PEAK OF FLIGHT

NEWSLETTER

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What Causes Engine Mount Damage In Rockets With Stuffer Tubes?

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PEAK OF FLIGHT

What Causes Engine Mount Damage in Rockets With Stuffer Tubes?

By Tim Van Milligan

Robin L. writes: “I flew my brand new built “old stock” Optima a couple of times on these reloadable motors. The problem I had was the engine holder is getting burned by the high heat generated through the aluminum casing of the reloadable engine. I cannot fly it again that way because the paper will not stand another heat treating like the last two launches. What can be done? I suppose I need to use only black powder paper rolled engines because they don’t get so hot. What can I use to replace the engine holder with something that has a high resistance to heat? I hope you do an instruction video on this subject and I know I cannot be the only one that has had this problem.”

What you’re seeing here could be one of two problems. The first possibility is what is called the “Hibachi effect.” This was explained in detail in Peak-of-Flight Newsletter #28 at: https://www.apogeerockets.com/education/downloads/Newsletter28.pdf. Essentially, it occurs in composite motors where the delay was drilled out to create a shorter time between engine burnout and ejection. The shorter delay leaves a lot of delay inside the rocket motor even after the ejection charge fires. The after-burning of this excess delay propellant pumps heat into the body of the rocket, which could cause the damage. There is a video animation of what happens to the delay grain at: https://youtu.be/b-8gsP2xI2M. But I don’t think that is what is happening here. The reason is that I have some experience working on the Optima kit when I was a designer at Estes in 1991. We saw similar damage to the engine mount tube from our own testing of the rocket.

Based on my experience, what I think is happening from the description given is that there is damage to the engine mount tube in front of the rocket engine. This occurs with long rockets like the Optima.

Figure 1: A page from the 1990 Estes catalog showing the size of the Optima rocket kit. Source: http://www.ninfinger.org/rockets/nostalgia/90est46.html.

The Estes Optima is D-engine powered, is based on the BT-80 (2.6” diameter) tube, and it is nearly 40 inches long. Because it is so big, it also has a very large internal volume. The issue with big rockets like this, is that you need a larger ejection charge to pressurize the inside of the rocket in order to properly deploy the parachute. Unfortunately, the Estes D motors have only one size ejection charge.

So rocket designers use a little trick to reduce the volume inside the rocket that needs to be pressurized. We use what is called a “stuffer tube.” Essentially, it is a very long engine mount tube that runs through the middle of the rocket. Only the portion of tube in front of the stuffer

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tube and the inside of the stuffer tube need to be pressurized by the ejection charge. The air surrounding the engine tube is not pressurized by the ejection charge **(Figure 2)**.

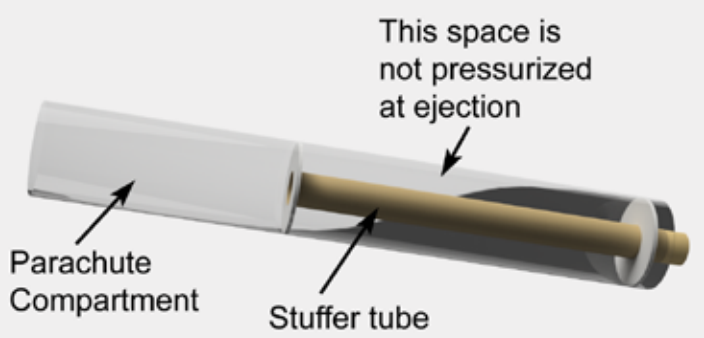
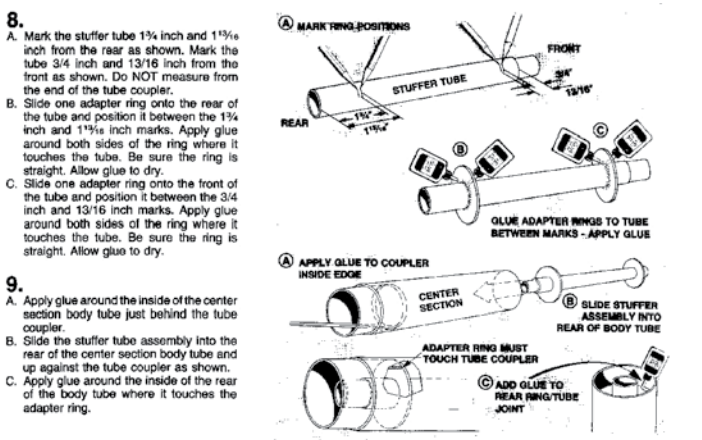


Figure 2: The stuffer tube inside of the rocket decreases the volume that has to be pressurized so that the chute is ejected properly.



