TRIPOLI GERLACH Research Rocketry News

TRIPOLI PREFECTURE [illegible]8

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TRIPOLI GERLACH Research Rocketry

TRIPOLI PREFECTURE #138

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

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

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ON THE COVER Robert Dehate (center on trailer, facing camera) and crew raise his 185-pound, two-stage rocket on the rail prior to flight at the Black Rock Desert on September 30, 2011. The BALLS launches at Black Rock finds many large projects such as this never seen at other locations.

Photo by: Mark Canepa

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WHAT'S UP

Well it's July and LDRS is upon us. If you haven't registered yet the deadline is July 10th. After that the price of fun goes up on the Playa. To register go to the website www.ldrs32.com and click on REGISTRATION in the menu.

Good news is the BoD has approved NAR flyers are permitted to fly on Tripoli Research days under their NAR Safety Code. This opens LDRS 32 to be five days of Research Flying. All Tripoli and NAR members are free to fly to their Certification Levels under the rules of their organization.

BALLS 22 Registration is now open on their website: www.balls22.com click REGISTRATION on their menu. Deadline for BALLS registration is September 14th - or pay a higher fee on the Playa.

HAMSTER DANCE III is set for September 19th, the Thursday before BALLS. Once we have the BALLS Range set up we will all caravan down to Smoke Creek, the site of the old Amateur Rocket activities in the days before Tripoli. Don't miss out on this fun, easy and laid back event. Sign up at: www.hamsterdancelaunch.com

KEN GOOD

Nearing the end of a serene day at LDRS at Lucerne in 2010, TRA Treasurer Bruce Lee and I were left behind to work with the Discovery Channel crew (who were still filming) while the rest of the BoD departed to prepare for that evening's TRA Members' Meeting /Dinner. As we stood on the lake bed while the TV folks prepared a take, a loud whooshing of rocket motors and a huge smoke cloud appeared at one of the away cells, and not from a rocket taking off. As people at the cell were seen running out of the smoke, Bruce and I almost simultaneously said, “That's an accident.”

And indeed, an accident it was. I did not immediately appreciate how intimately knowledgeable I would become of the circumstances. I would spend the next several hours focusing on working with the LDRS launch organization to help ensure emergency medical responders attended to several injured parties, caused by the unintended ground ignition of rocket motors of a large clustered multi-stage project that was being prepared. But I also gathered information, and would become the point person for the inevitable insurance claim/investigation that would follow… and also the lawsuit that would be filed almost a year later by one of the injured people.

Although I could devote many pages (as I did) to fully report what happened, leave it to say many issues in range management and rocket prep safety should have been better managed at LDRS 29, and absolutely must be better managed as we proceed to fly increasingly inherently dangerous rocket projects. In fact, it became a case study in how not to manage the flight preparation of a significant high power rocket.

There is indeed an unspoken code in which we tend to let people we regard as “experts” proceed with what they are doing. But that is an error, and we must be brave, mouthy, rude, outspoken enough to speak up to stop something that looks like it's not the correct thing to do. I was part of a good example of this at BALLS last Fall, when the Tripoli Pittsburgh/NASSA team was getting ready to fly their ambitious Phoenix P-motor project. Several of us had just completed the tasks required to get this large aluminum rocket on its launch rail and ready to be fired, and we had retreated to a “safe distance” from the rocket….. except that in actuality, we had not. TRA President Stu Barrett, who was also out on the playa assisting had in fact moved to a safe distance, and came forward to those of us who hadn't, yelling, “C'mon you guys – you're not far enough away from a research P-motor for cripes sakes!” Stu woke us up. I was embarrassed that I myself, former TRA president and constant safety nag had to be told this… but Stu was right. A fact reinforced when after we had moved to an approved distance, the motor catoed, blowing burning chunks of propellant geyser-like over the playa. Yes, even those who “know better” sometimes don't, and we are all obliged as rocketry colleagues to speak up when needed and break the unspoken code.

