TRIPOLI GERLACH Research Rocketry News

TRIPOLI PREFECTURE # 138

JANUARY 2013

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TRIPOLI GERLACH
Research Rocketry
TRIPOLI PREFECTURE #138

JANUARY 2013 Vol. 03 No. 01

PUBLISHED EXCLUSIVELY FOR
THE MEMBERS OF TRIPOLI GERLACH
AND ANYONE ELSE INTERESTED

Tripoli Gerlach was founded as a National Prefecture under the Tripoli Rocketry Association, Inc. Devoted to Research Rocketry and the Black Rock Desert area of Nevada, we welcome all qualified Tripoli Members having a Level 2 certification or higher.

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If you have anything to contribute in the way of information, articles, photos or whatever, please send them to Tripoli Gerlach Headquarters. Visit our WebSite on-line at;

WWW.TRIPOLIGERLACH.ORG

ON THE COVER The Tripoli Gerlach Mascot Rocket stands ready for another great year of rocket activities.

This year will see it at three events at Black Rock: LDRS, HAMSTER DANCE & BALLS!

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RENEWALS

January 1st is the beginning of our fiscal year and with that all Member's Dues are - due! All Tripoli Gerlach Members were mailed a renewal form. If you haven't done so yet please fill it out and send it to our Treasurer Dave Rose along with your dollars.

As of January 1st we have not received renewals from the following members:

Waysie Atkins
Paul Holmes
Bruce Kelly
Deb Koloms
Robin Meredith
Chuck Rogers
Mark Canepa
Doug Gerrard
Micheal Leenellett
Bob Schoner

Feel free to use the form on Page 4 to renew. See you in the Summer!

DISCLAIMER

Tripoli Gerlach does NOT promote nor certify any activities presented here as safe nor appropriate to all readers of this Publication. Information is for educational purposes only. Tripoli Gerlach, its members & officers, the authors of articles presented and the Tripoli Rocketry Association, Inc. are not responsible for reader's activities, conduct or participation in the use and pursuit of any content presented.

CALL FOR BY LAWS CHANGE

Tripoli Gerlach was set up as a Research Rocketry Prefecture for Tripoli members who prefer to launch at Black Rock in Nevada. It is based in Gerlach, Nevada and has no actual members residing there. It was never designed, nor intended to be an elite group, but did want its members to be qualified to conduct Research Rocketry activities as defined by the Tripoli Rocketry Association, Inc. To this extent we required persons interested in joining the Prefecture to hold at least a Tripoli Level 2 Certification.

Apparently there are some other parties wishing to form strictly Research Prefectures and have approached Tripoli for Prefecture status as a Research Prefecture. They too want to require a Level 2 Certification for its members and have set Tripoli Gerlach as the example.

It becomes obviously clear that if one Prefecture can do it so can many. This in turn would lead to Prefectures all over the place to require, or I should say, limit their membership to a specific group; leaving many National members out of the picture in the hobby.

Since Tripoli Gerlach was the first to have a Level 2 membership requirement based on its intention and location, no one questioned us and the world was at peace. However, our uniqueness seems to have grabbed the attention of others who, apparently, wish to duplicate our status. As a Prefecture in 100% support of the National Tripoli Organization we need to address this.

Our Level 2 requirement is written in our By-Laws and to make a change to the By Laws requires a Business Meeting as stated:

VII CHANGES TO BY-LAWS
A. The Tripoli Gerlach By-Laws may be changed or altered, only at a business meeting announcing such changes and having a quorum present. Any and all items within Tripoli Gerlach By-Laws may be changed, except Chapter VIII, DISOLUTION.
B. To insure a stable platform any and all changes to the By-Laws approved by a majority of a Quorum shall not be able to be re-acted upon for a period of one year.

Since we only have one Business Meeting a year to make a By Laws change would require time. We have an opportunity to hold a Business Meeting in July at LDRS 32 where we can act upon this. BUT we need to do something to assist the Tripoli BoD from having other parties requesting this requirement.

As Prefect I proposed we change our By Laws Membership Requirement:

II MEMBERSHIP
A. Membership in Tripoli Gerlach shall be open to any and all serious minded rocket enthusiasts, no matter where his or her place of residence, holding a current National Tripoli Membership and certified within the Tripoli Rocketry Association with a Level 2 or higher.

To read:

II MEMBERSHIP
A. Membership in Tripoli Gerlach shall be open to any and all serious minded rocket enthusiasts, no matter where his or her place of residence, holding a current National Tripoli Membership .

On December 3rd a special vote was taken of all members of Tripoli Gerlach to vote YES or NO on this change. This posting announces our results

Response has been very enthusiastic with just about all members voting YES. Actually no one voting voted NO. The general consensus is that this, in no way, would affect the group's status as a Research Prefecture and would open up the group to new people seriously interested in advancing into Research Rocketry.

Six responses contained very good positive input for us to address at the next Member's Meeting. One member abstained, though not because they were against this.

With this our next step is to change any public posting of the old Level 2 requirement and begin accepting any National Tripoli Member in good standing into our Prefecture. The posted public By Laws will reflect this change and we will operate with it until our next Member's Meeting, at which time we will ratify the change and it will become our official document once again.

Four members did not vote.

No members voting voted against this change. No negative comments were voiced. All members voting are thanked for their quick and appropriate votes.

MEMBERSHIP

Membership in Tripoli Gerlach runs from January to January and is open to any and all National Tripoli Members in good standingl. You can join anytime of the year however, your Membership renews every January.

Of particular interest should be High Power and Research Rocketry conducted at Black Rock, Nevada. Potential Members should commit to attending at least one launch at Black Rock. We encourage and support the BALLS launch conducted by APHRA.

We also hold our annual Members Meeting Friday evening of the BALLS Launch which gives us the best opportunity to have the most members present. This is the time we hold our Elections, and conduct our Prefecture business for the year. The meeting includes a Free Spaghetti Dinner, which has proven very popular - it's FREE.

In addition to a serious interest in Rocketry activities a potential member should have an interest in the Black Rock Desert area of Nevada. Many members participate in Trekking, our name for getting out and exploring the desert and surrounding areas to appreciate the natural environment.

It is a known fact once you see Black Rock you'll return year after year - or at least make an effort to do so. We do realize that because of personal reasons it might be hard to attend every year. All we ask of our members is that they TRY.

If you are interested in joining us please use the Membership Application provided here.

MEMBERSHIP APPLICATION

Please fill out this form completely. It is necessary to supply us with your TRA number and certification level. Membership runs from January to December. Renewal will be January 1st,

YEARLY DUES ARE $20.00

Make Check for $20 Payable to

DAVE ROSE
13385 Lincoln Way
N. Huntingdon, PA 15642

If at all possible please E-Mail your photo to be posted to:

shadow@pghmail.com

NAME ____________________ TRA# ________

ADDRESS ____________________ CERT LEVEL ____

CITY ______________ STATE ______ ZIP ________

E-MAIL ______________@______________

PHONE (______) ________-__________ CAN WE PUBLISH (YES) (NO)

HOME PREFECTURE ____________________

PERSONAL WEBSITE ____________________

As a member I will abide by all rules set forth by the Prefecture as well as those set forth by the National Organization. I pledge to pursue a commitment to the Prefecture's designated Launches & Activities and support the Prefecture to the best of my ability.

____
SIGNATURE

____
DATE

TRIPOLI GERLACH
Research Rocketry
TRIPOLI PREFECTURE #138

www.tripoligerlach.org

THINGS YOU MAY NEVER SEE AGAIN

Last issue we gave you the story about the Paiutes placing various areas on their reservation in Nixon Off Limits to all non tribal members. This means a lot of extremely interesting "natural wonders" are no longer available to visitors to the Black Rock Desert area.

