TRIPOLI Report

JOURNAL OF THE TRIPOLI ROCKETRY ASSOCIATION, INC.
Volume 28 Number 4 - November 2017

The *TRIPOLI REPORT is* the business and communications publication of the Tripoli Rocketry Association Inc.

Submissions to this publication, in the form of articles, opinions, and photos, are accepted. The ***TRIPOLI REPORT*** reserves the right to reject or edit any material submitted.

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Cover photo: Big rockets need big pads and make big holes. As with the game of golf we must remember to fill in our divits. *Photo by Gerald Meux Jr.*

Photo to Left: Jose Guerricabeitia's "Bugs In It" lifts off on an L1120 motor. *Photo by John McVey*

Tripoli Private Discussion Forums

The Tripoli Rocketry Association supports on-line forums for TRA members, hosted on the TRA website

Along with other features and information available only to members at **www.tripoli.org**, the forums provide an opportunity to interact with TRA members around the globe.

To access the TRA forums, log on to the tripoli.org website, using your 5 digit member number and your password (*note - when accessing the website for the first time, select 'Reset Password' and follow the instructions to set your initial password*). Once logged on select "Forums" at the top of the screen.

For assistance with the website or online forums, please contact **bvb@tripoli.org**

TRIPOLI ROCKETRY ASSOCIATION, INC.

FROM THE PRESIDENT

by Steve Shannon

Lack of Respect for Launch Hosts and Site

At BALLS this year, after the range closed on Saturday night, a group of young people who attended BALLS dug a hole in the playa a short distance (much less than the required safe distance) ahead of the flight line, half-buried a large carbon fiber cased motor, and ignited it. This was done without the permission or knowledge of Tripoli Gerlach or any of the launch crew. To make matters worse, they then left their burned up, half-buried trash and ignition leads still planted in the playa.

The next morning a lady from Friends of Black Rock found the mess and started to clean it up. What do you suppose was going through her mind at the time? What *impression of Tripoli* would be left with her? If she complained to BLM, how would *they* receive the news?

Fortunately, Fred Azinger prevented her from picking up the sharp pieces with her thin gloves, and then he dug up and cleaned the spot himself. To Fred Azinger, I say "Thank you for positively representing Tripoli." Unfortunately, human nature being what it is, when that lady talks about what she saw, heard, and experienced during the BALLS weekend, which part of her story is likely to gain the most traction? Nothing gets communicated as quickly as negative news. What if she had cut herself on the carbon fibers?

The rules at BALLS prohibit campfires built on the surface of the playa. I'm pretty sure that a spent rocket motor, blackened and sticking out of the ground with wires hanging off it, would seem like a greater offense to a BLM person or casual bystander. Whether it is worse or not, that perception is equally capable of damaging the reputation of Tripoli and the BALLS event.

It's very easy to lose a good launch site. As President Reagan said, “Any jackass can kick down a barn.” It's not quite as easy to leave a good impression on landowners, neighbors, and spectators but that's what we each need to try to do. Every one of us has a responsibility to learn the rules of a launch site and to show respect and appreciation for the efforts of the launch organizers. Every flyer and spectator should strive to leave the site in better condition than when we got there, by packing out everything we bring, by being careful not to leave burns, ruts, or holes in the surface, and by cleaning up trash, both our own and somebody else's that may have been there for years.

I hope the young man and his companions who left the trash behind for others to pick up reads this and learns from it. I was young once and I can't claim to have always done the most responsible things, but if I can learn, so can they.

FROM THE EDITOR

by Ken Good

The Constantly Changing Cutting Edge

This month has seen the loss of Ron Schultz, the founder of LOC Precision, supporter of the early high-power rocketry movement, and a strong advocate of Tripoli in its days of transition to a modern, international rocketry organization (see page 12 of this publication). I well remember Ron and his wife Deb from those days when LDRS was new, and they were creating some of the first high-power-compatible kits, more or less in their own residence. I recall thinking that it may be difficult for Ron to actually make a living at this, and wondered how successful his nascent company may be. In fact, I bought a Laser-LOC 1.5 kit from him, as much or more to give some modest business to him as opposed to actually needing the rocket. Of course, I suppose I needn't have worried, since LOC survives to this day under subsequent owners.

Ron Schultz and Ken Good (to Ron's right) discuss things with New Jersey rocketeers at the Z-1 Launch of 1986. From "SNOAR News" - July, 1986.

I kept that kit for a number of years, finally building and flying it many times, only to lose the rocket, but with someone locating the weathered nose cone a few years later. I still have it (see photo) and it reminds me of how Ron made things in those days. It's a beautiful, lathe-turned hardwood item, which was originally fitted to a heavy-walled fiber-tubing airframe with high-quality plywood fins. That was pretty much the formula for cutting edge high-power rocketry then; as we know, much has changed.

Jumping forward to 2017, I have fresh memories of BALLS this past September. I can't say there was much cardboard and plywood flown there to represent the current state of our most advanced high-power hardware. Carbon fiber, aluminum, and fiberglass, with aspirations of Mach 3 and 300K feet (with, of course, Ky Michaelson's two space shots) constitute our current cutting edge. This is the progress we have witnessed in the three decades since Ron Schultz kicked off his company. We have been led to where we are now by the very spirit Ron engendered, and which so many in Tripoli and supporting companies have sustained.

Laser-LOC 1.5 turned-hardwood nosecone, from an early LOC Precision kit.

There is now a wide band of high-power rocketry activity in which TRA members engage across our international footprint. LOC Precision and many other companies support that range of flying, which is clearly wider and more diverse now than it ever was in the early days.

Those of us who knew Ron Schultz will miss him, even though we may not have seen him in some time. But all of us - even those who never met Ron – should think of where Tripoli and high-power rocketry is today, and salute him for his important role in pushing us forward.

2018 TRIPOLI BOARD OF DIRECTORS CALL FOR CANDIDATES

by Bill Riley, Election Committtee

Now Is Your Chance To Step Up

As we close out this year and look ahead to 2018, it's time for Tripoli members to weigh their interest, ability, and availability to serve as a director of the Association. Serving the hobby in this role affords one the opportunity to collaborate in leading our international organization. If you have a desire to work closely as a member of the Tripoli leadership team serving your fellow flyers, then now is the time to polish up your resume.

Resumes may be submitted beginning December 19, 2017, and must be received by 23:59 PST February 17, 2018. Complete resumes must be received by this date; all submissions will be acknowledged. Late submissions or edits cannot be accommodated.

According to our bylaws, eligible candidates must be at least 21 years of age and a Tripoli member in good standing. Resumes should describe your qualifications for the role and any other relevant information that demonstrates your competency to serve as a director of the Association. A suitable current photo of you must be included with the resume, and you may optionally include a link to an online video hosted on the Tripoli Rocketry Channel*. Candidate resumes, photos, and videos will be published on the Tripoli website by March 1, 2018, and in that month's Tripoli Report issue.

As a candidate for the board of directors, your participation in discussions on the Tripoli website forums is encouraged, demonstrating your availability and accessibility. Taking advantage of these tools will enable the membership to get to know you better.

All eligible voting members as of February 28, 2018 will receive instructions for online voting via email. Online ballots will be open on March 19, 2018, and close on May 11, 2018 at 23:59 PST. A valid email address and your current membership card are required to participate in the online election. Per the association bylaws, manual ballots may be submitted in person at the annual meeting.

This is your opportunity to serve the organization and your fellow flyers by submitting your candidacy to serve on the Board of Directors.

Please submit resumes or questions about the election process to BRiley@Elections-Tripoli.org.

*Please contact the election committee, BRiley@Elections-Tripoli.org for video submission details.

