PEAK OF FLIGHT
NEWSLETTER

ISSUE 415 | APR 19th 2016

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Launching an E-Engine in a D-Engine Rocket

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PEAK OF FLIGHT

Launching an E-Engine in a D-Engine Rocket

By Tim Van Milligan

What do you need to do to your D-engine powered rocket when you want to put an E-size rocket engine into it? This is a common question we get here at Apogee Components, because a lot of people want to step up in size or thrust and get into those mid-power rockets.

But confusion arises because there are three types of rocket motors and they look a little different. And E-engines are that crossover point from low-power rockets that use an engine hook to high-power rockets that use different methods of holding the rocket engine into the model. A lot of people want to fly those bigger motors, but still want the model to be able to use the D-size engines that can be used on smaller launch fields. In essence, they want maximum versatility with the rocket. And I don't blame them for this, as I have the same desire too.

In this article, I'll go over the different options you have when converting a rocket kit from D-size to E-size rocket motors. But let me say here at the beginning that there isn't one "best" way of doing things. There are several different options available, and you'll have to pick one for your situation. They are all good! So don't fret that you're making a poor choice. This is one situation where all the options are equally good.

What You Are Familiar With

People that are new to model rockets and have a few launches to their credit are very familiar with the basic engine mount shown in **Figure 1**. I'll go over the different parts, in case you are not familiar with their purpose.

1. **Rocket Engine** - An Estes black-powder propellant motor has a brown paper casing, and the E-size engines from Estes look very similar to the D motor sizes. The only way to tell the difference is to compare the lengths. The D-size engine is 2.75 inches (70mm) long, where the E-size is exactly one inch longer at 3.75 inches (95mm) long. The rocket engine is replaced after each flight, because the propellant is consumed during the flight.

2. **Engine Mount Tube** - The engine mount tube is what holds the rocket engine. The tube is typically made from paper, and is strong enough to withstand the thrust created by the motor. The engine is NOT glued into the engine mount tube, because it has to be removed and replaced between flights.

3. **Centering Rings** - Since the engine mount tube is usually smaller in diameter than the outer tube of the rocket, you will need rings to center the engine mount tube within the bigger tube. Their purpose is to concentrically align the motor with the centerline of the rocket. In other words, you want the thrust created by the rocket motor to be straight along the centerline of the rocket. If the rocket engine were to be canted within the rocket, then the entire model would turn

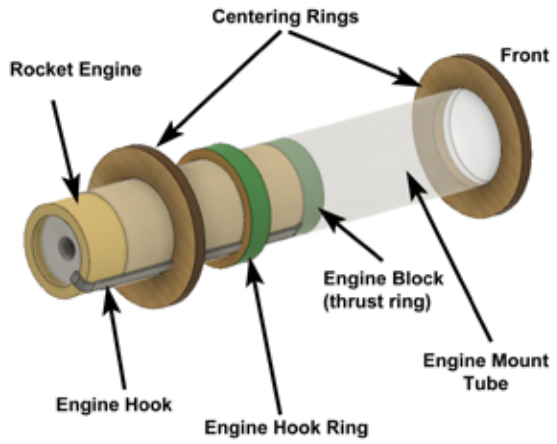

Figure 1: Basic engine mount layout

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and go unstable during the flight. The rings must also be strong enough to withstand the thrust of the rocket engine. Should the rings break, then the rocket motor would fly though the inside of the model instead of pushing the entire rocket into the air. This is very rare on D or E powered motors, so don't worry about it.

4. **Engine Hook** - This is a bent piece of metal that clips over both the front and back ends of the rocket engine. The purpose of the engine hook is to hold the rocket from sliding either forward or rearward within the engine mount tube. The metal part is somewhat flexible, and you will bend it outward to slide the rocket engine into the engine mount tube. Once it is inserted, it will spring back and hold the engine in place.

