RRS NEWSLETTER

THE OFFICIAL JOURNAL OF THE REACTION RESEARCH SOCIETY INC.

January-February 1992

For the Advancement of Rocketry and Astronautics

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Silver Girl II Finally Becomes Airborn

By Mark Grant

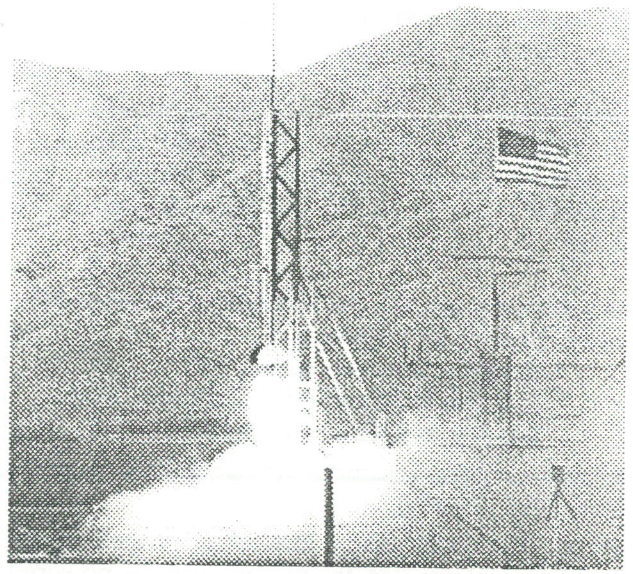
After two and a half years of on-again, off-again work, my rocket project finally came to life. On a windy October afternoon, the Silver Girl II, named after a line in the Simon & Garfunkel song "Bridge over Troubled Water", left ground zero, and delighted the crowd with a 35 second flight. Unfortunately, since the timer was set to deploy a parachute 37 seconds into the flight, the rocket never had a chance to survive, and will never fly again.

I have begun writing a full report on the project, but I wanted to take time now to briefly explain the launch and subsequent flight.

For those of you who were out there know that the flight occurred on the second launch attempt of the day. The first launch attempted failed due to burst disk problems, i.e. the LOX burst disk never burst. This burst disk was designed to rupture at 150 psi at at LOX temperature, with the fuel disk going at 180 psi at ambient temperature. Hopefully these burst disks would provide a ox-lead at start. Well, needless to say they didn't. After power was killed to the flight Marrotta valve (opening the valve), the fuel and ox tanks pressurized but only the fuel disk ruptured. After dumping a couple seconds worth of fuel on the ground, the pressurization valve was quickly closed to prevent further pressure build up in the LOX tank and eventually LOX disk rupture, possibly leading to the formation of gel. GN2 dissolution and/or chilling in the LOX, i.e. the volume of the GN2 (pressurization gas) in the LOX tank was decreasing from the cold temperatures or going into solution with the LOX, probably caused a delay in pressure buildup leading to the fuel rich start.

This problem was resolved by replacing the LOX disk with a much thinner disk. So after the LOX tank was emptied, cameras reloaded, and nosecone pyrotechnic charge replaced, we were ready for a second attempt.

The second countdown went smoothly and at T minus 0 the engine ignited, the Silver Girl slowly cleared the tower, turned windward and thundered down range. After following a circular course, the rocket augured into the desert floor, leaving nothing to be salvaged. The rocket was found 4650 ft down range, according to G. Dosa's careful measurements, and probably only achieved about 5000 ft in attitude.



The Silver Girl II, a liquid oxygen & kerosene propelled rocket successfully leaves the launch tower.

At first it was thought that the rocket turned into the wind from "weather cocking" alone. However inspection of the engine revealed that one of the fuel orifices was plugged, leaving a LOX stream heading straight toward the throat. The oxidizer stream notched the throat and created a thrust vector. This thrust vector, coupled with the strong wind, turned the bird down range. This changed the flight profile and greatly

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Inside this issue

The Reaction Research Society, one of the two oldest Amateur Rocket Societies in the nation was organized in 1943 as a non profit civilian organization whose purpose is to aid in the development of reaction propulsion and its applications, and to promote interest in this science. The Society owns the Mojave Test Area, referred to as the MTA, a 40 acre site located two and one half hours north of Los Angeles. It is at this location were several hundred rockets, using both solid and liquid propellants, have been static tested and launched. Currently there are over 50 members.

