Skylighter
Over 1,000 Products for Making Fireworks & Pyrotechnics
1-800-372-7056
Your Cart | Login
Customer Service
Order Status
Age Check

Home | Blog | Get Free Fireworks Projects
Deal of the Day! CLICK HERE
Search Go

Like Share 89 people like this. Sign Up to see what your friends like.
G+

How to Make Model Rocket Engines

Get exclusive supply discounts, fireworks projects, and cutting edge pyro tips
Make fireworks quickly & easily!
Your Email
Sign Up Now

Why make your own Estes black powder rocket engines?

"This here's a story about a man named Ned,

His grandson Jake called, and this is what he said,

Pap, I've got an Estes rocket and a question for you,

Can you make a motor for it, with a homemade fuel?"

Swimmin' pools, movie stars...

Oops, I'd better get back on topic here.

I have to admit something right off the bat. I led a deprived childhood. I never had an Estes model rocket to play with. This might explain many things about my personality. But, I digress.

I've often heard fellow fireworkers point to their first childhood Estes rockets as one of the major influences that got them moving on their lifelong path playing with pyro. It sounds like a good, safe, socially acceptable point of departure for such a journey.

But, such was not my fate. My first experiments were much less commercially marketable.

Now, I have to admit something else. I'm a die-hard do-it-yourselfer. I've built complete houses, and when my water main broke this spring, down 10 feet underground, I rented a backhoe, refreshed my memory on how to operate it, dug a huge hole, and repaired the plastic water line. I much prefer to do things myself.

So, the thought of buying packages of reloadable black powder motors for model rockets sort of rubs me the wrong way. To me, the heart and soul of a rocket is its motor. If I'm going to make a model rocket, I want to be able to make the rocket engine myself.

Indeed, a few weeks ago, my grandson Jake did call me. He asked if I knew how to make motors for his Estes rocket. I told him that since I knew how to make end-burning, black-powder rocket motors, I was confident that we could figure out how to make one to power his model rocket.

That conversation spurred me on into this next phase of the second childhood I'm currently living: making motors for Estes rockets. If I was going to show Jake how to make them, I'd better figure out how to do it myself first.

How to make a model rocket engine

I'll be using the high quality, Skylighter TU1066, 3/4-inch ID rocket tubes for these rocket motors. I have tooling for making end-burner rockets, similar to TL1270, which works well with these tubes. It would be possible to use homemade tooling similar to that which was shown in *Making Gerbs*.

Based on this starting point, I went to the website, http://www.hobbylinc.com/prods/tc_est.htm, and researched the specifications of some common Estes rocket motors. There are a couple of common sizes, D12-5 and E9-6 for example, which are spec'd at 1-inch OD, like the rocket engine tubes I want to use for the homemade models.

Estes' rocket motor nomenclature has three values in it. The letters A through E refer to the "total impulse" of the motor, or the total power of the rocket. Each succeeding letter, B, C, D, E, indicates an approximate doubling of total rocket engine power. So, the E rocket motor referred to above would have twice the total power of the model D rocket engine. That means that an E rocket engine should fly about twice as high as an Estes D rocket engine.

This "total impulse" or total rocket power combines the rocket engine's average thrust with the amount of time that it burns. If two rocket engines have the same average thrust, but one burns for twice as long as the other, the longer-burning engine would have twice the total power as the one which burns for less time, even though each had the same average thrust.

This average thrust of an Estes rocket engine is indicated by the number after the letter. The D12-5 motor has an average thrust of 12 Newtons (4.45 Newtons equals 1 pound). The E9-6 rocket motor would have an average thrust of 9 Newtons. The E rocket engine is longer than the D motor, so even though it has a lower average thrust, it has twice the total power since it burns longer than the D.

The number after the "dash," for instance the 5 in D12-5, means that after the thrust burn of the rocket engine, there will be a 5 second delay before the parachute ejection charge activates.

The info on those rocket engines led me to model rocket bodies, which use them, and I settled on using an Estes "Eliminator" which comes mostly pre-assembled. This rocket body can use any of these model engines: D12-5, D12-7, E9-6, or E9-8.