BoD ACTIVITIES

BOARD OF DIRECTORS MEETING

Date: July 20th, 2017

Time: 19:00 EST

Location: LDRS 36 Host Hotel

Present: Steve Shannon
Debra Koloms
David Wilkins
Dave Rose
Burl Finkelstein
Gerald Meux
Stu Barrett
Tom Blazanin

Apologies: Dick Embry

Proxies: David Wilkins for Dick Embry

Motion: Approve minutes from last meeting on 15-Jun-17

Moved: Koloms
Second: Shannon
Passed: Unanimously

Tripoli TMP and NAR Junior Programs

Discussed adding a TRA L1 class flight as part of the TMP and this gets recorded as part of the members' progress. For a TMP L1 flight.

Motion: Amend the TMP rules to add the ability to have a L1 flight as part of the program and this to be performed with a mentor. Once the TMP member turns 18 this will be recognised as a successful L1 certification for the member.

Moved: Shannon
Second: Koloms
Passed: Unanimously

Action: Add mentor to UCF and add this to the UCF/Members database – David Wilkins

LDRS Update

- Landowners are clearing out a large site.
- Looking at a cheaper alternative for the banquet.
- Web page to be live before BALLS.

Complex Distances Change to TRA Research Code

Bob Brown objects to the change made to the Research Code to make it safer.

At his Airfest launch he is going to raise a petition to revert the change made to the TRA Research Safety Code that bought it in line with NFPA 1127's safe distances for multiple flights. Bob Brown is also going to bring this to Mid-West Power

The only fatality caused by a rocket in this hobby was a result of a multiple rocket launch, wasn't TRA or NAR, but was a small rocket. This is talking about K motors; they would cover the distance in a few seconds.

Too many objects in the air represent one of the biggest risk activities. It's crazy logic to ignore a real risk just because it hasn't resulted in an incident.

The rule manages the distance, so reducing the number of rockets in-flight reduces the distances.

***Action*:** Gerald to follow up with Bob Brown on the multiple launches distance, and make it clear he can submit a proposal if he wants a change considered.

New TAP nomination (David Raimondi)

Gerald provided additional positive feedback that David would make a great TAP.

Motion: Approve appointment of David Raimondi to the TAP committee

Moved: Shannon
Second: Wilkins
Passed: Unanimously

BALLS Update

Tom advised that the BLM says the lake is drying out nicely, but generally out by the Quinn River sink. Repairs to Bruno's Hotel will be done by BALLS. Lacy (from Bruno's) and her son went out around the Burning Man area; you can drive on the playa but 6 inches down it is wet.

Aeropac is holding Aeronaut on 4/5 August; if they have trouble with Aeronaut BALLS maybe be at risk.

Tripoli Gerlach continues to watch the condition of the playa.

Can FAA allow a move of the extreme altitude launch location further west given the condition of the playa?

Dick, Steve, and Kent will be speaking to FAA at the Salt Lake City meeting.

Tom advised that Jim Green from Aeropac says that the playa is drying, and based on his experience, it is drying quickly. They have had multiple 100+ degree days. In

his opinion the playa will be dry for BALLS.

Research FAQ

Research FAQ is updated and we will accept all the Steve Shannon updates and then publish it to the website.

SharePoint Update

SharePoint remains down. We don't have a backup site, hosted by Greg Deputy, we have data out of the virtual machine and we rebuild it. The rebuild will include an update to SharePoint 2010. We have the data secured, and using DropBox as an interim space for now.

PayPal Cutover completed

Cutover of all join and renewals for members are now directing to Dave Rose. This removes Bruce Lee from this process.

Spaceport Cup / ERSA

Tony Alcocer did a huge amount of work to support the event. Steve Shannon spoke to Tony suggesting that Tripoli could provide safety checking program to help. It was agreed it would be a good idea.
Tony will discuss the option with the hosts, i.e. that this might be a great time to suggest the additional support.

Meeting adjourned: 22:12 EDT

BOARD OF DIRECTORS MEETING

Date:	August 17th, 2017
Time:	21:00 EDT
Location:	Teleconference
Present:	Steve Shannon Debra Koloms David Wilkins Dick Embry Burl Finkelstein Gerald Meux Gary Rosenfield Tom Blazanin
Apologies:	Dave Rose
Proxies:	Tom Blazanin for Dave Rose

Tripoli TMP change implementation

Some feedback has been received, stating that the TMP test is difficult. Can we look at giving them a learner's permit, i.e. access to the range while they are learning?

Questions are online, so they can be practiced.

Consensus is not to give the early access; the exam must be passed before a junior member has access to the range.

Drag Race safe distances

No change in the view of the BoD. Nothing presented so far has addressed the reason for the change, and that is safety.

The change to the code was part of the safety code review, and the code was adopted as a whole.

We need empirical data to justify a change at the NFPA level. The risk is real and just because we haven't had an incident, it's not acceptable to conclude that it is safe.

There are myriad examples where this flawed approach has proven lethal.

Gerald followed up with Bob and he won't raise a change to the rule as there is not support for it on the BoD.

It's up to the proponents that this is safe for them to prove with data that it can be conducted safely.

LDRS Update

Tripoli Central California is still working on banquet at the Harris Ranch, with registration, banquet and parking to total less than $100. Banquet will be an appetiser and a drink or two entrées can be ordered separately.

Website is still in preparation, but really needs to be available for November 1st. at the absolute latest.

BALLS Update

Five Class 3 flights expected this year, including Jim Jarvis with a multi-stage flight - a two-stage Q to M with expected altitude of 200,000 feet.

New plastic/paper wrist bands in four colors. Flyers are Green, Away Cells are Yellow, Staff/BoD are Blue. Spectators will be White.

Pre-registrations have picked up steadily since the announcement that BALLS is a "go."

We will have a BoD meeting on the Thursday evening at 7PM PST at the backroom of Bruno's.

Action: Tom to book back room at Bruno's

FAA Update

Salt Lake Center is concerned that we are being restricted to access airspace. They are looking at the conflict with playa access issues.

Spoke at length about the Reno MOA being used for air refuelling and why we are getting windows. BLM is doing an environmental survey; Dick has submitted some input to this and the draft will be submitted to the BoD for comment.

Anything east/north-east of BR-15 will be a problem as surface conditions are poor on the playa.

We are still discussing for next year to move the location, however this will depend upon FAA.

BLM and FAA will be onsite at BALLS.

SharePoint Update

SharePoint framework is built and is ready. Need to work with Greg Deputy to bring it online, and will be bare of old data. The old data is secured but we need to extract the documents and re-upload.

The new site will also be SSL secured.

Worst case - we will bring it online in Melbourne until it can be relocated to Seattle.

TMT Motor Certifications expiry

Tripoli got behind in re-certifying, and there are now motors that need to be re-certified.

The process will need some sort of blanket action, to re-certify

We also need folks to report via the MESS function. This needs to be re-enforced. Maybe we look at prefects or a designate doing MESS reports.

Steve has also been in discussion with CAR and NAR S&T to have a summit meeting in April during the NASA SLI event to discuss uniformity in motor certification policies.

Meeting adjourned: 22:21 EDT

BOARD OF DIRECTORS MEETING

Date:	September 21st, 2017
Time:	19:00 PDT
Location:	Bruno's, Gerlach, NV
Present:	Steve Shannon Debra Koloms David Wilkins Dick Embry Dave Rose Gary Rosenfield Tom Blazanin
Apologies:	Gerald Meux Burl Finkelstein
Proxies:	Steve Shannon for Burl Finkelstein

BALLS Update

Late start on Thursday due to weather - it's very cold. Will move to a 9AM start for tomorrow.

