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APOGEE PEAK OF FLIGHT NEWSLETTER

Properly Sizing Parachutes for Your Rockets

INSIDE:

- Working with Parachute Descent Rates
- Refinishing Damaged Tubes
- Website Worth Visiting

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"Are Your Descent Rates Decent?": Calculating How Fast Your Models Fall

by **John Manfredo**

{Ed. Part I of this article comes from the book: "Model Rocket Design and Construction" by Tim Van Milligan.}

PART I

Parachute Design

Parachutes can be used on almost any size rocket. A parachute can control the model's descent speed more accurately and bring the model down more slowly than any other recovery method. The best parachutes are made from strong, thin, soft, flexible material. For small models, thin plastic sheets work very well because they can be folded up tightly to fit into small-diameter body tubes. Some sources for parachute canopies include: Mylar®, plastic drop cloths, dry-cleaning bags, trash bags, and gift-wrapping plastic. Use care when selecting a plastic material for a parachute. Test it by trying to tear it in both directions-sometimes the material is strong in one direction but weak in another. Use only plastic that is strong in both directions. For rockets with a descent mass greater than 300 grams (10.5 oz.) use a cloth material like cotton, silk, polyester, or nylon. These materials can withstand the larger opening forces that bigger models can create. Heat-resistant parachutes can be made from certain types of plastics and cloths. For a plastic chute, you can try oven-roasting bags. They are used to cook large turkeys and other game birds, and are typically made out of nylon®. For a heat resistant cloth, Nomex® works very

Rocket Under Nice, Open Parachute

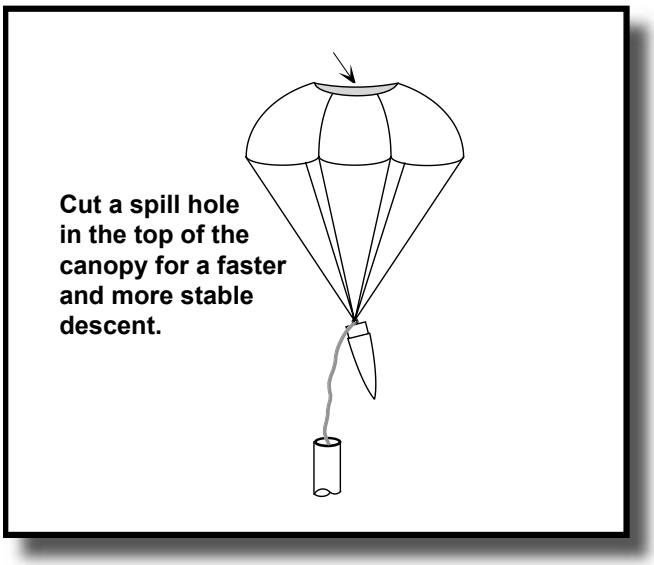

Fig. 1 Use of Spill Hole in a Parachute

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well. It is often used to make flight suits for pilots and jackets for fire fighters. Some model rocket manufacturers sell Nomex® parachutes.If you want the rocket to come down slightly faster and without drifting far in windy conditions, cut a spill hole in the top of the canopy (Fig. 1). This allows air to flow through, increasing the descent rate.The larger this *spill hole* the faster the model will fall. Again, try to find a material with a high-visibility color, both in the sky and on the ground.

Parachute Size

As a general rule of thumb, design the 'chute so the descent velocity of your rocket is 3.5 to 4.5 meters per second (11.5 to 14.8 feet per second). You can determine the area of the parachute from the following equation:

$$S = \left(\frac{2 \times g \times m}{\rho \times C_d \times V^2} \right)$$

Fig. 2 Area for Round Parachutes

where S is the area of the parachute, g is the acceleration due to gravity; which has a value of 9.81 m/s2 at sea level, m is the mass of the rocket (with empty engine) as measured in grams, r is the density of air (1225g/m3) at sea level, Cd is the coefficient of drag; estimated at 0.75 for a round canopy, and V is the descent velocity you choose. If you want a round canopy, the diameter is found by the formula:

$$D = \sqrt{\frac{4 \times S}{\pi}}$$

Fig. 3 Diameter for Round Canopies

where D is the diameter of the parachute and π (pronounced "pie") has a value 3.14. The chart shown in figure 4 is a quick reference for typical sizes of parachutes versus their descent mass, based on a round canopy. If you are using a canopy of another shape you can easily find the area from the following formula valid for regular polygons:

Rocket Mass	Parachute Diameter
20g	22cm (8.5″)
40g	31cm (12″)
80g	43cm (17″)
100g	48cm (19″)
150g	59cm (23″)
200g	69cm (27″)
300g	84cm (33″)

Fig. 4 Round Canopy Decent Masses

$$Area = \frac{n}{4} \times D^2 \times \tan\left(\frac{180^o}{n} \right)$$

Fig. 5 Formula for Polygon Parachutes

where n is the number of sides, and D is the distance as measured across the polygon's flats. As shown in figure 6, there are listed the areas of four common parachute shapes, which are circles, squares, hexagons, and octagons.

