# TRIPOLI *Report*

JOURNAL OF THE TRIPOLI ROCKETRY ASSOCIATION, INC.
Volume 29 Number 1 - Winter 2018

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:** Vern Knowle's STAR FIRE is an 8" diameter, 12.5 feet tall vehicle. It has a central 75mm motor mount and six 38mm outboard motor mounts. It is designed to carry a camcorder in the lower payload bay with a remotely controlled TV transmitter and still cameras in the forward payload bay. *Photo by Vern Knowles.*

**Photo at Left:** STAR FIRE on an AMW M2500 Green Gorilla motor and two air-started J350 outboard motors.
*Photo by Vern Knowles.*

### 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*

Recently I've become aware that not everyone understands the FAA classifications of amateur rockets: Class 1, Class 2, and Class 3. All three are defined in FAR 101.22. (https://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=14:2.0.1.3.15#sp14.2.101.c) All Tripoli members should be familiar with these definitions. TAPs and Prefects should understand them very well.

**Class 1** – Model Rocket. These have less than 125 grams of propellant and the rocket must have no more than 1500 grams of mass, including the motor. Generally speaking, Class 1 rockets need no waiver. Interestingly, several high power rocket motors have less than 125 grams of propellant.

**Class 2** – High Power Rocket. This includes everything that is not Class 1 but not to exceed 40,960 Newton-seconds of total installed impulse (a full Class O motor). Although Class 2 rockets generally require a Certificate of Authorization (COA), one COA (also referred to as a waiver) can cover all of the Class 2 rockets flown at a particular launch site for a year.

**Class 3** – Advanced High Power Rocket. This includes everything else. That's really how FAA defines it, but let me explain it more specifically. Any rocket that contains more total impulse than the upper limits of an O motor (40,960 Newton seconds), whether in a single motor, a cluster, or staged motors, is Class 3. Although it's a ridiculous example, if you have two motors in your rocket, one is a 100% O with 40,960 N-s and the other is an Estes ½A, your rocket is Class 3. It's simply impossible mathematically to have 2 O motors in a rocket and still consider it Class 2. The FAA requires that each and every Class 3 flight attempt must have its own COA, Certificate of Authorization.

The data analysis for a Class 3 rocket COA is much more complex than those for a normal COA. In order to assist our members, Tripoli instituted the Class 3 Committee which helps provide data analyses for those members who would like to fly Class 3 rockets. Although technically a flyer might be able to submit data to the FAA for a Class 3 rocket, Tripoli requires that all Class 3 rockets flown at Tripoli sanctioned launches must be reviewed and approved by the Class 3 Committee before submission to the FAA. Why is that important? Because we have a very good reputation with the FAA and we want to keep it that way.

Note - We also require members to submit any rockets that might fly higher than 50,000 feet for review by the Class 3 Committee. However, this is an internal Tripoli requirement, not at all related to the FAA requirements. Flying higher than 50k does not make a rocket Class 3. Please do not confuse the two.

# FROM THE EDITOR

by Ken Good

Last issue, we noted the passing of Ron Schultz, a man who was with TRA from the beginning of the high power movement and was a leading light in the movement. In this issue, you will find Chris Pearson's tribute to Irv Wait, a man who could be considered one who kicked off high power proper. We all get old, and the years take their toll on us; they also remove those who formed a basis for the modern Tripoli.

Many of us are of course saddened when it happens, but many more likely don't know about such people. And we know that many current fliers weren't even alive when high power's "founding fathers" were laying the bricks upon which we were built. That's the way it works, and senior members such as your editor can only try to point out where we came from and to whom we owe some degree of thanks.

But when these things happen - when we lose those earlier contributors - and a new TRA Board of Directors election happens, the same concern I have had for some time comes to the surface. It is simply this: who will lead TRA for the next 50 years of our existence, presuming we continue?

I can think back to the first days myself, and recall how far we have come. I hope we can continue, and continue to have relevance in this world. In the pages of the *Tripoli Report*, members have seen reported the trials and triumphs of TRA and its members. We have done great things, that no doubt are often missed in the larger cognizance of our world. But whether we have been in the spotlight or the shadows, we have been inspirational, educational, and aspirational. We have value that mustn't be lost, and dreams yet to be fulfilled.

Bill Riley put forth his call for 2018 TRA Director candidates in our past issue, and we are re-printing this as a reminder. As I always do in this column, I urge those considering stepping up to help lead TRA to take that step. Existing directors, sooner or later, reach the point where they want to step down and hand off to new blood. We want to keep continuity and talent, while still positioning ourselves to meet those challenges and fulfill the dreams of the next decades - our future history.

# 2018 TRIPOLI BOARD OF DIRECTORS CALL FOR CANDIDATES

**by Bill Riley, Election Committtee**

## Now Is Your Chance To Step Up

*Editor's Note: The following is a "reminder" re-print of Bill Riley's original article published in the November 2017 issue of the Tripoli Report.*

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.

## CALL FOR ARTICLES

The TRIPOLI REPORT is looking for articles that may be of interest to the members of the Tripoli Rocketry Association. These can be in the form of a technical paper regarding anything from construction to opinions. Articles are open to photography, propellants, software, etc. MS Word documents are requested along with photos and/or drawings. Photos must be at least 300 dpi in JPG or PNG format. Please submit your material to:

KEN GOOD, Editor
ken.good@tripoli.org

## FREE ADVERTISING

Free ads are available to manufacturers and/or vendors of High Power & Research Rocketry products, who support Tripoli through donations and/or promotions. Ads are available on a space available schedule. With no guarantee as to size or location in the publication, Ads must be size adjustable. A private Design Service is available with a very reasonable fee. For complete information on Tripoli's free advertising offer contact:

TOM BLAZANIN, Production
justtom@rimworld.com

# BoD ACTIVITIES

**BOARD OF DIRECTORS MEETING**

| | |
|---|---|
| Date: | November 16th, 2017 |
| Time: | 19:00 EST |
| Location: | Teleconference |
| Present: | Steve Shannon<br>Debra Koloms<br>David Wilkins<br>Dave Rose<br>Burl Finkelstein<br>Gary Rosenfield<br>Gerald Meux<br>Tom Blazanin<br>Dick Embry |
| Apologies: | None |
| Proxies: | None |

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**TMT Update**

TMT are expecting new load sensors next week.

NAR has certified the CTI reloads in the AT cases; a representative sample for each motor size up to four-grain reloads.

**LDRS Update**

Gerald reported that the website is up and running. Some who have looked at it felt the website was confusing to get event information; appears to be a shopping site. Gerald is to work with James Dougherty to improve the site to be more informative as to event details and directions.

Accommodation now back at the Harris Ranch as is the Banquet

No Fireworks; night launch on one night and a band on the same night.

Want to move the Banquet to Friday, from the normal Saturday. No issues; we will reschedule our meetings to suit a Friday Banquet, with an Open Board meeting on the Thursday before. This will shift the election calendar.

**FAA / BLM Update**

FAA quiet right now.

BLM is waiting for after-event updates and fees for those groups for this year, so they can be added to next year's permit.

BLM have been requested to ensure our access to the playa. The request is to make sure we have access with respect to the exclusion zone, so they do not block access for XPRS/Arliss. Some concerns that they are blocking Rt. 447 and limiting access to the playa.

**Insurance**

All three bills have been paid; D&O and GL insurance have been paid. We received a 10% discount on the previous year.

We need to keep focused on our safety culture, to make sure we can continue to reduce the cost of our insurance.

New Policies will be available in the new year after it has been bound.

**Publications**

Discussion about the publication schedule for the Tripoli Report. The intent is to publish four issues per year. The election timetable needs to be considered, makes it hard to fix it to a calendar or season dates.

***Action:*** David Wilkins to discuss schedule and process with Ken Good.

***Update:*** It has been agreed with Ken Good he will post out a proposed schedule and will collect available minutes from SharePoint.

**ROC Launch**

Gerald attended the recent ROC launch. It was very visible that Air Traffic was rerouting, and highlights the need to make sure we release airspace when we have finished using it. Airspace is a shared resource.

Rockets were also being launched without a spotter, and before deployment, LCO moving onto the next rocket. LCO must be assured the rocket doesn't present a risk before moving onto the next rocket to be launched.

***Action:*** Gerald to advise ROC that the practice needs to review this practice from the perspective of safety.

ROC has also advised they have secured a five year permit for their site.