Summarizing all this, it really comes down to a few key considerations. First off, all applicable safety codes must be followed at all times, and not just “sort of” followed. Second, we must be vigilant to those areas not always explicitly defined in a safety code. Things like how many people do we really need or want out at a launch pad, who is wandering about our range and how are we controlling who is going where, do we really understand our big, complex projects (or our simple ones) and are we scrupulously following correct procedures, or are we groping about or taking short cuts.

Finally, we have to treat our rocket projects like full-blown space vehicles. High Power rocketry has grown up now – way up. In many cases, we are flying rockets that are beyond the capability of what some civilized countries could manage half a century ago. We can't think of flying high-power rockets as a sort of jazzed-up picnic in a park with the kids flying a few Estes model rockets. We have to think and behave like professionals, like we were an actual space flight company doing this for a living, and directly responsible for any bad outcomes. If we think of modern, high-power rocketry this way, we introduce a mental discipline that will be resistant to laxness and neglect, and committed to following flight procedures that are safety code compliant, and which manage risk responsibly.

Unless all high-power flyers move our collective risk management to the levels required by the rockets we are flying, we are living on luck and the law of averages. It will only be a question of time before the really big accident happens that kills someone, and we can watch mournfully as high power rocketry disappears in a blur of lawsuits, restrictions, and prohibitive legislation. Perhaps that LDRS 29 incident was the sobering example we needed to see, to help us commit to the actions that will permit high power rocketry to continue onward, as it has done since it was begun so many years ago.

Never be complacent, when in doubt speak up!

BRUNO'S

BRUNO SELMI
EMPEROR OF GERLACH

Everyone who goes to Black Rock whether to launch rockets, go hunting, film commercials, land sail, explore or just heading for California the hard way has to have met Bruno. He's the biggest business in town owning the Bruno's Casino, Bruno's Restaurant, Bruno's Texaco, Bruno's Trailer Park, Bruno's Motel, Bruno's Cattle Ranch, Bruno's Farm and Bruno's What Ever You Need I got It For You!

With all of his accomplishments his most outstanding feature is his ability to remember people. He may honestly not remember your name but he will remember YOU. Have a conversation with him once and he will remember you two, three years later. He'll remember your job, your kids, your health. If you talk to him about it he'll remember you.

Bruno was born Giovanni Bruno Selmi on July 20th. 1923 in Lucca, Italy, about 60 mile away from Tuscanny, Italy. As a boy in Italy he was into Bicycle Racing and was even awarded a prize by the Pope for winning a race. You should hear the story, Bruno's a great story teller - except you really have to pay attention as he speaks broken English.

His stories are boundless; like when he ran his truck off the road and in his words. "Ima bounce ana bounce ana bounce ana bounce ana bounce!

You would think after being in this country over 65 years he'd speak better English! He does however, speak perfect Spanish, (ya sure!) and we sorta think he speaks English way better than he presents.

Bruno came to the US in 1946 following his two brothers Dominic and Joe. He arrived in the U.S. and worked at his brother Dominic's ranch in Dayton, Nevada just East of Carson City, until he got a job at the defunct Gypsum plant , then called Portland, in Empire.

Bruno's brother Joe had a bar in Gerlach, which still exists although Joe passed away several years ago. In the evenings after work Bruno would hang out there to hear a girl named Francis sing. Francis became Bruno's wife in 1950.

They had one child, Lena Skeekie Selmi. Today we know here as Skeekie Courtney.

Bruno bought the Longhorn Bar, which is now Bruno's Casino & Country Club, in 1952. Ever after that its been an uphill expansion of acquisitions for him.

This year Bruno turn's 90 and his mind is still a steel trap of memories, so unlike most people his age. Once you meet him you can't help but long remember him too.

Bruno with his current main squeeze, Mary.