Unofficial title for this year's event: “Frosty Balls”

Highest planned flight is 300,000 feet flight. Currently 12 flights are planned for > 100,000 feet

FAA Update

Some issues with the lead time to file NOTAMS; FAA are not entering them until the last 24 hours. Confusion between the required time to file it, and we should follow what is on the waiver.

We need to follow the letter of the waiver to ensure consistency.

Dick suggested we talk to the FAA and see if we can get Reno MOA, segmented this could allow better access to BR15 on weekdays. This will take time, as airspace changes require consultation with other stakeholders.

Dick is concerned about a conflict with Burning Man closing off access to the playa, which is preventing access to airspace. Japanese students were held back at 12 Mile, delaying them. We have to work this out.

Action: Dick to discuss with Burl to determine our rights in relation to access to Black Rock.

Airfest Feedback Session

The BoD reviewed the questions which were presented at Airfest, and will be responding to them on the Tripoli Forum.

Spaceport Cup Article

Steve has been speaking with Andy Berger and Tony Alcocer about teaching them rocket safety, and also allow us to monitor the development of their

technologies. We should participate with ERSA to support the Spaceport America cup.

Action: Steve Shannon going to work with Andy and Tony on discussions with ERSA

Action: Steve to talk to Roy about Outreach Committee

TMT Update

Load cell was damaged during some research testing. Burl to work with Alan on a possible change in the stand design to limit future damage.

A summit between NAR/CAR/TMT will occur a couple of days before SLI next year.

TMP Changes Implementation

Do we issue an L1 badge to TMP flyers who achieved their M1 cert flight or do we issue a new M1 pin that gives the certified member something they can aim for? An L1 badge would be given on the member becoming 18 years of age.

Action: Dave Rose to get quotes for a new pin.

We do not have reciprocity with the NAR Junior Level 1, so we can't recognise the NAR Junior L1 flight.

Publication Archive

HQ has copies of all the printed publications. We have members requesting digital access. It's a major undertaking and digitising this will be very time consuming.

Anything we currently have digitally, or has been created electronically, is being published to the website.

Members are volunteering to do it, and if they have access to a commercial scanner, it might be possible to be done cheaper.

We would also need Bruce Kelly's permissions. We need to secure that in writing, as HPR was separated from Tripoli and a release needs to be secured to protect Tripoli.

Motion: Purchase the rights to HPR magazine for $500 from Bruce Kelly.

Move: Tom Blazanin
Second: Steve Shannon
Aye: Shannon, Koloms, Wilkins, Rose, Blazanin, Finkelstein, Rosenfield, Embry
Nay: None
Motion Passes unanimously

***Action*:** Tom Blazanin to discuss with Bruce Kelly and we pay for the rights to the HPR magazine to a limit of $500.

***Action*:** Dave Rose to look into possible services to scan the existing content at HQ.

Membership Consultation

Members should engage with the BoD via the member's forum as the BoD is viewing this actively.

We need to communicate how to subscribe email to the forums.

We need the forums to be mobile accessible, but due to OpenSource, to fix the TapaTalk link.

***Action*:** David to see what it will cost to get the link fixed to support

Home built electronics and Level 3 flights

James Russell has real concerns about altimeters that are kits and being used in Level 3 flights. His principle concern is build quality.

Homemade electronics becomes a research-style item, e.g. Hardware and Software/Firmware is of their own creation. These shall not be used for any certification flights.

Commercially supported kits such as Eggtimer/Missileworks or commercial altimeters are approved for certification flights.

***Action*:** Steve Shannon to discuss with James and post to the sticky thread on the forum for further input.

Election Timeline

Election Committee timeline, Bill Riley has just finished moving but David will follow up with him for a timeline.

Manufacturer's Committee

Gary Rosenfield suggests we create a manufacturer's committee.

***Action*:** Gary to create a discussion paper of the purpose and scope; is it limited to motor manufacturers and needs to have an independent BoD member.

Once we have the scope we should poll the members to see if someone would like to chair it. Chair needs to be independent.

Meeting adjourned: 21:15 EDT

COMING IN THE NEXT ISSUE . . .

BASIC TEST STAND
MAKING HOLES
TAPPING HOLES
USING DIES

BOARD OF DIRECTORS MEETING

Date: October 19th, 2017

Time: 19:00 PDT

Location: Teleconference

Present: Steve Shannon
Debra Koloms
David Wilkins
Dave Rose
Burl Finkelstein
Gary Rosenfield
Gerald Meux

Apologies: Tom Blazanin
Dick Embry

Proxies: Dave Rose for Tom Blazanin
David Wilkins for Dick Embry

TMT Capabilities

Request for new load cells to provide TMT the ability to test motors of all sizes through 2000 lbs. thrust.

Discussion of support for hybrids in addition to APCP. We must be able to certify hybrids, but because of the additional cost of test apparatus which allows vertical testing, the option remains for TMT to visit the vendor to calibrate and then certify on the manufacturer's test cell.

It makes sense to have TMT capable of testing the full range of motors, up to 98mm case size. TMT also to explore looking at 6" (153mm motors).

Motion: TMT to get an estimate for a 10,000 lbs. load cell and required infrastructure to support 6" motors

Moved: Deb Koloms
Seconded: Steve Shannon
Aye: Koloms, Shannon, Wilkins, Rose, Embry, Meux, Finkelstein, Blazanin
Abstain: Rosenfield
Motion passes

TMT Update

A regular phone call between three NAR/CAR/TMT chairs and respective presidents, to work on issues ahead of the summit meeting at Huntsville.

LDRS Update

Still awaiting an update from Tripoli Central California (TCC) on a number of issues, including the website and other issues.

Steve spoke to James Dougherty, and TCC have moved away from the Harrison Ranch. Looking into a new host hotel.

Possible fireworks show one evening. Perception could be that Tripoli is endorsing a fireworks event; this cannot be promoted as part of the LDRS event. It needs to be a separate commercially provided and insured event for the activities if they go forward at all.

James also looking to put up an air-conditioned tent, to help folks during the event, as temperatures can reach 110 F during the May dates. Good idea!

Waiting on advice of website go-live; needs to be up by 11/1/17.

FAA Update

Dick Embry has asked about night launches in the upper Midwest. Chicago Center is adamant about not allowing night launches. There is a lot of traffic out of Chicago and the Chicago Center Manager is concerned about conflicts. This is unlikely to change for this location.

One of the center manager's concerns is the perception of aircraft seeing rockets streaking up towards them, even though it's below them. Pilots have no idea how high that rocket will fly.

IT Update

Replacement SharePoint site is ready, will be uploaded shortly, and new usernames/passwords will be issued to all users. Older data will be on-loaded following the new site becoming available.

BLM and Burning Man

Burning Man Inc. is getting a larger time-window which may conflict with BALLS, ARLISS/XPRS. The overlap is mainly around their clean-up events. If the attendance is increased this could lead to a longer lock-out from the playa.

Burl to make sure BLM is advised of our schedule to make sure ARLISS/XPRS and BALLS events are not impacted by Burning Man clean-up. The issue of 12 mile being closed is a major issue.

BLM has indicated it is aware of the rocketry activities and won't do anything to prevent our access to the playa.

Tripoli BLM permit for Black Rock will be moved across to Deb Koloms to manage, and will continue to be managed for all prefectures using the playa.

M1 Certification Pins

Dave obtained quotes for a M1 pin for TMP certified members. Setup costs $500 for a minimum order of 250 pins.

Motion: Approve the purchase of 250 M1 certification pins for $500

Moved: Dave Rose
Seconded: Deb Koloms
Aye: Koloms, Shannon, Wilkins, Rose, Embry, Meux, Finkelstein, Blazanin, Rosenfield
Passes unanimously

Conversion of Old Magazines to Digital

Quotes from service providers was $650-$1200 per issue.