Estes "Eliminator" Model Rocket

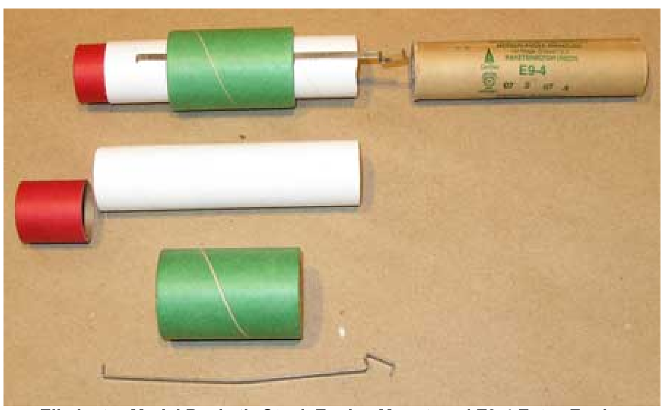
I bought a couple of the model rockets with the idea that I'd use one to fire store-bought Estes rocket engines, and I'd modify the other one as necessary to experiment with my homemade engines.

In addition to the rocket bodies, I also purchased some Estes D12-5 and E9-6 rocket engines. These motors employ the same type of high-quality paper tubes I'll be using. The Estes D engines are 2.75 inches long, and the E's are 3.75 inches long.

But, alas, the Estes model rocket engine tubes were not the 1-inch outside diameter specified at the website listed above. They are actually only about 15/16-inch OD. This is going to require me to make a modified motor mounting system in order to use my slightly larger, 1-inch OD tubes and motors.

Modifying the standard Estes rocket engine mount
Normally step 1 of my Eliminator model rocket's assembly instructions would have me assembling the stock Estes engine mount. But since my rocket engine tubes are slightly larger than the OD of the stock Estes rocket engine tubes, I will have to modify the Estes engine mount. The stock Estes model rocket engine assembly and parts are shown in the photo below.

Notice that there are basically two mounting tubes, the long white tube, and the short green tube. The E size Estes rocket motor shown is inserted into the white tube until it is held in by the metal clip. As you can see, normally the white tube fits inside of the green tube, and the whole assembly fits into the tail of the plastic model rocket body.



Eliminator Model Rocket's Stock Engine Mount, and E9-4 Estes Engine

The total weight of the model rocket engine mount and engine is 91.5 grams (3.2 ounces), of which 69.5 grams (2.45 ounces) is the weight of the motor, and 22 grams (0.8 ounce) is the weight of the mount. I've learned, after playing with girandolas and black powder rockets for a while, that their weight is critical. The total weight of a black powder rocket will determine whether or not it will fly, and if it does, how high it will go. Also, the weight of the rocket engine and mount contributes to the aerodynamic balance of the flying rocket. So I'll want my homemade motor and mount to weigh about the same as the stock versions.

In the stock rocket engine mount, the engine slides into the white tube and forward until it hits the part of the metal clip, which is projecting through the wall of the white tube. The motor is held in with the other end of the metal clip, and this becomes critical when the parachute ejection charge ignites. That ignition will pressurize the rocket body, and "try" to eject not only the nosecone and parachute out its front, but also the motor out its back. The clip is what prevents the motor from being ejected.

The red tube at the front of the motor mount also helps hold the model rocket engine in place during the thrust and coast phases. It is hollow to allow the ejection charge gasses to burst forward into the rocket body tube and eject the parachute.

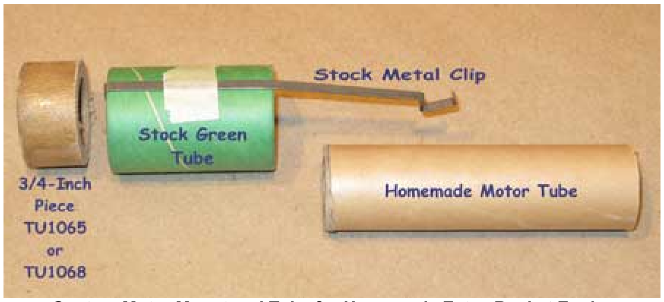
So, since my homemade motor tubes have different dimensions than Estes' rocket tubes, I have to find some way to hold my 1-inch OD motors in place, front and back, and keep the front of the motor mount hollow so that the parachute can be ejected.

