). In some cases, it can be advantageous to build in a foam wedge at the bottom of the parachute to ease the transition from the parachute pack onto the seat pan.

In many aircraft with relatively upright seating (close to 90^o, such as the Citabria, 1-26, etc.), a backpack parachute is usually the best choice. However, the pack must be long enough to rest on the seat bottom and support its own weight without dragging on the shoulders of the wearer. Conversely, it must not be so long that it rides up around the wearer's ears and forces the shoulder restraint straps up unnecessarily.

If the pilot desires a back type parachute in an aircraft such as the Pitts (and similar types like Great Lakes, Skybolt, etc.) with tight cockpits, relatively upright seating and close clearance between the pilot's face and the instrument panel, we generally recommend a back parachute that is thickest at the bottom and thinnest at the top in order to keep your face out of the instruments. Of course, the problem with the thickness at the bottom is that you may begin to run out of leg room.

However, if sufficient headroom is available, a seatpack parachute is usually a better alternative in these particular aircraft. We recommend this because the cockpits of these aircraft are relatively deep (which usually allows sufficient headroom even with the seat parachute) but fairly short front-to-rear (which puts your head close to the panel and your stomach close to the stick). The thin backpad used on the seatpack chutes causes minimal loss of leg room and allows the user to keep his head at the maximum distance back from the instrument panel.

Most military (and many civil) aircraft built prior to 1960 and almost all World War Two and earlier military aircraft (T6, T28, P51, T33, etc.) were designed to use seatpack parachutes. Because the old military seatpack parachutes were such painful abominations, many people switched to a back or chair type chute for these aircraft. However, there are now seatpacks on the market that are very comfortable and much easier to wear and adjust. In fact, Butler Parachute Systems has developed a series of WARBIRD Special Seatpack parachutes for use in these aircraft—and we even make them in Olive Drab to complement those painstaking restorations. Some of you may remember Bill Melamed's Harvard that won Grand Champion Warbird at Oshkosh in 1989—with our Warbird Seatpack parachutes in the seats!

Some aircraft have no space available for a conventional parachute such as a back, seat or chair type, but may have space available on a shelf area behind the head and shoulders of the pilot, in which case our headrest chute may be used. The headrest chute is a variation on our standard back parachute and is available in a variety of sizes built to order only.

In some other aircraft with very tight cockpits (or very large pilots), a quick attachable chest (QAC) parachute may be the only viable solution. The Voyager world flight was just such an instance, and we developed two special chest pack parachutes for use by Dick Rutan and Jeanna Yeager. However, we consider the use of a chest parachute in this context to be considered in extreme circumstances only. We recommend against it because of the difficulty in manipulating the aircraft controls and the likelihood of snagging something on the parachute pack. Please call to discuss the situation if you feel that your only solution is a chest pack.

On the other hand, in many cabin aircraft, the BETA Quick Attachable Chest (QAC) parachute may be exactly what is needed. The BETA QAC is available in a variety of sizes, both with and without survival and flotation gear (see the Voyager reprint). We have sold several of these systems to ferry pilots who are making long over water flights.

PARACHUTE CANOPY TYPES

Most of the canopies commonly used in emergency parachute systems are "round" parachutes, which are what most people think of as a traditional parachute. Within the general category of round parachutes there are numerous variations in size, shape, materials, and functional characteristics. The common shapes are flat, conical and tri-conical, with the tri-conical having the highest drag coefficient with all other factors being equal. The common construction methods are "block" and "bias", with bias being the stronger with all other factors equal.

The common canopy cloth materials are all approximately 1.1 oz. per square yard but the permeability (airflow through the cloth) varies from standard military cloth (80-120 CFM) to Low Porosity military cloth (30-50 CFM) to "Zero" porosity (0-3 CFM) cloth such as F-111™. All other things being equal, reducing the permeability of the cloth will increase the drag and the opening shock and decrease the stability and filling time.