Also in past issues we gave stories of trekking about discovering a lot of interesting sites and neat things. One of the last areas closed in 2012 was the Great Stone Mother near Pyramid Rock. The above photo is a rare shot as seen from the water. The Great Stone Mother is on the right and Pyramid Rock, for which Pyramid Lake was named, is on the left.

This area is an almost spiritual place. Of course the Paiutes will tell you everywhere is spiritual and they are mostly right. The Pyramid Rock area abounds with Tuffa formations and one can spend several days there exploring - but be careful of the giant meat eating spiders!

The water is crystal clear with waves that look and sound as if you were at a seaside beach. You can not get to the Pyramid Rock without getting wet as it is an actual island and it is said the giant meat eating spiders are much bigger there.

A place most may never get to see is the Needles area shown in the two photos below. It is a large area of Tuffa formations at the north end of Pyramid Lake. It can be seen quite nicely from the road, in a panoramic view of nearly the entire area. But things you won't get to see is how bizarre this place is up close.

As with most areas; photos do not do things justice. Time was when anyone could visit the area and marvel at the scenery.

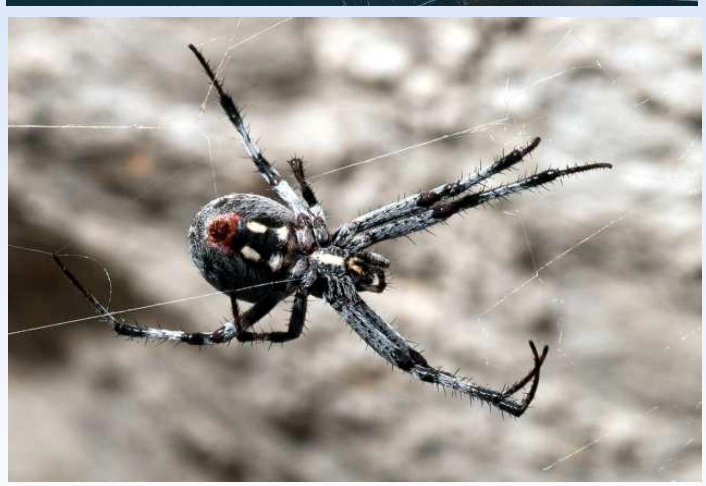
An area offen viewed by people streaming their way North to Gerlach is called the BeeHives. It is also on the list of banned places. These unique Tuffa formations are right out in the open for all to see but being on Reservation Land one can not venture any closer than their view from the road.

Two sites banned have petriegyphs that are more than just drawings on the rocks. These are actual carvings in the rocks. Most petriegyphs are painted with some having an attempt at stone work. These are actual carvings set for the ages. Naturally the Paiutes wish these preserved as sacred.

Meanwhile back at the Great Stone Mother site the black volcanic beach sand is rippled with permanent "foam" A closer look reveals miniature sea shells. The center shell in the photo is big at less than ¼" across.

The most unique feature at this area is on the Pyramid itself and can not be seen from the shore. It is on the west side of the rock facing the town of Sutcliff across the lake. It is a Geyser spouting hot water out about three feet from the water surface.

The last thing we show is the actual existence of the giant meat eating spiders of Pyramid Rock and surrounding area. These suckers are big and mean. When approached, and you approach by accident, they will actually charge you and hold their ground - and even lurch toward you in threat. These photos of the spiders, like all the rest, do not do justice. Maybe someday you'll be able to see for yourself.



AP COMPOSITE BASICS

Back in the Pre-Research days of Tripoli, long before Prof. Terry McCreary's Experimental Composite Book, Randy Sobczak, of PlasmaJet wrote a paper on AP Composite Basics. It covered all aspects of AP Composite Motor Making before reloadable motors existed. It was actually published in The TRIPOLITAN, though few picked up on it and, with the author's permission, is republished here for your review.

Propellants function to impart motion to an object through the conversion of potential energy into useful or kinetic energy. Two ingredients, a fuel and an oxidizer, neither of which will burn satisfactorily without the presence of the other, are necessary in a propellant system.

Two main classes of propellants are recognized on the basis of physical character: liquid propellants and solid propellants. Most solid propellants belong to one or the other of two types. Homogenous propellants contain both the oxidizer and fuel in the same molecule and may also be referred to as monopropellants. These systems, consisting mostly of nitrocellulose and nitroglycerine in a colloidal mixture, are called double-based propellants.

The second type is the heterogenous or composite propellant, where the oxidizer is a finely ground inorganic salt and the fuel is plastic in nature, binding the propellant grain structure together. Black powder, the oldest of propellants, falls into this category since it uses potassium or sodium nitrate as the oxidizer and sulfur as both binder, and with charcoal, as a fuel.

Modern composite propellants first emerged in the late 1940's. These incorporated various thermoplastic and thermosetting resins or elastomers with a variety of nitrates or perchlorates as oxidizers. Perhaps the most popular of the composite propellant systems in current use consists of ammonium perchlorate as the oxidizer and usually a copolymer or terpolymer of butadiene with other monomers such as acrylic acid or acrylonitrile as the binder.

This document will examine the design and construction of composite propellant rocket motors using hydroxyl terminated poly butadiene (HTPB) and ammonium perchlorate (AP)

PRINCIPLES OF SOLID PROPELLANT ROCKETS

As solid propellants have certain advantages over liquid propellants, composites may be more desirable for some applications than the familiar black powder formulations. All solid propellants possess a high degree of reliability by virtue of design. Once ignited, a solid rocket normally operates according to a preset thrust program, which is primarily determined by the configuration of the propellant grain. The amount of thrust which may be obtained from a given grain design is largely determined by the propellant composition. Composite propellants burn at higher temperatures and pressures than black powder, with a net result that pound for pound, they can deliver about two and one half times the power of a black powder motor.

PROPELLANT CHARACTERISTICS

Fundamental to the design of any solid propellant rocket is a simple geometric principal: The burning surface of a solid propellant recedes in parallel layers. Because of this, solid motors are self-stabilizing. That is, should small convex or concave irregularities arise on the burning surface, as would happen if an air bubble was trapped in the propellant grain, such irregularities would disappear as burning proceeds. This is significant because as bubbles are encountered, the burning surface of the propellant and consequently the internal pressure of the motor and the burn rate of the propellant are increased. When this exceeds the design parameters of the motor, rapid overpressurization occurs, leading to a catastrophic failure.

The burning rate, r, of a solid propellant is the linear rate of consumption in a direction normal to the burning surface. It typically ranges from 0.1 to 2.0 inches per second and is primarily influenced by combustion pressure, propellant composition; and to a lesser degree by the ambient grain temperature and the velocity of gas flow past the burning surface. Burning rate may be expressed by the following equation:

Equation #1

$$r = aP_c^n$$

The burning rate, r, is in inches per second; the pressure of combustion is in pounds per square inch; and 'a' and 'n' are constants.

Propellant composition and pre-ignition temperature are the determinants for the value of the constant 'a', which ranges between .002 and .05. The pressure or burning rate exponent 'n' is solely a function of the propellant formulation with negligible influence of the bulk temperature. Typical values for the burning rate exponent range from 0.2 to 0.5, but in some cases may vary between 0 and 0.9. The burning rate exponent is of critical importance in maintaining the stable operating pressure of any rocket motor.

During combustion, a rocket functions in a state of dynamic equilibrium. A stable operating pressure is maintained by a delicate balance between the rate at which gas is being generated by the burning propellant and the rate at which it is being expelled through the nozzle. This is affected by an area ratio between the propellant burning area and the nozzle throat area. This ratio is known as Kn, where:

Equation #2

$$Kn = \frac{A_b}{A_t}$$

and the specific formulation of a propellant and its burning rate exponent, will determine the operating pressure of a given motor. The relationship between and operating pressure of a given motor is expressed by the equation:

Equation #3

$$P = B(Kn)^{\frac{1}{1-n}}$$

where 'P' is the pressure in pounds per square inch, 'B' is a constant for a specific propellant, and 'n' is the same pressure or burning rate exponent as appears in the burn rate equation (Equation #1).