First, I eliminate the white mounting tube altogether. And it appears that if I slightly modify the ID of the green tube, I can make everything fit. I was able to peel some layers off from the inside of the stock green motor mount tube, so that my homemade motor will slide into it.

I also have some Skylighter TU1065 and TU1068 paper rocket tubes, which have an OD of 1.25-inches, the same OD as the green tube. The ID of these tubes is 3/4-inch, which will allow my parachute ejection gasses to pass through. That ID is small enough that the rocket motor can slide up against it and serve as a "stop" to prevent the rocket engine from pushing forward during thrust. So, I cut a 3/4-inch long piece of TU1065, and use it to replace the stock red tube that Estes supplies as part of its motor mount.

The design of my modified mount to accommodate my homemade motors is shown below. The metal clip will end up sandwiched between the green tube and the rocket body tube once the green tube gets glued into the rocket body. I have bent the clip slightly, so it will clip onto the end of the motor when it's inserted. Both tube sections will be glued in place inside the rocket body tube.

For some tips on cutting paper tubes for model rocket engines, please refer to *Cutting and Treating Paper Tubes*.



Custom Motor Mount and Tube for Homemade Estes Rocket Engine

This custom motor mount assembly weighs 20 grams, which is just about the same as the stock one. So far, so good.

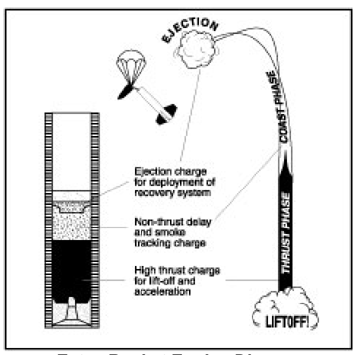
Whether I'm installing the stock or the custom motor mount, I glue them in place per the instructions, so that the end of the motor projects out past the end of the rocket body tube 1/4-inch when the motor is fully inserted.

I'm now confident that with a bit of creativity, any type of stock Estes rocket engine mount can be modified and adapted to accommodate a homemade motor.

I went ahead and completed the rest of the rocket assembly per the original Estes model rocket instructions. The final flying weight of the rocket was 170 grams (6 ounces) with the stock motor installed.

Dissecting an Estes model rocket engine

The following diagram is from the Estes "Rocketry 101" educational information, available at the http://www.esteseducator.com website. It shows the various sections of an Estes model rocket engine and how each section performs during flight.



Estes Rocket Engine Diagram

This is a relatively typical end-burning model rocket engine construction, where a clay nozzle is rammed in the end of the tube, and a solid black powder rocket fuel grain is then rammed above the nozzle. There is no hollow core going up into the black powder grain, therefore the name "end-burner."

Estes uses two types of black powder rocket fuels in the motor diagrammed above: a powerful "thrust" rocket fuel, and a less powerful "delay" fuel. These two sections of rocket fuel are topped off by a powerful ejection charge, which produces volumes of gasses quickly in order to eject the nosecone and parachute.

A dissected stock E motor below shows the various sections of the motor.

A Dissected Estes E9-6 Model Rocket Engine

In this motor, the nozzle was about 1/2-inch thick, weighed 5.5 grams, and had a 5/32-inch "aperture," or hole. The 2.5-inch long, 38-gram rocket fuel grain was extremely solid and hard, like one single cylinder of rocket fuel. When tapped with a metal rod, the rocket fuel grain "tinks" like a piece of fired clay dish.

The nozzle hole projected another 1/8 inch into the model rocket fuel grain. I test-burned a chip of the thrust-fuel grain; it burned instantaneously as one would expect full-strength black powder to do.