Suspension line breaking strength generally ranges from 400 to about 700 lb. for personnel parachute canopies. Reinforcing tapes on the canopies vary widely in strength and bulk as well. Of course, stronger is better in both cases, but the increase in strength must be balanced against the increase in bulk.

Most modern round parachute canopies (those produced in the past 15 years or so) utilize a deployment "diaper" or equivalent device. Diapers come in several shapes, but all are designed to keep the skirt of the parachute closed until the suspension lines are fully deployed with load on them. The lines may or may not be stowed on the diaper; those which provide for stowing the lines are referred to as "full stowage" diapers. We highly recommend the use of canopies with full-stowage diapers, as we believe they provide a more reliable deployment and opening. The down side of a full-stowage type diaper is that it tends to concentrate about one third of the bulk of the canopy in an area about one foot long and six inches wide. This leads to bulk distribution problems within the pack on some types of parachutes (primarily chair chutes). Butler Parachute Systems manufactures a deployment diaper in several sizes that can be retrofitted to a variety of canopies that were not so equipped.

8. BETA XTC-500 Canopy - Live Test Jump

Another feature of most modern round canopies is that they are steerable, which is extremely useful not only because it provides a limited amount of maneuverability but also greatly reduces oscillation and thus the potential for landing injury. All canopies installed in Butler Parachute Systems products must be steerable. The Waters' 4-Line Release Kit is available for installation on canopies not originally equipped for steering (such as military surplus canopies).

PARACHUTE CANOPY SIZE

The "size" of a parachute can be a very misleading number due to the variety of ways that different manufacturers express the measurements. The number that you usually see in sales literature is what we call the "Advertising Diameter" and is determined by measuring from the skirt to the apex of the canopy and multiplying by two. Note that as an extreme example, if you measure a 15' long windsock with this method you can call it a 30' diameter parachute.

The ***"Nominal Diameter"*** is used in engineering work and performance calculations and is found by expressing the ***finished area*** of the parachute as an equivalent diameter using the formula $\mathbf{D^2 = 4A/Pi}$. For example, a conical parachute with an advertised diameter of 26 feet might have a finished area of 412 $ft.^2$ and thus a nominal diameter of 22.9 feet. In contrast, a parachute with a nominal diameter of 26 feet would have a finished area of 531 $ft.^2$, found by using the usual formula of $\mathbf{Area = Pi\ R^2}$.

However, all discussion of diameter aside, the number that really matters is the ***"Drag Area",*** which is the finished canopy area multiplied by the drag coefficient. The higher the drag area, the lower the rate of descent will be for a given weight. Based on the factors discussed above, one can see that the drag area goes up with increasing canopy size and increasing drag coefficient (related to type of cloth and canopy shape).

The charts in Appendices 1 & 2 list most of the commonly used round parachute canopies together with actual measurements taken from samples of each type. The drag coefficients listed are based on information in the Air Force Recovery Systems Design guide and are only estimates. The actual performance numbers may vary, but the relative ranking among the canopies listed is believed to be fairly accurate.

You will note that our BETA XTC-500 canopy has the largest drag area of any canopy on the list. This is not by coincidence—we started with the largest cloth area of any currently available personnel parachute (with the exception of the military 28') and then developed a design with the highest known drag coefficient of any personnel canopy in the world. The result—quite naturally—is the largest drag area canopy available for emergency parachute use.

Appendix 3 shows the relationship between rate-of-descent and time or distance fallen before impact (the calculations ignore air drag). This table will allow you to visualize the physical effects of some particular rate of descent. For example, 24 fps is approximately equal to your velocity after jumping off a 9' high wall—probably survivable but certainly not much fun.