This newsletter is a bimonthly publication by the RRS and is intended to provide communication between members, and other societies.

President	Frank Miuccio
Vice President	Robert Anderson
Secretary	Tom Mueller
Treasurer	Steve Majdali
Editor	Mark Grant

Information regarding the Society and Membership can be obtained by writing to:

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Silver Girl II (con't)

reduced the flight time. Instead of propelling the rocket straight upward, the rocket's impulse powered the rocket down range greatly increasing the distance but greatly reducing the attained altitude. The rocket also appeared to be under powered. A low c* performer for an injector (the blocked fuel orifice didn't help) and/or insufficient pressurant gas flow is probably to blame. Too bad I didn't have any instrumentation to answer some of the unknowns.

After examining the wreckage, it appears that all the payload components worked. The camera took footage, the timer started, but the parachute never had a chance to prove itself. Too bad the film was shredded in the impact. Since the rocket didn't spin at liftoff, the camera probably took some great pictures.

So after lots of long hours of work, my project finally came to a close. All in all I am satisfied with the results; nobody got hurt, I learned a hell of a lot, and Silver Girl II thrilled us all for 35 seconds one fall afternoon. One thing I found was the tremendous support that I have from my friends. The project would of never got off the ground without the support of my close group of rocketeers, Dave Crisalli, Scott Claflin, Brian Wherley, Dave Matthews, and Steve

Continued

From the Editor

I would first like to thank you for electing me to be the RRS editor for 1992. I feel lucky to hold this position during such a dynamic time for the RRS. I would like to acknowledge Phillip Pesvento (RRS editor 1990) and Donald Trimborn (RRS editor 1991) for building the strong base for this newsletter, and also giving me a challenge to continue to "carry the torch", so to speak.

I have outlined several goals this year for the newsletter. The first is to bring the newsletter into the desk top publishing world, putting my Macintosh to good use. I would also like to see more educational articles in the newsletter. I feel that since one of the RRS main thrust is to educate those interested in the field of rocket propulsion, the newsletter should be used as a vehicle to achieve that goal. Additionally, I have talked to some of my liquid propulsion buddies, and we all plan to do a better job documenting the work we have accomplished, and to pass along the lessons learned. I also plan on writing a series of articles titled "So You Want to Build a Liquid Rocket?", containing all the good stuff one needs to know to build a liquid rocket successfully and safely. As far as the solid side of the group, I am asking for help. It would be great to have the same educational material given on solid propulsion. I know there is a lot of expertise on this subject in this group, so send me some articles guys.

Finally, I hope to use the newsletter to improve communication between members, and relive some of the work of others in the group. For example, I plan to include a order form of RRS items for sale. Hopefully, by centralizing activities, both the RRS can benefit from increased revenue, and the consumer can get what they want.

In closing, I am proposing the newsletter become a bimonthly publication. I feel this will allow enough time for a complete, informative, well written newsletter to be produced. I do plan on providing monthly communication to inform members of meetings and events by the means of post cards during the off newsletter months. I hope that I will accomplish these goals and provide an exciting and enjoyable newsletter. Please let me know your thoughts, concerns etc.

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Silver Girl II (con't)

Palm, thanks guys. Also thanks goes out to Frank Miuccio, Steve Luhn, Niels Anderson, Steve Gates, and Bruce Markle for all their help. And finally thanks to my wife Lesa for all her help, patience, and understanding.

January & February 1992 Meeting Highlights

The January meeting was attended by several members of the Independent Rocket Systems (IRS). This group, a spin-off of the PRS, is a highly active rocket group experimenting in both solid and liquid propulsion. Their current project, a 16' liquid propellant rocket using Nitric Acid and Furfuryl Alcohol, initiated the communication between the IRS and RRS. The IRS would like to launch some solid rocket and static fire their liquid propulsion system at the MTA prior to the rocket launch in Nevada this summer. For the past four years, the group has been using Lucerne dry lake bed for most of the testing. However, the lack of facilities and severe altitude restrictions (9000 ft) for launches at Lucerne have have caused the IRS to look for other sites. During the meeting, Paul Mcluown presented pictures and a video of the groups activities over the past several years.

I personally welcome the interaction between the two groups and hope than an agreement can be reached that would be a benefit to both groups.