**IT Update**

In the past we have discussed using video/desktop sharing for the teleconferences. This will provide ability to share more complex presentations and provide assistance to members

**Motion:** Purchase a WebEx license for a single host for $349 USD per year

Moved: David Wilkins

Seconded: Deb Koloms

Aye: Shannon, Koloms, Wilkins, Rose, Embry, Rosenfield, Meux, Blazanin, Finkelstein

Motion passed unanimously

David demonstrated the new SharePoint and showed some of the new navigation features and layout.

Steve, Deb and Gerald provided some feedback with permissions errors they were encountering.

HQ has been requested to use the new site, though still awaiting confirmation they are using it again.

Meeting adjourned: 22:03 EST

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**BOARD OF DIRECTORS MEETING**

Date: December 21st, 2017

Time: 19:00 EST

Location: Teleconference

Present: Steve Shannon<br>Debra Koloms<br>David Wilkins<br>Dave Rose<br>Burl Finkelstein<br>Gary Rosenfield<br>Gerald Meux<br>Tom Blazanin<br>Dick Embry

Apologies: None

Proxies: None

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**TMT Update**

TMT awaiting delay column samples from AeroTech for Alan and Steve to conduct testing.

Still waiting for second batch of load cells to enhance testing capabilities.

Discussion of Contrail proposal to offer a person to witness Hybrid testing locally. Tom Sanders sent through a recommendation for a person to be an offsite tester for TMT.

The consensus is that TMT will identify persons to act as a witness, and persons submitted by motor vendors may not be ideal given the potential conflict of interest.

Suggestions of persons capable/willing to serve should be sent to the TMT Chair – Alan Whitmore. The same would be true of suggestions for any of the committees; submit names to the respective Committee Chair.

**LDRS Update**

Website directions have been created and are about to be posted, along with the host hotel and other items. Gerald is assisting James Dougherty with updates of common items.

Host Hotel is the Harris Ranch and conference rooms are organised for the BoD meetings.

Rather than paying individually and then submitting receipts, reservations for the directors will be created as a group by Dave Rose. Directors must provide their arrival and departure dates to Dave.

***Action:*** All directors to advise Dave by next Teleconference

**FAA / BLM Update**

BLM comments on the environmental impact; James Dougherty provided a great analysis of the damage caused by Burning Man. Dick has also secured some Universities to provide responses in support of our position.

Dominic Pitto is taking over from Marie; both are Burning Man liaisons. He apparently is hard to contact.

Important - Some groups on the BLM permit who have flown at Black Rock still have to pay their fees to BLM. If groups don't pay, then their permit will not be issued for them next year.

Under new FAA rules, Drones/Boost Gliders now must be registered with the FAA. As long as a launch site has a TFR they are permitted, but visual sight must be maintained.

Burl has sent another letter to his congressional office highlighting the need for BLM to consider our access needs to the Playa. Burl has not received a response to this yet.

**Class 3 Committee**

Ken Overton has resigned; work pressures mean he no longer has time for this.

Kent Newman has suggested that Greg Deputy and Kevin Trojanowski co-chair in the interim. Steve is waiting to hear back from them.

We need to secure more analyst resources for C3RC. Joe Bevier would make a good Analyst; Steve contacted Joe.

### New TAP Request

Josep Maria Garrell - Has only completed his L3 in September, 2017 but has been a long time flyer with his group in Spain assisting and supporting other flyers. With no TAP in the region, he is the best candidate of the community there, and has his clubs and other TAPs in Europe's support.

**Motion:** Accept Josep Maria Garrell as a member of the TAP committee

Moved: David Wilkins

Seconded: Steve Shannon

Aye: Shannon, Koloms, Wilkins, Rose, Embry, Rosenfield, Meux, Blazanin, Finkelstein

Motion passed unanimously

### Year-End Financial Reporting

The P&L is published at LDRS each year, and is not published unless requested by a member throughout the year.

### IT Issues

TAP/Prefects will now be auto-subscribed to the relevant forums. For TAPs, James Russell is supportive. Directors will also be part of the same forums. Directors will also get emails from the TAP and Prefect forums.

### LDRS Bids

We should start encouraging groups to bid for LDRS in 2019

Meeting adjourned: 22:07 EST

# Tripoli Rocketry Association
# Class 3 Review Committee 2017 Year-End Review

***Prepared by: Dr. Kenneth J. Overton***
***TRA 11924 L3 TAP***
***Chairman, Class 3 Review Committee***

2017 was a year in transition for the Class 3 Review Committee (C3RC) with Kent Newman stepping down as Chairman after many years defining and leading Class 3 efforts for Tripoli.

**Committee Role**

The C3RC fulfils two primary roles for the Tripoli membership:

1. Provides technical review and consultation on all Class 3 projects flown by Members. This review is provided to the lead Flier listed on the Submission, and forms the basis for the "Supplemental Information to Line 7 on Form 7711" document prepared by the Flier and submitted to the FAA in support of his/her Certificate of Authorization request (Form 7711).
2. Provides technical review of all projects anticipated to exceed 50,000' AGL. These reviews are provided to the Flier and the Launch Director of the intended launch event.

It is important to note that the C3RC provides a review and consultation function and does not "authorize" or "approve" flights. Determination of whether or not a particular project flies is the responsibility of the Launch Control Officer and Range Safety Officer during the event.

**2017 Committee**

Ken Overton, Chairman
Kent Newman, Analyst
Chuck Rogers, Analyst
Kevin Trojanowski, Analyst
Greg Deputy, Analyst
Dick Embry, Advisor

**Highlights (and Lowlights) of the Year**

1. ↑ First Class 3 Flight in Minnesota. David Leininger successfully flew (and recovered) Big Yeller in North Branch, MN, on July 8th to 10,246' (GPS)
2. ↓ RockSim Pro. Several months working with Apogee on resolving bugs in RockSim Pro resulted in some progress. However, the most critical software defect remains unaddressed – unrealistic, unpredictable behavior in the Dispersion Analysis. This defect remains unresolved and resulted in the tool being unusable for C3RC activities.
3. ↑ Development of Alternative Dispersion Analysis Approach. In light of the inability to RockSim Pro, an alternative approach was developed to determining maximum expected dispersion. This approach uses RASAero II to predict altitude and landing distance based on launch angle. These data form the basis of a probabilistic model for maximum landing distance, and as a corollary, maximum allowable launch angle.
4. ↓ Class 3 project flown (unsuccessfully) during BALLS 26 without FAA Certificate of Authorization (CoA).
5. ↑ Analysis performed on Class 3 project flown during BALLS w/o CoA, which produced recommendations to the Tripoli Board of Directors.
6. ↑ Review of ten (10) Class 3 Projects. See below.
7. ↑ Review of twenty four (24) 50K Projects. See below.

**Flight Results**

**Class 3 Projects**

- Inquiries received from 13 project teams
- Reviews were performed on ten (10 projects).
- Of the reviewed projects:
  - 1 was withdrawn (Overton)
  - 1 scheduled for BALLS did not fly (DeHate)

§ 1 flew successfully in Minnesota mid-year (Leininger)
- § 1 flew successfully at Spaceport (USC)
- § 1 flew unsuccessfully during AIRFest (Cadre)
- § 5 flew unsuccessfully during BALLS 26

o BALLS 26 Flights

- § None of the Class 3 flights during BALLS 26 were successful
- § Failure modes includes:
  - · Motor CATO (2)
  - · Airframe failure (1)
  - · Recovery Failure (1)
  - · Stabilization Failure (1)
  - · Sustainer did not light (1)

o No flights (successfully or otherwise) either exceeded the waiver, or recovered outside the defined recovery area.

