High Altitude Rocket Deployment

Charge Tests

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This is a series of tests I've been meaning to do for some time. I have performed a few of these tests in the past, but I didn't document them very well. So here goes a series of tests to see how different approaches to apogee charges will work in a low pressure environment.

The test rig is PVC vacuum chamber. I have two sealed bulkhead penatrators for charge ignition, the lid is o-ring sealed to the case, while there are outside clamps, they are not used and a 6 pound weight is used to add a little weight/resistance to the lid. The vacuum source is an old freezer compressor. I don't have a real accurate

gauge, but the gauge I have puts it down to about 27" of Hg (over 50,000'). I pegged a pressure transducer that reads down to 15 kPa which corresponds to over 40,000' altitude.

These tests can't really simulate an actual deployment since the conditions aren't the same as a rocket would see. I'd have to contain the entire recovery section and nose cone of a rocket in a vacuum chamber to do that. In these tests the charge is firing into a vacuum in the chamber, but the lid of the chamber is being held back by atmospheric pressure, for a 10" diameter lid that's about 1075 pounds of force holding the lid on. The small charges I'm setting off won't even bring the inside of the chamber back to ambient pressure. So these tests are intended to tell me only one thing, that is if the charge is burning fully or not.

Product	Soda Straw Weight per Inch	.61"x.05" Latex Tubing per Inch	.5"x.05" Latex Tubing per Inch
Red Dot	.27 grams	1.785 grams	.926 grams

Test Number	Product Tested	Pyro Weight	Tube	Lid Weight	Photo	Video	Unburned Pyro	Results
1	Red Dot	2 grams	.61" x .05" Latex	6 pounds	vacdeploy1.jpg	vacdeploy1.wmv	1.7 grams 85%	Poor. Failed deployment.
2	3F Black Powder	2 grams	.61" x .05" Latex	6 pounds		vacdeploy2.wmv	1.7 grams 85%	Poor. Failed deployment.
3	3F Black Powder	2 grams	.75" ID x 2" L aluminum tube	6 pounds	vacdeploy3.jpg	vacdeploy3.wmv	<1%	Good.
4	Red Dot	2 grams	.75" ID x 2" L aluminum tube	6 pounds		vacdeploy4.wmv	~70%	Poor. Failed deployment.
5	3F Black Powder	2 grams	.61" x .05" Latex	6 pounds	vacdeploy5.jpg	vacdeploy5.wmv	1.7 grams	Poor. Failed deployment.
6	3F Black Powder	2 grams	.75" ID x 2" L aluminum tube	6 pound	vacdeploy6.jpg	vacdeploy6.wmv	0 grams	Good.

Tests 1 and 2 both resulted in only about .3 grams of powder burning, with the remainder being scattered unburnt. It's clear the latex tubing isn't strong enough to contain the burning process long enough.

Here's an aluminum deployment canister I made.

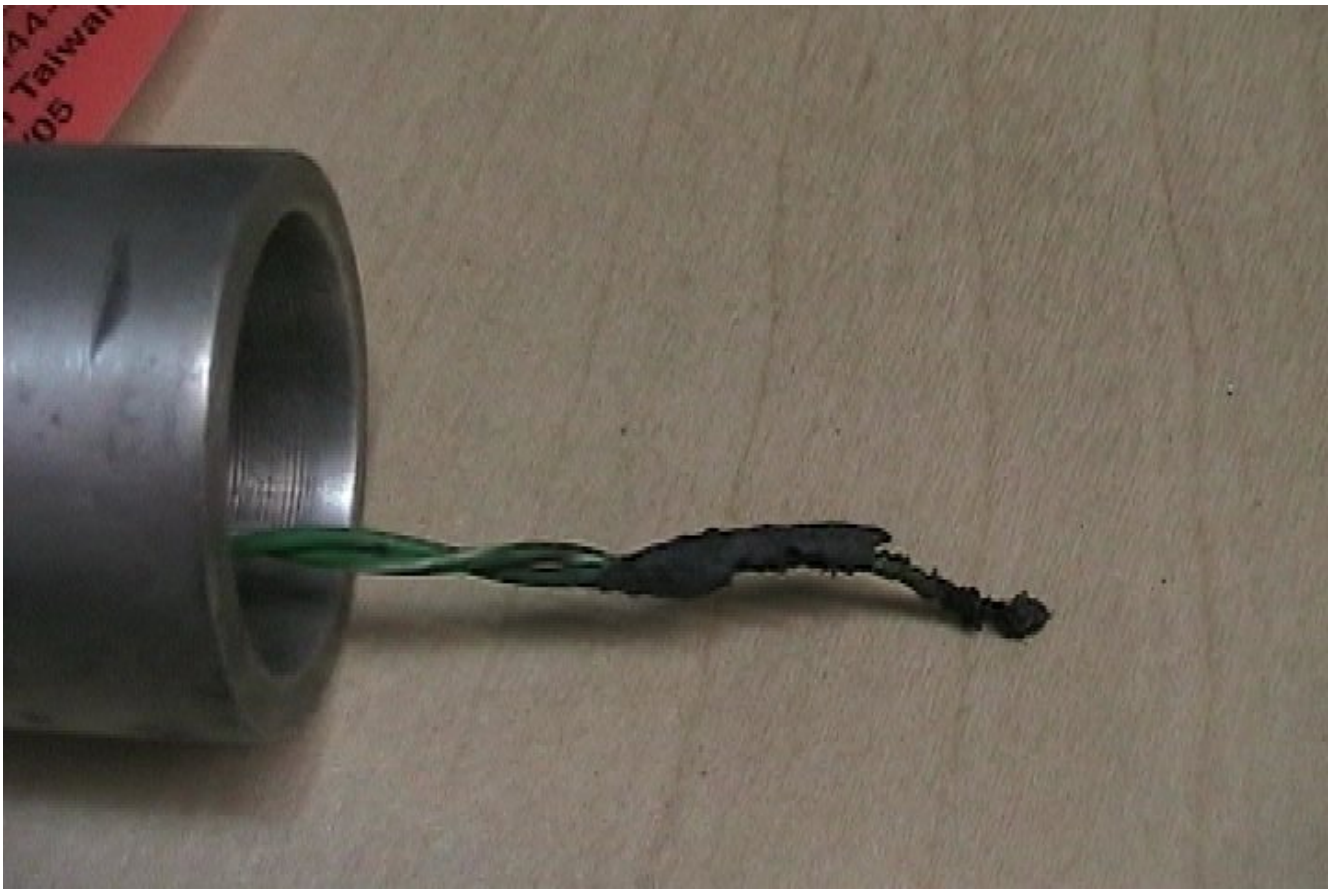
Test 3 used an aluminum tube 1" OD x .75" ID x 2" internal length. I drilled a 5/64" hole for the e-match through the bottom and used 5 layers of 3/4" wide x 7 mil black electrical tape to cover the opening, and 1 layer of the same tape around the outside perimeter to help hold the tape in place. This tube will hold a maximum of about 13.6 grams of 3F black powder or 6.7 grams of Red Dot. I used cellulose wadding to fill the void in the canister above the black powder. If you look at the picture you can see the tape has an opening that was blown open between layers of tape, I'd guess the opening filled with the cellulose and caused the whole tape cover to be blow off. I think a little more tape would help. I should note, I didn't seal the e-match hole going into the canister. It's a very small hole, and shouldn't alter the performance much anyway. But what it does is allows the pressure out of the canister as a vacuum is applied. I don't want the canister blowing open from internal pressure. I think the key to complete combustion is containment during the burn, not trying to make the burn initiate at sea level pressure.