5. **Engine Block** - This is a ring that goes inside the engine mount tube, directly in front of the engine hook. The purpose of the engine block is to prevent the engine hook and the rocket engine from sliding forward. Without the engine block, it is possible for the metal engine hook to slide forward, as shown in **Figure 2**. I've seen this happen far too often, and it makes removing the rocket engine after the flight a lot harder. You have to grab the hook with a pair of pliers and tug it back to where it should have been. There is sometimes damage to the engine mount tube, but it is repairable if you can get an engine block glued into the engine tube in front of the hook.

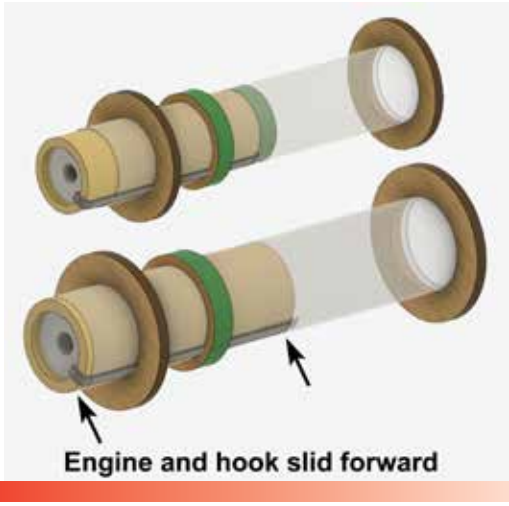

Figure 2: Example of engine hook that has slid forward

What I like to do, if I see that the rocket engine and hook are sliding in the tube, is to put masking tape over the hook and the engine to prevent it from shifting forward during launch (**Figure 3)**. This is an easy fix, as long as there is room for tape on the aft end of the engine mount tube. That is why I recommend putting that aft centering ring on the engine mount tube at least one-half inch (13mm) from the edge of the tube. At this position, it also makes it easier to bend the engine hook during insertion and removal of the rocket engine.

Figure 3: Secure a sliding engine hook in place with tape

6. **Engine Hook Ring** - This ring is optional on an engine mount. Often times, a layer or two of masking tape will be sufficient. The purpose of this external ring (or tape) is to prevent the forward part of the engine hook from bending upwards when the rocket motor is being inserted into the model. Typically, the aft centering ring will be sufficient to prevent this, which is why it is optional.

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With a basic knowledge of the components of an engine mount, we can now discuss the challenges of going from a D-size engine to an E-size.

The Model Is Already Built

Even if the rocket is already built, you still have some options available to you.

Option 1: Use a composite propellant E-size rocket motor. If you want more power for your rocket, remember that you have other choices besides Estes motors. The simplest option is to pick an E-size rocket engine from Aerotech or Cesaroni. The nice thing about composite motors is that they have twice the energy density of black-powder propellant. So they have the same physical size and approximate weight of a black powder D motor, but the power of an E motor! (**Figure 4**).

Figure 4: Motor comparisons (top to bottom): D-size Estes motor, E-Size Aerotech composite motor (this can fit within the same engine hook as a D-size Estes motor), then the E-size Estes motor

Essentially, you can just simply drop a composite motor directly into the engine mount of your model rocket if it is already built. I would suggest that you pick one of the motors with a low average thrust. The reason is that these motors have a more gentle push off the launch pad, and your rocket isn't stressed much more than it would be on an Estes D12. You can tell the average thrust by looking at the number directly after the letter "E" in the name of the motor. For example, Aerotech has an E15 motor that would work in most any rocket that could take an Estes D12. Cesaroni has a E22 that is a little bit more powerful, but would probably also be an acceptable substitution.

I would stay away from the Cesaroni E75, because that has a very high average thrust and would stress the rocket considerably, especially the fins. Unless the rocket is built to take high thrust motors, the E75 could take off so fast that the drag force could strip the fins off the airframe.

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Option 2: Let the motor hang out the back of the rocket. If you want to use the longer Estes E size rocket engines, this option is available. Here, the motor doesn't slide all the way into the engine mount tube where the engine hook clips over the rear edge. The engine hook is bent upwards and rests on the side of the rocket engine.