Looks like it's best to do a crowd source and members, who want to volunteer to do this in small groups, starting with the 2003 Tripoli reports and working back from there.

We have two volunteers, and tests to be done to make sure we have an archive version and a version for publication.

2003 to be the first year to be processed

Meeting adjourned: 22:19 EDT

RON SCHULTZ

December 8,1947 • November 1, 2017

Ron Shultz, founder of LOC PRECISION, passed away on November 1st, 2017 of lung cancer and other complications.

Ron was a major contributor to the rise of High Power Rocketry, developing rocket kits specifically designed to accommodate large composite motors above the G range. He was a presence all over the country, promoting not only his LOC kits but composite motor manufacturers AND the young Tripoli Rocketry Association.

Though Ron retired from rocketry several years ago with the sale of his company, his rocket designs and contributions to High Power Rocketry still live on today as a major part of HPR and the Tripoli Rocketry Association, Inc.

Thank You Ronnie

THE HOBBY SHOWS

by Chris Pearson

It was with some sadness today that I learned the iHobby Expo, formerly called the RCHTA Show, has been cancelled and is not expected to ever resume. The original RCHTA Show, (Radio Control Hobby Trade Association) was, as its name suggests, an association of RC plane manufacturers. In the fall of each year, they had an industry show, which at first was open only to hobby shop owners and others in the business. They later allowed first trains, then crafts and even things like doll houses and scrapbooking in. They also began to allow the public to attend the show. The last time I was there, Thursday and Friday until 6PM were trade days, Friday night and all day Saturday and Sunday were open to the public.

The show was traditionally held at the Chicago Convention Center, now called McCormick Place. It was the largest hobby show in the US, second only in size to the Berlin (Germany) Hobby Show. In the 1980's and into the 90's, if you had a hobby business, you had to be at that show. Of course, the big two model rocketry companies, Estes and Quest, exhibited their new wares to the hobby shop owners and public. A smattering of other model and high-power rocket companies also attended, such as Custom Model Rockets, Starlight Model Rockets, PML, NCR, Aerotech and LOC/Precision. However, the hobby landscape changed in the late 90's. It just wasn't the Internet that hurt the hobby industry or caused the shuttering of hobby shops. The interests of young people changed from hobbies like plastic models and rocketry to video games and later social media. The last president of Centuri, Jeff Flygare, complained to me at NARAM-20 (1978) that "all the kids were putting their quarters in Pac Man games and not buying rockets anymore". So the writing was on the wall decades ago.

It also became prohibitively expensive to attend hobby shows, either as a manufacturer or a shop owner. The displays for companies like Estes, Futaba or SIG were huge and it cost a fortune to build, ship and assemble the displays at the convention center. The Chicago Convention Center is controlled by the Teamsters, so you had to use union labor to unload your truck, move and assemble your display. You want an AC outlet to plug your VCR into? $75 per day per outlet! In later years, because of complaints, you were allowed to move and build your own display as long as you didn't need tools to do it. You could also plug in your own AC cords, and not have to wait for an electrician to do it for you. Even if you were a hobby shop owner, the motel rooms around the convention center were expensive, even if you stayed in a second rate place like a Holiday Inn. Food and rental cars were also very expensive, compared to say, Orlando.

In 2012, they moved the now renamed iHobby show to Cleveland, Ohio and shortened the show to three days in an effort to reduce costs for the attendees. I, myself and others from NOTRA ran the booth for Tripoli and our club at the show. The result of the move was that many of the big-name companies, including Lionel, Futaba, Estes and Quest, chose not to attend. They moved it back to Illinois the following year, but held it in the Schaumburg Convention Center, outside Chicago. They then changed management companies and moved the venue to Edison, NJ, but the result was even more vendors and manufacturers fled the show. After four years of declining attendance and a general lack of interest by manufacturers and the public, the decision was made this past August to cancel the show permanently. In the end, it had become a two-day mid-week show back in Schaumburg, IL, which this year was scheduled for October 4-5.

The iHobby Expo follows other US hobby shows into oblivion like the IMS (International Modelers Society) Show.

The HMA (Hobby Manufacturers Association) who ran the now defunct iHobby show has started another hobby show to take its place. It is the Rocky Mountain Hobby Expo, and it's being held in Denver, CO. If you absolutely have to go to a hobby show, here is the link: http://www.hmahobby.org

Unless you attended one of these shows at its peak, you could not understand the incredible excitement of going into a place as big as a football stadium and have it filled wall to wall with hobby stuff. The feeling was electric! It was an absolute geek fest and hobby sensory overload! On the public days, the line waiting to get into the show was wrapped around the building an hour before opening. Even though I was on my feet for 14 hours in the North Coast Rocketry booth some days, I really enjoyed the show. I look back on those days with a certain amount of nostalgia. I will miss it.

NEW TO BURNSIM? OLD USER AND STILL CONFUSED?
THIS WILL HELP

BURNSIM for DUMMIES

THE MISSING MANUAL

by Chris Pearson & Greg Deputy

Understanding The Screen Layout • Recognize Big Words • Make It All Work

Back in the early days of HPR, many people, including myself, experimented with making our own motors, mainly because there were virtually no composite motors available at the time! Propellant formulas were then a closely guarded secret. Today, many common formulas are available free on the Web, and many other like-minded Research rocketeers are usually willing to share their formulas. Commercial classes in propellant mixing and motor construction are routinely held and available to anyone. And many Prefectures have propellant making seminars that are open to members interested in making their own motors.

For those high-power rocketeers who want to enter the realm of Research (or EX) rocketry, BurnSim is a valuable tool which allows the enthusiast to design and test various motor designs and propellant formulas before mixing and casting propellant for the first time. This can save a great deal of time, chemicals and expensive hardware as motor burns can be simulated without having to mix and burn propellant in an actual motor.

Unfortunately, there is no instructional manual for BurnSim. Help is available by pressing F1, but it is very limited. You have to know what you're looking at to understand everything that BurnSim is telling you. While it is good to have someone around that is experienced in using it, many times this is not an option.

While many of the terms used in BurnSim are self-explanatory (i.e., grain diameter and length), many are not. The following is a list of definitions and some suggestions of values and figures that could be valuable for those using BurnSim for the first time.

Nozzle and Thrust

Nozzle Throat Dia. – The diameter of the narrowest part of the nozzle throat in inches.

Nozzle Exit Dia. – The final diameter of the diverging section of the nozzle in inches.

Expansion Ratio – The ratio of the nozzle exit area divided by the nozzle throat area. BurnSim will calculate this automatically from the Throat and Exit diameters.

Ambient PSI – If you launch at sea level this value is 14.7 psi. If you launch from higher altitudes or air-start a motor, you will have to convert the altitude pressure to psi.