Parachute Shape	Area Formula
Square	D^2
Hexagon	$0.866 \times D^2$
Octagon	$0.828 \times D^2$
Circle	$1/4 \times \pi \times D^2$

Fig. 6 Common Parachute Shapes

PART II

Putting it into Practice

Before going any further, please understand that it is critical to our calculations that we use measurements that are uniform. If you want to use English measurements, use them in all calculations; if you choose to use Metric, use Metric in all. For our purposes here we will use Metric.

So now that we see how to calculate the needed size of parachute, let's actually go through the process step-by-step. We'll start by figuring out the weight of the rocket you are trying to find the parachute size for. For instance, let's say that the given weight for our rocket is 25 ounces. The first thing to do is convert this over to grams. A handy web page for this is: http://www.metric-conversions.org/weight/ounces-to-grams.htm. It allows

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you to convert meters over to inches. Our 25 ounce rocket now weighs in at 708.74g (round out the numbers to 2 decimal places).

Now start plugging numbers into the equation from figure 2. Everything in that equation is entered in except for our descent velocity. We are going to choose 4.5 meters per second. Of course, due to the fact that the equation calls for "V^2" and not just "V", our 4.5 meters per second needs to be squared before entering it in to the formula. Therefore, 4.5 changes into 20.25 meters squared/seconds squared as you see in equation 1.

$$S = \frac{2 \times 9.81 \frac{m}{s^2} \times 708.74g}{1225 \frac{g}{m^3} \times .75 \times 20.25 \frac{m^2}{s^2}}$$

Equation 1

The fact that the equation asks you to square not only the descent velocity number but also the meters and seconds is easy to overlook! Make sure you watch this very closely. We can start by cancelling out a few things as you will see in equation 2.

$$S = \frac{2 \times 9.81 \frac{m}{\cancel{s^2}} \times 708.74\cancel{g}}{1225 \frac{\cancel{g}}{m^{\cancel{3}}} \times .75 \times 20.25 \frac{\cancel{m^2}}{\cancel{s^2}}}$$

Equation 2

$$\frac{m}{\frac{1}{m}}$$

Equation 3

The 2 "seconds squared" and the 2 "grams" can be cancelled out. The "meters squared" can be cancelled out totally and that leaves only 1 "meter" left with the density of air. This leaves us with 1 meter on top of the equation and 1 "meter" on the bottom, which is simplified in equation 3. With the top "meter" being a numerator and the bottom "meter" being a denominator within a denominator we need to move the bottom one up to the top as shown in equation 4.

$$S = \frac{2 \times 9.81 m^2 \times 708.74}{1225 \times .75 \times 20.25}$$

Equation 4

$$S = \frac{13905.55 m^2}{18604.69}$$

Equation 5

This gives us the final setup before multiplying and dividing things out seen in equation 4. After multiplying this out we come up with equation 5. Then, by dividing this, we come up with our area of the parachute needed as seen in equation 6.

$$S = .75 m^2$$

Equation 6

$$D = \sqrt{\frac{4 \times .75}{3.14}}$$

Equation 7

Next, as shown back in figure 3, we will need to calculate the "diameter" of the parachute from the "area" that we now have. Plugging our numbers into the equation, we now have what is shown in equation 7.

After multiplying and dividing this we get the equation shown in equation 8. Finally, go ahead and find the square root of .96. Your answer should be .98.

$$D = \sqrt{.96}$$

Equation 8

The only thing left to do is to convert this answer back to inches so that we can find out what the diameter of the parachute is. For those of you who need a little help, you can go back to that handy web page to convert this number back again:http://www.metric-conversions.org/length/meters-to-inches.htm. The final answer is 38.58" in diameter.

Conclusion

Hopefully, this article will help you when you are trying to find just the right size parachute for your next project. For others, you may be thinking, "That's just too much 'number crunching' for me." That's okay! We have you covered on that. Go to: http://www.apogeerockets.com/rocksim.asp and try out the Rocksim software! It makes calculating parachute size a breeze as well as so much more!

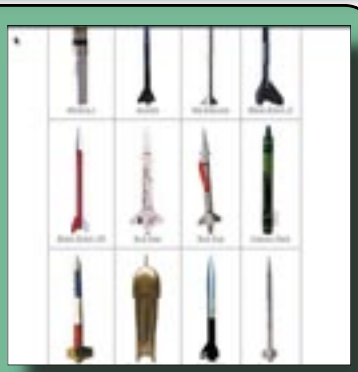
Part II of this article is by John Manfredo. He is the Education Coordinator at Apogee Components. He's Level 1 High-Power Certified and has been building his own rockets for the last 30 years.