Small changes in the value of 'n' can lead to significant changes in the operating pressure of a rocket motor and consequently in the propellant's burn rate which was shown in Equation #1 to be pressure dependent. If 'n' is 0.3, (1-n) is .7 and 1/(1-n) is 1.42. A 20% increase in burning area would cause a 30% increase in pressure. But if 'n' should be 0.8, (1-n) is .2, and 1/(1-n) would be 5. For such a propellant, that same 20% increase in burning area would cause a 148% increase in pressure. It becomes evident that propellants with high exponents are to be avoided, as small variations in the burning surface such as when bubbles become trapped within the propellant grain or cracks are present in the grain, lead to greatly magnified variations in chamber pressure.

SPECIFIC IMPULSE

The quantity of energy available from a rocket propellant is determined by the chemical nature of the oxidizer and fuel molecules, as well as by the chemical nature of the reaction gas products. This is most conveniently expressed as specific impulse, Isp, which is an effective measure of the performance of various propellant systems compared to one another. The higher the Isp value, the more efficient the propellant. Specific impulse may be considered to be the amount of thrust, which is available for each pound per second of propellant burned. It is the reciprocal of the specific consumption of propellant and is expressed in pounds of thrust per pound of propellant used per second. This is found by dividing the thrust, or total impulse (It) by the weight flow rate expressed in pounds.

Equation #4

$$Isp = \frac{I_t}{W_t}$$

The range of specific impulse for most ammonium perchlorate composite propellants may vary from near 170 to approximately 230, with a common figure around 200. In comparison, the Isp of black powder is between 70 and 80, roughly two and one half times less than that of a composite propellant. The total impulse of a rocket motor describes the total amount of energy stored in that motor. Thus, the total impulse of a motor containing 2 Lbs of propellant having a specific impulse of 210 would be: It= Isp x Wt or 210 sec. x 2.0 lbs = 420 lb-sec. Depending on the grain design, this motor would be capable of producing 420 pounds of thrust for 1 second, 105 pounds of thrust for 4 seconds, or any combination of thrust x time which would come out with a product of 420 lb-sec.

MOTOR DYNAMICS

Regardless of the propellant system used or the Isp of a given propellant, the design of a nozzle is a fundamental criterion in the construction of a rocket motor. The rocket nozzle functions to transform the heat energy of combustion into the kinetic energy of a high velocity gas stream with the maximum possible efficiency. Nozzle theory is based upon the laws of thermodynamics, gas dynamics and fluid dynamics. A basic understanding of nozzle function is of paramount importance to the proper design of rocket motors. Derivations and discussion of the fundamental laws pertaining to the conservation of matter and energy, and of the dynamic processes involved, are presented in depth in the proper texts for the interested reader to pursue. The following discussion of combustion process and nozzle theory will provide the basis for general understanding.

COMBUSTION OF COMPOSITE PROPELLANTS

The combustion of composite propellants occurs in different phases, with the oxidizer particles decomposing in the midst of the decomposing fuel matrix. Ammonium perchlorate itself does not melt, but rather undergoes an exothermic decomposition resembling that of homogenous propellants. Adjacent streams of fuel-rich and oxidizer--rich gasses rise from the surface, and immediate reaction is not possible until mixing by diffusion is complete. The combustion process takes place in three distinct zones, the foam, fizz, and flame zones. At the combustion surface, the gas velocity is relatively small and possesses little kinetic energy. It is in the flame zone that the final reaction occurs and the majority of the heat and gaseous products are evolved. There, the high pressure of the expanding gasses forces the gas particles to the rear, causing a slight decrease in potential energy at the nozzle entrance, but an increase in velocity.

NOZZLE THEORY

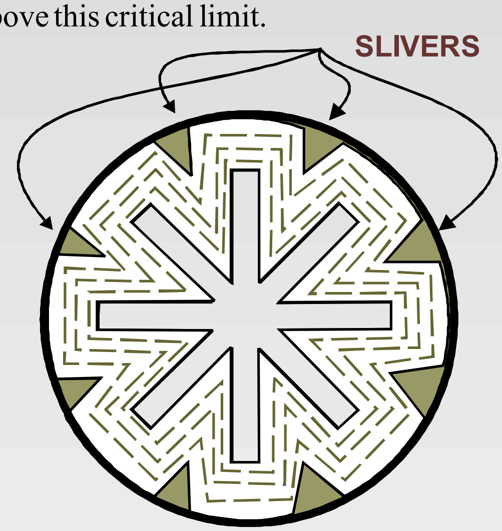
There are three basic types of rocket nozzles: subsonic, sonic, and supersonic. It is the supersonic nozzle which is of interest, consisting of three parts; a convergent section, a throat of specific diameter and therefore area, and a divergent section. Nozzles of this type are often called DeLavel nozzles, after their inventor, and may be thought of as two cones joined at their verticles by a short, straight throat section, with all transitions being smooth so as to avoid disturbances in gas flow.

When gas enters the converging portion of the nozzle, the decreasing cross-sectional area causes the flow to speed up. The maximum velocity which can be obtained in the converging portion of the nozzle occurs at the throat, and corresponds at that section to the local sonic velocity. In practice, this will not occur unless the ratio of chamber pressure to throat pressure reaches a certain minimum value, the critical pressure ratio, which corresponds to thirty-two pounds per square inch absolute or twice the ambient atmospheric pressure. Once this chamber pressure has been reached, the velocity of gas at the throat will always correspond to the critical throat velocity regardless of further chamber pressure increases.

Once the exhaust gas has reached sonic velocity, several of its major flow properties change. This may be used to advantage by the addition of a diverging section to the nozzle. Gas velocity increases into the supersonic range and pressure decreases, as expansion of the exhaust gasses takes place over the entire length of the divergent section. Optimum expansion occurs when the pressure of the exhaust gasses at the exit plane of the nozzle is equal to the ambient pressure. This will be found at a specific cross-sectional area of the nozzle exit, Ae, of a given rocket, which may be related to the throat cross-sectional area as the nozzle area expansion ratio.

Equation #5
$$E = \frac{A_e}{A_t}$$

Thrust is lost when the area ratio varies in either direction from the optimum. There are upper and lower pressure limits for all propellants. Very high chamber pressures, above 6000 psia for most propellants, cause erratic and rapid burning, frequently leading to catastrophic failure of the motor. On the other hand, many propellants will not support combustion at low pressures. This may be advantageous as a safety feature, but must be taken into account when designing the grain geometry so as to minimize the unburned propellant residue or "slivers" at motor burnout. For a particular propellant grain having a fixed surface area exposed to combustion, there exists a maximum effective throat area which will maintain a chamber pressure high enough to support combustion. Most solid rockets employ nozzles which will maintain chamber pressures well above this critical limit.



It is hoped that the preceding discussion provides the basis for an appreciation of the intricacies involved with designing solid propellant systems. Let us now examine the practical application of theory.