**50K Projects**

o 25 projects reviewed

o Post-flight reports received on 20 projects.

o Of the 20 projects reporting:

- § 5 did not fly
- § 4 projects flew successfully
- § 11 projects flew unsuccessfully

o Failure modes includes:

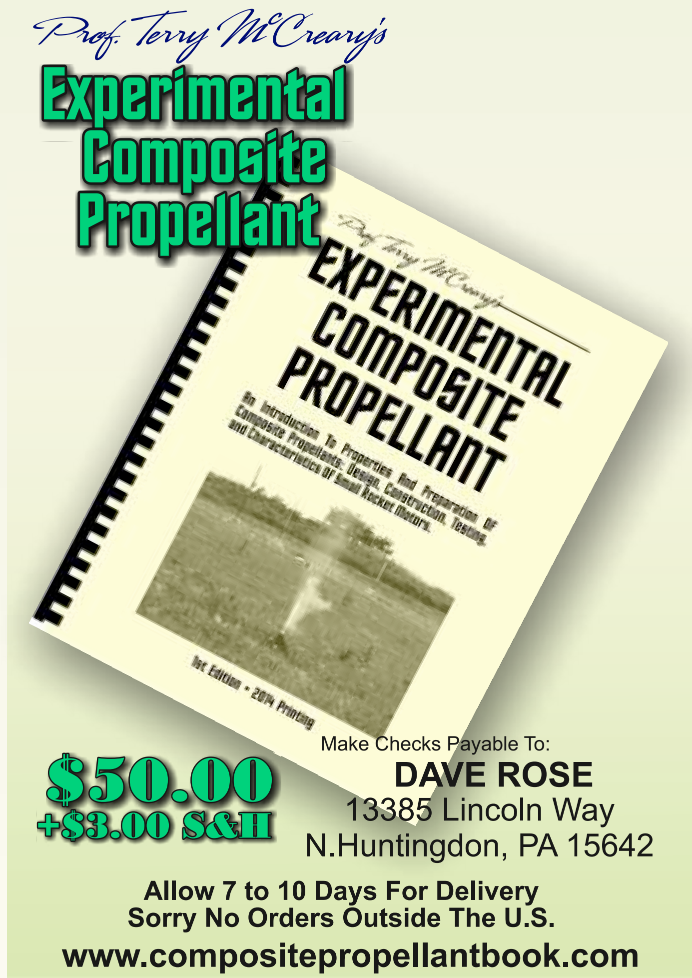
- § Motor CATO (1)
- § Airframe failure (3)
- § Failure to light sustainer (2)
- § Recovery failure – early or no deployment (5)

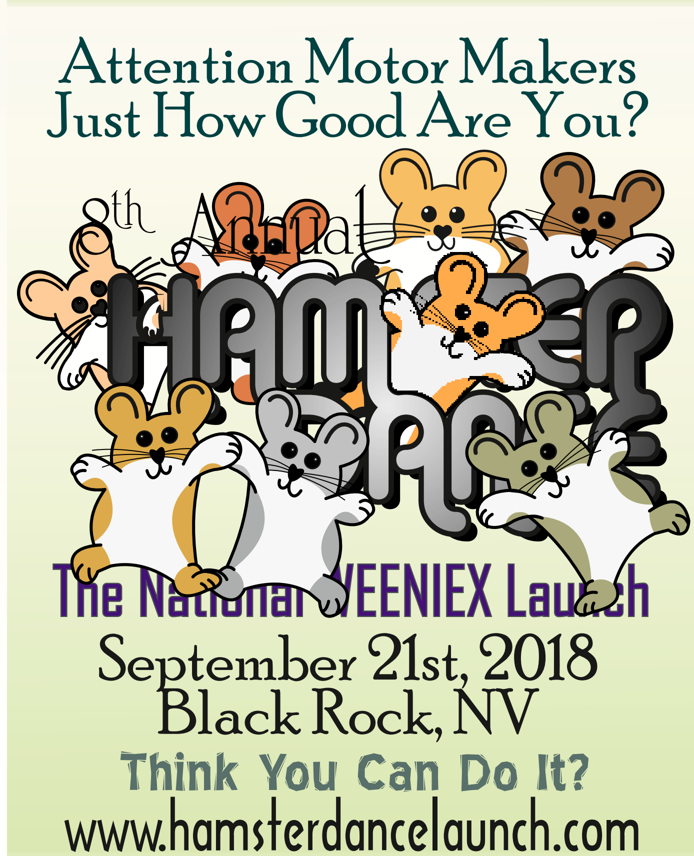
o No flights (successfully or otherwise) either exceeded the waiver, or recovered outside the defined recovery area.

**Challenges Facing the Committee**

Moving forward, the C3RC faces a number of challenges, specifically:

1. Recruiting additional Analysts to support the workload.
2. Maintaining and developing relationships with key FAA contacts in the face of turnover, both within the C3RC and the FAA.
3. Development of an effective replacement, and supporting process, for RockSim Pro.
4. Improving communication within TRA Membership regarding the C3RC, its role, and procedure.



# TMT REPORT

*by Alan Whitmore*
*Tripoli Motor Testing*

Commercial motor testing activity in the past 3 months resulted in the certification two new Aerotech 38mm J motors (both were certified in the plugged configuration):

- J435WS Super White Thunder, a DMS motor
- J520W White Lightning reload for the 38/1080 case

Other efforts here in North Carolina have included the acquisition and calibration of 0-25 lbf, 0-50 lbf, and 0-100 lbf load cells. This means that TMT is now ready and able to certify motors down to the C range if NAR or CAR ever experience problems in getting model rocket motors certified in a timely fashion.

A great deal of focus and effort has also gone into the measurement of delay element timing; this has been applied to already-certified Aerotech, Loki, and CTI motors. The goal of this project is to quantify and understand the variation in delay element timing that has been observed in different static testing facilities, at different launch sites, and by different flyers.

The desired outcome is to be able to make a full report to the TRA membership in the future, addressing factors that influence the actual timing of the pyrotechnic ejection charge delay devices used by all of the major commercial motor manufacturers.

When enough data has been acquired that we can say something definitive about why the delay element timing of all commercial motors seems to vary the way it does, with the collaboration of NAR Standards and Testing and after consultation with the TRA BoD, we will be in a position to publicize this information. Stay tuned.

# Irving Stringham Wait

## December 28, 1928 - December 18, 2017

### *The True Father Of High Power Rocketry*

Considered to be the true "Father of High Power Rocketry" for his development and sale of the first commercially available composite model rocket motor.

***by Chris Pearson***

Irving Stringham Wait, 88, of Seymour, Indiana, died on Monday, December 18, 2017, at his home with his family by his side.

Born December 24, 1928, in Glen Cove, NY, he was the son of Harold V.A. Wait and Marion Stringham Wait. He was a 1946 graduate of Glen Cove High School and received a B.S. degree in Agricultural Science from Earlham College, Richmond, IN, in 1952.

He was a rocket engineer for 26 years and a farmer for 10 years. He began his professional rocketry career in 1955 with Thiokol Chemical Company (Minuteman) and Hercules Powder Company (Polaris) military rockets. He organized Rocket Development Corporation (RDC) in Utah for developing and marketing static test equipment for the model rocketeer as an outgrow of his work.

In 1963, he relocated to Seymour, adding model rocket flight kits and accessories. In 1966, he expanded his black powder motor line into composite propellants for industrial and university applications. In 1967, an RDC rocket and empty motor casing became part of the aerospace exhibit at the Smithsonian Institution in Washington, D.C., as an example of employing low cost model rocket concepts in construction of vehicles for professional use. In 1984, some of the composite engines were acquired by a movie company for use in the film “Mosquito Coast” with Harrison Ford. Others were used to launch weather balloons.

Old time rocketeers will remember RDC as one of the small model rocket companies that competed against the "Big Two", Estes and Centuri, during the 1960's. In reality, RDC was a professional rocket company that sold model rockets as a side. His company marketed A & B class black powder motors as will as rocket kits. He also sold the "Ignitrite", a novel igniter design incorporating Jetex wick and advertised for use in clustered motor kits. In 1968 he introduced the "Enerjet 8" motor. It was the first commercial APCP motor sold to model rocketeers. The "8" was the peak thrust in pounds, with a total impulse of 7.5 pounds which comes out to about an 33 n-s E21 today. RDC also sold other motors in this line ranging from an Enerjet 40 to and Enerjet 336, which, of course, were not available to modelers. The propellant had an Isp of 170 (not bad for the time) and cost a whopping $2.75 each! For those of us who were used to paying 35¢ for an A motor, this was a lot of money.

Enter into the picture Lee Piester, of Centuri Engineering Co. Lee, to his credit, understood that as rocketeers advanced in the hobby they would eventually want to fly larger models with motors more powerful than a B or C. In the mid-60's he purchased the Coaster Corp. which sold D-G black powder motors. These motors were incorporated into the Centuri line-up as "Mini-Max" D, E and F motors. There was also a line of large scale kits. However, Lee realized that large black powder motors have their limitations, and were labor intensive to produce and expensive to ship. He purchased RDC outright to get the composite motor technology which became the Enerjet line of E and F motors in 1971. The large scale kit line was also upgraded for the more powerful composite motors. The RDC "Ignitrite" evolved into the Centuri "Sure-Shot" igniter. Irv then went back to producing professional commercial rocket motors.