Since the February meeting date fell on Valentines Day, the meeting was cancelled to allow members to be with their Valentines. Who said rocket scientists weren't romantics?

Dave Crisalli gears up for Spring Launch

By D. Crisalli

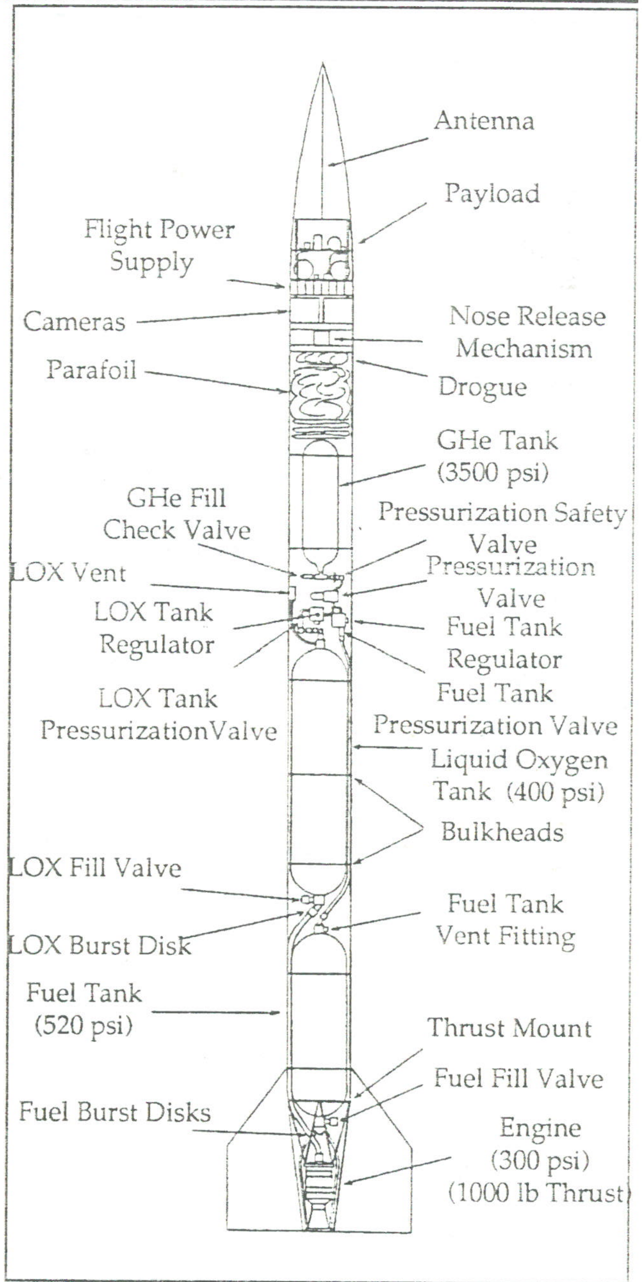
Editor's Note: Dave Crisalli is currently constructing a large liquid propelled sounding rocket. If all goes well, the rocket will achieve an unprecedented 200,000 feet in altitude. The rocket is scheduled for a spring launch at White Sands Missile Test Grounds.

The following information is provided as a status report on the liquid propellant sounding rocket project. Included are drawings of the vehicle, static test stand, static test system schematic, test parameters and a sketch of the 50 foot portable launch tower now under construction.

New and stronger propellant tanks have been fabricated. Work is also starting on the components of the flight structure and payload (which may include a TV camera and transmitter, and a GPS receiver for accurate altitude determination).

To test several of the subsystems for this rocket, Brian Wherley and I are building a 600 pound thrust LOX/Alcohol rocket. It is similar in size to Mark Grant's at 6 inches in diameter and 12 feet long. We hope to fly it at the MTA to check out the TV system, the roll stabilization system, and the parachute deployment device that will all be used on the larger rocket.