Surprisingly, the delay fuel was only about 1/2 inch thick, and was a medium gray in color. I expected it to be black and to occupy more space, since it burns for so long. A bit of the delay fuel burned very slowly, and it produced a small amount of white smoke as it burned.

Embedded in the top of the delay fuel was a 1/8-inch layer of granular black powder ejection charge. When scraped away from the rocket engine's delay fuel grain, this ejection charge weighed 0.5 grams.

On top of the ejection granules was a thin layer of clay, which I imagine pops off easily when the column of fire inside the motor hits the ejection charge. This will allow the gasses from the charge to eject the parachute.

The most important data on this motor is its thrust. Thrust is what powers the rocket skyward. I'll need to make homemade rocket engines having close to the same amount of power, if I want rocket flights equaling the altitude I get with stock motors.

I have a scale, which has a load cell platform and a remote digital readout console. I use this scale to test my rocket engines and record the digital readout of the thrust/power from rocket engines.

An E9-4 rocket engine's thrust phase lasted for 3 seconds and produced about 2 pounds of thrust on average. The delay fuel burned for 4 seconds and produced no thrust.

Estes E9-4 Rocket Engine's Thrust Measured with a Digital Scale

(Click Image to Play Video)

This Estes Eliminator rocket will fly highest with an E motor. A D rocket engine will result in a lower altitude, and is recommended for first flights. When I tested a D engine on the test stand, the thrust phase lasted for 2 seconds and produced about 1.8 pounds of thrust (rocket power).

How to make a homemade Estes rocket engine

Tips on making rocket nozzles, and the clay mix they are made from, can be found in the *Making Nozzle Mix* article. Additionally, some basic information on how to make an end-burner rocket engine and the tooling used to make them can be found in *How To Make End-Burner Rocket Motors*.

I'll be using one-pound (3/4-inch ID) end-burner rocket tooling, similar to Skylighter TL1270 tooling.

Skylighter TL1270 End-Burner Rocket Tooling

I'll be making the motors using the methods in the article cited above, with some slight exceptions: I will not be dampening the black powder rocket fuel immediately prior to use. I also will not be pressing these rocket engines with a hydraulic press, but hand-ramming them instead with a rawhide mallet. No tube support is needed when the motors are made this way.

First, I want to try the simplest-to-make black powder rocket fuel, a screened 75/15/10, potassium nitrate/airfloat charcoal/sulfur mix. So I screen 15 ounces/3 ounces/2 ounces of each chemical respectively through a 100-mesh screen, using commercial, hardwood airfloat charcoal from Skylighter.

If any of the potassium nitrate won't pass through this screen, I grind it more finely in a coffee mill per the instructions and cautions contained in Fireworks Tips #112.

I rammed a rocket engine with a 2.25-inch long fuel grain using the simple, screened, black powder fuel. This motor burned for 7 seconds and only produced between 0.2 and 0.25 pounds of thrust. When it burned, it sounded puny compared to the Estes engines.

Well, I suspect I have a ways to go before I can make a motor that will get this model rocket up and flying. There are a couple of ways to increase the power of a rocket motor like this.

I can switch from commercial, hardwood airfloat charcoal to a homemade charcoal. For tips on making homemade charcoal. I have some homemade spruce/pine charcoal, which I know makes more powerful black powder than does commercial hardwood airfloat.

I like using homemade charcoal, and I could pass that skill along to Jake as we work on this project. So, I think I'll try the same procedure as my initial one, but substitute homemade spruce/pine airfloat for the commercial charcoal.

This second rocket engine burned for 6 seconds, with a thrust of 0.25 - 0.27 pounds. I'm heading in the right direction, but have a long way to go yet.

With a 6-ounce black powder rocket, based on my past experience using end-burner motors on girandolas, I'm guessing that I'll need at least 0.75 lbs of thrust to even start to lift the rocket, and more like 1.2 pounds to really get her to fly.

Another way to speed up black powder is to ball mill it. For information on ball milling, see *Ball Mill 101*. I'm going to ball mill both batches of rocket fuel for two hours to see how significantly that increases its power.