Other professional rocket engineers also entered model rocketry as a side business in the '70's, notably John Rahkonen of Pro-Dyne, George Roose of FSI, Frank Kosdon, John Davis and Scott Dixon. John would later team with Gary Rosenfield to form Composite Dynamics. Gary would later start Aerotech. Other non-professional rocketeers would also start motor companies in the 70's, such as Mark Mayle of SSRS/Crown and Randy Sobszak of Plasmajet. They all owe a nod of gratitude to Irv Wait.

In the late mid-80's, long before the introduction of modern "effects" propellant, RDC produced the first truly smokey composite model rocket motor, which was sold by North Coast Rocketry as the "Whirlwind" E motor until about 1990. It used a novel propellant containing potassium perchlorate instead of AP.

Those of us who are lucky enough to have known Irv, and this goes back to the pre-Tripoli days, will speak only good words of the man and his dedication to unknowingly laying the foundation of today's High Power Rocketry hobby and sport.

RIGHT: An early Irv Wait, as remembered, with an RDC test stand. Definitely 'Old School.'

# BASIC TEST STAND

## How Basic Can You Get?

Based on Charles E. Roger's ENGMOD documentation, the early members of Nevada AeroSpace Science Associates (NASSA) constructed a most primary test stand to characterize their own propellants. At the time, a fully computerized load cell test stand was financially too expensive and none of the then-current members were electronics capable. Crude by today's standards, and despite its tongue-in-cheek approach, this test stand operated perfectly.

For beginning motor techs with limited finances, this may prove an acceptable solution. It also proves that basics work.

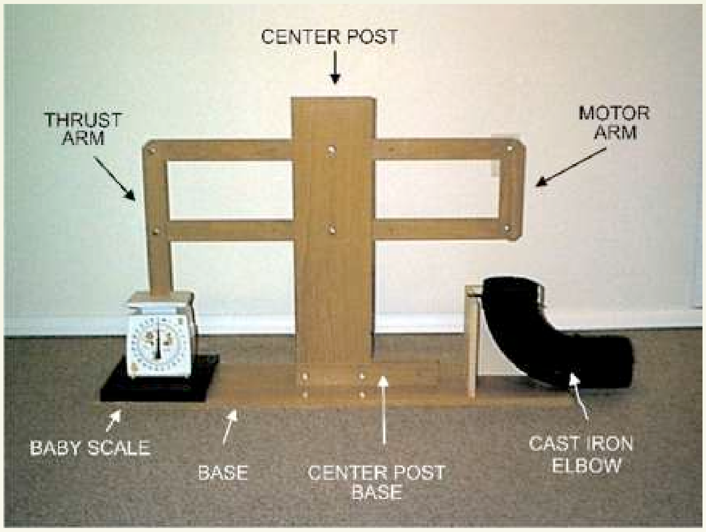
The test stand is constructed of wood using a standard baby scale and a 5" cast iron sewer pipe elbow. The Center Post is adjustable to accommodate 54mm test motors of various thrust levels.

The double beam horizontal struts hold exactly vertical the Thrust Arm and the Motor Arm. This assures direct transfer of thrust from one arm to the other and keeps the whole mechanism aligned.

The top photo shows the basic components, which just about anyone can build with a minimal amount of tools. Do not skimp on construction and make sure everything is aligned and solid. This stand will have quite a lot of stress applied to it and as long as everything is aligned you will have no problems.

The bottom photo shows the stand in actual operation. You can see the Center Post has been moved closer to the cast iron thrust deflector to accommodate a higher motor thrust. The Thrust Arm is directly placing the transferred energy to the baby scale which shows actual thrust that is generated.

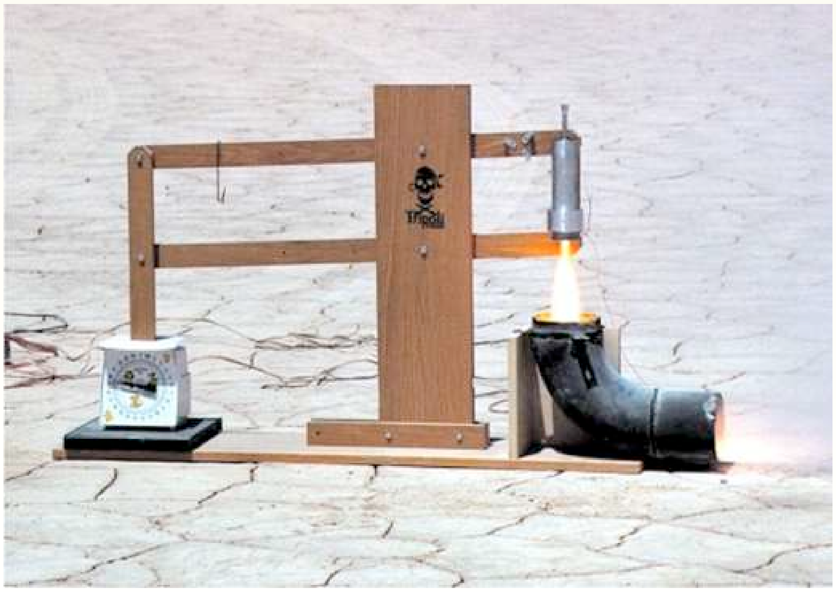
With a video camera the entire operation is recorded. All that is needed is the scale's reading but it is suggested to record the entire view capturing not only the readings on the scale but actual fire operation of the motor. This will be handy in cases of motor malfunctions and anomalies like chuffing and the dreaded cato.




The acquired video can then be reviewed at leisure and data can be extracted. The video can be viewed at different speeds and zoomed views to ensure exact data is obtained. While today's Test Stands are more sophisticated, back in the early 90's for a group of beginner Motor Researchers, this system did its job to point us in the right direction.

The entire test stand cost all of $12 to build. $9.95 being the cost of the baby scale. The sewer pipe was stolen(!) and the wood was free. It's crude but it works.

As a final note: Please keep in mind that the cast iron pipe gets really, really HOT!!



The photo shows the Test Stand in operation. Thrust variations could be adjusted by leaving everything in place and simply moving the board

# MAKING HOLES

*by Tom Blazanin*

**DRILL–noun**
**a. a shaftlike tool with two or more cutting edges for making holes in firm materials, especially by rotation.**
**b. a tool, especially a hand tool, for holding and operating such a tool.**

Confusing, but a drill is a tool that holds a tool of the same name. The term refers to both holder and a device.

Just about anyone doing anything requires holes. Our rocketry activities are a major example. We need round holes for vents, sheer pins and mounting electronics, fins, and the list can go on.

Drilling a hole into an object nowadays is relatively easy; all you need is a drill motor and a drill bit, right? Well almost - the motor must have the right capacity, and the drill bit must be the right type and size for the material that is being drilled. There are also a number of other items needed: a center punch, lubricating oil, a vise, depth marker, etc.

**SAFETY FIRST ALWAYS**
It's pretty hard to protect your hands except with your eyes, and you can protect your eyes by wearing safety glasses of some sort. They come in all kinds from regular glasses to cover-over goggles that will offer side protection from flying debris. It is most important at all times to have your eyes watch where your hands are.

**DRILL MOTORS**
The first tool for consideration is the drill motor. It has to have enough power, rated in amps, to rotate the largest drill bit diameter you plan to use to make a hole in the hardest material you are using.

Electric Drill Motors


Battery Powered Drill Motor

Floor Mount Drill Press

Today, hand drill mounts have been replaced with electric or battery powered versions that make this work easy. The advantage with an electric drill motor is they never die in the middle of a job. And while today's battery powered drill motors are more powerful than ever, they still don't compare with a corded electric powered one for durability in the long run. Still, a good quality battery powered drill motor works for most jobs.

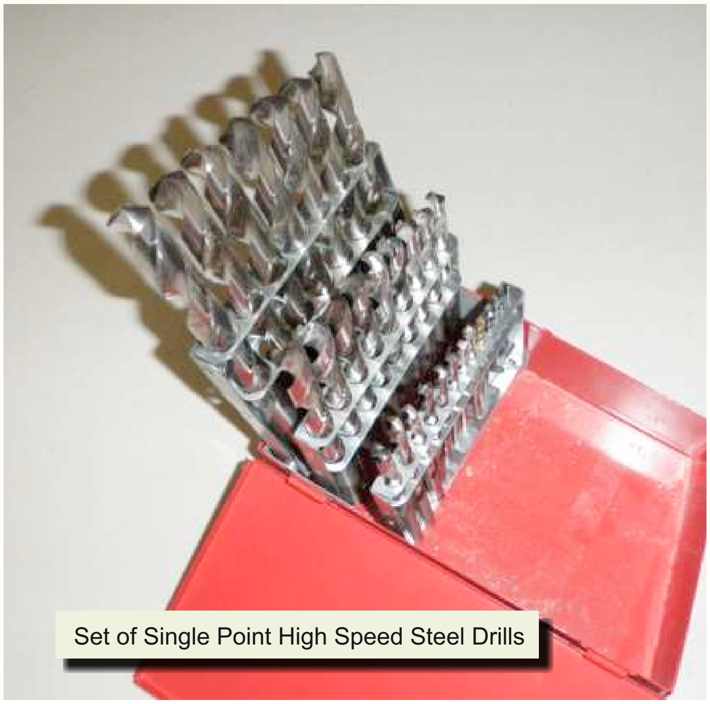
Nothing can freehand drill holes as precisely as does a drill press. They come in either a floor model or a smaller bench model. Both offer the ability to more carefully feed the drill bit into the work piece.