Appendix 1. Canopy Measurements and Characteristics

Canopy Type Manufacturer & Model	Adv. Dia. (feet)	Nominal Dia.(ft.)	Weight (lbs)	FAA TSO Category	Finished Area	Gore Area (sq.ft.)	# Gores	Gore Width	Gore Height	Line Break	Fabric Type (wt./permeability)	Const. Type	Diaper	Steerable
Butler Parachute - XTC-500	26.00	25.24	9.00	C23b, Cat. B	500.40	20.85	24	31.50	13.03	550	1.1 oz. 0-3 CFM	Bias	yes	TriVent
National - Phantom 22	22.00	18.73	4.12	C23b Low	275.63	15.31	18	35.00	126.00	400	1.1 oz. 0-3 CFM	Black	yes	TirVent
National 360 - Phantom 24	24.00	20.74	5.10	C23b Stand	337.85	16.89	20	35.00	139.00	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
National 425 - Phantom 26	26.00	22.92	6.13	C23b Stand	412.50	18.75	22	36.00	150.00	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
National 490 - Phantom 28	28.00	24.91	7.00	C23b Stand	487.50	20.31	24	36.00	162.50	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
Security 150 (26 LoPo)	26.00	22.69	7.50	C23b Low	404.25	16.84	24	33.00	147.00	400	1.1 oz. 30-50 CFM	Black	no	T-Vent
Security 250 (26 LoPo)	26.00	22.89	8.00	C23b Stand	411.67	17.15	24	32.50	152.00	550	1.1 oz. 30-50 CFM	Bias	no	T-Vent
Security 350/850 (SAC)	22.00	21.10	5.80	C23b Low	349.60	17.48	20	30.00	148.75	400	1.1 oz. 0-3 CFM	Bias	yes	TriVent
Strong 26' LoPo	26.00	22.07	7.50	C23b Stand	382.52	15.94	24	30.50	150.50	600	1.1 oz. 30-50 CFM	Black	yes	TriVent
Strong 26' LoPo Light	26.00	21.20	6.13	C23b Stand	352.84	16.04	22	31.00	149.00	400	1.1 oz. 30-50 CFM	Black	yes	TriVent
FFE (Handbury) Preserve I	24.00	21.97	6.00	C23b Stand	379.19	17.24	22	34.00	146.00	550	1.1 oz. 0-3 CFM	Black	yes	TriVent
FFE Preserve III	24.00	20.28	6.00	C23b Low	323.13	16.16	20	33.00	141.00	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
FFE Preserve III-1	24.00	21.27	6.50	C23b Low	355.44	16.16	22	33.00	141.00	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
FFE Preserve IV	22.00	19.75	5.00	C23b Low	306.25	15.31	20	36.00	122.50	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
North American 26' TriCon	26.00	24.43	9.25	C23b Stand	468.85	19.54	24	31.00	148.00	600	1.1 oz. 0-3 CFM	Bias	yes	T-Vent
North American 22' TriCon	22.00	19.14	6.00	C23b Low	287.80	14.39	20	31.50	126.00	600	1.1 oz. 0-3 CFM	Bias	yes	TriVent
ParaInnovators R1	21.00	21.03	7.00	C23b Low	347.50	17.38	20	36.00	139.00	550	1.9 oz. 0-3 CFM	Bias	yes	TriVent
ParaInnovators R2	23.50	20.21	6.00	C23b Low	320.83	16.04	20	35.00	132.00	550	1.1 oz. 0-3 CFM	Black	yes	TriVent
ParaInnovators R4-1	26.00	22.76	6.50	C23b Stand	407.00	18.50	22	37.00	144.00	550	1.1 oz. 30-50 CFM	Bias	yes	TriVent
ParaInnovators R4-3	26.00	22.76	6.20	C23b Low	407.00	18.50	22	37.00	144.00	400	1.1 oz. 0-3 CFM	Black	yes	TriVent
USAF/USN 28' C-9	28.00	27.16	12.00	Note 2	579.15	20.68	28	37.00	161.00	550	1.1 oz. 80-120 CFM	Bias	no	no
USN 26' Conical	26.00	22.84	8.50	Note 2	409.75	18.63	22	36.00	149.00	550	1.1 oz. 80-120 CFM	Bias	no	no
USArmy 24' Flat	24.00	22.31	9.30	Note 2	391.00	16.29	24	34.00	138.00	550	1.1 oz. 80-120 CFM	Bias	no	no

NOTES:
1. TSO C23b, Standard Category requires a 5000 lb. shock load test for the parachute system. Low Speed requires a 3000 lb. shock load.
2. The FAA considers military surplus canopies equivalent to Standard Category.
3. TSO C23c went into effect in 1984, since that time, no new round parachutes have been certificated under TSO C23.