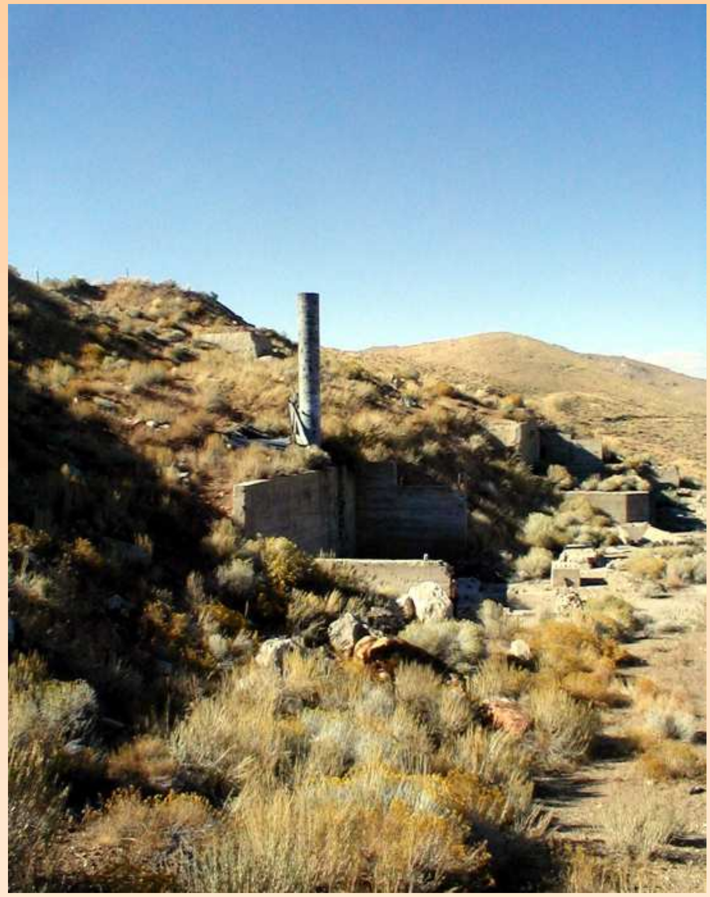
NIGHTENGALE

The Black Rock area is peppered with mining areas from years gone by. Gold and Silver mines were abundant and now just empty holes and shafts remain. Copper mines flourished for a while and most are now gone. Empire has its Gypsum pit still “open” but without a processing plant it too will soon be a part of history.

The town of Nixon, south of Gerlach, was near home to a rather large Tungsten mine. While the mine is now closed much of its existence still remains.

Tungsten was discovered in the Nightingale district in 1917, and enough was found that they hauled it down to a mill at Toulon, 40 miles to the southeast. In the early 1930's they built a 100-ton concentrator on site but it never got much of a workout. Tungsten production was intermittent until World War II, but then slowed down again until about 1956, when interest petered out altogether.

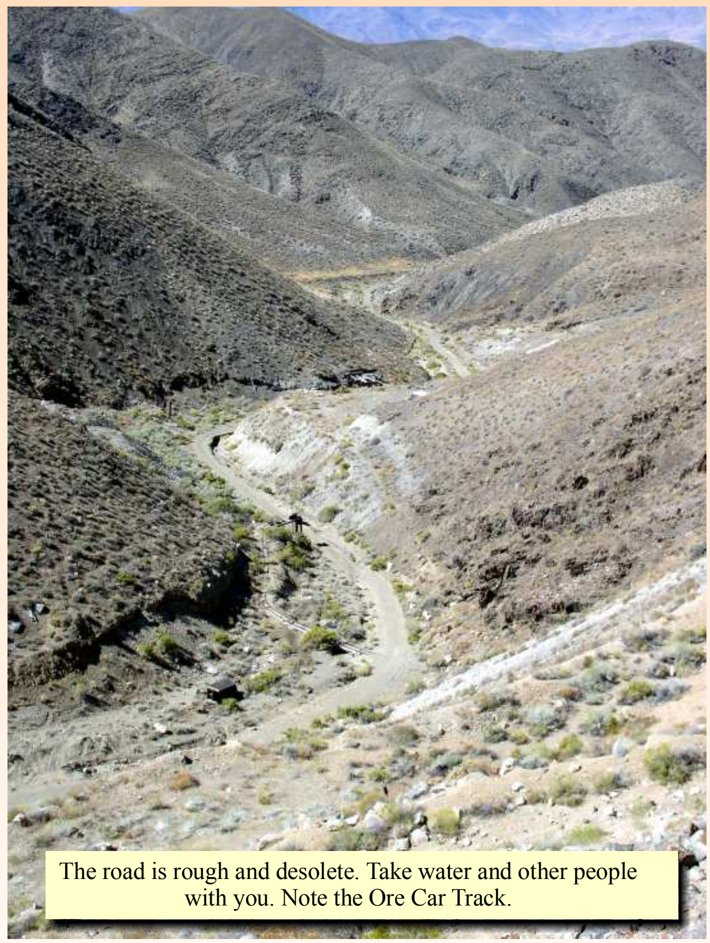
While not as romantic or exciting as gold, tungsten has its uses, and was particularly important during wartime. Its uses in high speed metal-working equipment, steel, armor, and armor-piercing shells made tungsten a vital war commodity. Tungsten was in such short supply during the war that the War Production Board mandated