A hand drill motor should be kept to a 3/8" chuck while a drill press can easily handle up to a ½"bit.

**DRILL BITS**

Next on our list are the drill bits themselves. There are many different types of drill bits, such as high speed steel, carbide tip, and special points; each handles a specific purpose. Working on metal, or composite material, use a standard single point, uncoated, high speed steel bit. They work well as long as you keep them sharp and let the bit do the cutting. Never apply force when drilling a hole. You'll only dull the bit faster and get nowhere.

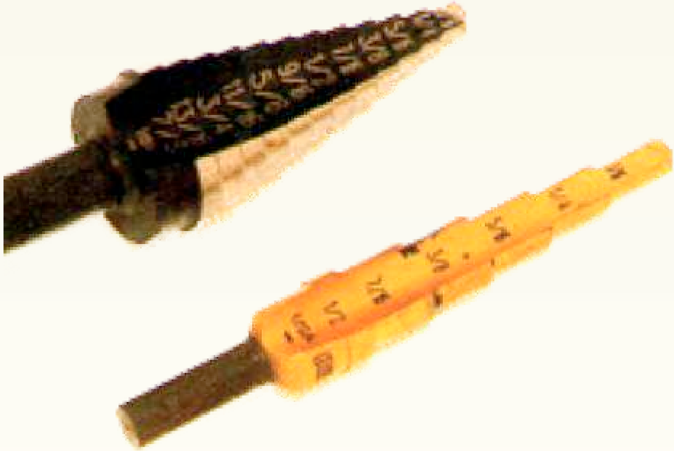
The latest in drill bits are the titanium coated twist drills that are mounted in 1/4" quick-change hex shanks. These are ideal for hand-held battery powered drill motors or a drill press.



Set of Single Point High Speed Steel Drills

Titanium coated drill bits are becoming more common

For drilling sheet metal Step Drills work best. They make cleaner holes than standard twist drills and they are less likely to grab thin sheet metal and rip it. Again don't force it, let it do its thing. Large Step Bits are called Knock Out Bits.



A Pair of Step Drills are great for Sheet Metal

Hole Saws are for making large holes. They usually come in sets but can be purchased separately. Be warned, not all Hole Saws cut metal. A good set like these MATCO, or the Craftsman Professional line, will serve well. They are designed to operate at 150rpm with plenty of lubrication.

There is another method for making large holes. A special bit called a Fly Cutter has an extendable cutting bar. It can be adjusted to make a hole in very large sizes. Fly Cutters, while being able to be used on a Drill Press, are mainly designed for doing metal work on a Milling Machine.


Set of Carbide Interchangable Hole Saws

A Circle Cutter has an adjustable bar which carries the cutting tip. The cutting tip is reversible so you are able to make inside OR an outside hole. It is NOT intended for use on metal objects.

It is designed to operate on a Drill Press. Never ever use a Circle Cutter in a hand held Drill Motor.

In addition to these drill bits presented there are a myriad of other specialty bits which we may not need in the pursuit of our rocket activities.


Above: Wood Paddle Bits • Below: Carbide Masonary

Paddle Bits used for wood and Masonry bits that have a special carbide tip for boring through rock & cement, (both shown above) serve their purpose well.

Forstner-style bits can go where no other drill bits dare. The reason is simple: A Forstner bit is rim-guided while other bits are center-point guided. That means you can use all or only part of the bit's diameter to drill overlapped, angled or partial holes. Forstner bits also shine when it comes to drilling clean, precise 90-degree holes and large-diameter holes. Carbide-tipped Forstner-style bits excel at drilling the precise, flat-bottomed holes required for Casting Tube holders. Plus, unlike other drill bits, the rim-guided Forstner bit can drill into end grain without deflection.

Forstner bits do have their drawbacks and are not a substitute for your everyday twist- or brad-point bits. For one thing, they are more expensive: A 1/4-inch. Forstner bit costs between $3 and $23. They're also designed primarily for use in a drill press, although Forstner bits that are 1 in. or smaller can be used in a hand drill if the bit's center point is firmly engaged. Forstners also

require a very slow rpm rate and thus are slow cutting. As the photo shows, a Forstner bit cuts with it's outer rim, not the centerpoint. This makes for unique situational possibilities. Finally, they are very difficult to sharpen.

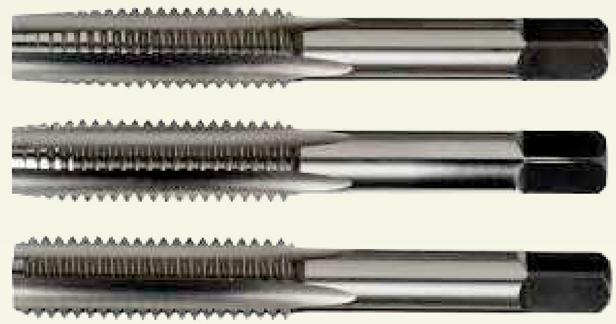
All said, you do not need to have all the presented drill bits or drills. Hopefully now you know what is available when that special situation comes up.

# TAPPING HOLES

by Tom Blazanin

Many aspects of High Power & Research Rocketry require drilling a hole and placing threads for attachment purposes. Drilling the holes are easy; creating the threads are just as easy if you have the right tools and know how.

A tap cuts a thread on the inside surface of a hole, creating a female surface which functions like a nut. The three taps in the image to the right illustrate the basic types commonly used by most machinists. They are generally referred to as hand taps, since they are, by design, intended to be manually operated



**TAPER TAP**: The small tap illustrated at the top of the image is similar to a plug tap but has a more pronounced taper to the cutting edges. This feature gives the taper tap a very gradual cutting action that is less aggressive than that of the plug tap. The number of tapered threads typically ranges from 8 to 10. A taper tap is most often used when the material to be tapped is difficult to work (e.g., alloy steel) or the tap is of a very small diameter and thus prone to breakage.

**INTERMEDIATE TAP**: Sometimes called a second tap or plug tap. The tap illustrated in the middle of the image has tapered cutting edges, which assist in aligning and starting the tap into an untapped hole. The number of tapered threads typically ranges from 3 to 5. Plug taps are the most commonly used type of tap. In the US they are commonly known as plug taps, whereas in Australia and Britain they are commonly known as second taps.

**BOTTOMING TAP**: or plug tap. The tap illustrated in the bottom of the image has a continuous cutting edge with almost no taper — between 1 and 1.5 threads of taper is typical. This feature enables a bottoming tap to cut threads to the bottom of a blind hole. A bottoming tap is usually used to cut threads in a hole that has already been partially threaded using one of the more tapered types of tap; the tapered end ("tap chamfer") of a bottoming tap is too short to successfully start into an unthreaded hole. In the US they are commonly known as bottoming taps, but in Australia and Britain they are also known as plug taps.

**BEGINNING**

When making holes it is most important to use a SHARP drill bit. It is unbelievable the difference that a sharp bit will make. Drill bits are fairly cheap, especially the smaller sizes that we use most of the time, so if you are having trouble drilling a hole in something,, the first thing you want to do is make sure that you are using a bit with a good cutting edge. If you are not sure, go buy a new one.

Next, is to use some type of cutting fluid. Some cutting fluids are made specifically for certain metals, so make sure you are using the proper fluid for the type of metal you are drilling. Near the end is an easy explanation of lubricating fluids.

Before you attempt to start drilling a new hole, ALWAYS center punch the material you are drilling to keep the drill bit from walking around all over the place when you are trying to get it started. If you can't get a good indentation in the material with a center punch, then the metal is probably too hard to drill and you will only screw something up if you keep trying. More than likely you'll break the tap.

Once you have drilled your hole to be tapped, chamfer the rim where the tap will be inserted. This will help steady the tapping process and help keep the tool straight and aligned, and will also aid in the tap cutting into the material to start.