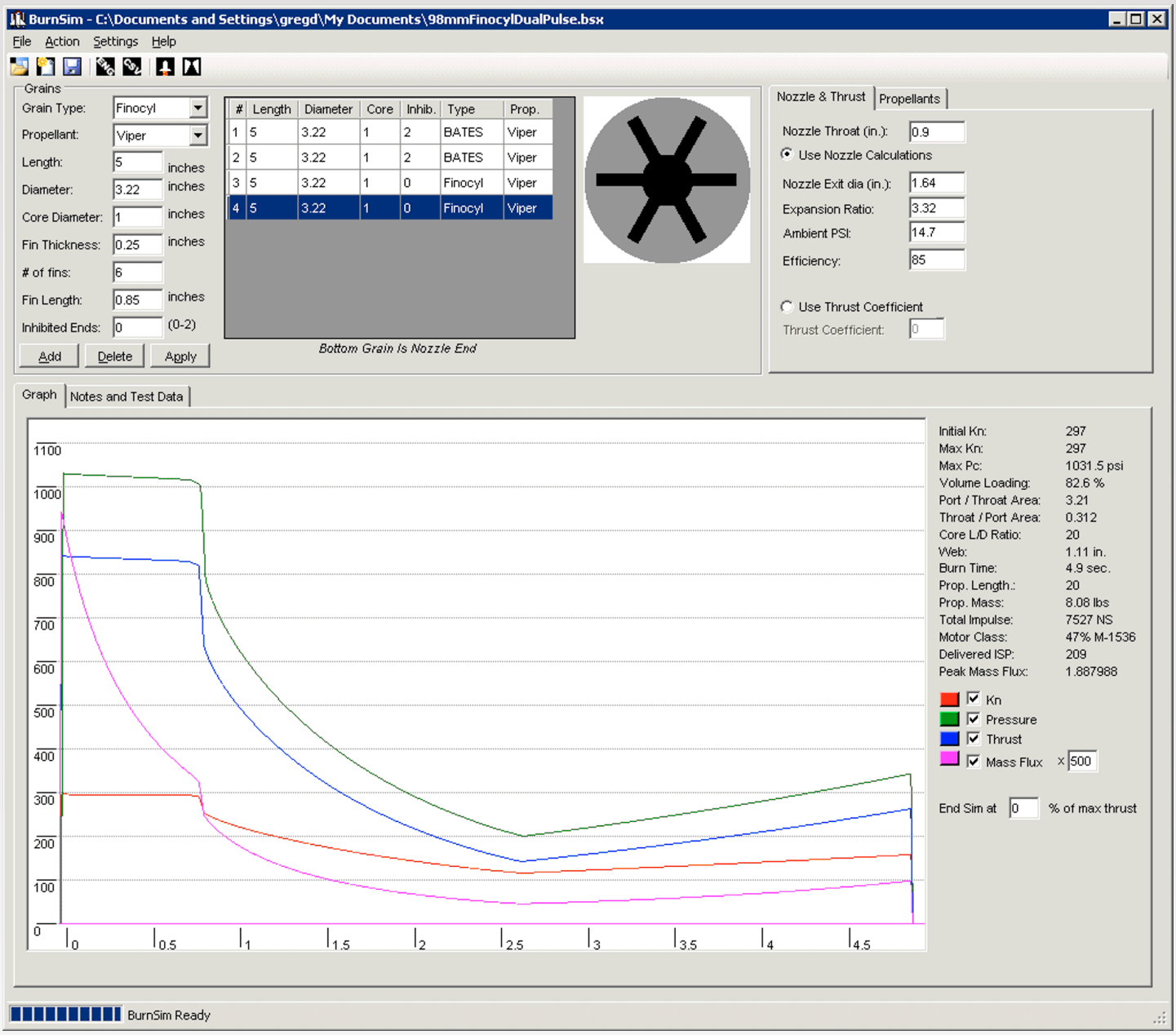
Efficiency – Usually set to 95%, assuming that you are using valid c* numbers for your propellant. Smaller motors will tend to have a lower efficiency, larger motors a higher one.

Thrust Coefficient – The amount a motors thrust is augmented by nozzle effects. Values usually range from 1.2 to 1.4. 1.25 is the value normally used.[1]

Propellants Standard Properties

C* - The Characteristic Velocity, also called c-star or simply c*, is a figure of thermochemical merit for a particular propellant and may be considered to be indicative of the combustion efficiency. [2]

Char. ISP – Characteristic Specific Impulse (Isp*) is the expected propellant performance in seconds not



BURNSIM Screen Capture for Reference Use

including nozzle contribution. This is not the same as Delivered ISP.[3]

BR Coef (a) – The Burn Rate Coefficient (a) is a propellant characterization value and is defined as the "rate constant." The value of a depends of particle size of the oxidizer and solid fuel and generally indicates how temperature affects the burn rate.[4]

BR Exp (n) – The Burn Rate Exponent (n) is a propellant characterization value, represents the "molecularity" and describes the burn rate of the propellant at a given chamber pressure.[4]

Density – The measured propellant weight in pounds per cubic inch (lb/in3).

S. Heat Ratio – Specific Heat Ratio refers to the ratio of the heat capacity of propellant burning at constant pressure (CP) to heat capacity at constant volume (CV) of the propellants exhaust products. [5] Usually set at a value of 1.25.

Mol. Mass – Molecular Mass refers to the mass of a molecule. It is calculated as the sum of the mass of each constituent atom multiplied by the number of atoms of that element in the molecular formula. This value is optional in BurnSim, not required for normal simulations.

Graph

Initial Kn – The propellant surface burn area divided by the throat area at motor start up. [6]

Max. Kn – The propellant surface burn area divided by the throat area at its maximum, often at burn out.

Max. Pc – Maximum combustion chamber pressure experienced during motor burn. [7]

Volume Loading – Total percentage of motor volume that is propellant.

Port/Throat Area – Ratio of the bottom grain port area to the nozzle throat area. [8]

Throat/Port Area – Ratio of the nozzle throat area to the bottom grain port area.

Core L/D Ratio – Ratio of the length of the propellant core divided by the core diameter.

Web – The thickest depth of the propellant that the flame front will burn through. In a Bates grain motor that is the distance from the outside edge of the propellant grain to the outside of the core. It varies for other core geometries.

Burn Time – Actual operating time of the motor in seconds.

Propellant Length – Total length of the propellant grain(s) in inches.

Propellant Mass – Total mass of the motor propellant in pounds.

Total Impulse – The time integral of the thrust over the operating duration of the motor. Units are those of force multiplied by time, typically pound-seconds (lb-s) or Newton-seconds (N-s).

Motor Class – The commercial motor class letter designation and the average thrust in N-s. Also shown is what percentage (%) of that letter class the motor actually is.

Delivered ISP – The actual Total Impulse divided by the propellant weight or mass.

Peak Mass Flux – The peak propellant weight flow rate in pounds per square inch of core area. This is currently calculated at the bottom of the last grain only. It is a measurement of the mass of exhaust products moving through a given area and can be used to measure the onset of erosive burning.[9]

End Sim at % of max thrust – Not necessary to specify for normal operation. Many professional motor manufacturers set this value at 10%.

Notes:

[1.] Thrust Coefficient - This is an override value, to be used if the user wants to specify a thrust coefficient, rather than have BurnSim use the nozzle dimensions to calculate it. BurnSim calculates the value which changes as chamber pressure changes, so is usually more accurate than specifying a static value.

[2.] It is recommended that you use the value for c* as calculated by ProPep or other software. Values gathered experimentally can vary widely.

[3.] The Specific Impulse that a propellant is capable of producing (either theoretical or delivered) is the key "yardstick" of performance potential. In its basic form, Specific Impulse can be considered to relate the thrust produced by a unit mass (e.g. 1 lb or kg) of propellant over a burning time of one second.

Characteristic Specific Impulse (Isp*) is the expected propellant performance in seconds not including nozzle contribution.

Theoretical Isp is the ideal specific impulse delivered with a perfect nozzle. With a real world nozzle and motor the delivered specific impulse is typically 85-95% of the theoretical specific impulse.

The delivered Specific Impulse (Isp) of the propellant is simply the Total Impulse divided by the propellant weight or mass. Thus, the units for Specific Impulse are pound-seconds per pound (lb-sec./lb), or simply "seconds." In small motors the delivered Isp is often smaller than calculated or theoretical.

Isp = c*/acceleration of gravity (G). If you have a good c* value for a propellant, you also have the Isp*.

Also, BurnSim converts that on the fly. If you put in a c* value, Isp * is updated, and vice versa.

[4.] The Burn Rate Coefficient, like the Exponent is a value that must be determined experimentally through either ballistic motor tests or strand burn rate tests.