that all replaced automotive ignition points be returned to salvage the tungsten in them.

Up the road skirting the southern end of dry Lake Winnemucca you will find the ruins of this tungsten-gathering venture. Taking that road up the canyon will take you to the mine site. Be advised this road requires a 4WD vehicle.

The place is strewn with decaying buildings and peppered with open mine shafts just begging you in. Do not enter. There are many places and objects of a historic nature.



The road is rough and desolete. Take water and other people with you. Note the Ore Car Track.

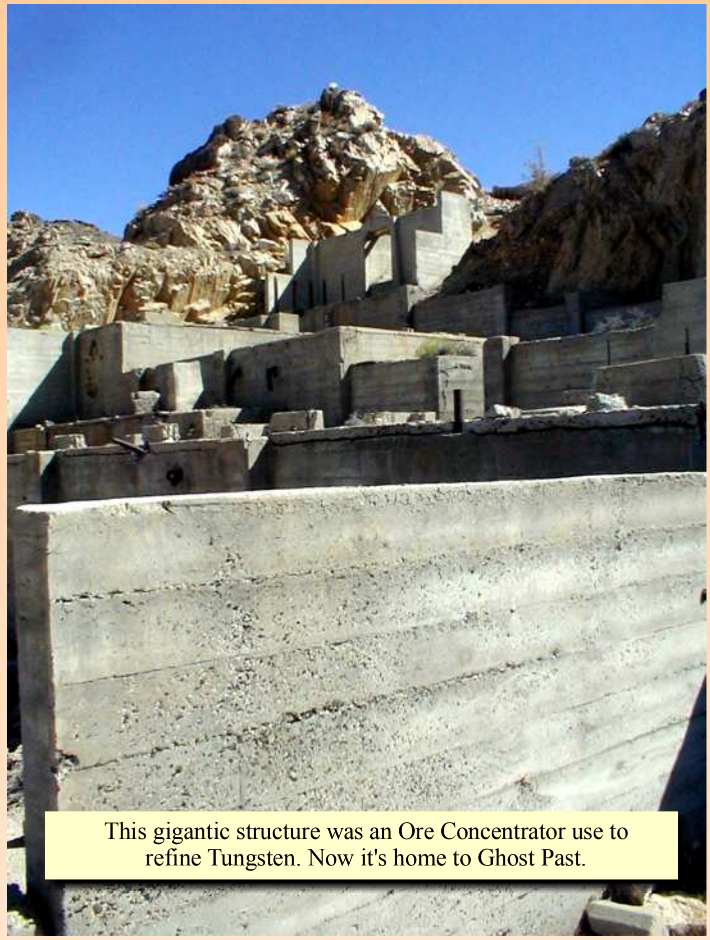
Even more fascinating are the ruins of the MGL mine and mill, in the canyon about 7 miles north of the turn-off for Nightingale. However, the road is washed out bad in more than a few places, and the going can be hairy.