While those batches were being ball milled, I went ahead and pressed a rocket engine using some finely granulated, commercial Meal-D black powder that I had on hand. I wanted to see what sort of thrust a known, good, powerful black powder fuel would create when hand-rammed in one of these homemade rocket engine configurations.

That motor burned for 3 seconds and produced 1.5 pounds of thrust, and I'm confident that it could have enough power to lift the rocket.

Once my two fuels had been milled, I made rocket engines using them and burned them on the test stand.

The motor made using the milled spruce/pine charcoal black powder burned for 3 seconds and produced about 1.3 pounds of thrust on average. Now we're getting somewhere. The ball milling made a huge difference.

The rocket engine made using the milled, commercial airfloat charcoal black powder burned for 3.5 seconds with an average thrust of 1 pound. Even this motor sounded and "felt" as though it might send the rocket into flight.

Note: When I use the term "commercial hardwood airfloat charcoal," I am of course referring to what I have on hand. Who knows what wood this was actually made from at the charcoal factory? My store-bought charcoal may be quite different from your store-bought charcoal, depending on what wood was used to make them on the day of the week it was made. So, your results may vary from mine.

Okee-doke. Switching to the homemade spruce/pine airfloat charcoal increased the engine's thrust a bit, and ball milling the fuels made a huge difference.

Another way to increase the power of the rocket is to decrease the diameter of the engine's nozzle aperture. The tooling I'm using creates a 3/16-inch nozzle hole. I could try going down to a 1/8-

inch hole, but doing so would necessitate ramming a solid nozzle and drilling the hole, as I described in *Making Gerbs*. I'd rather keep this project simple for Jake, and continue to use my stock rocket tooling.

One additional procedure that may increase the power of the black powder fuel is to slightly dampen it, screen the comp several times to thoroughly integrate the water, and dry it. I used this method when making the rocket fuel for the one-pound black powder rockets that I wrote about in *Glitter-Tailed Rocket with Willow Diadem Horsetail Finish*.

Another significant advantage to using fuel that has been dampened, screened, and dried is that the fuel is slightly granulated instead of being finely powdered and fluffy. This makes ramming the powder into the motor tubes much less messy.

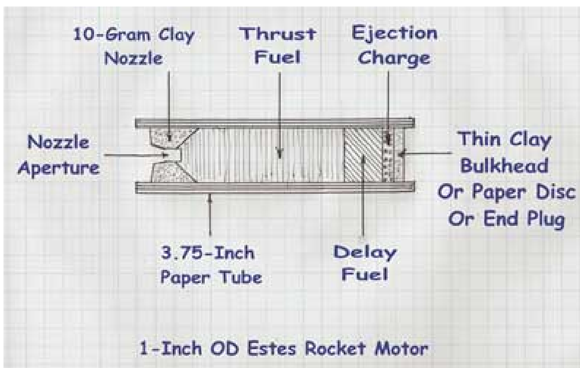
I went ahead and dampened 3 ounces of each rocket fuel with 10% water, screened it, and allowed it to dry overnight on kraft-paper lined trays.

A motor made with commercial-airfloat fuel, processed in this manner, burned for 3.4 seconds and its thrust averaged between 1 and 1.2 pounds.

A motor made with the spruce/pine charcoal fuel burned for 2.8 seconds and produced an average thrust of between 1.3 and 1.5 pounds.

So, processing the fuels with the water slightly increased their power. I'll make engines with these two processed rocket fuels, commercial-airfloat and homemade spruce/pine charcoal, ball milled, dampened/screened/dried, and see how the rocket flies with them.

This is the final rocket motor configuration I have in mind.



Cross-Section of Homemade Replacement Estes Model Rocket Engine

I'm going to use a simple Tiger-Tail Star composition for the delay fuel, eliminating any binder that would be used when making stars. This is a very slow-burning composition.