There are a couple of things you have to do first before you use this option. First, you have to restrain the rocket engine from moving rearward at ejection. This is actually easy to do. You can simply put a wrap of masking tape over the engine hook and the engine mount tube as shown in **Figure 5**. Yes… This is ugly looking. But it is effective at keeping the rocket engine in place where it can't slide rearward. And the front part of the engine hook and the engine block prevents it from sliding forward up into the rocket.

Figure 5: Taping the longer motor in place with a shorter engine hook

The second caveat is that this is an option only if the rocket is very stable. The stability margin, which is the distance that the Center-of-Gravity (CG) is ahead of the Center-of-Pressure (CP), must be large. If you hang the rocket engine out the rear of the rocket, you will be shifting the Center-of-Gravity of the model aft, which is destabilizing (bringing the distance between the CG and the CP closer). In other words, it makes the model tail heavy and less stable. So before you go and let the rocket hang out of the back end, you have to check the stability first to see if there is sufficient margin to allow the CG to shift rearward and still be stable .

You can do this in a software program such as RockSim (**Figure 6**: https://www.apogeerockets.com/Rocket_Software/RockSim) or one of the other stability programs on the market. Load the rocket engine into the model, and note where it balances. That is the CG location . The software will tell you the CP location. As long as the CG is in front (towards the tip) of the CP, the rocket will be stable enough to fly. The rule of thumb is at least one body tube diameter of distance between the CG and the CP, which is a good reference to go by.

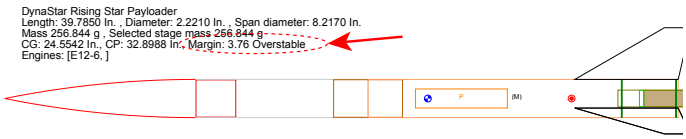

Figure 6: Checking rocket stability in RockSim

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Option 3: Major surgery on the rocket kit. This is the least likely option, because tearing things out of the rocket can damage those parts that you don't want modified. In this case, you'd want to remove the engine hook and the engine block, but without damaging the engine mount tube or the centering rings. This is easier said than done though. If you wanted to do it, I'd suggest a long screw driver or a chisel and a hammer to chip out the engine block. After you have most of it removed, you could come in a dowel wrapped with sand paper (or a circular file) to smooth out the residual part of the engine block that might remain in the tube.

Removing the tang of the engine hook that protrudes into the tube is extremely difficult. A metal file is what you'd probably use. In reality, it might be easier to tear out the entire engine mount tube and centering rings and replace those parts. In which case you may want to go back to the first option in this list, because using composite motors is so simple, I doubt that there would be anyone that wanted to go through the trouble of doing major surgery on the rocket to remove the engine block.

Options For When The Model Is Still Unbuilt

If you haven't built the rocket yet, and you want to fly it on E motors instead of D's, then you have a lot of additional options.

www.apogeerockets.com/RockSim/RockSim_Information

Option 4: Use a longer engine hook. Many people are comfortable using engine hooks because they've had good experience using them in smaller rockets. And there are longer hooks available for use with the Estes rocket engines (https://www.apogeerockets.com/Building_Supplies/Motor_Retainers_Hooks/Engine_Hooks/inEin-Size_Engine_Hooks). When you replace the standard D-size hook for an E-size, the only change you have to make is where you cut the slot for the front part of the hook. Since the E-size hook is 1.0 inches (12.7 mm) longer than the D-size hook, you'd just position that slot 1.0 inches forward of where it is normally positioned.
If you want to fly an Estes D-engine in your new motor mount, you need to put a spacer tube in front of the rocket engine when you put it into the model (**Figure 7**). "Where do you get a spacer?" That is a common question that we are asked. Estes does sell a thick 1-inch long spacer tube for this purpose. But why spend the money if you can make your own? All you need is a burnt out D or E size rocket engine and a small saw. Just hack off the back end of the used engine, and you instantly have the spacer you need. Remember to save those old used rocket motors… they are useful in a number of ways like this one, and also for pushing in engine blocks.