While the Nightengale area is where most people stayed and most of the Tungsten was mine, the MGL mine and

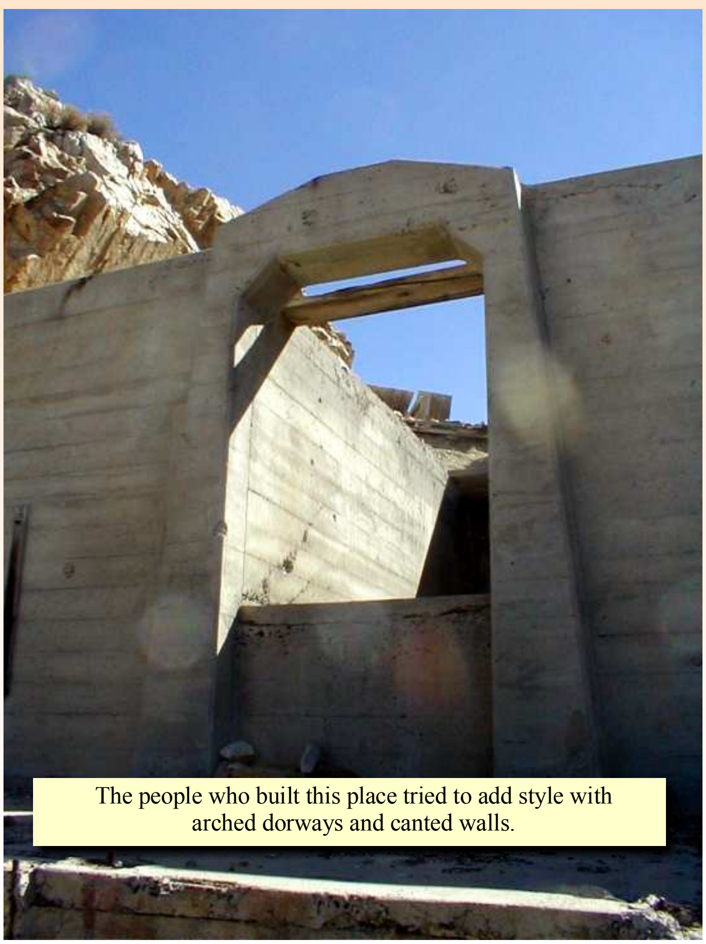
mill is where the largest structures are found. It has a few mine shafts but most impressive are the concrete structures still standing.

Looking much like an Indian Cliff Dwelling the people who built it added Deco Art to its character thinking this was to be a long term venture. Which it wasn't!

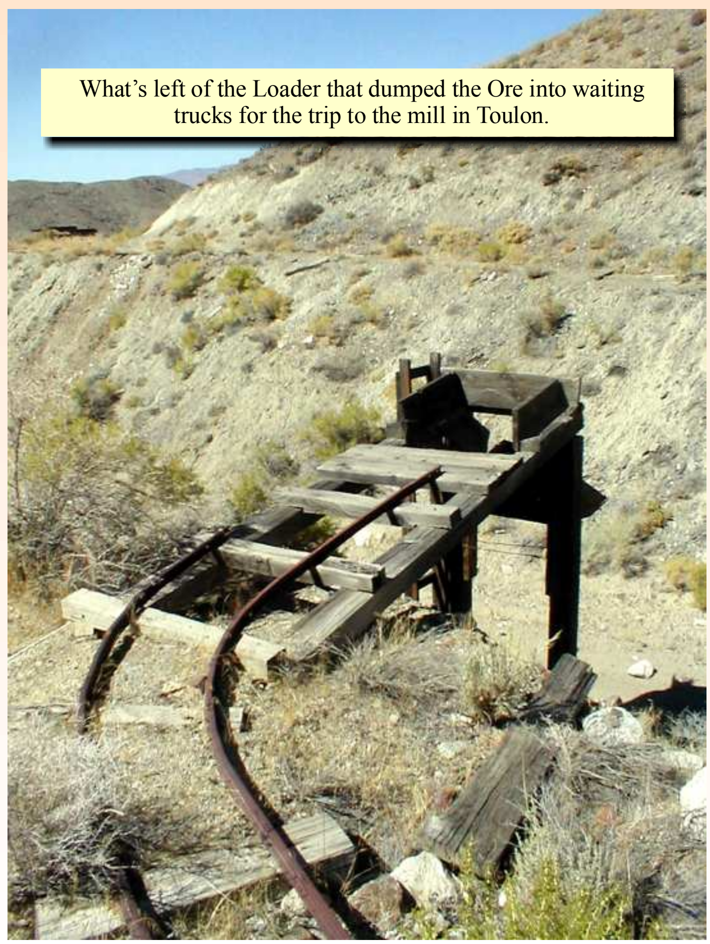
Directions: From Fallon, west on Highway 50 to Fernley; north on SR447 to Wadsworth and proceeding to Nixon; proceed north 1.8 miles, turn right on local road; proceed 11.7 miles and take right fork 10.6 miles.