Appendix 2. Rate of Descent for Canopies Ranked by Drag Area

Canopy Type Manufacturer & Model	Adv. Dia. (feet)	Nominal Dia. (ft)	Area (sq.ft.)	Drag Coeff.	Drag Area (sq.ft.)	Rate-of-Descent (ft/s) at Sea Level Standard Day 100	125	150	170	(Gross weights shown in next row) 200	225	250	300	350	400
National - Phantom 22	22.00	18.73	275.63	0.95	261.85	17.92	20.04	21.95	23.71	25.35	26.88	28.34	31.04	33.53	35.84
North American 22' TriCon	22.00	19.14	287.74	1.01	290.62	17.01	19.02	20.84	22.50	24.06	25.52	26.90	29.47	31.83	34.02
FFE Preserve IV	22.00	19.75	306.25	0.95	290.94	17.00	19.01	20.82	22.49	24.04	25.50	26.88	29.45	31.81	34.00
USArmy 24' Flat	24.00	22.31	391.00	0.77	301.07	16.71	18.69	20.47	22.11	23.64	25.07	26.43	28.95	31.27	33.43
ParaInnovators R2	23.50	20.21	320.80	0.95	304.76	16.61	18.57	20.35	21.98	23.49	24.92	26.27	28.77	31.08	33.22
FFE Preserve III	24.00	20.28	323.13	0.95	306.97	16.55	18.51	20.27	21.90	23.41	24.83	26.17	28.67	30.97	33.10
Strong 26' LoPo Lite	26.00	21.20	352.84	0.89	314.03	16.37	18.30	20.04	21.65	23.14	24.55	25.88	28.35	30.62	32.73
National 360 - Phantom 24	24.00	20.74	337.85	0.95	320.96	16.19	18.10	19.83	21.41	22.89	24.28	25.60	28.04	30.28	32.38
Security 350/850 (SAC)	22.00	21.10	349.60	0.93	325.13	16.08	17.98	19.70	21.28	22.75	24.13	25.43	27.86	30.09	32.17
ParaInnovators R1	21.00	21.03	347.50	0.95	330.13	15.96	17.85	19.55	21.11	22.57	23.94	25.24	27.65	29.86	31.92
FFE Preserve III-1	24.00	21.27	355.44	0.95	337.67	15.78	17.64	19.33	20.88	22.32	23.67	24.95	27.34	29.53	31.56
USN 26' Conical	26.00	22.84	409.75	0.83	340.09	15.73	17.58	19.26	20.80	22.24	23.59	24.86	27.24	29.42	31.45
Strong 26' LoPo	26.00	22.07	382.52	0.89	340.44	15.72	17.57	19.25	20.79	22.23	23.58	24.85	27.22	29.40	31.44
Security 150	26.00	22.69	404.25	0.89	359.78	15.29	17.09	18.73	20.23	21.62	22.93	24.17	26.48	28.60	30.58
FFE (Handbury) Preserve I	24.00	21.97	379.19	0.95	360.23	15.28	17.08	18.71	20.21	21.61	22.92	24.16	26.47	28.59	30.56
ParaInnovators R4-1	26.00	22.76	407.00	0.89	362.23	15.24	17.04	18.66	20.16	21.55	22.86	24.09	26.39	28.51	30.48
Security 250	26.00	22.89	411.67	0.89	366.39	15.15	16.94	18.56	20.04	21.43	22.73	23.96	26.24	28.34	30.30
ParaInnovators R4-3	26.00	22.76	407.00	0.95	386.65	14.75	16.49	18.06	19.51	20.86	22.12	23.32	25.55	27.59	29.50
National 425 - Phantom 26	26.00	22.92	412.50	0.95	391.88	14.65	16.38	17.94	19.38	20.72	21.97	23.16	25.37	27.41	29.30
USAF/USN 28' C-9	28.00	27.16	579.15	0.77	445.95	13.73	15.35	16.82	18.17	19.42	20.60	21.71	23.79	25.69	27.47
National 490 - Phantom 28	28.00	24.91	487.50	0.95	463.13	13.48	15.07	16.50	17.83	19.06	20.21	21.31	23.34	25.21	26.95
North American 26' TriCon	26.00	24.43	468.85	1.01	473.54	13.33	14.90	16.32	17.63	18.85	19.99	21.07	23.08	24.93	26.65
Butler Parachute - XTC-500	26.00	25.24	500.40	1.28	640.51	11.46	12.81	14.03	15.16	16.21	17.19	18.12	19.85	21.44	22.92