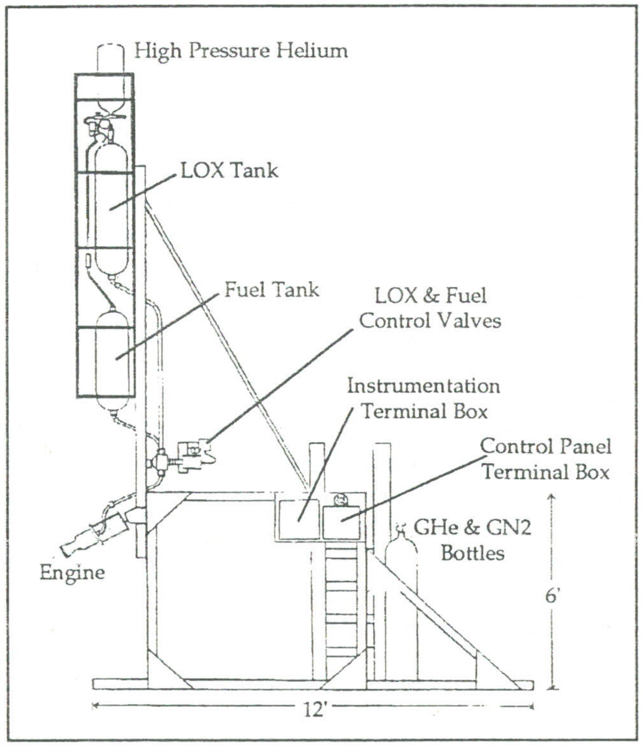
A complete set of drawings, design calculations, and data analysis are in work for both projects and will be available at the completion of each project. As an interim measure, I have given George Dosa a copy of a 5 minute video report and a compilation of drawings, procedures, project outlines, and pictures for the RRS files.



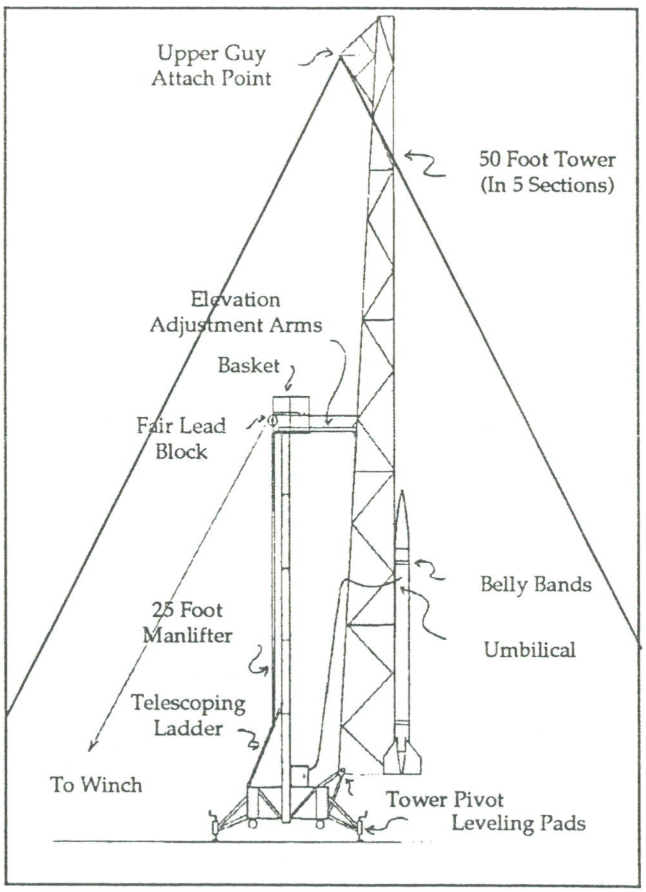
Layout of D. Crisalli's LOX & Kerosene Propelled Rocket to be Launched at White Sands Test Range