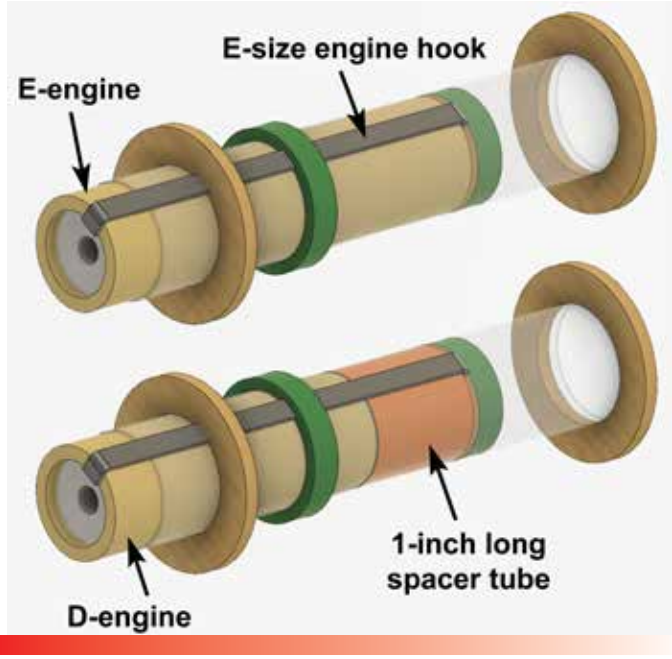

Figure 7: Using an engine spacer to accommodate for a longer engine hook

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Option 5: Leave out the engine block and engine hook. This is my personal fall-back position, because it is the cheapest one. I build so many rockets for testing, that leaving parts off the rocket can save me a lot of money. When you leave out the engine block and the engine hook, you have to have an alternate way of holding the motor in place. In this case, I simply wrap tape around the perimeter of the motor where it exits the tube. The tape must also go over the tube where the engine sticks out (**Figure 8)**.

Figure 8: Taping the motor directly to the motor mount tube

Many people question whether or not the tape is strong enough to hold the rocket motor in place. The answer is that it can easily restrain the motor. I've been taping in motors for decades, and it works just fine. I even came up with pre-cut motor tape strips made from vinyl that I use for competition rockets (https://www.apogeerockets.com/Building_Supplies/Motor_Retainers_Hooks/Motor_Tape_Strips/Motor_Tape_Strips). The only thing you have to check is to make sure the nose cone isn't too tight on the front of the rocket. If it is, then Newton's Third Law of Motion comes into play (for every action there is an equal and opposite reaction). In this case, when the ejection charge pressurizes the inside of the rocket, it puts strain on the tape. And if the tape isn't strong enough, it could allow the engine casing to be spit out the back end of the rocket. If that happens, the rest of the rocket will come down without an open parachute. Just check the fit of the nose cone to make sure it is not too tight. There is a video on our web site that will show you how much fit is acceptable: https://www.apogeerockets.com/Advanced_Construction_videos/Rocketry_Video_197.

Option 6: Use a Screw-on Engine Retainer. A screw-on engine retainer adds a bit of professionalism to your rocket because it looks so much nicer than either masking tape holding the motor in, or even an engine hook. Screw-on engine retainers are typically used in high-powered rocketry to hold the motor in place in the rocket. So in this option, we're taking a high-power rocketry approach to holding the rocket motor in place. This is the option where many modelers are a little confused. They don't have experience with high power rocketry, so the concept of moving the location of the engine block is new or a foreign concept.

The screw-on retainers work by capturing the thrust ring that is built into the rear of the rocket motor. Most composite propellant rocket motors have the thrust ring built into the back end of the motor. Essentially, this is the "engine block" that prevents the motor from sliding through the engine mount tube of the rocket. Because it is on the rear of the rocket engine, you do NOT need an engine block inside the engine mount tube of the rocket kit. It would be redundant.