This gigantic structure was an Ore Concentrator use to refine Tungsten. Now it's home to Ghost Past.



The people who built this place tried to add style with arched dorways and canted walls.



What's left of the Loader that dumped the Ore into waiting trucks for the trip to the mill in Toulon.

THE ARCH

One of the neatest sites to see heading for the Nightengale area is natural. It's a stone arch located about half way there and on the west side of the “road”. While you can’t drive up to it you can park and walk. You’ll need a sharp eye, or binoculars, but it can be seen from the road and is worth the hike. Luckily, like the Nightengale Area, its not on Indian land so you can enjoy it all you want.

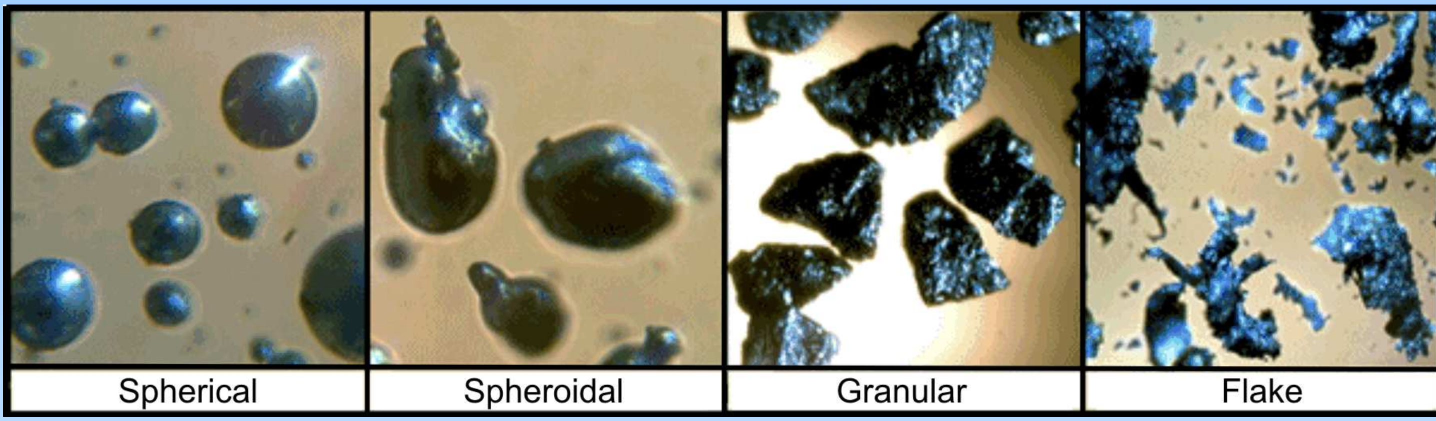
2013 FLOOD

The Black Rock area gets major rains almost every year. In 2006 Heavy waters ran down the Granite Mountains north of Gerlach and was the major cause of the Guru Road destruction. It also continued into town and through Bev’s MINERS CLUB, nearly wiping it out.

This year the much needed rain, which helps heal the Black Rock playa, struck south of Gerlach about 31 miles north of Fernley and destroyed Route 447. Not to worry, the Road Crew should have it fixed by the time we get there!

PARTICLE SIZES EXPLAINED

JOE PSCOLKA



You will often see chemicals in fireworks and propellant formulas that look like these:

Aluminum, atomized, 22 micron
Aluminum, -325 mesh
Aluminum, -325 mesh, spherical, 22 micron

Do you really know what those particle sizes really mean? What is really being described? When they say "-325 mesh" and "22 micron", what's the difference? And why does it matter to you?