Static Test Parameters

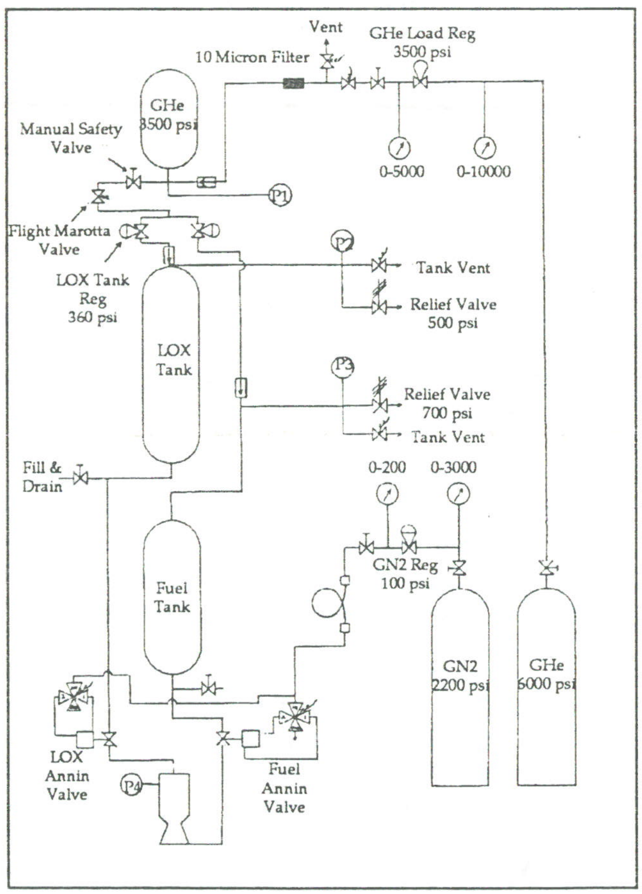
Engine	
Thrust	1000 pounds
Chamber Pressure	300 psi
Fuel Flow Rate	1.34 #/sec
Oxidizer Flow Rate	3.2 #/sec
Expected Isp	220 seconds
Mixture Ratio	2.4
Throat Area	2.159 sqin
Throat Diameter	1.658 in
Expansion Ratio	4
Thrust Coefficient	1.4
Cylindrical Chamber Length	6.0 in
L*	36 in
Injector	
Pattern	24 F-O-F Triplets & BLC
Boundary Layer Coolant (BLC)	32 at Injector Face 24 at Nozzle Inlet
Oxidizer Orifices	24 Holes - 0.067 in dia
Fuel Orifices	48 Holes - 0.034 in dia
Oxidizer Side Delta P	67 psi
Fuel Side Delta P	215 psi (80 psi injector + 135 psi cooling jacket)
System	
Fuel Tank Volume	2300 cuin
Oxidizer Tank Volume	3200 cuin
Total Fuel Weight	53 lbs
Total Oxidizer Weight	131.4 lbs
Burn Duration	Approximately 60 secs



Static Test Stand



Launch Tower Assembly



Static Test Schematic

So You Want To Build a Liquid Rocket?

By Mark Grant

At the request of some RRS members, I have started a series of articles discusing the design and fabrication of a liquid propellant rocket. I hope these articles will provide enough information so that anyone interested could start a liquid rocket project of their own. These articles will be written from an amateur rocket standpoint, namely how to design a sounding rocket. I don't want to write a boring tutorial on the physics of liquid propulsion, and you probably don't want to read one. There are already plenty of good books on that subject, namely "The Design of Liquid Propellant Rocket Engines" (NASA SP-125) by Huzel and Haung, or "Propulsion Elements" by Sutton and Ross. I do want to convey that any rocket project deals with very exciting but possibly dangerous technologies. Safety has to be the number one priority. So please make use of the Society's resources/ experience to ensure a safe and successful project.

Since writing from the perspective of first hand experience may prove the most useful, I plan to use my project and others as examples. If you have any questions regarding different types of systems that I don't cover, please send them in and I will respond to the best of my ability.

This first article deals with 3 questions one must answer before beginning such a project. Throughout the project, there are many questions to be addressed, but the answers to three basic questions really anchor the design. These are (1) propellant choice, (2) selection of chamber pressure, and (3) selection thrust level and corresponding burn duration.

Propellant Choice

For the amateur rocketeer on a tight budget, the propellant should be cheap, available, easy to handle, and provide reasonable performance. This narrows a vast number of combination to a few. These are LOX/RP-1 (or Kerosene), LOX/Alcohol, and Nitric Acid/Furfuryl Alcohol for possible bipropellant combinations. Hydrogen Peroxide is about the only choice for a monopropellant. There are a few other propellant combinations to choose from, but the combinations listed have all been successfully used in amateur rockets in the past.

There is a certain romance with the choice of LOX/Kerosene as propellants. To use the same propellants that the mighty F-1 rocket engines used to take man to the moon strikes a cord. Additionally, this propellant combination is the cheapest, most readily available, and gives reasonable performance. A LOX dewar holding roughly 300 pounds of LOX can be obtained easily through a welding supply distributor for about $70. Although there are some difficulties with handling a cryogenic liquid, especially a strong oxidizer, but the price, performance, availability and cost usually out weigh the disadvantages.