NOZZLE DESIGN

The mechanical requirements for nozzle fabrication are quite stringent. The material utilized must exhibit good machinability or ease of fabrication while retaining excellent resistance to erosive change under the most extreme conditions. The throat section is usually made from graphite or some non-ablative material which is surrounded by insulation to keep the outside structural material cool. The inside of the exit cone in large motors is made from such materials as asbestos-phenolic backed by an external structure to contain the nozzle pressure. Fiberglass phenolic laminates and ceramics have all seen application as nozzle materials in small rocket motors, but problems with cost, fabrication, and erosion have limited their use. By far, the most simple and economic solution has been the full diameter graphite nozzle, machined from readily available rod stock which fits snugly into the inside diameter of the motor. The major drawback of this system is that the graphite acts as a heat sink and in larger or long burning motors may cause charring of non-metallic motor casings. This difficulty may be circumvented by suspending a graphite nozzle insert of significantly smaller diameter than the motor case in a high temperature epoxy which provides insulation for the casing. Thermosetting high temperature injection molded plastics combine the erosion resistance of graphite with the insulating properties needed to protect the motor wall, and are currently enjoying widespread usage. Their major disadvantage is the high initial cost of tool and die fabrication.

When designing a rocket nozzle, consideration must be given to the angle of convergence, the angle of divergence, the nozzle area ratio, and the nozzle throat area with its relationship to the propellant burning area, Kn. All of these parameters must be precisely calculated from complex equations in order to optimize motor performance and efficiency. However, some useful generalizations may be drawn. The convergent cone half-angle, varies between 15 degrees and 45 degrees, with 30 degrees being a good compromise and 45 degrees being a more space and material efficient choice. For the divergent cone, a nozzle half-angle, between 12 degrees and 18 degrees, has been found experimentally to be optimum, with 15 degrees being a good choice in high thrust motors.

The nozzle area expansion ratio, E, that is the ratio of nozzle exit area to throat area, deserves more attention. Expansion of the exiting gasses is ideal when the external pressure is equal to the nozzle exit pressure, and the motor delivers maximum thrust. An under expanding nozzle will discharge the exhaust at a pressure greater than the external pressure, because the exit area is too small. Thus, the gas expansion is incomplete within the nozzle and continues outside. The nozzle exit pressure is higher than the atmospheric pressure. An over expanding nozzle is one in which gasses are expanded to a lower pressure than the external pressure due to it having an exit area which is too large. Separation of the gas jet from the nozzle wall will result, reducing the exhaust velocity, thereby leading to a loss of thrust. The formation of shock waves is also of concern with improperly designed nozzles. It is best to design a nozzle with the optimum expansion ratio or one which under expands the gas jet slightly. A ratio of 1:3 to 1:4 is appropriate for composite motor systems operating in the 300 psia to 400 psia range. At higher pressures, the area ratio would increase. This would also be the case for sounding rockets operating at high altitudes where the exhaust gasses must expand further so that they can match the lower atmospheric pressure at the nozzle exit plane. The upper stage nozzle of such vehicles often have exit diameters ranging from five to seven times the throat diameter.

THROAT DIAMETER

The final parameter which must be considered in nozzle design is the throat area. As has been previously discussed, the propellant characteristics of burn rate, "r" and pressure exponent, "n" must be considered when choosing the area of the throat. By substituting Equation #2 into Equation #3, the relationship of the throat area to the operating pressure and burning area is demonstrated:

Equation #6

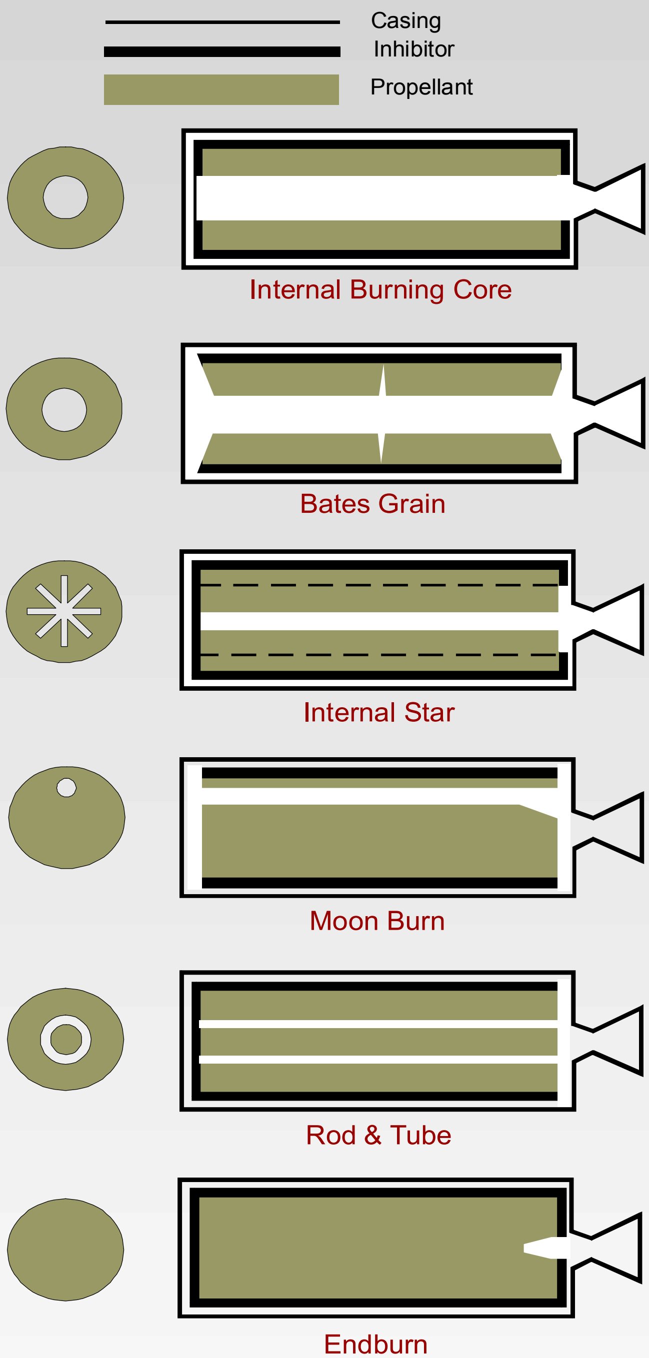
$$P = B\left(\frac{A_e}{A_t}\right)^{\frac{1}{1-n}}$$

The operating pressure is subject to the weight and strength limitations of the motor casing, while the burning area is a function of grain geometry.

GRAIN GEOMETRY

All of the many variations of grain geometry fall into three broad classes. Regressive grains have a large initial surface area which decreases as burning progresses. Neutral burning grains will maintain a constant burning area and progressive grains exhibit an increase in burning surface as propellant is consumed. Each of these categories have inherent advantages and disadvantages. For example, a moonburning grain geometry with regressive characteristics would be useful in long burning, relatively slow traveling rockets going to high altitude. The high thrust of this initially progressive geometry would be desired at the beginning of the flight when vehicle weight is high. As the rocket gains altitude, its mass is decreasing as propellant is consumed. At the same time, the frictional resistance or drag decreases as the atmosphere thins, and the grain geometry becomes regressive as it burns out to a sustainer phase. In this way, a subsonic velocity with its lower drag coefficient may be maintained, thus optimizing vehicle altitude. When constant thrust is desired, neutral burning grains are called for. This is characteristic of an endburning charge consisting of a solid cylindrical section of propellant which is inhibited on all surfaces, except at one end, so that it will burn like a cigarette. The end is often machined into a cone shape to increase the initial surface area. Such charges have a constant burning area (unless the end is coned) and have a very long burning time, with very limited applicability for composite rockets. Hollow rod or rod and tube geometries will also provide neutral burning characteristics while exposing more propellant surface area and providing higher thrust levels than are available with endburning designs.