A low value for n (0.2-0.4) is desirable. Low n values means that the propellants burn rate will be less sensitive

to pressure change.

The values of a and n cannot be predicted except approximately. These are empirical quantities: a and n can change from one propellant batch to another.

Burn rate catalysts may increase either a or n, or both, depending on the type of catalyst. Metals generally increase both a and n.

[5.] Specific Heat Ratio - can be calculated using ProPep or other software.

[6.] Initial Kn is the area ratio of the burning propellant surface/area of nozzle throat. This is not minimum Kn, but initial Kn, that is, when the motor propellant first ignites. Chamber pressure is directly related to Kn, but because of the burn rate exponent this relationship is not linear.

[7.] Max Pc – Try to keep the maximum chamber pressure between 500-1000 psi. Higher pressures might damage your hardware. Open the nozzle throat to lower pressure. Binder rich smoky or sparky propellants need higher chamber pressures to operate efficiently. Reduce nozzle throat to increase chamber pressure. If chamber pressure gets too low, the propellant will not sustain combustion and will either extinguish or "chuff."

[8.] Port/Throat Area – If this number drops below 2.0 you will get a yellow warning indicator. If it drops below 1.0 you will get a red danger indicator. Enlarging the core on the nozzle-end grain is a good way to solve this problem. Except for extreme L/D ratio motors, no part of the core should be less than the diameter of the nozzle throat.

[9.] Erosive burning (or "erosivity") is the process where the high temperature gasses flowing at a high velocity inside the motor over the burning surface of the core speed up the burn rate of the propellant. See the Mass Flux/Erosivity Chart below.

Mass Flux/Erosivity Chart.

NON-EROSIVE		MAXIMUM RECOMMENDED EROSIVITY	
Max Pressure	**Core Mass Flux**	**Max Pressure**	**Core Mass Flux**
Pc = 400 psia	$\leq$1.00 lb/sec-in^2	Pc = 400 psia	$\leq$2.00 lb/sec-in^2
Pc = 500 psia	$\leq$1.20 lb/sec-in^2	Pc = 500 psia	$\leq$2.25 lb/sec-in^2
Pc = 600 psia	$\leq$1.38 lb/sec-in^2	Pc = 600 psia	$\leq$2.50 lb/sec-in^2
Pc = 700 psia	$\leq$1.57 lb/sec-in^2	Pc = 700 psia	$\leq$2.75 lb/sec-in^2
Pc = 800 psia	$\leq$1.75 lb/sec-in^2	Pc = 800 psia	$\leq$3.00 lb/sec-in^2
Pc = 900 psia	$\leq$1.79 lb/sec-in^2	Pc = 900 psia	$\leq$3.25 lb/sec-in^2
Pc = 1000 psia	$\leq$1.83 lb/sec-in^2	Pc = 1000 psia	$\leq$3.50 lb/sec-in^2
Pc = 1100 psia	$\leq$1.87 lb/sec-in^2	Pc = 1100 psia	$\leq$3.75 lb/sec-in^2
Pc = 1200 psia	$\leq$1.91 lb/sec-in^2	Pc = 1200 psia	$\leq$4.00 lb/sec-in^2
Pc = 1300 psia	$\leq$1.95 lb/sec-in^2	Pc = 1300 psia	$\leq$4.25 lb/sec-in^2
Pc = 1400 psia	$\leq$2.00 lb/sec-in^2	Pc = 1400 psia	$\leq$4.50 lb/sec-in^2

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HEAT AND PRESSURE

by ***PAUL DENTENT***

You may not be able to learn how to perform complex calculations. But, it is important that you learn to think in terms of what is actually happening inside of a solid rocket motor when it is operating. Saying “the motor blew-up because the pressure was too high" gives no insight into how the pressure got that way. Such a statement only describes the end result. There are two primary failure modes in rocketry solid motors: excessive heat (BURN THROUGH) and excessive pressure (RUPTURE). Most of the failures seen in rocket motors result from one of these two conditions, and both, though separate, are directly related to each other.

BURN THROUGH: the result of too much heat being transferred to the hardware. Heat is transferred to the case (or other motor parts) until the structural integrity of the construction material is weakened to the failure point.

Heat transfer is determined by three factors:

1 - How much heat is present (average temperature)
2 - How long is the heat present (duration)
3 - How much pressure is present

Pressure can greatly accelerate the rate of heat transfer. A good example of this is the difference between a "torch" and a "blow torch". Pressure in a motor is critical because it can "kill" the motor two ways: Enough pressure can obviously blow the motor apart (RUPTURE) but slightly less can cause enough heat transfer to "bake" the casing to the point that its strength is compromised. When this happens even lower pressure becomes sufficient to destroy the construction materials by "burning through”. When dealing with experimental propellants, a high metals content, without adequate shielding (liners), will lead to a burn through by the metal's combustion generating too much heat. Another factor of "burn through" is duration, or too much burn time. Even at what would otherwise be safely within temperature and pressure limits, sufficient heat can still damage the construction materials if the duration of operation is long enough.

CASE RUPTURE (bursting): The end result of the motors internal pressure exceeding the strength of any of the motors structural materials. One of the primary causes of excessive pressure is bonding failure between the propellant and the casting liner resulting in too much surface area exposed to the flame front. This has the effect of raising the Kn. This in turn, raises the internal pressure to more than the construction materials can withstand.

Note: There are two ways to raise Kn: restrict the nozzle or increase the propellants burn surface area. There are many other ways to raise internal pressure. A higher Kn is only one of the ways to raise pressure within the motor.

A burn rate that is too high will also create too much pressure. Excessive burn rates can be caused by any and all of the following factors:

1 - Excessive Oxidizer
2 - Excessive metals which create too much heat
3 - Too much burn rate catalyst
4 - Too much pressure

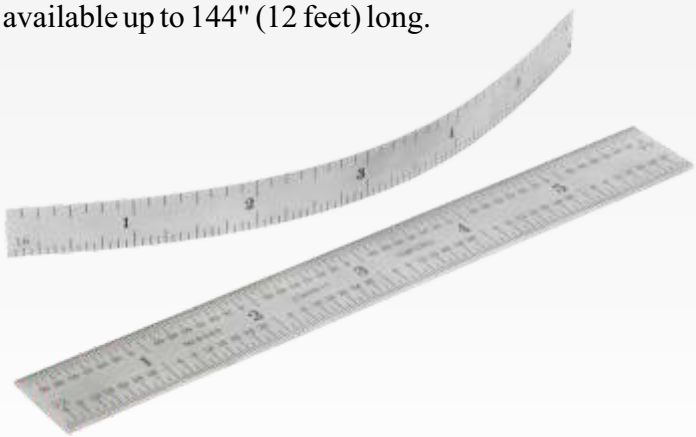
Pay special attention to #4. It sounds like double talk but . . .pressure will increase the burn rate and an increase in burn will increase pressure. This is because AP based solid fuel is "pressure sensitive". This is in fact what pressure sensitive means. A higher burn rate has exactly the same effect as an increase in the burn surface area. Sounds like double talk but each result in an increase in pressure.

USING A STEEL RULE

The steel rule is a basic measuring tool. When used correctly, a good steel rule is a surprisingly accurate measuring device.

What is a steel rule?
Some people confuse rules and scales. A scale is a measuring device used by architects and engineers that assists them in making drawings to a scale other than full size. A rule is used to measure actual sizes. (But don't ask about shrink rules, which are used to make casting patterns and include an allowance for shrinkage of the casting during cooling.)

Steel rules come in many sizes and formats. Basic 6" and 12" steel rules come in flexible and rigid forms. Flexible rules are usually ½" wide and 1/64" thick. Starrett calls flexible rules "semi-flexible." Rigid rules are usually ¾" wide and 3/64" thick. Starrett calls rigid rules "spring-tempered."
While most steel rules are 12" long or shorter, they are available up to 144" (12 feet) long.