Kerosene can be obtained at any hardware store for under $2.00 a gallon, or diesel fuel can be substituted for about $1.25 a gallon. As far as performance goes, this combination has a theoretical specific impulse equal to 249 seconds at sea-level (mixture ratio of 2.28, a chamber pressure of 300 psi). With a reasonable injector design, you can expect to obtain an ISP around 200 seconds at sea-level. Design improvements can increase this specific impulse number, but they are usually too costly for the amateur rocketeer. Both Dave Crisalli and I choose these propellants in our rockets.

LOX/Alcohol, usually cut with water to a 75% alcohol/25% water combination, is another attractive choice. This combination was used in the Redstone and V-2 engines. The alcohol is more expensive, about $6/gallon, but is posses some nice features. One feature Scott Claflin liked was the appearance of the LOX/Alcohol plume. After observing the bright yellow "ratty fox tail" of LOX/Kerosene, he knew something had to change. And thus, the choice of LOX/ Alcohol was made. An additional benefit of this combination is that at a mixture ratio of 1.35, equal volume tanks can be used. It was this attraction that lead Steve Palm to choose these propellants. He had two old "breathing oxygen" tanks of the same size that he could use in his rocket. This propellant choice would allow him to use these tanks efficiently with no excess ullage. In addition, the increase of fuel flow, compared to LOX/RP would provide extra cooling margin in his Atlas Vernier thrust chamber. This combination has a theoretical specific impulse equal to 238 seconds at sea-level (mixture ratio of 1.3, a chamber pressure of 300 psi). Again, you can expect to obtain about 200 seconds.

Although more expensive, there is a commercially available version of a 75%/25% alcohol mixture in the form of "151 rum" The added benefit here is that this propellant is fit for human consumption in the event the test is cancelled and the propellant must be off-loaded.

The choice of Nitric Acid/ Furfuryl Alcohol has many benefits as well as a host of disadvantages. Dan Ruttle successfully used these propellants in his rocket launch in 1987 at Smoke Creek Nevada. Since this combination is hypergolic, spontaneous combustion of the two liquids upon contact, no ignition system is required. Also, since the two propellants are storable at ambient temperatures, no handling of cryogenic liquids is required. However these propellants, in particular Nitric Acid, are expensive, difficult to obtain, and toxic. Furfuryl Alcohol can be purchased

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from chemical suppliers for about $5 a pound. On the other hand, >90% Nitric Acid, the concentration needed for hypergolic behavior, can only be bought in large quantities for a reasonable price, or in small quantities at very high prices. One can order it by the rail road tank car for a reasonable price/pound, but who can afford 40,000 lbs of oxidizer. On the other hand, smaller reagent grade quantities, >99% concentration, can be purchased for a sky-high price of $120/liter. There has been some communication between a chemical supply house in Arkansas who sell Inhibited Red Fuming Nitric Acid (IRNFA) in 30 gallon lots for $450 plus a $500 deposit on the shipping container. This contact will be investigated further and results reported. Currently, however, these propellants remain difficult to obtain. The performance is slightly better than LOX/RP.

Due to the toxicity of these propellants, special care must be taken when handling them; self contained air breathing apparatus and protective clothing are a must. There are also transportation laws to be dealt with governing the transport of these propellants.

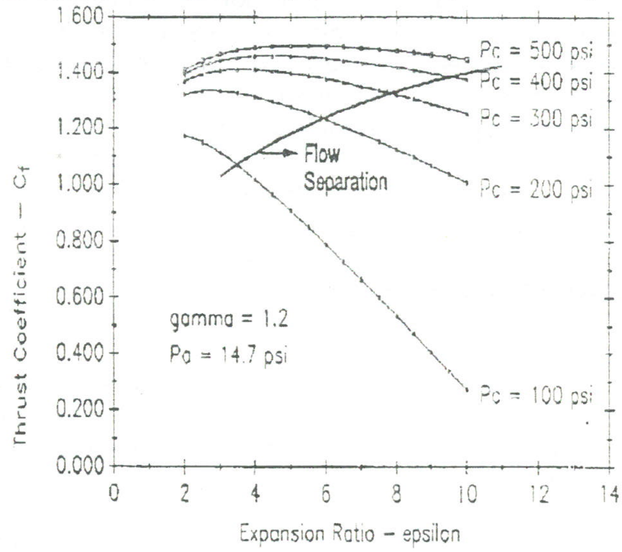
It is this authors judgement that this propellant choice should be avoided, unless dealing with small quantities or planning on building a second stage system where the benefit of hypergolicity is a major advantage.