8.

A. Mark the stuffer tube 1¾ inch and 1 13/16 inch from the rear as shown. Mark the tube 3/4 inch and 13/16 inch from the front as shown. Do NOT measure from the end of the tube coupler.

B. Slide one adapter ring onto the rear of the tube and position it between the 1¾ inch and 1 13/16 inch marks. Apply glue around both sides of the ring where it touches the tube. Be sure the ring is straight. Allow glue to dry.

C. Slide one adapter ring onto the front of the tube and position it between the 3/4 inch and 13/16 inch marks. Apply glue around both sides of the ring where it touches the tube. Be sure the ring is straight. Allow glue to dry.

9.

A. Apply glue around the inside of the center section body tube just behind the tube coupler.

B. Slide the stuffer tube assembly into the rear of the center section body tube and up against the tube coupler as shown.

C. Apply glue around the inside of the rear of the body tube where it touches the adapter ring.

Figure 3: The Estes instructions for the Optima showing the installation of the stuffer tube.

The Estes Optima uses the stuffer tube, as can be seen from the instruction sheet (**Figure 3**) found at: http://www.spacemodeling.org/jimz/est2035.htm.

While the stuffer tube works great for reducing the volume that the ejection charge must pressurize, something weird and unexpected happens. The engine tube becomes burnt and charred right in front of the rocket engine.

This is weird, because normally you don't get charring of the tube from the ejection charge. You can have a long minimum-diameter rocket, and it never experiences this type of problem. It only occurs within rockets that have long stuffer tubes.

Additionally, it doesn't matter if the engine is black powder or a composite motor. The damage still occurs right in front of the motor. We saw the damage with the D engine, which was the motor that the kit was designed around. That is why I don't think this is the Hibachi effect, even though the question originally talked about the use of composite propellant motors. The ejection charge of both types of motors is the same, so they produce the same amount of heat.

We did some experimenting when I was at Estes to figure out what was going on. What we did was to put a sleeve (a paper tube) over the outside of the engine mount tube just in front of the engine. I can't remember if we did this as a temporary repair to the rock-

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et to get it flying again, or what. But as soon as we put a sleeve over the tube, the problem went away. No new damage occurred.

When we built a new rocket from scratch with the sleeve over the engine tube in front of the engine, we didn't notice any damage at all. If the rocket engine was "hot" or somehow had an overly powerful ejection charge, we would have expected some sort of damage in front of the motor. Be we never saw any on rockets that had a sleeve over the engine tube. We even cut the rocket open looking for damage, and we only found a light coat of soot, like you'd find in any rocket after it was flown.

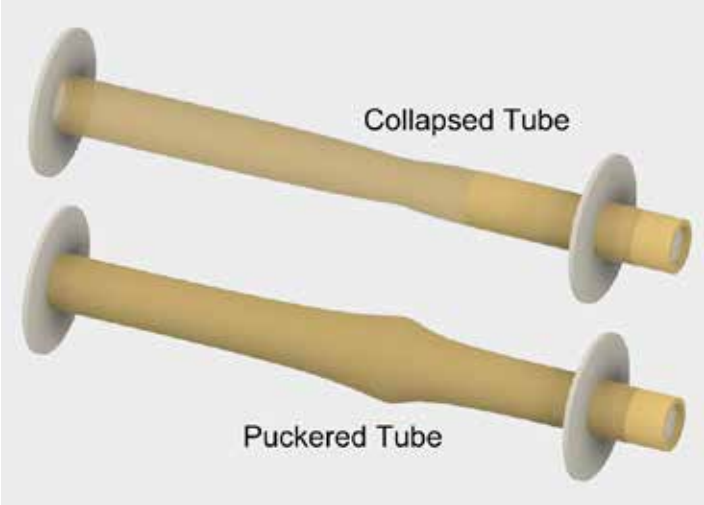

Figure 4: The tube is deforming in front of the motor, allowing the heat to concentrate and char the inside of the tube.

