# Calculating the descent rate of a round parachute

By Dr. Jean Potvin

## Parks College Parachute Research Group

**How to calculate the descent speed of a round parachute:**

For most of its trajectory, the descent speed of a round parachute has a near-constant value which can be computed from:

$$V = \sqrt{\frac{2W}{\rho C_D S_0}}$$

This formula is a consequence of the fact that during its descent, the parachute's own drag is balanced by the combined weight of the parachute and its load. The parameters appearing in the formula are as follows:

$C_D$ = parachute drag coefficient which is approx 0.75 for a chute without holes or slits cut in the fabric; same value in both Metric and English unit systems
$\rho$ = Air density. Near sea level its value is given by:
0.00237 sl/ft$^3$ (English units) and 1.225 Kg/ m$^3$ (Metric)
Near 4000 ft or 1219 m above sea level =
0.00211 sl/ft$^3$ (English units) and approx. 1.07 Kg/m$^3$ (Metric)
W = weight of the parachute + load, in *pounds* (English) or *Newtons* (Metric)
V = vertical descent velocity, here expressed in ft/sec (English) or m/sec (Metric)

$S_0$ is the total surface area of the fabric used to build the parachute, plus the areas of the holes and vents cut in the fabric if present. The units of $S_0$ are in ft$^2$ (English) or m$^2$ (Metric). This definition is such that when vents are cut in the fabric, the value of $S_0$ remains the same but the value of $C_D$ becomes smaller.

*Nominal diameter vs. constructed diameter*

Note that the parachute will be characterized by what parachute engineers called *nominal diameter $D_0$*, a number computed from this formula:

$$D_0 = 2\sqrt{\frac{S_0}{\pi}}$$

Engineers also use the notion of *constructed diameter* $D_c$, a number that is calculated from the measurement of the canopy's actual radius when holding it up by the apex. Here the radius is the distance between the apex and the canopy skirt (or "hem", where the suspension lines are attached); $D_c$ is then twice the value of that radius. The values of $D_0$ and $D_c$ will be the same only when the parachute is built out of a flat circle of fabric.

*Alternate designs*

Most parachutes used in aerospace today are *not* based on flat circles but rather on shallow cones, bulged hemispheres or other non-flat surfaces. It turns out that these designs optimize the value of $C_D$ for pretty much the same amount of fabric as that of flat canopies. But these parachutes are much more complicated to build and moreover $D_c \neq D_0$.

*Parachute stability and venting*

Usually parachutes will swing wildly because of the air spilling from alternating sides of the canopy. This swinging can be reduced by cutting a hole at the parachute's apex, or altogether eliminated by cutting a large number of holes all over the canopy. But remember that adding vents will increase the descent speed. In the case of apex venting, the area of the apex hole should be about 1 to 10 percent of the parachute's flat surface area, depending of the desired trade-off between a slower descent speed and improved stability. Remember, the larger the hole, the faster the descent speed, since the value of $C_D$ will decrease in the process.

Examples of designs that improve stability besides apex venting are shown in an article by Dr. C. W. Peterson in *Physics Today*, August 1993. The magazine *Physics Today* can be found at university and college libraries.

**Making an experimental/toy parachute**

Constructing an experimental round parachute is very simple: just cut a piece of fabric in the shape of a circle. The fabric type can be cut from a plastic garbage bag, but such a chute won't last very long and will puncture easily. Using the nylon fabric of tents will yield a more durable product. Real parachutes use a reinforced version of that nylon.

**For detailed info about parachute design and rigging:**

- D. Poynter, The Parachute Manual-Vols 1&2, Para Publishing , Santa Barbara, CA
- T.W. Knacke, Parachute Recovery Systems Design Manual, Para Publishing , Santa Barbara, CA

**Also, see the following web page:**

- Aerodynamic Decelerator Technology