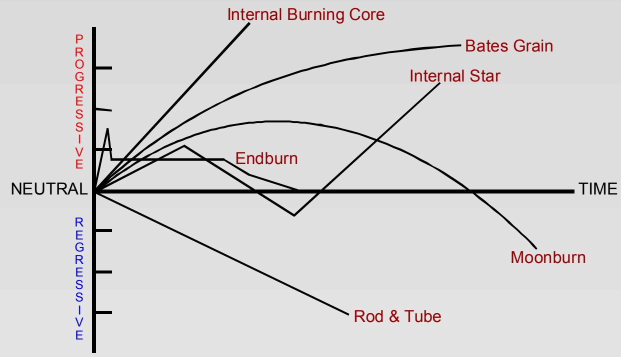
PROPELLANT GRAIN CROSS SECTIONALS



Progressive burning characteristics are found in internal burning case-bonded charges. An internal burning charge, as its name implies, burns outwardly from the internal perforation. It may have single or multiple ports in a variety of shapes, which provide these motors with high levels of thrust over moderately short burn times. Such motors are useful in boosting large or heavy payloads. These propellant grains may be severely stressed during motor function, particularly at the internal perforation. Moderate tensile strength 100-150 psi) and good elongation (30-70%) are necessary for cases bonded charges.

Thrust programs may be designed so as to combine the characteristics of progressive, neutral or regressive burning in a single motor. For an internal burning star grain shape, the initial surface area can be made nearly equal to the outside or final area of the grain.

GRAIN GEOMETRY BURNING CHARACTERISTICS



During burning, the surface will increase slightly, then decrease to a minimum, then increase gradually until the points of the star reach the outer surface. At that point, there will be left semi-lunar sections, or slivers, which will burn out with ever decreasing area. Progressive-regressive profiles are characteristic of moonburn grains first designed by Bill Wood, which utilize an offset core, which is approximately 25% of the grain diameter. Initially, such motors are progressive core-burners up to the point where the expanding core reaches the case wall. Then, the remaining propellant, which is now in the shape of a crescent moon, burns regressively. A "D" shaped grain consisting of a solid rod with a thin slice cut off lengthwise will exhibit a similar thrust profile.

A working knowledge of the interrelationships already discussed between operating pressure, propellant burn rate, and propellant surface area leads to a second manner in which the thrust program of a given motor may be varied by changing the throat diameter. By using an ablative nozzle material, which erodes at a known rate during motor function, the Kn of a motor may be changed in conjunction with the surface area of propellant burning. Thus, it is possible to design a neutral burning motor by combining a progressive grain geometry with an ablative nozzle, thus maintaining a xx constant Kn burn rate, and operating pressure.

MATERIALS

MOTOR CASINGS

The combustion chamber or motor casing functions as a simple pressure vessel. High strength and low weight are of primary concern when choosing a casing material. For large rockets in the early years, steel was been a frequent choice. A case failure can project shrapnel quite a distance and cause great damage. Aluminum is a lighter metal, but the thicker walls necessary to fabricate a casing of the same strength as steel, results in no net advantage other than in a case failure aluminum has proven to have a low projectile character. It is obvious with all things considered aluminum is your metal of choice. Of the metals, titanium is by far the strongest and lightest, but it is very difficult to fabricate and is an expensive alternative.

Aluminum motor cases are the rule for reloadable motors. They hold up well to repeated use and are relatively easy to fabricate.

Smaller composite rocket motor casings, referred to as single use motors, are generally made from phenolic paper or cloth, or fiberglass. These materials are exceptionally strong and very light, and possess the added advantage of having a decreased hazard potential from shrapnel in the event of motor detonation. Fiberglass casings may be manufactured from glass cloth or by filament winding where plastic or more commonly epoxy impregnated fiberglass is wound over a mandrel to form a tube. When the resin is cured, the mandrel is removed to make the casing. When using filament, it is desirable to maintain a 55-60 degree angle of winding so as to prevent the formation of micro-porosities extending through the walls of the finished casing.

The phenolic based materials are lighter and less expensive than their fiberglass counterparts, as well as being more resistant to the high flame temperatures of composite propellants. They are also much weaker than fiberglass and therefore contraindicated for use in high pressure motors. In some cases, thin wall phenolic tubes are used as rigid liners into which propellant grains may be cast, then machined and loaded into motors.

Many motor casings will incorporate a liner as insulation. Most often it is fabricated from the same binder as the propellant and filled with inert materials such as titanium dioxide, silicon dioxide, and/or other high temperature resistant materials. Asbestos free high density gasket material, (1/32") available at automotive supply stores, is an easy to use alternative when desired.

EPOXIES

Epoxy compounds have received widespread utilization as the material of choice for sealing bulkhead and nozzle closures of small rocket motors. These materials are well adapted for withstanding the high heat and high pressure environment of motor function. An almost infinite number of formulations are possible based on the specific primary resin, modifying resin, and additives such as reactive diluents, bonding agents, surface active agents, fillers, and curatives.

An excellent and readily available epoxy may be found at local hobby shops which cater to radio control airplane enthusiasts: SIG One Hour Cure Epoxy is a medium viscosity clear epoxy suitable for gluing full diameter nozzles and delays.

When "floating" a nozzle of substantially smaller diameter than the motor casing, a reinforced, filled epoxy is required. These materials are commonly used for potting or encapsulating electronics components and are available in various viscosities and thermal conductivities. Biwax Corporation's Formula 411 works well for this application.

THE PROPELLANT SYSTEM

OXIDIZER

The primary use of ammonium perchlorate, NH4CLO4, is as an oxidant in solid propellants. It is also used in explosives, mines, shells, timing devices, and pyrotechnics. It is produced from anhydrous ammonia, aqueous hydrochloric acid, and sodium perchlorate. Ammonium perchlorate is a white crystalline solid with a molecular weight of 117.49 and specific gravity of 1.95. It is slightly soluble in water. Pure ammonium perchlorate is stable below 65.6°C and undergoes an endothermic reaction at 240°C, followed by two exothermic steps at 275°C and 470°C. Contamination with metallic salts such as those of copper, chromium, and iron catalyzes the second decomposition step so that it occurs at progressively lower temperatures as the impurity concentration is increased. Ammonium perchlorate is a strong oxidizer which is not explosive unless contaminated. It constitutes an extreme fire hazard in contact with oxidizable substances, organic materials, ammonium compounds, cyanides, sulfur and sulfur compounds, powdered metals, phosphorus and metal salts. Strong acids may react with perchlorates to generate perchloric acid, a dangerous explosive if allowed to contact oxidizable materials. Ammonium perchlorate crystals have piezoelectric properties, and may generate a charge upon stress de-formation.Ammonium perchlorate contains 34%

available oxygen, considerably less than that of the sodium or potassium salts. Nevertheless, because of the weight fraction of solids in their combustion gasses, propellants containing it have overall performance characteristics exceeding that obtainable with either of the other two oxidizers. It also has the advantage of not producing smoke.

Ammonium perchlorate propellants produce hydrogen chloride and other chlorine compounds during combustion. In high humidity or a moist atmosphere, the hydrogen chloride will condense into a dangerous fog of hydrochloric acid. The exhaust gasses of these motors are toxic, as well as being highly corrosive to many materials.

PARTICLE SIZE

Ammonium perchlorate is produced in three ordinance grades. The fine classified grade is available in 55 micron and 90 micron sizes, both coated with tricalcium phosphate (TCP) as an anti-caking agent. Regular-Class I is 200 micron and Coarse-Class II is 400 micron in size. The latter two grades are offered with or without the TCP and may be rotary rounded, producing spheroidal grains.

The shape of the grains and particle size of the oxidizer are of critical importance in a propellant formulation, influencing the burning rate, processing properties and the physical properties of the propellant. In general, a decrease in particle size results in an increase in burning rate, with the most significant effect in the submicron range up to about one hundred microns. The effects of crystal size are sometimes so significant that a whole series of propellants can be made with the same composition by merely varying the particle size.