Why does the sleeve prevent damage? We surmised that one of two things was happening when the ejection charge went off in the rocket. We think that the tube is changing shape in front of the motor. Either it is collapsing slightly or it is expanding (see **Figure 4**).

It might pucker (bloat outward like a balloon) because of the sudden increase in pressure inside the tube when the ejection charge creates a large spike of hot gas.

Alternately, because the gas is flowing so quickly through the tube, the other scenario that might be happening is that the tube is collapsing slightly, and becoming more constricted. The Bernoulli Theorem says that when the gasses speed up, the pressure becomes lower within the tube, which would be the force that causes the tube to become constricted.

Really, we need some additional research on what is actually occurring. But whatever is happening here, the heat is charring the inside of the tube, weakening it.

By putting a sleeve over the outside of the tube, like the one shown in Figure 5, the tube is prevented from deforming. It is stiffer because it has extra wall thickness. This allows the gas to pass through without restriction.

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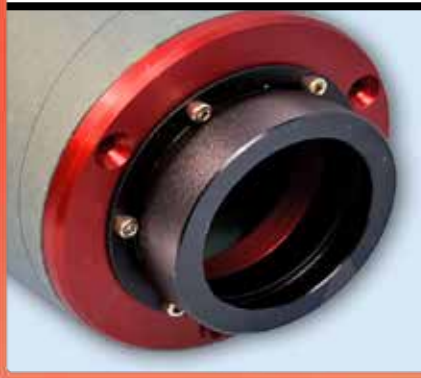

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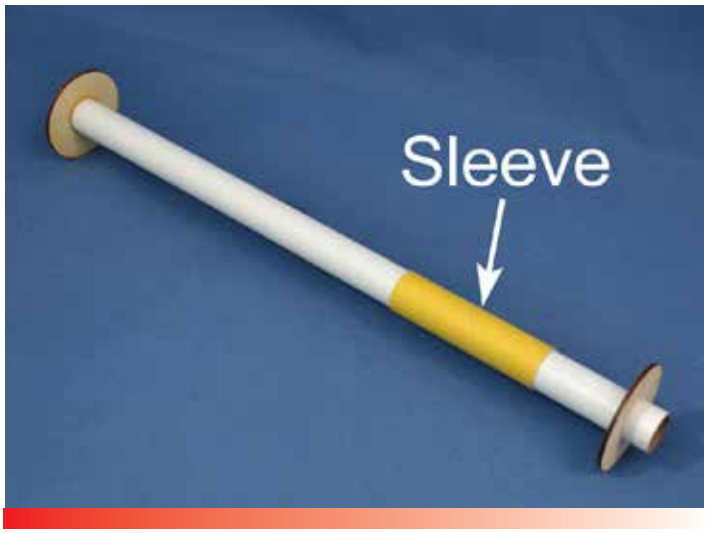

Figure 5: The sleeve on the tube prevents the tube from deforming, preventing damage from the ejection charge.

It doesn't take much reinforcement of the tube either. We found that a 4-inch long sleeve positioned right in front of the engine is enough to prevent any damage of the stuffer tube (**Figure 5**). We do sell such a tube here at Apogee (part number 10090 at: https://www.apogeerockets.com/Building-Supplies/Body-Tube-Couplers/13mm-to-24mm-Couplers/AS-24-Airframe-Sleeve-for-24mm-tubes), which we created for the rocket we call the DynaStar Grappler (https://www.apogeerockets.com/Rocket_Kits/Skill_Level_2_Kits/Grappler_Rocket_Kit). It is a long rocket, similar in size to the Estes Optima.

Now, most people would just use a thick-wall tube. Or they might change to something like fiberglass or blue tube to prevent the damage from the ejection charge. That does work, but I like the sleeve because it is a simple and lightweight solution. Not to mention that it is relatively inexpensive too.

If you don't have a sleeve, you can easily make your own for your rocket. We have instructions for making a sleeve tube in Peak-of-Flight Newsletter #330 (https://www.apogeerockets.com/education/downloads/Newsletter330.pdf). This is one of those unique problems that make rocketry a challenge. You have to do some experimentation to find out what is causing the issue Personally, this is the type of challenge that makes rocketry fun for me.

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.