Again the taps we work with are called hand taps and will fit into Tap Holders. These are specifically designed to hold and manipulate the tap as you work it manually. The photo shows a TEE Handle holder and two Vice Type holders for small and larger taps.

One other thing: Its is a lot easier to run a tap straight with a tap wrench than a adjustable wrench. When you break off a tap because you insisted on using an adjustable wrench or a pair of vise grips, remember you were told!

Threading holes requires 3 things to do it right.

FIRST The right size drill bit (sharp of course)
SECOND The right tap set (3-taps). Also, taps must be sharp. Taps can wear out and get dull edged.
THIRD Proper cutting fluid.

Check the charts at the end of this article to find the right size drill bit to use with the tap size you are working with.

If you are tapping into a thin piece of metal, 1/8" or even 1/4" use the Taper Tap (the one with the most taper) Start the threads about a turn and a half, add some cutting fluid, then run the tap in a couple more turns. then you want to back the tap back out about half to a full turn, this breaks the chip. run the tap in a couple of turns then back it off again. Do this until you have reached bottom or have gotten the desired length of thread. Don't forget to add fluid as you go.

For material thicker than 1/4" it is best to follow the steps as outlined:

**1**. Mark the location for the threaded hole with the tape measure and scribe. With the center punch and hammer, center mark the hole location.

**2**. Refer to the drill and tap chart to determine the correct size of the drill bit required for the tap. If the hole is larger than ½ an inch, you will need to drill a pilot hole before you can drill the final hole size. Do not use a pilot hole that is larger than 40 percent of the diameter of the final hole size. A larger pilot hole will cause the final drill bit to bind and break, resulting in a poor final hole quality or injury to the person drilling the hole.

The proper diameter for the hole to be drilled is called the Tap Drill Size.

**3**. Insert the drill bit into the drill. Apply cutting fluid to the center mark that you placed on the metal and onto the drill bit. Drill the hole through the metal, using steady pressure. Apply additional cutting fluid as necessary to keep the drill bit cool. If you are drilling into stainless steel, pump the trigger to keep the drill bit moving slow. Increased drilling speeds will result in your drill bit heating up and losing its cutting edge. With stainless steel, slower is always better.

**4**. Clean the shavings from around the drilled area with a clean rag. Insert the proper tap into the tee handle. It is NOT advisable to use a drill to run the tap through the hole as even slight pressure other than straight down will break the fragile carbide tap.

**5**. Liberally coat the tap with cutting and tapping fluid. With the tap aligned straight with the hole, turn the tee handle clockwise to start tapping the hole.

**6**. Eliminate tap binding by turning the tee handle backwards 1/4 of a turn after each revolution of the tee handle. The 1/4 turn back will remove filing build-up from the front edge of the tap. Apply tapping fluid to the tap before continuing the tap into the hole.

**7**. Reverse the tap to remove it from the threaded hole. Attach the flapper wheel to the grinder and remove the burr from the hole. Test the threads with the correct size bolt to ensure that the bolt threads correctly.

**PLASTICS**

When working with plastic turn the tap handle slowly clockwise 1/4 turn. Then turn it counterclockwise--this is to remove plastic shavings. Turn the tap another clockwise 1/4 turn before turning it counterclockwise again. Continue in this fashion until the entire hole has been threaded. Finally, remove the tap by turning it counterclockwise and wipe away any plastic shavings from around the hole entrance.

**LUBRICANTS**

The use of a suitable lubricant is essential with most tapping and reaming operations. There are many good lubricants available on the market today. Recommended lubricants for some common materials are as follows:

***Carbon Steel*** Petroleum-based or synthetic cutting oil.

***Alloy steel*** Petroleum-based cutting oil mixed with a small amount (approximately 10%) of kerosene or mineral spirits. This mixture is also suitable for use with stainless steel.

***Cast iron*** No lubricant. An air blast should be used to clear chips.

***Aluminum*** Kerosene or mineral spirits mixed with a small amount (15–25%) of petroleum-based cutting oil. WD-40 and 3-In-One Oil are acceptable substitutes in some cases.

***Brass*** Kerosene or mineral spirits.

***Bronze*** Kerosene or mineral spirits mixed with a small amount (10–15%) of petroleum-based cutting oil.

# STANDARD DRILL & TAP SIZES

| Tap & Clearance Drill Sizes | | | | Tap Drill | | | | Clearance Drill | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Screw Size | Major Diameter | Threads Per Inch | Minor Diameter | 75% Thread for Aluminum, Brass, & Plastics | | 50% Thread for Steel, Stainless, & Iron | | Close Fit | | Free Fit | |
| | | | | Drill Size | Dec. Eq. | Drill Size | Dec. Eq. | Drill Size | Dec. Eq. | Drill Size | Dec. Eq. |
| 0 | .0600 | 80 | .0447 | 3/64 | .0469 | 55 | .0520 | 52 | .0635 | 50 | .0700 |
| 1 | .0730 | 64 | .0538 | 53 | .0595 | 1/16 | .0625 | 48 | .0760 | 46 | .0810 |
| | | 72 | .0560 | 53 | .0595 | 52 | .0635 | | | | |
| 2 | .0860 | 56 | .0641 | 50 | .0700 | 49 | .0730 | 43 | .0890 | 41 | .0960 |
| | | 64 | .0668 | 50 | .0700 | 48 | .0760 | | | | |
| 3 | .0990 | 48 | .0734 | 47 | .0785 | 44 | .0860 | 37 | .1040 | 35 | .1100 |
| | | 56 | .0771 | 45 | .0820 | 43 | .0890 | | | | |
| 4 | .1120 | 40 | .0813 | 43 | .0890 | 41 | .0960 | 32 | .1160 | 30 | .1285 |
| | | 48 | .0864 | 42 | .0935 | 40 | .0980 | | | | |
| 5 | .125 | 40 | .0943 | 38 | .1015 | 7/64 | .1094 | 30 | .1285 | 29 | .1360 |
| | | 44 | .0971 | 37 | .1040 | 35 | .1100 | | | | |
| 6 | .138 | 32 | .0997 | 36 | .1065 | 32 | .1160 | 27 | .1440 | 25 | .1495 |
| | | 40 | .1073 | 33 | .1130 | 31 | .1200 | | | | |
| 8 | .1640 | 32 | .1257 | 29 | .1360 | 27 | .1440 | 18 | .1695 | 16 | .1770 |
| | | 36 | .1299 | 29 | .1360 | 26 | .1470 | | | | |
| 10 | .1900 | 24 | .1389 | 25 | .1495 | 20 | .1610 | 9 | .1960 | 7 | .2010 |
| | | 32 | .1517 | 21 | .1590 | 18 | .1695 | | | | |
| 12 | .2160 | 24 | .1649 | 16 | .1770 | 12 | .1890 | 2 | .2210 | 1 | .2280 |
| | | 28 | .1722 | 14 | .1820 | 10 | .1935 | | | | |
| | | 32 | .1777 | 13 | .1850 | 9 | .1960 | | | | |
| 1/4 | .2500 | 20 | .1887 | 7 | .2010 | 7/32 | .2188 | F | .2570 | H | .2660 |
| | | 28 | .2062 | 3 | .2130 | 1 | .2280 | | | | |
| | | 32 | .2117 | 7/32 | .2188 | 1 | .2280 | | | | |
| 5/16 | .3125 | 18 | .2443 | F | .2570 | J | .2770 | P | .3230 | Q | .3320 |
| | | 24 | .2614 | I | .2720 | 9/32 | .2812 | | | | |
| | | 32 | .2742 | 9/32 | .2812 | L | .2900 | | | | |
| 3/8 | .3750 | 16 | .2983 | 5/16 | .3125 | Q | .3320 | W | .3860 | X | .3970 |
| | | 24 | .3239 | Q | .3320 | S | .3480 | | | | |
| | | 32 | .3367 | 11/32 | .3438 | T | .3580 | | | | |
| 7/16 | .4375 | 14 | .3499 | U | .3680 | 25/64 | .3906 | 29/64 | .4531 | 15/32 | .4687 |
| | | 20 | .3762 | 25/64 | .3906 | 13/32 | .4062 | | | | |
| | | 28 | .3937 | Y | .4040 | Z | .4130 | | | | |
| 1/2 | .5000 | 13 | .4056 | 27/64 | .4219 | 29/64 | .4531 | 33/64 | .5156 | 17/32 | .5312 |
| | | 20 | .4387 | 29/64 | .4531 | 15/32 | .4688 | | | | |
| | | 28 | .4562 | 15/32 | .4688 | 15/32 | .4688 | | | | |
| 9/16 | .5625 | 12 | .4603 | 31/64 | .4844 | 33/64 | .5156 | 37/64 | .5781 | 19/32 | .5938 |
| | | 18 | .4943 | 33/64 | .5156 | 17/32 | .5312 | | | | |
| | | 24 | .5114 | 33/64 | .5156 | 17/32 | .5312 | | | | |
| 5/8 | .6250 | 11 | .5135 | 17/32 | .5312 | 9/16 | .5625 | 41/64 | .6406 | 21/32 | .6562 |
| | | 18 | .5568 | 37/64 | .5781 | 19/32 | .5938 | | | | |
| | | 24 | .5739 | 37/64 | .5781 | 19/32 | .5938 | | | | |
| 11/16 | .6875 | 24 | .6364 | 41/64 | .6406 | 21/32 | .6562 | 45/64 | .7031 | 23/32 | .6562 |
| 3/4 | .7500 | 10 | .6273 | 21/32 | .6562 | 11/16 | .6875 | 49/64 | .7656 | 25/32 | .7812 |
| | | 16 | .6733 | 11/16 | .6875 | 45/64 | .7031 | | | | |
| | | 20 | .6887 | 45/64 | .7031 | 23/32 | .7188 | | | | |
| 13/16 | .8125 | 20 | .7512 | 49/64 | .7656 | 25/32 | .7812 | 53/64 | .8281 | 27/32 | .8438 |
| 7/8 | .8750 | 9 | .7387 | 49/64 | .7656 | 51/64 | .7969 | 57/64 | .8906 | 29/32 | .9062 |
| | | 14 | .7874 | 13/16 | .8125 | 53/64 | .8281 | | | | |
| | | 20 | .8137 | 53/64 | .8281 | 27/32 | .8438 | | | | |
| 15/16 | .9375 | 20 | .8762 | 57/64 | .8906 | 29/32 | .9062 | 61/64 | .9531 | 31/32 | .9688 |
| 1 | 1.000 | 8 | .8466 | 7/8 | .8750 | 59/64 | .9219 | 1-1/64 | 1.0156 | 1-1/32 | 1.0313 |
| | | 12 | .8978 | 15/16 | .9375 | 61/64 | .9531 | | | | |
| | | 20 | .9387 | 61/64 | .9531 | 31/32 | .9688 | | | | |