Tiger Tail Star Composition for Delay Fuel

Chemical	Percentage	4-ounce batch	115-gram batch
Airfloat charcoal	0.47	1.9 ounces	54 grams
Potassium nitrate	0.47	1.9 ounces	54 grams
Sulfur	0.06	0.25 ounces	7 grams

I simply screened this composition through a 40-mesh screen three times, slightly dampened it with water, as I did with the rocket fuel, and dried it.

For the ejection charge, I dampened some of the rocket thrust fuel with 5% water, and pressed thin black powder pucks with it. These pucks were dried and crushed, black powder similar to what was made in *Making and Testing High-Powered Black Powder*. I'll use the black powder granules, which pass a 10-mesh screen kitchen colander, but won't pass a 20-mesh screen.

I can vary the duration of the thrust phase of the rocket engine by varying the length of that black powder fuel grain. 3/4 inch of the thrust fuel burns for about 1 second. So if I want, say, 2 seconds of thrust, I can ram 1.5 inches of that black powder fuel. Each 3/4 inch of that fuel weighs about 8 grams.

Similarly, the delay fuel burns for about 1 second per 3/16 inch of that fuel. So if I want 2 seconds of delay, I'll ram 3/8 inch of that fuel. Each 3/16 inch of the delay fuel requires about 2 grams of it.

In this way, I can adjust and fine-tune my model rocket flights for any altitude I want.

To make a motor, I rammed the clay nozzle using 10 grams of clay nozzle mix, with 12 whacks with my rawhide mallet. If I'm using a spindle that has a hole drilled in the center of it for black-match fusing, as I described in the end-burner article, I simply allow that hole to get filled with clay, which I'll remove with a drill bit at some later time. I'm not using the black-match fusing technique in this project.

Then I rammed the black powder thrust fuel in flat-teaspoonful increments and 8 hits of the mallet for each increment. Then I did the same with the delay fuel.

I poured in 2 grams (a heaping 1/4 teaspoonful) of my ejection charge and only lightly tamped that powder flat by hand-pushing the ram into the rocket engine.

I tried capping the ejection charge with a lightly tamped clay disc, with mixed results. During this research and development, my worst calamities occurred when the parachute did not deploy, seriously damaging the rockets.

I got the best parachute ejections when I capped the ejection charge off with a 3/4-inch paper disc, DK0600. I put the disc on a piece of masking tape, which was a bit larger than the disc. That way, when I pressed the disc in, the tape folded up on its edges and made it fit a bit more snugly--no gluing necessary. If I'd had 3/4-inch paper end plugs, PC0800, I would have used them by just pressing them into the rocket tube and using no glue.

Here's a photo and video of a test of a homemade model rocket engine, made with 3 seconds of thrust (24 grams of black powder fuel), and 3 seconds of delay fuel (6 grams).

Homemade Estes Rocket Engine

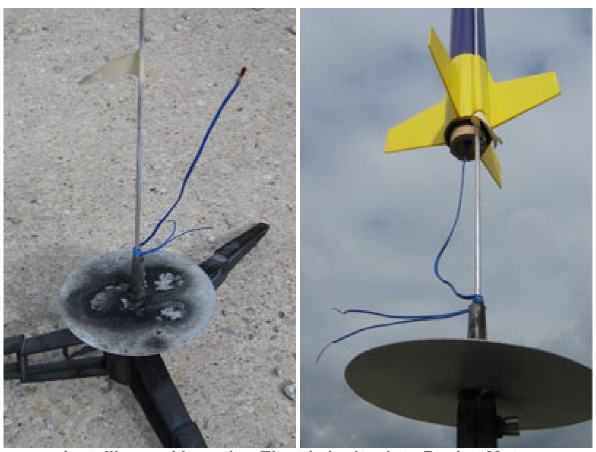
(Click Image to Play Video  ***)***

I now have stock Estes D and E model rocket engines, and homemade motors made with the two different charcoals. It's time to go out to the rocket range for some testing.

Flying my homemade Estes model rockets

To launch these rockets, I purchased an Estes rocket launch pad. I want to fire them electrically. So, instead of Estes igniters I used homemade electric igniters made with GN5040 ematch blanks and the GN5050 electric match dip kit. Here's a little tutorial on using these materials to make electric match igniters.