Hydrogen Peroxide, a monopropellant, might be the best suited amateur rocket propellant. The propellant is fairly easy to handle and its decomposition gases, 1800 °F, give a reasonable performance of 146 seconds. It has been used successfully by members of the RRS in the past. The problem again is availability. The 90% concentration is only made in West Germany and sold by the rail road tank car. If a source could be found, this rocketeer may take on another rocket project. As an a aside, H2O2 can be also be used as an oxidizer in bipropellant systems. Quite some time ago George Dosa built a beautiful H2O2/alcohol rocket that was never flown.

Selection of Chamber Pressure

This choice is relatively straight forward. From a safety stand point, it is of benefit to keep the operational pressures of the different components low. This increases the safety factor on tanks and chambers and thus reduces the chances of tank rupture, especially when the tanks are full of propellants. It must be kept in mind that mixed and unburned propellants usually are pound for pound the equivalent in explosive force of TNT.

On the other hand, higher chamber pressures increase combustion and nozzle performance. An optimum value can be determined by examining the effect of chamber pressure on the nozzle thrust coefficient, Cf. Cf represents the additional thrust developed by the diverging portion of the de Laval nozzle. For this reason the thrust coefficient is often considered a measure of nozzle performance. From the figure below, one can see that significant increases in Cf can be attained by increasing the chamber pressure up to about 300 psi. Only minor gains can be attained above a 300 psi chamber pressure. It was thus concluded that a chamber pressure around 300 psi would take advantage of the increase in the Cf value without taxing the requirements of propellant tanks and chambers. This would also lead to propellant tank pressures in the 350 to 500 range, values attainable for our level of sophistication and/or resources. This value is only a rule of thumb and should not be viewed as being set in stone. D. Crisalli's, S. Claflin's, S. Palm's, B.



Effect of Chamber Pressure on Thrust Coefficient

Wherley's, and my rocket all had chamber pressures ranging from 300-350 psi.

Selection of Thrust Level and Burn Duration

These two choices must be played against themselves before a conclusion can be reached. You want enough thrust to provide a reasonably high-g takeoff (3 to 10 g's since we only use fin stabilization for guidance), but you would like sustained thrust to achieve high altitudes. High flight velocities at low altitudes leads to high drag forces. Overcoming these forces results in an inefficient use of your rocket's propulsion. Thus, lower flight velocities at low altitudes (lower takeoff thrust) and corresponding longer burn durations results in higher attained altitudes . Other practical considerations must also be taken into account. How big of a project do you want to take on? Do you have the machines big enough to produce the parts required? Do you have some available hardware

continued next page

you plan to use in your project? Do you have any special goals, i.e. payloads, altitudes etc., that need to be met? Where do you plan to launch and what are the corresponding altitude limits? Hopefully some examples will shed some light on how to come to a conclusion on this subject.

In my case, I wanted a rocket that was fairly easy to handle, about 8-10 feet tall. I also knew that I could get my hands on a Condor chamber, which would eliminate the need to fabricate a thrust chamber. Assuming a chamber pressure around 300 psi, this would set my thrust level. Since I also planned on launching at the MTA, I knew I would have to limit the projected attained altitude. After playing with a trajectory program, I settled on a 300 lbf thrust, 12 second burn time system, of which I could fit in a 6" diameter rocket about 10 ft tall and attain an altitude around 20,000 to 30,000 feet.

In Dave Crisalli's case, he already had a 1000 lbf engine from his 1976 Navy project. To size his rocket, he based the decision on what size part his lathe could handle. Since he could turn 12" parts, he decided to make a 12" diameter rocket. Thinking BIG, he decided to carry as much propellant as he could while maintaining a reasonable takeoff acceleration. Thus he ended up with a 45 second burn duration. After the dust settled, he ended up with a 20 foot long monster of a rocket that will hopefully break 200,000 feet in altitude.

In Scott Claflin's case, he selected a thrust level of 1666.66. Why you may ask? Thinking ahead, he thought that if he clustered 3 of these systems he would achieve 5000 lbf in thrust. Knowing propellant flow rates, and the volume of existing propellant tanks he planned to use, the burn duration was set. As you can see, there are many different factors that influence these selections.