MULTI-MODAL PROPELLANT SYSTEMS

In practice, most composite propellants are multi-modal, consisting of several different sizes of oxidizer in specific ratios. The larger 200μ and 400μ grains are rounded to spheres so as to present the smallest possible surface area per volume of oxidizer. The smaller crystals of ground oxidizer will then fit into the interstices between the larger particles. The net result is a propellent with high solids loading which is not fuel rich and thus maximizes the Isp and mechanical properties of that propellant.

BINDER SYSTEM

BINDER

Hydroxyl terminated polybutadiene (HTPB) is a long chained clear liquid rubber polymer. First used as a binder and fuel in solid propellants by Aerojet in 1962, HTPB is chemically a polyurethane because it is cured with isocyanates. Reaction sites for cross linking are provided by hydroxyl (-OH) radicals at several points along each chain, as well as at terminal ends. It is the three dimensional matrix of the cross-linked rubber chains which impart the important mechanical properties to a propellant. The ability of a propellant to withstand high strain rates is directly related to the low temperature properties of the binder, such as elongation and brittle point. In high solids loaded propellants, a modulus of 400©700 psi with good elongation and tensile properties is required, particularly when case bonding. With a glass transition temperature near or below –100, HTPB has excellent characteristics.

PHYSICAL DATA

Boiling point	300-C
Specific gravity	@25-C.90
Viscosity (Brook)	@25-C6000
Strain capacity	@-65-F25-35%

The actual mechanical properties of a specific propellant are a function of the exact formulation, i.e. by the size distribution and amount of solids, the ratio of binder to curing agent, and the amount of plasticizer.

CURATIVE

As previously mentioned, HTPB is cured by isocyanates. Some require an elevated temperature (oven cure) of 125°+F to activate, while others such as isophorone diisocyanate (IPDI) or PAPI; are active at room temperature. Such curatives are usually present in the range of 8-10% of the rubber content of the propellant, based on calculation of the activity of the particular agent used. These curatives are all toxic compounds, with some more so than others. Among the room temperature curing agents, toluene diisocyanate gives the shortest pot life and is the most toxic. PAPI-901 and N-100 are two good choices for low toxicity and adequate pot life for room temperature curatives. Care must be taken to ensure that all propellant components are kept dry, as isocyanate groups will react with water, producing a substituted urea and liberating CO2 in a gassing reaction.

PLASTICIZER

A number of very low viscosity plasticizing agents may be added to a propellant for improved wettability which will allow higher solids loading and consequently improve performance. These agents will improve the mechanical properties of a propellant, retard oxidation and embrittlement to a certain extent, and when used as a significant portion of the binder system (25-30%), will allow for some propellants to be pourable.

Dioctyl adipate (DOA) is a high quality grade of D1-2-ethylhexyl adipate which is used as a diester fluid for synthetic lubricants. This colorless liquid has low acute oral toxicity, but is considered as a high health hazard due to its mutagenic and carcinogenic effects.

Dioctyl azelate (DOZ) is a similar product with a slightly higher molecular weight and lower toxicity.

Isodecyl pelargonate, (IPDI), is another synthetic oil of even lower viscosity than DOA, which is an excellent plasticizer.

In effect, most any low viscosity type of oil may be used as a plasticizing agent. The advantage of the aforementioned products lies in their wetting ability and ultra low viscosity.

BONDING AGENTS

Most published propellant formulations will contain a bonding agent. These compounds react with the surface of the ammonium perchlorate crystals (frequently releasing gaseous ammonia) and facilitate actual bonding of the rubber to the crystal. Without such an agent, the oxidizer crystals are simply retained physically within the propellant, captured in effect by a three dimensional matrix of rubber. Without a bonding agent, crystals of oxidizer which are on cut or machined surfaces of a propellant grain will be lost during processing, leaving a fuel rich surface.

TEPANOL (Dynamar Bonding Agent/Processing Aid HX-878) is one such bonding agent and commonly comprises 0.25% of the entire propellant formulation. Bonding agents greatly improve the mechanical strength and properties of a propellant, but are not of significance in small rocket motors.

METALLIC FUELS

Finely divided metals are added to almost all composite propellant formulations. These fuels provide a variety of benefits and enter into some very complex interactions during combustion. Spheroidal aluminum is perhaps the most commonly used metal in composite propellants, found in various formulations from near 1% up around 18%. The ballistic performance of aluminized propellants is greatly increased, raising the Isp in the range of up to 10% when compared to the same formulation without metal. It must be noted, however, that this effect is not significant in small rocket motors, where the metal is not in the combustion chamber long enough to be consumed, and is mostly expelled in the exhaust gasses in the molten form. The addition of aluminum to a propellant will also serve to dampen acoustic oscillations, thus minimizing the possibility of grain fracture at ignition, and also making ignition easier, especially in small motors. The net effect of aluminum of burn rate is usually not large and may be positive or negative.

When considering metallic fuels other than aluminum, those with low molecular weight are desirable. Those which might be of benefit to propellant application may be determined by considering the density and the heat of formation of the metal oxide. Beryllium heads the list and has been reportedly used, but has the problem of producing toxic combustion products. Boron, lithium and silicon all have higher heat content per gram than aluminum, and are potential additives. Magnesium has also been used, but imposes a hardship on the binder due to its lower heat content and lower density.

BURN RATE MODIFIERS

Numerous compounds are utilized to modify the burn rate of propellant systems. Most exert a positive catalytic effect, while some such as oxamide decrease the burn rate by insulating the heat wave and slowing the progression of combustion. Addition of inert compounds (chalk) or substituting less active oxidizers (ammonium chloride, sulfate) for a portion of the AP in a propellant will also slow the rate of burn.

By far, the majority of modifiers are catalysts which in some manner enhance the rate of burning. The effects which these compounds have on the dynamics of combustion is an exceedingly complex area of research.

At this point, it will suffice to say that catalysts exert their effects in relationship to combustion pressure and concentration. An effective range may be determined, above which the increase of catalyst percentage has diminishing returns without significant increase in burn rate.

The following is a partial listing of some frequently utilized burn rate catalysts with brief comments about each one:

PROMOTERS

Manganese Dioxide (MnO_2) - Positively catalyzes solid phase reactions. MnO_2 is a strong positive catalyst for the decomposition, but is a negative catalyst for the deflagration of A.P.

Iron (III) Oxide (Fe_2O_2) - An excellent and readily xxxxxx

available catalyst. It will increase burn rate more than MnO2 will at same level. Fe_2O_2 promotes the complete decomposition of AP at 270-280 degrees.

Chromium (III) Oxide (Ci_2O_2) - Primarily enhances the low temperature decomposition of AP, allowing that reaction to go to completion. Chromium oxide exerts a much greater effect on burn rate than manganese dioxide, and at the 2% level is superior to iron oxide in low pressures, up to about 600 psia.

Copper Chromite ($Cu_2Ci_2O_7$ or CuO - ÀCu Cr_2O_3) - has a significant effect, but varied on burn rate. Analysis has shown that copper chromite catalysts differ from company to company and may not even be the same from batch to batch. Propellants containing copper chromite become brittle and do not age well.

Cupric and Cuprous Oxide (CuO and CuO_2) – Both catalyze the low and high temperature decomposition of AP, and promote ignition. Cupric oxide (CuO) is superior to copper chromite and even chromium oxide as a burning rate promoter.

Ferrocene (Dicyclopentadinyliron, $C_{10}H_{10}Fe$) and its derivatives Catocene and N-Butylferrocene – These liquid burn rate promoters are based on two five membered cyclopentadinyl groups with a ferrous ion (Fe) sandwiched between. These compounds interact with aluminum during combustion. Decreasing the particle size, and thus increasing the surface area of aluminum to react, will increase the burn rate of propellants containing these compounds.