Here's how I rigged the ematch igniters: First I wrapped the ematch leads around the launch rod, pointing the ematch head straight up. Then I lowered the rocket down the rod until the igniter head inserted into the rocket-motor nozzle aperture. This is the one application where I do remove the electric match protection shroud.



Installing and Inserting Electric Igniter into Rocket Motor

I then extended the ematch wires about 6 feet over to my electric firing box. It's nice to be able to fire the rockets with a wireless remote control from 50 or 75 feet away, or to let the kids push the button.

One other homemade component of the rocket launch that I made was fireproofed wadding to go into the model rocket body tube between the engine and the parachute. Estes sells little packets of fireproofed toilet-paper squares for this purpose.

I sprayed some paper towels with Universal Fire-Shield, Paper Shield P-3000, available on-line at http://www.firechemicals.com. Once it dries, this product fireproofs porous materials like paper and string. I've sprayed it on the tissue paper I used for homemade sky lanterns.

A lightly balled-up wad of the treated paper towel stuffed into the rocket body-tube, followed by the parachute and rubber-band shock-cord (folded up in another piece of the paper towel), really protected the parachute, strings, and rubber band from the heat of the ejection charge.

Fireproof Wadding to Protect Parachute During Ejection

I went out to the approved rocket launch area in my local state park, and flew some of my model rockets. The Estes D engines propelled the Eliminator rocket a good 500-700 feet high, and the E engines really sent it up there, probably over 1000 feet high.

My homemade rocket engines made with the commercial airfloat charcoal fuel flew about 500 feet up. The spruce/pine charcoal fuel sent the rocket up another one or two hundred feet higher than that, comparing favorably with the stock Estes D motors.

Estes Rocket With Homemade Engine in Flight

(Click Image to Play Video)

All in all, I flew rockets with about a dozen Estes stock engines, and about the same number of my homemade motors.

Results
You can hear my glee in the final video. Flying the rockets was truly an enjoyable, child-like experience. Good fun.

And, any day spent learning something new is a good day in my book. I learned how Estes rockets work, and what goes into one of their motors.

I learned how to duplicate the performance of those stock motors with my own homemade motors. And now I know I can direct Jake as he makes his own motors for his rockets.

Finally, a good day at the rocket range is a day when the rocketeer brings the rocket back home in mostly one undamaged piece, ready to fly again another day. I got to do that today.

Have fun with your Estes rockets, your kids and grandchildren, and your "inner child."

Enjoy,

Ned

Materials Needed

- Airfloat Charcoal (CH8068)
- Ball Mill (TL5005)
- Disk, 3/4-inch (DK0600)
- Ematch Blanks (GN5040)
- Ematch Dip Kit (GN5050)
- Estes Model Rocket
- Mallet (TL4100)
- Paper Plug, 3/4-inch (PC0800)
- Potassium Nitrate (CH5302)
- Rocket Tooling (TL1270)
- Rocket Tubes, 3/4-inch ID (TU1066)
- Rocket Tubes, 1-1/4-inch OD (TU1065 or TU1068)
- Sulfur (CH8315)

Read and review these Fireworks Safety Articles before starting any fireworks project.

Like Share 89 people like this. Sign Up to see what your friends like.

G+

IF YOU ENJOYED THIS PROJECT...

You'll love seeing the rest of our fireworks projects.
Get new projects, plus:

- Advance notice of new fireworks-making kits
- New products before anyone else
- Free products and discounts of as much as 50%

Enter Your E-mail Address Here submit

100% Secure 128 SSL Encryption
Order Online 24 Hours a Day, 7 Days a Week, 365 Days a Year
Privacy Policy
365-Day Money Back Guarantee

(540) 338-3877 - Fax (540) 338-0968 - 9:00AM to 5:00PM (Mon-Fri) ET
© Copyright 2017 Skylighter, Inc. All Rights Reserved
Contact Us | Easy Returns | 1 Year Satisfaction Guarantee | Privacy Policy