Hopefully, this article has given some insight as to the thought process that goes in the early stages of a liquid rocket project. Stay tuned for more.

Upcoming Events

A launch and static test firings have been planned for the weekend of March 7th & 8th at the MTA. The planned firings are:

<u>Static Tests</u>

1) Scott Claflin's 1600 lbf LOX/Alcohol system. This system was successfully fired in March of 91. Scott has refitted his system with a flight pressurization bottle (scuba tank) and fabricated a new ablative liner for the combustion chamber. This static test will characterize his flight system prior to flight.

2) Brian Wherley's & Dave Crisalli's 600 lbf LOX/Alcohol system. This will be the first test on this system. It features a F-O-O-F injector pattern, two fuel streams impinging on two oxidizer shower heads, housed in an ablative chamber similar to Scott Claflins design. There are high hopes that the injector pattern will provide good performance.

3) Steve Palm's 1000 lbf LOX/Alcohol system. This system was also successfully fired in March of 91. Steve has swapped out Atlas Vernier chambers, due to coolant flow blockage observed after the first test, made modification on his LOX dome to provide a better seal, and refitted his system with a flight pressurization bottle. This static test will characterize his flight system prior to flight.

4) Tom Meuller's 50 lbf LOX/Kerosene system.

<u>Launches</u>

5) Bruce Markel's radio controlled rocket with prepackaged solid propulsion system. Bruce has built a 1/3 scale rocket of Dave Crisalli's sounding rocket to explore guidance techniques. He has fitted the rocket with radio controlled servos to provide active guidance control from the ground. This flight will determine the sensitivity of the system.

Dave Crisalli will pyro-op the event. The tests should start early Saturday, and go throughout the day. We hope to complete all the firings on Saturday.

Mojave Test Area Map

Milage figures as shown are approximate

Bring plenty of food & water

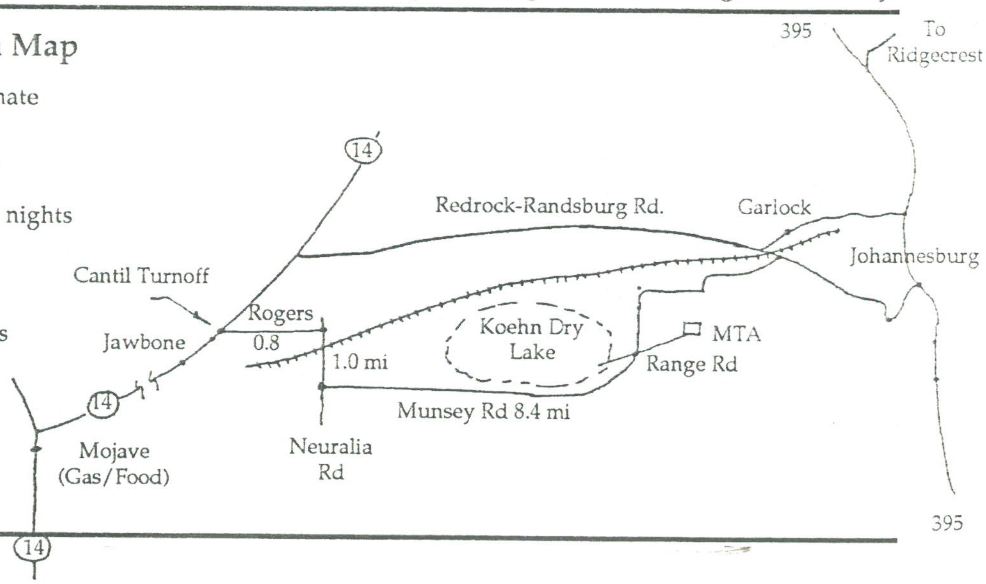
Be prepared for the Sun's rays & Cold nights

Be careful of snakes

Desert tortoises are a protected species

Watch for flash floods in river bads

Walking on dry lake bed is not recommended



Look here next issue for an RRS merchandise order form. Items will include shirts, video tapes, key chains, tie-tacks, mail flight envelopes, reports, etc.

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The March meeting will be held on March 13 at the Samwa Bank Building, 6th floor conference room at 8 pm. The building is located where the I5 intersects Washington Blvd in the City of Industry. See map.