3R
32nds
64ths
10ths
50ths

4R
8ths
16ths
32nds
64ths

5R
32nds
64ths
10ths
100ths

30 (Metric)
mm & 0,5mm
Both Sides

31 (Inch/
Metric)
mm & 0,5mm
Both Sides

What makes a good steel rule?
Conventional wisdom is that the best steel rules are machine divided. This means the graduations are cut on a machine that uses gearing to ensure the graduation

lines are evenly spaced and the correct distance apart.

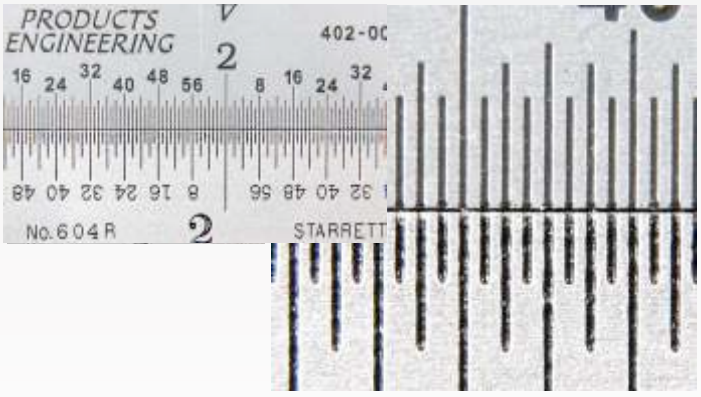
Most steel rules are now made by a photoengraving process called photo etching. A photosensitive resist is exposed through a precision master negative to create a pattern of masked and clean areas. An etching solution forms the graduations and other markings on the rule.

Good steel rules have uniform graduation line widths. Variation in line width makes accurate measurement difficult.

So let's take a look at the conventional wisdom. Are machine divided rules better than photo etched rules? When this marketing claim was first made, it was probably true. But now it is most certainly not true.

The process of machine dividing rules was developed about 125 years ago. It probably produced a major improvement in the accuracy of rules. But anything that relies on gears and mechanics must involve some measure of error, simply because the machine cannot be perfectly made.

Photoengraving, on the other hand, relies on a precision master to transfer the design to the rule. With a perfect master, each rule made from that master should also be virtually perfect. So the question becomes how well can a master be made? And the answer is very well indeed. The basic process for making steel rules is the same process by which computer processors and other integrated circuits are made with extreme precision. Current technology can create a master negative that is orders of magnitude better than required to make a steel rule.



The two major manufacturers of steel rules in the United States are the L. S Starrett Company (Starrett) and Products Engineering Corporation (PEC).

PEC makes steel rules for many of the other brands that are available in the United States. Starrett rules are machine divided, whereas PEC rules are precision etched. The preceding photos show the two companies' rules next to each other. The left photo shows the two rules at about full size. The right shows a section of each at a higher magnification. Which rule do you think is easier to read?

The material that a steel rule is made of is also important to the quality. Good steel rules are made from high-carbon spring steel that is hardened and tempered to Rc 47-52. They are chrome plated, usually with a satin finish, for corrosion resistance and readability.

You might have noticed the difference in color between the Starrett and PEC steel rules in the previous photos. PEC steel rules use a unique plating process to achieve a brighter, satin chrome finish that enhances the contrast between the black graduation lines and the surface of the rule. This also enhances their readability.

While you can find many inexpensive steel rules made of stainless steel, it is not a great material from which to make steel rules. The stainless steel used to make steel rules cannot be hardened to the level of spring steel and thus it tends to yield when bent, keeping the curve, and not snapping back to straight.

Both the long edges and the ends of steel rules should be ground for straightness and accuracy. Ends that are ground square, and in proper relationship to the graduations allow accurate measurements from the ends of the steel rule.

A properly made steel rule will have virtually no error in the graduations. Any error in the rule is between the first graduation and the end of the rule. The standards for this error are actually quite lenient. The first graduation can have an error between +0.004" and –0.002" and still meet the standards. Most steel rules will handily meet this standard.

Care of steel rules

Steel rules are precision measuring instruments. Don't use your steel rule as a scraper, screwdriver or pry bar. Don't drop it or bang it around. Keep your steel rule very lightly oiled.

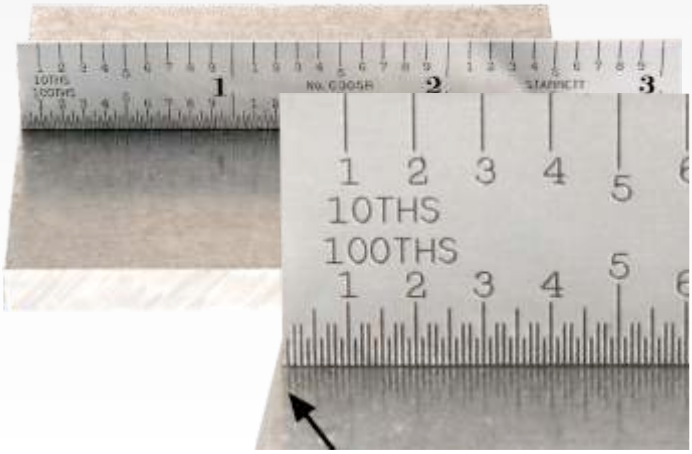
Inspect your steel rule periodically. Be sure that it is not bent or dented. Check that the corners are square and sharp. Be sure there are no burrs anywhere on the steel rule. If you find any of these problems, replace your steel rule.

Measuring
Here is the correct way to measure a part with a steel rule. Notice that we are measuring from the 1" graduation on the left. (Be sure to subtract 1" from the measurement you read.) It is more accurate to measure between two graduation lines than from the end of the rule.

It is okay to measure from the end of the rule when there is a hard stop that you can press the rule against. The accuracy of this measurement depends on the quality of the grinding of the end of the rule.

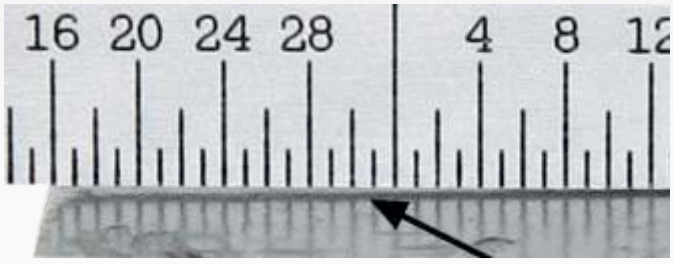
But trying to align the end of the rule with the edge of a part is simply not an accurate way to measure.

Be sure the graduations on the rule are adjacent to the part being measured. When the rule is laid flat on the part, you cannot get an accurate measurement because of parallax.



Be sure the steel rule is straight across the dimension you want to measure. If the steel rule is at an angle, the measurement cannot be accurate.

Another use for a rigid steel rule is to check the flatness of a part. Because the edges are ground, you can make a visual check of the flatness of a part by standing the steel rule on edge across the part. Try it in several places and look for light under the rule. With a good steel rule you should be able to see 0.0005" of deviation from flat.



How accurate is a steel rule?
In general, a measuring device is considered accurate to the smallest graduation. So a steel rule that is graduated to 1/64" is accurate to about 0.015". But with careful visual interpolation, you actually measure to about 0.005" with a good steel rule. That's about the width of one of the graduation lines.

PROPELLANT VACUUM CASTER

Text & Photos by ***Les Derkovitz***

WITH A LITTLE BIT OF THOUGHT THIS GROUP GOT IT RIGHT

One of the main problems most of us have making motors is eliminating air bubbles which can cause a motor to over pressurize and create havoc. This is especially true in large diameter motors where propellant is placed in pieces at a time to fill a casting tube. Despite the rumor, motor propellant is not poured, it is mostly "placed." This process can create voids in the propellant despite the best efforts to evacuate the propellant before casting it.