WEB SITES WORTH VISITING

The website I chose for this issue is one that I'm sure many of us in rocketry already know about. Nonetheless, I decided to highlight it due to the fact that there is so much good information there. As you can see, John Coker's website at http://www.jcrocket.com/ is our feature this time around.

John got back into rocketry in 1998 after a 20 year hiatus, which sounds a lot like my story. By the look of his projects, etc., he has done a bit more than myself in the same timespan, though! He has something for everyone. There is a great page that highlights everything from "starting out in the hobby" to "definitions" to "legal information". A must see for those just getting started in or coming back to the hobby!

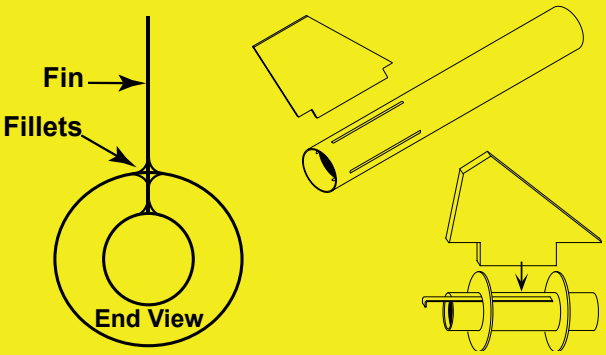
He discusses motors, designing rockets (and I must thank him for plugging Rocksim as the best design tool for the rocketeer), and where to find kits and materials. Of course, John touches on the safety aspect of the hobby and cautions that, *"Despite what you saw in October Sky, steel is not a good material for building your rockets"!* His "Fleet" page is quite extensive and shows what the status is for each individual rocket, of which there are 37 that I count. His "Quick Tips" section has many interesting ways of doing common rocketry-related building tasks that can help any rocketeer.



John's "Quick and Easy Fillet Tool" is quite simple but ingenious. He does lose some points, though, for having a "stunt spoon" picture in this tip! (Just kidding, John!) Again, I would emphasize to you that this website is definitely worth taking a few ganders at. I think you will appreciate the work the he has put into it. You will no doubt glean some useful information out of your time perusing its pages while dreaming up your newest design to unleash into the blue sky above!

DEFINING MOMENTS

"Through-the-wall fins" is the strongest way to attach fins to the rocket. A tab on the root edge of the fin fits in a slot cut into the wall of the body tube. Then you are able to create 6-way fillets: 2 at the fin-outer body tube, 2 at the fin-inner body tube, and 2 at the fin-motor mount tube. This creates the strongest of all possible fin attachments and is needed for higher power rocketry.

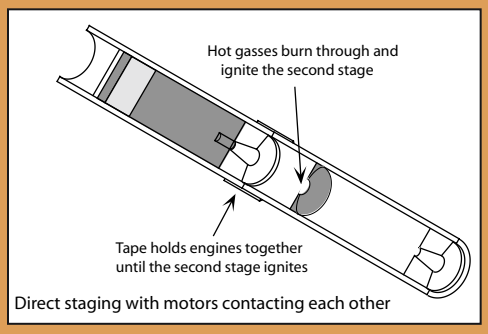


QUESTION AND ANSWER CORNER

This issue's question comes from David Reed.David asks, *"I'm coming back to the hobby and I was wanting to make sure of what I was reading. Is it not possible to direct stage composite motors? I'd prefer not to go the electronics route till later and I'm used to the old, reliable direct method."*

This is a good question with a good answer. And its something that was discussed before in Newsletter #98 (www.ApogeeRockets.com/education/downloads/Newsletter98.pdf).

Direct staging is a method of igniting one motor by another without assistance from other devices. Composite motors cannot be used for direct staging. Let's look at the reasons why they can't.

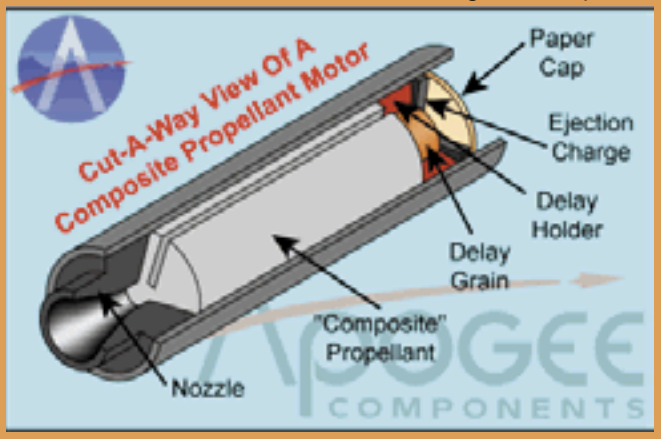


Direct staging with motors contacting each other

As seen in the drawing above, what happens is that the black powder from the booster burns through and then ignites the black powder in the upper stage. Black powder has a fast burn rate, where composite propellant is slow-burning and needs pressure to build up a high thrust.The hole down the center of a composite motor is there in order to allow more surface area to be exposed and increase the pressure.