# METRIC DRILL & TAP SIZES

| Metric Tap & Clearance Drill Sizes | | Tap Drill | | | | Clearance Drill | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 75% Thread for Aluminum, Brass, & Plastics | | 50% Thread for Steel, Stainless, & Iron | | Close Fit | | Standard Fit | |
| Screw Size (mm) | Thread Pitch (mm) | Drill Size (mm) | Closest American Drill | Drill Size (mm) | Closest American Drill | Drill Size (mm) | Closest American Drill | Drill Size (mm) | Closest American Drill |
| M1.5 | 0.35 | 1.15 | 56 | 1.25 | 55 | 1.60 | 1/16 | 1.65 | 52 |
| M1.6 | 0.35 | 1.25 | 55 | 1.35 | 54 | 1.70 | 51 | 1.75 | 50 |
| M 1.8 | 0.35 | 1.45 | 53 | 1.55 | 1/16 | 1.90 | 49 | 2.00 | 5/64 |
| M 2 | 0.45 | 1.55 | 1/16 | 1.70 | 51 | 2.10 | 45 | 2.20 | 44 |
| | 0.40 | 1.60 | 52 | 1.75 | 50 | | | | |
| M 2.2 | 0.45 | 1.75 | 50 | 1.90 | 48 | 2.30 | 3/32 | 2.40 | 41 |
| M 2.5 | 0.45 | 2.05 | 46 | 2.20 | 44 | 2.65 | 37 | 2.75 | 7/64 |
| M 3 | 0.60 | 2.40 | 41 | 2.60 | 37 | 3.15 | 1/8 | 3.30 | 30 |
| | 0.50 | 2.50 | 39 | 2.70 | 36 | | | | |
| M 3.5 | 0.60 | 2.90 | 32 | 3.10 | 31 | 3.70 | 27 | 3.85 | 24 |
| M 4 | 0.75 | 3.25 | 30 | 3.50 | 28 | 4.20 | 19 | 4.40 | 17 |
| | 0.70 | 3.30 | 30 | 3.50 | 28 | | | | |
| M 4.5 | 0.75 | 3.75 | 25 | 4.00 | 22 | 4.75 | 13 | 5.00 | 9 |
| M 5 | 1.00 | 4.00 | 21 | 4.40 | 11/64 | 5.25 | 5 | 5.50 | 7/32 |
| | 0.90 | 4.10 | 20 | 4.40 | 17 | | | | |
| | 0.80 | 4.20 | 19 | 4.50 | 16 | | | | |
| M 5.5 | 0.90 | 4.60 | 14 | 4.90 | 10 | 5.80 | 1 | 6.10 | B |
| M 6 | 1.00 | 5.00 | 8 | 5.40 | 4 | 6.30 | E | 6.60 | G |
| | 0.75 | 5.25 | 4 | 5.50 | 7/32 | | | | |
| M 7 | 1.00 | 6.00 | B | 6.40 | E | 7.40 | L | 7.70 | N |
| | 0.75 | 6.25 | D | 6.50 | F | | | | |
| M 8 | 1.25 | 6.80 | H | 7.20 | J | 8.40 | Q | 8.80 | S |
| | 1.00 | 7.00 | J | 7.40 | L | | | | |
| M 9 | 1.25 | 7.80 | N | 8.20 | P | 9.50 | 3/8 | 9.90 | 25/64 |
| | 1.00 | 8.00 | O | 8.40 | 21/64 | | | | |
| M 10 | 1.50 | 8.50 | R | 9.00 | T | 10.50 | Z | 11.00 | 7/16 |
| | 1.25 | 8.80 | 11/32 | 9.20 | 23/64 | | | | |
| | 1.00 | 9.00 | T | 9.40 | U | | | | |
| M 11 | 1.50 | 9.50 | 3/8 | 10.00 | X | 11.60 | 29/64 | 12.10 | 15/32 |
| M 12 | 1.75 | 10.30 | 13/32 | 10.90 | 27/64 | 12.60 | 1/2 | 13.20 | 33/64 |
| | 1.50 | 10.50 | Z | 11.00 | 7/16 | | | | |
| | 1.25 | 10.80 | 27/64 | 11.20 | 7/16 | | | | |
| M 14 | 2.00 | 12.10 | 15/32 | 12.70 | 1/2 | 14.75 | 37/64 | 15.50 | 39/64 |
| | 1.50 | 12.50 | 1/2 | 13.00 | 33/64 | | | | |
| | 1.25 | 12.80 | 1/2 | 13.20 | 33/64 | | | | |
| M 15 | 1.50 | 13.50 | 17/32 | 14.00 | 35/64 | 15.75 | 5/8 | 16.50 | 21/32 |
| M 16 | 2.00 | 14.00 | 35/64 | 14.75 | 37/64 | 16.75 | 21/32 | 17.50 | 11/16 |
| | 1.50 | 14.50 | 37/64 | 15.00 | 19/32 | | | | |
| M 17 | 1.50 | 15.50 | 39/64 | 16.00 | 5/8 | 18.00 | 45/64 | 18.50 | 47/64 |
| M 18 | 2.50 | 15.50 | 39/64 | 16.50 | 41/64 | 19.00 | 3/4 | 20.00 | 25/32 |
| | 2.00 | 16.00 | 5/8 | 16.75 | 21/32 | | | | |
| | 1.50 | 16.50 | 21/32 | 17.00 | 43/64 | | | | |
| M 19 | 2.50 | 16.50 | 21/32 | 17.50 | 11/16 | 20.00 | 25/32 | 21.00 | 53/64 |
| M 20 | 2.50 | 17.50 | 11/16 | 18.50 | 23/32 | 21.00 | 53/64 | 22.00 | 55/64 |
| | 2.00 | 18.00 | 45/64 | 18.50 | 47/64 | | | | |
| | 1.50 | 18.50 | 47/64 | 19.00 | 3/4 | | | | |

# DIES ON THE OTHER HAND

Tap and dies are metal threading tools. Taps make internal threads inside a hole and dies make external threads on a round rod. They are often used for rethreading (cleaning up existing threads).

In a Tap and Dies Set the dies are the circular items with "teeth" on the inside.