BURN RATE INHIBITORS

The burn rate of a propellant may be decreased by the substitution of up to 20% of the oxidizer with ammonium chloride or ammonium sulfate. The addition of zinc powder to a propellant will also slow the rate of burn, while also generating a dense, black exhaust. A fuel rich propellant, or one to which an inert component such as calcium carbonate has been added, will also burn slower. The use of an inhibiting compound, which will contribute to the combustion reaction, however, seems to be the more sensible approach.

RANDY SOBCZAK
PLASMAJET

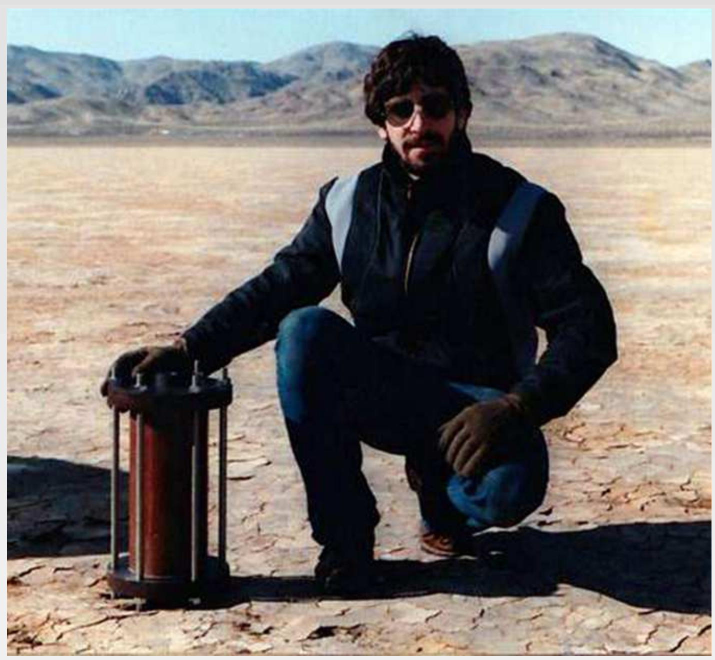
Back in the "Way Back" days of early Tripoli several persons were researching and producing Composite Rocket Motors. It was a time of free pursuit. People like Gary Rosenfield, with AEROTECH, Scott Dixon, with VULCAN SYSTEMS, and John Rakonnen and his PRODYNE were producing and selling Composite Motors on the open market.

Ranked with this group of innovators was Randy Sobczak and PLASMAJET. Randy produced some very aggressive motors that to this day are very sought after.

Randy & John Krell at Lucerne

Randy began experimenting with composites in the late 70's and teamed up with John Krell to form PLASMAJET.

To this day several PLASMAJET Motors, tested by Tripoli TMT in the early year, keep popping up and despite their age, work exceptionally well.



Randy Sobczak in the early PLASMAJET days testing propellant at Smoke Creek, Nevada

PLASMAJET Motors tested and approved by Tripoli TMT were:

F-17	H-36	H-95	H-124	H-116
G-39	H-83	H-116	H-64	H-121
E-40	H-64	H-121	H-95	I-124

These included PLASMJET's leading core-burners, moonburners and smoket formulartions.

All expired around 1997

HEAD END IGNITION

***Oliver Schubert,** after developing the No-Match Ejection System, developed an easy to build Head End Motor Ignition System that will work on any type and size motor that contains a Smoke Well or a Delay Charge Well. The concept is presented here with no dimensions since it is applicable to all size motors. The photos and accompanying text should present the concept in an easy to understand method. - you will need access to a metal lathe.*

Head End Ignition is a way to ignite a rocket Motor internally from an on board computer or altimeter. It is great for staging and even applicable to ground ignition as well. The system is based on a forward closure that has a delay column recess or what is called a smoke well.

The forward closure will require a hole tapped large enough to accommodate a model airplane engine Glow Plug, preferably a long type Glow Plug. You will also need to drill and tap a side hole for a screw to secure the "device" into the forward closure so it will not blow out at ignition. The photos will show this.

The list of items required to accomplish this are show in the photo to the right:

A - Pyrodex (do not use black powder as it must be compressed).

B- Double Sided Masking tape

C - Glow Plug, preferably the long type.

D - Any standard Forward Closure with a delay or smoke well.

E - Piston (3) (Must be Fabricated)

F - Extension Ring(2) (Must be Fabricated)

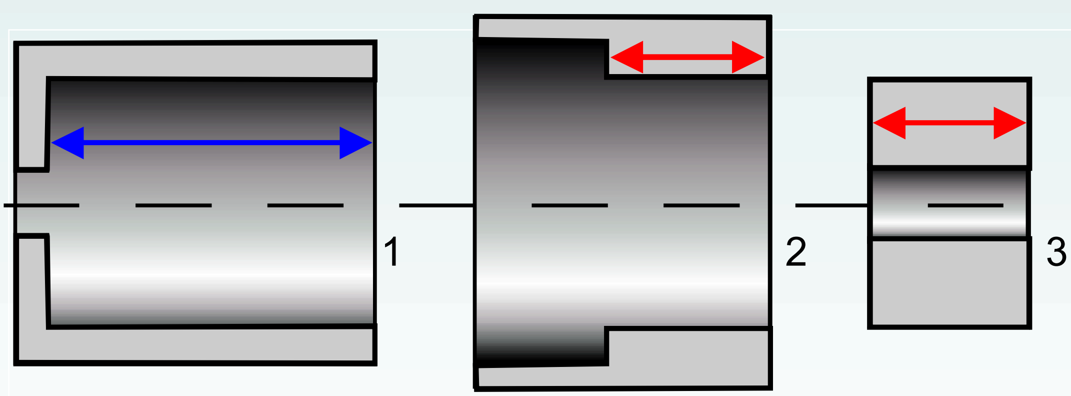
G - Charge Holder(1) (Must be Fabricated)

H - Two Wrenches

I - Small Washer

J - Large Washer

K - Bolt & Nut



The three cross-sectioned pieces in the drawing to the left need to be machined from aluminum stock. Dimensions are not included as they will vary with motor size.

What is important is the extension Ring and Piston. What ever diameter you are working with the length of the collar and Piston (both marked in red) must be 50% the depth of the of the Charge Holder well (marked in blue). This compresses the Pyrodex by 1/3rd creating a nice solid pellet.

The next very important item is the Bolt. If it is too small, the resulting core of the pellet is too small to pass

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The next very important item is the Bolt. If it is too small, the resulting core of the pellet is too small to pass all the gases through from the rear of the pellet where the burning begins (you may end up with a large "bang").

Determined the size of the core experimentally by starting with a small bolt and going bigger until the pellet burns without

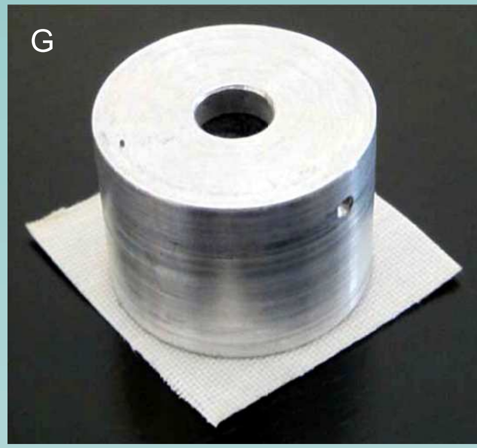
Head End Ignition is a way to ignite a rocket Motor internally from an on board computer or altimeter. It is great for staging and even applicable to ground ignition as well. The system is based on a forward closure that has a delay column recess or what is called a smoke well.

D. Using a wrench on top and one on the bottom tighten the nut down on the bolt until the large washer is flush with the Extension Ring. Once the unit is compressed let it sit for a minute before loosening and removing the nut & bolt. With the Extension Ring and Bolt removed you should have a semi-solid grain of compressed Pyrodex looking like **F**.