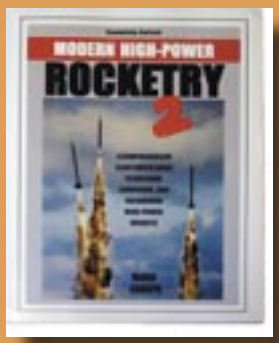
As you can see in the picture (top, right), the most common composite motors have either a slot down the middle or a hole where you insert the igniter all the way up to the top. This is where the delay grain is, which starts burning when the main propellant does. As 'Mr. Rocket' states, "You must remember, the rocket motor operates similar to a toy rubber balloon. The balloon needs a shell to hold the air, so that the pressure inside can only escape out in one direction: through the nozzle.In a rocket, the sides of the case and the bulkhead at the front are used to contain the gases inside - so they can be directed out the nozzle."

For one thing, the nozzle has too small of an opening for enough heat to get through to ignite the motor. And for the other, it takes more heat to get a composite



motor to ignite than a black powder motor as was mentioned before.

There are many good sources for information on staging composite motors: http://www.info-central.org/propulsion_staging.shtml, http://www.apogeerockets.com/education/newsletter49.asp, and http://www.apogeerockets.com/education/downloads/Newsletter91.pdf to name a few.



Another good resource is the book: *"Modern High Power Rocketry 2"* By Mark Canepa. It has lots of great illustrations to show how to put it all together. http://www.apogeerockets.com/Modern_hpr.asp

So again, in answer to the original question, direct staging unfortunately does not work with composites. If you would like to try to do some direct black powder staging, go to Apogee's webpage at http://www.apogeerockets.com/rocket_motors.asp. You will also find composite motors there that you can experiment around with to see the difference in the two types of motors. If you have a question, please feel free to send an e-mail to me at johnm@apogeerockets.com.

TIP OF THE FIN

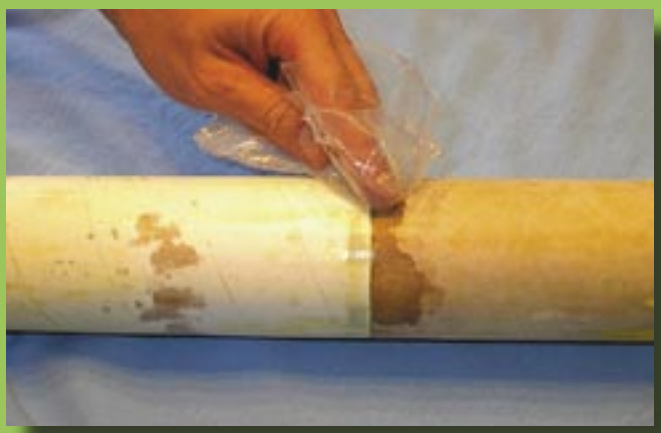
My tip for this issue revolves around a problem that I, and I'm sure many others have encountered. Your rocket just took a ride on the "Lawn-Dart Express" and you encounter a new problem. After sanding it down,

Damaged Tube

you find that the sanding got a little out of control and now you have a rocket with the "fuzzies". If you put a paint job on it now people will think your rocket is afflicted with a disease of some kind. Not to worry, though, for there is hope! First of all, get yourself some "thin" or "superthin" superglue (CA). At this point, make sure that you are in a well ventilated area. Next, squeeze some drops onto the affected areas of the tube that you want to fix. Then, using a plastic baggie, carefully rub the CA into the area that has been damaged.

Choose Thin CA Glue

Repeat this process until all the areas affected are taken care of. Allow the tube to dry thoroughly. Last,



Rubbing in the CA on the Affected Areas

but not least, take a piece of medium-grade sandpaper and sand the repaired areas down smooth and finish up with some 400-grit paper for a really smooth surface! The CA has penetrated enough into the cardboard to sufficiently allow sanding without getting the "fuzzies"! Now the surface is smooth enough to prime and paint. Now, if this technique is above your skill level or you just want to replace that tired, worn-out tube, then visit our web page for new tubes at http://www.apogeerockets.com/body_tubes_and_rings.asp. If you have a tip and we use it in this newsletter, we'll send you a HUGE 5-foot diameter Nylon® parachute! Please send them to johnm@apogeerockets.com.

Sanding Down the CA