Dies are used in the same manner as taps except they are used on a round rod instead of in a drilled hole. The die size you select should be the same size as the rod. IE If you want a 3/8" rod, you would use a 3/8" die.

In a Tap and Die Set you will find a Die Wrench which holds the particular dies you wish to use. Do not use channel locks or other tools to work the die.

Choose the correct die. When using a tap and die set, there are corresponding sets of taps and dies in the kit. You should use a tap to re-cut the threads of a hole when you plan to use a die, and vice versa. This is because, for example, if you only cut threads on the screw with your die and then try to stick the screw in the hole with the old threads, it probably won't fit well.

**CUTTING THREADS ON A METAL ROD**

1. Clamp the steel rod into the bench vice securely. Use the metal file to create a beveled surface along the edge of the rounded part of the rod. Secure the object you are working on in a vise and tighten it. If the object slips while you are cutting new threads, it will mess up the threads, and you will have to secure the object and start over.

2. Measure the gauge of the threads on the hexagon nut using the thread gauge. Depending on the type of nut you are using the threads may either be course or fine and metric or standard. Record the size of the threads by looking at the marking on the side of the gauge.

3. Select the correct die from the die set that correlates with your gauge reading from Step 2. Secure the die into the die wrench by tightening the set screws on both sides of the wrench until the die is firmly seated.

4. Apply cutting fluid to the steel rod. Position the die wrench perpendicular to the steel rod.

5. Work the tap and/or die by twisting slowly. Turn the die wrench clockwise until you feel resistance, then turn it counterclockwise to free it up a little. Turn it clockwise once more until you feel resistance again, and turn it counterclockwise to free it up. You'll probably feel resistance every twist or two, so go slowly and be patient. A good rule is for every turn of the wrench back it off one-half turn. Continue to turn the die wrench until the required length of steel rod is threaded.

6. Clean the threads with the shop towel to remove any metal shavings and excess cutting fluid.

7. Tighten the hexagon nut onto the new threads of the steel rod. Run the nut the full length of the threads and reverse it back off.

It is always recommend using a quality cutting fluid. This will extend the life of the tools and improves the quality of the threads.

# MANDREL EXTRACTOR

*by Chris Pearson*

We've all had mandrels get stuck in propellant. Sometimes even with the best prepping with release agents they seem to stick and we find ourselves using a rubber mallet to get the pesky ones loose.

You could machine your mandrels to have a tapered end, but that's really not a good way to get easy release.

A simple jig will do the job, along with a Snap Ring Motor Case like a Kosdon or a Loki, appropriate for the diameter of the grain you are working.

Study the diagram and you'll see how simply tightening the top nut will draw the mandrel upward and out of the propellant. Once the mandrel releases it will just about fall out by itself.

The hardest part is you must drill and tap a hole in the mandrel itself. It's not really hard if you have a drill press and a 1/4' 20 tap.

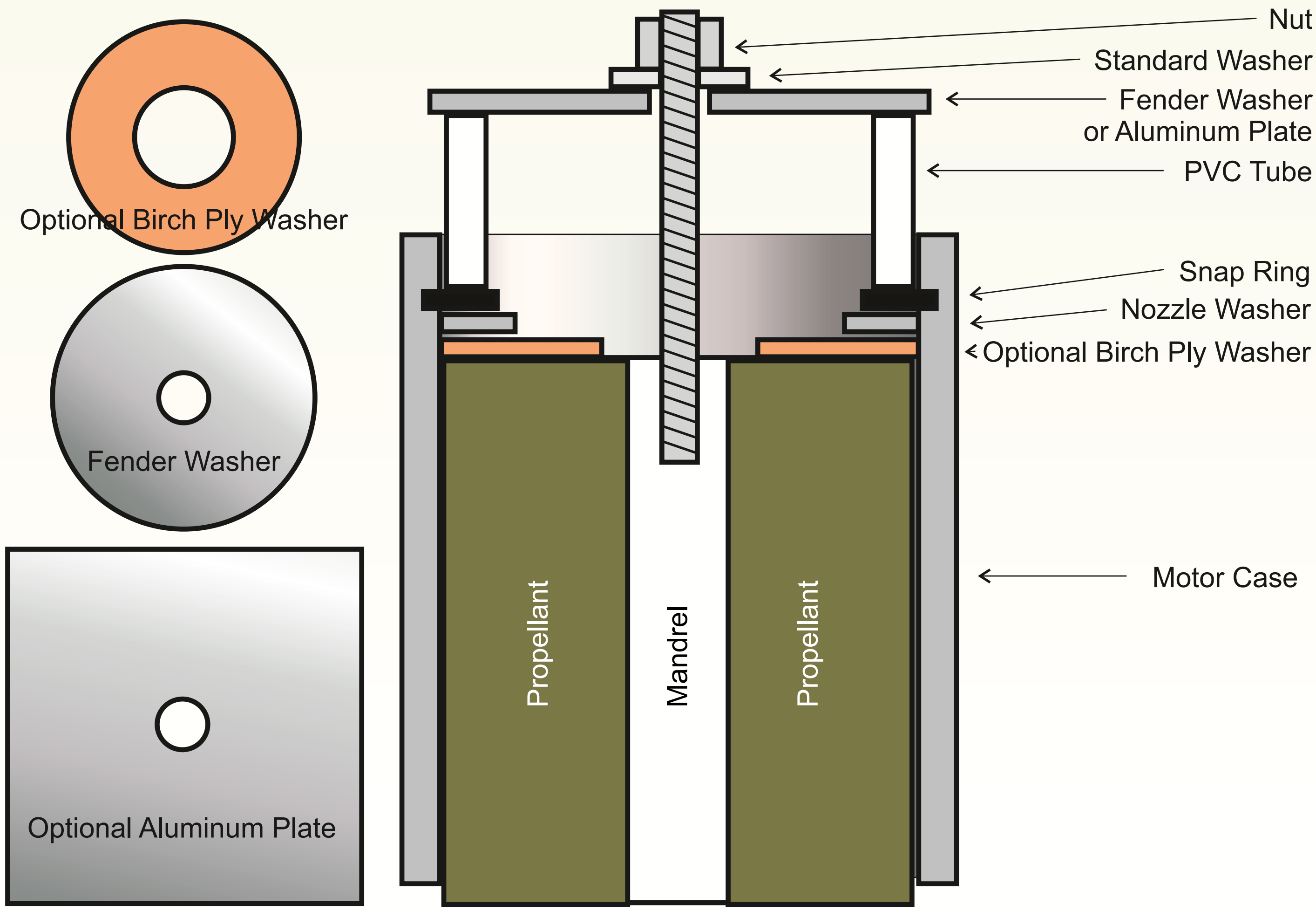
**ITEMS NEEDED:**

• 76mm case
• 76mm nozzle washer
• 76mm snap ring
• 2" schedule 40 PVC pipe (actual OD 2.375)- about 1" long or 2"schedule 40 coupler (actual OD 2.719)- about 1" long
•1/4" or 5/16" all thread (depending on mandrel thread) - at least 3" long or at least 3" long full threaded bolt w/ head cut off .
• Nut to fit the all thread.
•Washer to fit bolt
•3" OD fender washer or thick birch ply to cover PVC pipe, or strip of thick steel to cover PVC.

**WHAT TO DO**

Install snap ring and nozzle washer.

Install 2" fender washer or optional homemade backup disc. Not necessary, but prevents the grain from cracking.



The Disc center is opened for mandrel and disc OD to cover nozzle washer. Doesn't have to be perfectly round.

Screw in the all thread, or cut off bolt. into the mandrel bottom, screw into mandrel until it stops.

Insert grain w/ mandrel at bottom, into case.

Insert the PVC pipe or coupler. Coupler is less expensive.

Place the 3" fender washer on top of PVC. If the large washer is hard to find. Make out of thick plywood instead. It can be square or otherwise. Enough to cover PVC. Hole in plywood for all thread, or strip of thick steel washer for screw.

Tighten nut for extraction.

The mandrel should pop out the first 1/8" or -1/4" of extraction.

If its still hard to turn the nut, more than likely grain adhered to mandrel somewhere, probably because of poor release application.



LEFT: shows PVC placement

RIGHT: shows top plate, or large washer, and the all thread with nut and stop

# SIMPLE TROUBLE SHOOTING FLOW CHART

Many times despite our best efforts, (ahuh - sure), we often get caught in a bind and need to figger a way out. Whether at work or working on someone else's project, crap happens. This easy to follow Flow Chart will help expedite a solution in the quickest and simplest manner.