A discussion among several people took place at a BALLS launch to figure out a better way to cast larger 6" diameter grains. Present at the discussion was John Rakonnan, long time Amateur Rocket person and former Thiokol Propellant Master. He told us of a way to cast propellant under vacuum and assured us that this technique was proven and worth the effort. Under such a recommendation, several people began the development of a true Vacuum Casting System.

A complete working Vacuum Casting Machine capable of filling a 6" diameter Casting Tube is simple and workable.

Les Derkovitz headed up the development team; we should say "was" the development team. With assistance from Jerry McKinlay and Oliver Schubert, an apparatus was designed and fabricated that, with minor technical adjustments, became a working Vacuum Casting Machine.

Developing vacuum casting, both the hardware and the production techniques, was sort of a natural. These people had thought and talked about it for a long time, and after they had conducted a couple of disappointing casting sessions - pouring a motor for BALLS in which voids were coming up on the surfaces against both the mandrel and the casting base - the time was right to pursue vacuum casting. Because they poured motors in many different sizes and configurations, the challenge was to develop a casting chamber that could accommodate all the sizes dealt with in a convenient "one motor at a time" production session.

The concept is to have a chamber that contains the casting tube, is sealed and can be drawn down to a vacuum with our pump. Into that chamber the propellant has to be drawn in and injected into the casting tube. The "tube" of the chamber is a 30" inch long piece of the tube that we can make 6 inch motor grains with. We went with 30 inches because it is doubtful that we would cast a single grain any longer than 25 inches. The remaining 5 inches is needed to align the "spigot" from the ball valve to the casting tube via use of a hose.

A base plate was fashioned from MDF and plexiglass. In the photo to the left you see how the plexiglass sheet is sandwiched between the two pieces of MDF. A slot was routed out in the plexiglass to allow for the silicon gasket that would seal the bottom of the chamber. A set of 4 bolts pulls the vacuum chamber tube down against the gasket to preload it so that the chamber can pull a vacuum. The air board sander is attached to the base to vibrate the unit and settle the propellant.

The top of the chamber is another plexiglass vacuum

plate with a silicon gasket. This holds the mechanism to attach the vacuum pump plus introduce the propellant into the casting chamber and into the motor casting tube itself. These are made up of brass fittings, allowing the connection of the vacuum pump along with a vacuum gauge to monitor the degree of vacuum, plus a small ball valve to seal off the chamber if the pump is disconnected. This allows for the vacuum hose to be disconnected from the chamber and still maintain a vacuum inside. The idea here is to be able to use only one pump to degas the propellant in the usual way while using the same pump to draw the vacuum on the chamber. It saves time not having to draw a vacuum from scratch in the chamber when the pump is changed from the mixing bowl to the chamber. The gauge can show if any vacuum was lost.

The main challenge was developing a system that could introduce the propellant to the inside of the chamber without losing the vacuum. It was decided to go with a one inch brass ball valve having an aluminum funnel, used as a loading hopper, attached to the top. The theory being that the chamber could be drawn down with the ball valve closed and then the propellant could be added to the hopper. Once the funnel is full of propellant and the valve is opened, the propellant provides the seal as it is being drawn down into the chamber. Before all the propellant has been drawn out of the hopper, the valve is closed again and more propellant added to the hopper and the process repeated again until the grain is full of propellant.

A piece of flexible tubing is attached to the chamber side of the ball valve fitting and is used to guide the propellant to the casting tube inside the chamber. A special "Do-Dad" was de-signed to break up the propellant while introducing it into the casting tube. The tube can be manipulated, to a point, for targeting various size grains.

Last item is that air board sander attached to the base of the unit. While casting propellant the air sander is turned on and the vibration shakes the unit to help settle propellant as it is dumped into the casting tube; a little extra something to assure any possible trapped air is released. Under vacuum this possible trapped air is virtually non-existent.

Wooden base with the 6" aluminum chamber (not shown in position) and an air board sander explained in the text.

After reformulating the NASSA propellants to be more “pourable”, and casting up a couple of motors using the newly developed hardware, some problems were exposed and corrected that the original engineering did not foresee.

The Do-Dad is designed in two pieces for cleaning purposes and possible future modifications.

The Do-Dad assembled. Note the "flange" on the end

The "Do-Dad" piece is attached to the end of the flexible tubing. A hose clamp (not shown) assures it staying on during vacuum.

After the refinements were in place, casting under vacuum can be done with relative ease. However, clean up of all the additional hardware that comes in contact with propellant takes quite a bit longer. Also, even though the propellants are now more "pourable", one must work as fast as possible because it takes a long time to draw all the propellant through the one inch ball valve. Any delays will give the curative time to "kick" off the propellant enough to make it almost impossible to be drawn into the chamber. NASSA did go with a room temperature curative that gives as long a working time as possible.

As expected, grains cast under vacuum show no voids at all. When inspecting grains that have burned part way through and then extinguished, they show a very smooth burn surface. The surface does not look like that of the moon with the craters we are all used to seeing from motors not cast under vacuum. Now that the bugs have been worked out of the production techniques and the chamber has proven it's worth, they expect to cast most of their larger motors under vacuum.

The heart of the whole operation is the top plate. Just about self explanatory it resembles a large standard Vacuum Plate with a big funnel attached.

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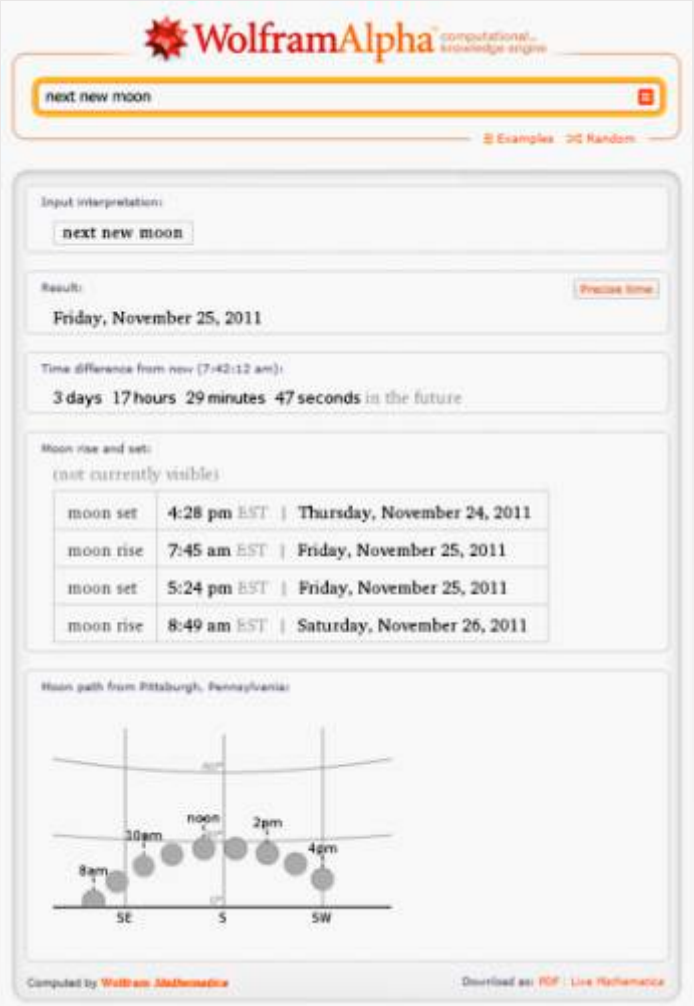

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