Well, it can definitely help you to know how the particle "size" ratings get assigned to metal powders. Most of the size ratings come directly from the wholesaler or manufacturer. But every so often we buy surplus materials which may not come with any additional information about the manufacturer, the size or shape of the powder.

The first step in the identification process is a visual inspection. You may be surprised how much you can tell about a sample just by looking at it. By observing the flow characteristics of a powder, and how it feels between your fingers, you can approximate particle size and shape. If you have experience with metal powders, for instance, you can often tell if a sample is granular (rough feeling), or atomized (round particles, feels smooth, pours and flows quickly and smoothly). If you cannot feel any particles between your fingers, you can assume the powder is probably finer than 200 mesh, or even less than 325 mesh (written as "-325 mesh.")

The next step is to verify those assumptions though quantitative and qualitative testing.

To determine if a material is appropriate to be used in a given formula you'll need to know the particle's shape (morphology), size, and distribution (granulometry). Shape, as shown above, is easily determined under a microscope and classified as atomized (spherical or spheroidal), granular, or flake.

Particle size is reported in one of two ways: either by mesh size (large and medium particles, generally larger than 325 mesh) or by microns (very small particles).

Why use two measurements?

US mesh size describes the number of openings per inch in a screen. So if a material is listed as -60 mesh it will all pass though a 60 mesh screen (the minus sign in front of the 60 means that all particles are smaller than 60 mesh). Conversely, if the material is described as +60 mesh, it would mean that all particles would be retained on a 60 mesh screen and are therefore larger than 60 mesh.

But mesh sizes can only go so far. After a point the individual wires that make up the screen are so close together it is no longer practical to measure using screens. In practice, particles smaller than 325 mesh are usually described in microns. A micron is one thousandth of a millimeter, or one millionth of a meter. The unaided human eye can see particles of about 40 microns. Smaller than that, you need magnification.

There is no truly accurate conversion from mesh size to microns, because the wire thickness' in screens vary all over the place. But approximate conversion tables are commonly used anyway. (In the table below, screen sizes of smaller than 600 mesh are shown, even though they don't exist in practice.)

"Mass Fraction Analysis" is used to determine large-to-medium size particle distribution in a sample. The powder is sifted through a set of nesting screens, each with progressively smaller openings (higher mesh numbers). By measuring the percent of material that remains on each screen, we can classify a material by its size distribution.

US MESH	MICRONS
10	2000
20	841
40	400
60	250
80	177
100	149
200	74
325	44
400	37
625	20
1250	10
2500	5

If you were to sift a Magnesium-Aluminum product (described as 180-325 mesh) through a stack of 180 mesh, 200 mesh, and 325 mesh screens, a mass fraction analysis might yield a particle size range that looks like this:

+180 Mesh	26%
180-200 Mesh	31%
200-325 Mesh	21%
-325 Mesh	22%

If the 180 mesh size was critical to your formula, you can interpret this to mean that 26% would remain on the 180 mesh screen (larger then 180 mesh) and 74% would pass through it (be smaller than 180 mesh).

Mass fraction by sieve analysis is a very helpful method of classifying coarse-to-medium particles, but what about the really small stuff?

When the average particle size is around 50 microns, sieve analysis is no longer practical, and doesn't adequately describe the particle sizes. Several methods are commonly used to measure really fine stuff: Gravitational Sedimentation, Laser Light Diffraction, Optical Light Microscopes, Scanning Electron Microscopes (SEM) and Transmission Electron Microscopes (TEM). The most accessible method to an amateur is an Optical Light Microscope.