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Not only that, it would prevent you from using longer and more powerful rocket engines in the model. So by leaving the engine block out, you have maximum versatility in which rocket motors you can use in the model. You can use short motors or long motors, and you don't have to change a thing to the model between flights. That means you don't need a spacer tube, like you would if you used a E-size engine hook.

The screw-on engine retainer is a two-piece system. One part of the retainer is permanently bonded on the rear end of the engine mount tube using epoxy. On the outside of the piece are screw threads. A cap is screwed over the top of these threads, which hold the rocket motor from sliding rearward out the back of the engine mount tube. So in summary, the thrust ring on the back of the rocket engine prevents the engine from sliding past the end of the tube, and the cap prevents the rocket engine from sliding backwards when the ejection charge fires (remember Newton's Third Law of Motion?).

To install the rocket motor (**Figure 9**), you unscrew the removable cap, slide the rocket engine into the engine mount tube until the thrust ring on the back butts up against the rear of the retainer portion. Then screw on the removable cap.

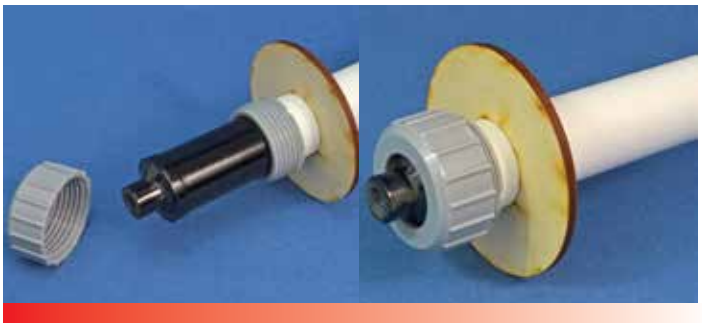

Figure 9: Slide the composite motor into place and then screw on the retainer cap

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Since the black powder E-size rocket motors from Estes don't have a thrust ring on the rear end of the casing, you may think that you can't use them with the screw-on retainers. But you can! You only need to make a thrust ring out of masking tape. Ideally, the thrust ring should be about 1/4 inch wide. You can buy 1/4-inch wide masking tape at a paint store, or you can use what you have available. Wrap at least a 1/4-inch of the tape around the rear of the rocket engine, and leave the excess tape hanging off the edge of the motor. After you have built up about 6 layers of tape, cut off the overhang with a hobby knife (**Figures 10-11**).

Figure 10: Wrap about 1/4in of tape around the edge and then cut off the excess with a hobby knife

Figure 11: Completed E-size motors with added thrust rings

Does tape work as a thrust ring? You bet! Just like taping in the motor in option #5, making a thrust ring out of masking tape works just as well too. The nice thing about the screw-on retainers, and why they are used so much in high-power rocketry, is that you can use longer motors in the model. So while you're just thinking right now of using "E" size engines, you can also use 24mm diameter F or G motors that are longer.

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Once you start considering those bigger motors, you have to plan for it in advance and use building techniques and better craftsmanship so that the rocket can withstand the forces of those higher-powered motors. For that, see our advanced construction videos (https://www.apogeerockets.com/Advanced_Construction_Videos/all) and the book Model Rocket Design and Construction (https://www.apogeerockets.com/Rocket_Books_Videos/Books/Model_Rocket_Design_And_Construction).

Conclusion

In this article I wanted to show all the different options you have available when you want to fly your D-powered rocket with E-size motors. From the questions we get here at Apogee Components, there seems to be a lot of confusion on how to do it. I suppose since there are so many options, it causes the brain to seize up while you're trying to figure out the "best" way to do it. But they are all good options. Hopefully this article will help you get the confidence you need to go for it.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor, and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward a M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http://www.apogeerockets.com) and also the author of the books: "Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics" and publisher of the "Peak-of-Flight" newsletter, a FREE e-zine newsletter about model rockets. You can email him by using the contact form at: https://www.apogeerockets.com/Contact.