29 mm "G" Class Experimental Rocket Motor

In an effort to make experimental rocketry available to more experimenters, I'm offering several solid rocket motors at low cost. These motors are intended for the "do it yourselfer" who may not have all the tools required to make these motors on their own. They don't come off an assembly line. I make them in my home shop and I am an amateur machinist, so please don't expect glossy perfection!

I'm not going to get into the legal aspects of amateur rocketry, nor am I going to go into safety aspects. It is up to the individual to assume responsibility for the knowledge required to make propellant for these motors and use them safely. Please visit my web site for information on propellant casting and safety issues. Also visit the links page on my web site for other sources of safety information.

The motor casing is 1.125" outside diameter made from .065" thick walled 6061 T-6 aluminum, casing length is a nominal 9". The forward bulkhead is solid bar 6061 T-6 aluminum with an o-ring gland cut for a 3/32" x 1" OD Buna N o-ring, Dash # 117. Nozzle is fabricated from solid, medium grain graphite and is very fragile, but should hold up to numerous motor firings provided care is used in the insertion, extraction, cleanup and handling of the nozzle. The o-ring gland in the nozzle is identical to the forward bulkhead and uses the same o-ring.

The nozzle comes with a throat diameter of .25", you may enlarge the throat if required by simply drilling it larger with a drill press or hand drill. The motor will perform well on a variety of propellants. I suggest KNSU (KNO3 and sucrose), KNDX (KNO3 and Dextrose) or APCP (ammonium perchlorate composite propellant. KNSO, KNER and ANCP are not recommended for this motor as their burn rate is too low for such a small motor.

Using the standard .25" diameter nozzle throat, below are some suggested grain geometries for each propellant.

KNSU or KNDX Propellants

65% KNO3/ 35% Powdered Sugar or Dextrose
Use this propellant and grain geometry for ATF exempt loads. This should result in a high "F" class motor, about 15.5 to 16.5 pound seconds total impulse.

Grain Diameter: .9"
Grain Length: 1.33"
Number of Grains: 3
Core Diameter: .375"
Nozzle Throat: .25" diameter

Kn Range: 160, 170, 148
Propellant Weight: 61.0 grams

KNSU or KNDX Propellants

65% KNO3/35% Powdered Sugar or Dextrose
Use this combination for pushing the motor to its full capability using a sugar propellant. This should result in a "G" class motor with a total impulse of 23 to 25 pound seconds.

Grain Diameter: .9"
Grain Length: 2"
Number of Grains: 3
Core Diameter: .375"
Nozzle Throat: .25" diameter
Kn Range: 208 progressive to 257
Propellant Weight: 91.53 grams

APCP

18% R54M, 12% 325 mesh atomized aluminum, 68% 200 um AP, 2% Isonate 143L.

Please note, the aluminum content is quite high for a small motor of this size. You could certainly reduce the aluminum content with no real loss of performance, simply replace some of the Al with AP. This motor again will fall into the ATF exempt category at 60.5 grams of propellant with a total impulse of about 24 pound seconds making it a solid "G" class.

Grain Diameter: .9"
Grain Length: 1.56"
Number of Grains: 3
Core Diameter: .375"
Nozzle Throat: .25" diameter

Kn Range: 176, 197, 185
Propellant Weight: 60.5 grams

The motor has enough internal length to push the loading, and total impulse even higher, but the throat may need to be enlarged at some point to keep chamber pressure at safe levels.

Casting sugar propellant grains for a motor this size can be a challenge. I use a 3/4" PVC pipe that fits into a coupler glued to wood base. A hole is drilled into the base for adding a coring rod after the propellant is cast into the tube. A PVC cap with a hole drilled in the top is used to center the top of the coring rod after the rod is inserted. I have a video which is free to download showing the process I use, only in this video I am using KNER propellant, which is much more fluid than KNSU or KNDX, it also is not prone to browning from overheating as KNSU and KNDX are.

There are other processes to cast propellant grains for small motors that may well work better than the system I use. By all means experiment and share your results with me! I use index paper or card stock as casting sleeves/inhibitors, then apply a layer of aluminum foil tape over the card stock once the grains have been removed from the casting stands.

The motor will need a thermal protection liner between the propellant grains and the inside wall of the casing. For sugar propellants I use a single layer of 120 pound index paper. You will need to cut a sheet of index paper to the casing internal length and inside circumference, make the paper slightly wider to overlap at the seam. Pre-curl the paper over a sharp table edge. Then either glue or tape the seam closed on the liner. When inserting the liner it should be a snug fit, but go in easily.

Sugar propellant grains need to have a little excess room in the diameter so they are free floating inside the casing because the propellant is brittle and needs pressure behind the grains to keep them from cracking. APCP propellant grains can fit in more snugly, and because APCP burns at about twice the temperature of sugar propellants, a heavier thermal liner is needed. I use the same index paper for APCP, but use a full two layers. The forward bulkhead has enough thermal mass, and is in a stagnant flow area of the motor and shouldn't require any thermal protection.

To assemble the motor I install the forward bulkhead first, applying silicone grease to the o-ring before sliding it on the bulkhead. I also apply a thin layer of grease to the casing wall where the bulkhead slides in. Once the bulkhead has been pushed in past the snap ring groove, install the snap ring making sure the flat side of the snap ring faces out. Be certain the snap ring is seated properly in the groove. Then use a wood dowel or rod of some sort to push the bulkhead tightly against the snap ring. Now insert the thermal liner, then the propellant grains. Now install a greased o-ring on the nozzle and insert the nozzle. Be careful to push the nozzle in just to the point it is flush with the inside of the snap ring groove. Now the nozzle snap ring can be installed. This size motor does not require a nozzle thrust washer.

Seal the nozzle end of the casing with foil tape if you aren't firing the motor right away. That will keep moisture out, as well as accidental sources of ignition.

To disassemble the motor you will need a 3/16” rod about 12” long. Insert the rod through the nozzle throat all the way to the forward bulkhead. Making sure the rod is centered in the middle of the bulkhead, tap the bulkhead out gently. Watch the bulkhead and make sure it isn't cocked to one side as it's tapped out. Once the bulkhead is out, use a 7/8” wood dowel to tap the nozzle out from the bulkhead end.

If the motor has been fired with a sugar propellant load, clean up with soap and warm water. But, make sure the nozzle is completely dry before using it again. Graphite is somewhat porous, and will absorb some water. If it's not allowed to dry thoroughly, the next time the motor is fired the heat may vaporize the water in the nozzle, causing the steam to crack the nozzle.

APCP propellant cleans up better with acetone. The acetone also evaporates quickly leaving little chance of nozzle damage. You may experience aluminum slag build up on the convergent nozzle surface as well as the throat. Be sure to maintain the proper throat diameter by removing any slag accumulation.