SIZING GUIDE

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Introduction

The Rouse-Tech CD4 CO_2 deployment system is designed to replace black powder deployment systems in amateur rockets. The CD4 system has two advantages over black powder systems:

- No residue to clean up after recovery, and no risk of a burned or melted parachute or streamer.
- No decrease in efficiency or reliability at extreme altitudes, i.e. > 40,000 feet. Black powder systems tend to fail at extreme altitudes due to poor heat transfer and combustion efficiency at low atmospheric pressures. The CD3 system is immune to this problem.

Optimally sizing an ejection system from a purely theoretical basis is a deceptively complicated matter. The mass of the two components to be separated, airframe material, shear pins, component coefficient of friction, and vent hole sizes all factor in to the problem. As with any “ejection charge calculator” or calculation, there is no substitute for ground testing your system, and we do not recommend flying any system for the first time without a ground test.
The CD3 system provides for two different CO_2 cartridge sizes: 16 and 38 grams.
We will present two methods for determining the optimal CO_2 cartridge size for your rocket, in ascending order of complexity. No matter which method you choose, remember that you should *always* ground test your system before flying it for the first time.

Method 1: Rough guidelines by compartment size
This method is based solely on typical charge sizes for typical rockets. It’s a rough starting point for your ground testing. Simply use the table below to locate the recommended CO_2 cartridge size for the diameter and length of the recovery compartment.

Recommended Cartridge size by recovery compartment length and diameter (typical)

	Length (in)											
Diameter (in)	6"	10"	14"	18"	22"	26"	30"	34"	38"	42"	46"	50"
2"	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g
3"	16 g	16 g	16g	16 g	16 g	16 g	16g	16 g	16 g	16 g	16 g	16 g
4"	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	16 g	38 g
5"	16 g	16 g	16 g	16g	16 g	16 g	16 g	16 g	38 g	38 g	38 g	38 g
6"	16g	16 g	16 g	16 g	16 g	16 g	16 g	38 g	38 g	38 g	38 G	38 g
8"	16 g	16g	16 g	16 g	16 g	38 g	38 g	38 g	38 g	38 g	NR	NR
10"	16g	16 g	16 g	38g	38	38 g	38 g	38 g	NR	NR	NR	NR
12"	16 g	16 g	38g	38	38 g	38 g	NR	NR	NR	NR	NR	NR

NR = Not recommended

Method 2: Sizing by Black Powder Equivalence

This method might be preferred for those experienced flyers who are comfortable with their own or published black powder "ejection charge calculators" or techniques. This method is also suitable for those retrofitting previously flown rockets with a successful base of experience.

Step 1: Determine the black powder charge (in grams) using the method you prefer. A widely used black powder charge calculator is available on the web at Rocketry Online's INFOcentral web page. Rocketry Online's URL is **www.rocketryonline.com**. You can find the calculator by going to the INFOcentral page and finding the "recovery" section. The "recovery" section's index has a "black powder use" page where the calculator resides. Note: There is no need to add in "extra" black powder charge for flights expected to exceed 20,000 feet.

Step 2: Multiply the black powder charge size (grams) by 5.0 to determine the amount of CO_2 (also in grams) required to achieve the same compartment pressure.

Step 3: Round *up* to the nearest sized CO_2 cartridge. Use this as the starting point for your ground testing.

Example: My previous rocket has flown and successfully deployed at 12,000 feet three times using a 2.5 gram black powder charge. What size CO_2 cartridge should I use to replace the black powder charge system?

2.5 x 5.0 = 12.5 grams CO_2. Round up to the nearest sized CO_2 cartridge: 16.0 grams.

Use a 16 gram CO_2 cartridge as the starting point for my ground testing.

Here's a brief description of the underpinnings of this "conversion factor" method (the black powder pressure calculation is borrowed from Ted Apke's "Ejection Charge Calculator" page on ROL's INFOcentral web page):

Quoting from Ted:

The ejection charge equation is:

$$Wp = dP*V/R*T$$

Where:

- dP is the ejection charge pressure in psi.
- R is the combustion gas constant, 22.16 (ft-lbf/lbm R) for FFFF black powder. (Multiply by 12 in/ft to get in terms of inches)
- T is the combustion gas temperature, 3307 degrees R for black powder
- V is the free volume in cubic inches. Volume of a cylinder is cross section area times length L, or from diameter D, $V=L*\pi*D^2/4$
- Wp is the charge weight (mass, actually) in pounds. (Multiply by 454 g/lb to get grams.)

Here's an example calculation. Suppose you want to generate 15 psi inside a 4" diameter rocket in a parachute compartment 18" long. That makes a volume of 226 in^3. The amount of powder you need will be:

$$Wp = 15*226(454)/12(22.16)\ 3307$$

$$Wp = 1.75 \text{ grams}$$

Continuing with the example provided by Ted Apke above, here's how to solve the same problem using CO2 instead of black powder:

Start with the ideal gas law: $n= PV/RT$

n= number of moles CO_2 required.
P= ejection pressure desired in atmospheres (1 atm = 14.7 psi)
V= volume of parachute compartment in liters (1 liter = 61 in^3)
R= universal gas constant (=0.08206)
T= Temperature of expelled CO_2 gas at deployment in degrees Kelvin (273K)

In this example:

P= 15psi = 1.02 atm
V= 226 in^3 = 3.70 liters
T= 273K

Number of moles CO_2 = (1.02*3.70)/(0.08206*273) = 0.168 moles.

Lastly, one mole of CO_2 = 44 grams, so 0.168 moles * 44g/mole = **7.41 grams CO_2**.

Thus, we have the result that 7.41 grams CO2 produces the same ejection pressure as 1.75 grams Black powder.

Dividing these results gives a ratio of 7.41 g CO2/1.75 g BP = 4.24. We recommend adding a safety factor of approximately 20%, resulting in a “conversion factor” of 5.0 grams CO_2 per gram of black powder.