NOTES:
1. Drag coefficients shown are in the mid-range of expected performance for each type canopy.
2. For cloth permeability of 30-50 CFM, 7% was added to the drag coefficient based on canopy shape.
3. For cloth permeability of 0-3 CFM, 15% was added to the drag coefficient based on canopy shape.
4. For landing altitudes above sea level, add approximately 2% per 1000' to the figures shown.

Appendix 3. Freefall Velocity vs. Distance Fallen (0 air drag)

Time (sec)	Distance (feet)	Velocity (ft/sec)	Distance (meters)	Velocity (m/s)
0.10	0.16	3.22	0.05	0.98
0.20	0.64	6.43	0.20	1.96
0.30	1.45	9.65	0.44	2.94
0.40	2.57	12.87	0.78	3.92
0.42	2.84	13.51	0.87	4.12
0.44	3.11	14.15	0.95	4.32
0.46	3.40	14.80	1.04	4.51
0.48	3.71	15.44	1.13	4.71
0.50	4.02	16.09	1.23	4.91
0.52	4.35	16.73	1.33	5.10
0.54	4.69	17.37	1.43	5.30
0.56	5.04	18.02	1.54	5.49
0.58	5.41	18.66	1.65	5.69
0.60	5.79	19.30	1.77	5.89
0.62	6.18	19.95	1.89	6.08
0.64	6.59	20.59	2.01	6.28
0.66	7.01	21.23	2.14	6.47
0.68	7.44	21.88	2.27	6.67
0.70	7.88	22.52	2.40	6.87
0.72	8.34	23.16	2.54	7.06
0.74	8.81	23.81	2.69	7.26
0.76	9.29	24.45	2.83	7.46
0.78	9.79	25.09	2.98	7.65
0.80	10.29	25.74	3.14	7.85
0.82	10.82	26.38	3.30	8.04
0.84	11.35	27.02	3.46	8.24
0.86	11.90	27.67	3.63	8.44
0.88	12.46	28.31	3.80	8.63
0.90	13.03	28.95	3.97	8.83
0.92	13.61	29.60	4.15	9.03
0.94	14.21	30.24	4.33	9.22
0.96	14.82	30.88	4.52	9.42
0.98	15.45	31.53	4.71	9.61
1.00	16.09	32.17	4.91	9.81
1.10	19.46	35.39	5.94	10.79
1.20	23.16	38.60	7.06	11.77
1.30	27.18	41.82	8.29	12.75
1.40	31.53	45.04	9.61	13.73
1.50	36.19	48.26	11.04	14.72
1.60	41.18	51.47	12.56	15.70
1.70	46.49	54.69	14.18	16.68
1.80	52.12	57.91	15.89	17.66
1.90	58.07	61.12	17.71	18.64
2.00	64.34	64.34	19.62	19.62

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