Here's two e-matches that failed.

I ran into an unexpected problem. I've been having e-matches fail. At first I thought it was from old e-matches, but the last two I just made have also failed. Considering I've had just about a 99.9% success rate with these, it seems unlikely it's just bad luck. In the picture above you may be able to see the indent left in the insulation from the heating of the nichrome wire. So the nichrome is heating and burning through the wire before it's setting off the pyro mix on the tip. It looks like I'll have to formulate a hotter pyro mix for the match heads. To get at the nichrome wire I had to crush the pyro mixture off the wire.

I spent the night working on new pyro mixes, the first attempt at a new mix failed in two attempts in the vacuum chamber, and the other two matches in the batch worked fine at ambient pressure. So I went back to a pre-dip mixture I had used a few years ago to fire matches on low voltage. I fired one match in the vacuum chamber and it worked fine, the second match was used in test 4 and it worked fine too. This pre-dip mixture is very, very sensitive. If someone needs it for a high altitude flight, drop me an e-mail. But I'm not going to post it here simply because it's so shock and temperature sensitive.

Test 4 was odd. If you watch the video you can hear two distinct pops, I have no idea what caused that, other than a spark landing on some unburned powder. The Red Dot in the aluminum tube didn't fair much better than in the latex tube. Take a look at the picture below...



The match after test 4.

You can see the outer layer of normal match mixture didn't even fully burn. The only place that burned was the area where the pre-dip had been applied. This is proving to be a bigger problem than I had expected. In hind sight, one of the Defiance e-matches showed the same problem that I'm finding here. The nichrome had burned open, but the pyro mix didn't burn. I may be lucky I had an apogee event at 29,000'. On the other hand, the Defiance-H flew to over 23,000' and both matches seemed to fire. From only those two "in flight" data points, it suggests somewhere in the 25,000' range extra measures will need to be taken to assure successful apogee deployment. The early trend also seems to indicate black powder is somewhat more reliable than Red Dot.

Tests 5 and 6 are repeats of test 2 and 3. These tests confirmed the results of tests 2 and 3 with exactly the same results. Another positive note was that all four of the new pre-dipped e-matches worked fine. The aluminum canister in test 6 was covered with 7 seven layers of 3/4" electrical tape stretched just enough to make it conform to the top of the canister. Two layers of tape were tightly stretched around the outside of the canister to help hold the tape in place, one at the top and one about midway down.

Conclusion:

Smokeless gun powder such as Red Dot requires much more confinement to achieve complete combustion in the 50,000' to 60,000' range. Black powder also requires more confinement at those altitudes. While thin walled latex tubing wasn't adequate confinement, that's not to say heavier walled latex tubing wouldn't work. I suspect it would. But in my case the thin walled latex tubing would be too long to be effective. High altitude small diameter rockets that require less amounts of black powder could likely get by with the heavier tubing.

At some point in the future I'll try to re-visit these tests and add more data points. It seems the latex tubing is effective up to about 25,000', I will no longer use the latex tubing on flights approaching that altitude. E-matches are also an area of concern and should be tested before used in high altitude flights.