Place the unit, PyroDex side down, onto a piece of double sided masking tape as shown in photo **G**. This will actually hold the PyroDex secure for final placement.

Note the "dimple" on the side of the Container. This will mate up with a set screw in the forward closure and secure the unit in the closure itself.

With the tape in place trim off the excess as shown in photo **H**.



Remove the last backing from the double sided tape and place the unit, PyroDex side down, into the well of the forward closure as in photo **I**. Make sure the Container dimple and the hole drilled in the closure for a set screw are aligned. Then press to secure the Conatiner into place. Once set complete securing the Container with a set screw.

Besides the little hole drilled and tapped for a set screw the Forward Closure must be modified on top by drilling and tapping a hole to accommodate the Glow Plug as shown in the center photo **J**.

The hole where the glow plug screws into has to be the length of the glow plug thread plus ~1/16" so there is room for a bit of pyrodex powder. You may need to manufacture a disk that increases the back wall thickness of the rear closure and press-fit it in, unless you're making your own closure, before cutting the threads for the glow plug.

Fill the Glow Plug hole with a small amount of PyroDex, not more than 1/8th inch. Install the Glow Plug and the closure is ready for motor assembly.

This unit is very reliable and has worked 100% of the time in repeated testing and actual use in several rocketry projects such as Tom Blazanin's DARQUE SOL Flying Saucer Project and more recently in Ken Good's Internally Staged DRAKE Project.

While this article is basically designed to present the concept of a simple Head End Motor Ignitor it does cover the bases. No dimensions are given as stated since motor sizes vary but this system is easy to understand and build. A small metal lathe is required and a free afternoon is all that's needed.

Any inquiries on this system can be answered by Oliver by E-Mail at: **Oliver07@cox.net.**

A glow plug needs low voltage (1.5V) and high amperage (~3-5A). An e-match (which is what an altimeter is designed to fire) needs 9V at about 1A. Oliver's NoMatch unit uses the output from the altimeter to turn on it's own low voltage battery that is capable of providing the 3-5A needed for the glow plug. Aside from the voltage difference, the 9V batteries we are using are not capable of providing the high amperage.

In a nutshell, the NoMatch changes the 9V 1A from the altimeter to 3V 5A for the glow plug. FYI: I'm actually giving the glow plug too much voltage which - if applied to long - will burn out the glow plug, but there is no standard 1.5 V battery available that can provide the high amperage required for the glow plug. Since altimeters turn on only for 1 sec, this is not an issue.

Find out more about NO MATCH at: **www.lvhq.net/nomatch**

LETS VISIT TOM BLAZANIN

The quite and low profiled Tom Blazanin lives in a semi-double wide mobile home he calls The Compound. It has an attached garage with outside access only but Tom has put it to good use.

Called Area 748, after his address, he has organized the entire place for working on Rockets and making motors.

Area 748 is laid out with tools and supplies surrounding a central portable work area that doubles with a built in table saw. Completed rockets are hung from the ceiling and the entire place is in constant evolution.

With a metal lathe, drill presses, saws, compressor, mixers and tools; Area 748 is equipped to handle any rocket venture and is openly shared with other rocket people in need of space and tools..

As a partner with Dave Rose in GRAPHIX & STUFF and DT Research Rocketry a lot of the equipment and material is joint ventured, which works out unusually well.

With only a single car garage to work out of, additional storage space is naturally required. Area 748b (below) shares space in GRAPHIX & STUFF's work room to store Chemicals, Casters & Liners, other Tubing and Equipment.

AREA 748c (below right), used to store additional rockets, shares a room with GRAPHIX & STUFF's Apparel Inventory. It is also used, when needed, as a place to dry newly painted rockets as well.

WWW.RESEARCHROCKETRY.COM

A CALL FOR MORE SCIENTIFIC TRUTH IN PRODUCT WARNING LABELS

As concerned citizens, and those particularly interested in science, we applaud the recent trend towards legislation that requires the prominent placing of warnings on products that present hazards to the general public. Yet we must also offer the cautionary thought that such warnings, however well-intentioned, merely scratch the surface of what is really necessary in this important area. This is especially true in light of the findings of 20th century physics.

We are therefore proposing that, as responsible citizen/scientists, we join together in an intensive push for new laws that will mandate the conspicuous placement of suitably informative warnings on the packaging of every product offered for sale in the United States of America. Our suggested list of warnings appears below.

WARNING: This Product Warps Space and Time in Its Vicinity.

WARNING: This Product Attracts Every Other Piece of Matter in the Universe, Including the Products of Other Manufacturers, with a Force Proportional to the Product of the Masses and Inversely Proportional to the Distance Between Them.

CAUTION: The Mass of This Product Contains the Energy Equivalent of 85 Million Tons of TNT per Net Ounce of Weight.

HANDLE WITH EXTREME CARE: This Product Contains Minute Electrically Charged Particles Moving at Velocities in Excess of Five Hundred Million Miles Per Hour.

CONSUMER NOTICE: Because of the "Uncertainty Principle," It Is Impossible for the Consumer to Find Out at the Same Time Both Precisely Where This Product Is and How Fast It Is Moving.

ADVISORY: There is an Extremely Small but Nonzero Chance That, Through a Process Know as "Tunneling," This Product May Spontaneously Disappear from Its Present Location and Reappear at Any Random Place in the Universe, Including Your Neighbor's Domicile. The Manufacturer Will Not Be Responsible for Any Damages or Inconvenience That May Result.

READ THIS BEFORE OPENING PACKAGE: According to Certain Suggested Versions of the Grand Unified Theory, the Primary Particles Constituting this Product May Decay to Nothingness Within the Next Four Hundred Million Years.

THIS IS A 100% MATTER PRODUCT: In the Unlikely Event That This Merchandise Should Contact Antimatter in Any Form, a Catastrophic Explosion Will Result.

PUBLIC NOTICE AS REQUIRED BY LAW: Any Use of This Product, in Any Manner Whatsoever, Will Increase the Amount of Disorder in the Universe. Although No Liability Is Implied Herein, the Consumer Is Warned That This Process Will Ultimately Lead to the Heat Death of the Universe.

NOTE: The Most Fundamental Particles in This Product Are Held Together by a "Gluing" Force About Which Little is Currently Known and Whose Adhesive Power Can Therefore Not Be Permanently Guaranteed.

ATTENTION: Despite Any Other Listing of Product Contents Found Hereon, the Consumer is Advised That, in Actuality, This Product Consists Of 99.9999999999% Empty Space.

NEW GRAND UNIFIED THEORY DISCLAIMER: The Manufacturer May Technically Be Entitled to Claim That This Product Is Ten-Dimensional. However, the Consumer Is Reminded That This Confers No Legal Rights Above and Beyond Those Applicable to Three-Dimensional Objects, Since the Seven New Dimensions Are "Rolled Up" into Such a Small "Area" That They Cannot Be Detected.

PLEASE NOTE: Some Quantum Physics Theories Suggest That When the Consumer Is Not Directly Observing This Product, It May Cease to Exist or Will Exist Only in a Vague and Undetermined State.

COMPONENT EQUIVALENCY NOTICE: The Subatomic Particles (Electrons, Protons, etc.) Comprising This Product Are Exactly the Same in Every Measurable Respect as Those Used in the Products of Other Manufacturers, and No Claim to the Contrary May Legitimately Be Expressed or Implied.

HEALTH WARNING: Care Should Be Taken When Lifting This Product, Since Its Mass, and Thus Its Weight, Is Dependent on Its Velocity Relative to the User.

IMPORTANT NOTICE TO PURCHASERS: The Entire Physical Universe, Including This Product, May One Day Collapse Back into an Infinitesimally Small Space. Should Another Universe Subsequently Re-emerge, the Existence of This Product in That Universe Cannot Be Guaranteed.