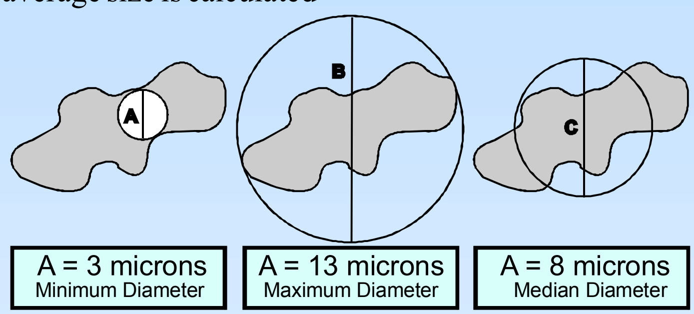
So how is a particle measured with a microscope? Do you need some kind of tiny ruler? As funny as that might sound, that's exactly how it's done. The microscope can be fitted with a gizmo called a Reticule Micrometer. After it is calibrated, it can be used to measure the size of individual particles in a powder sample right down to 1 micron.

But just because you can measure it, that doesn't mean it's a simple task.

Sure, measuring spherical material is fairly straightforward. After all, you're really just measuring the diameter of little balls. But what about flake, granular, and spheroidal samples? Digital imaging and software can drastically decrease the time needed to perform measurements and reduce error rates. But it appears that most if not all of the automated equipment measures any particle shape as if it is spherical. Because of this, there is not really a standard method for assigning a particle size.

Selecting the method seems to be based mostly on what you'd like your results to state. Below is an imaginary particle and three circles representing different measurement methodologies.

In the first example the measurement is across the smallest dimension of the particle. This method might be used to describe the particle in terms of its reactivity by describing the particle in the smallest possible size. Method B might be used conversely; to describe the particle's largest dimension. Arguably the most accurate methodology would be using example C, where an average size is calculated



No matter what method is used, the results would normally be presented to you, the end user, as an average size (3 micron), a particle range (3 to 15 micron) or a frequency distribution (30% <5 micron, 10% 5-10 micron, 60% 10-15 micron), or some variation thereof.

So why does particle size or shape matter?
The shape and size of a particle has a huge impact on its reactivity. Flake particles have a large surface area that can be in contact with an oxidizer when compared with a spherical particle. Granular particles often have sharp edges that can ignite more easily than the smooth, round edges of an atomized powder.

Selecting powder with a different particle size or shape can create a wide variety of changes in motor performance, such as burn time, specific impulse, chamber pressure, etc.

Motor makers: Right now, as you look at the aluminum powder options from a chemicals suppliers list, you are probably asking yourself: "what is the difference between spherical and spheroidal aluminum?" Or, for that matter, "what does it matter that a particle shape is granular, or flake, or atomized?"

Funny you should ask. I was just about to tell you. Herewith follows:

Particle Shapes 101:
Before you embark on this area keep in mind that particle shape is not the only factor influencing how a metal powder will perform in a motor composition. The size of a particle of metal, whether it is coated or not, and other factors are just as important as particle shape.

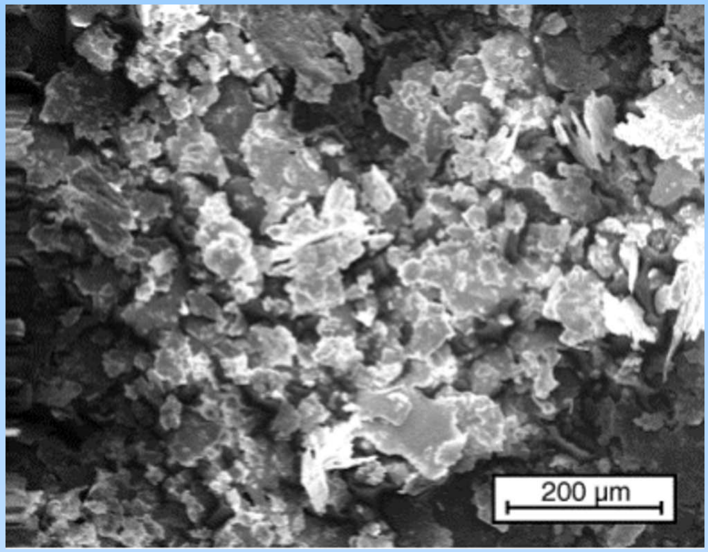
Particle shape matters mostly because of its impact on pyrotechnic composition reactivity. Think about it. Which is easier to light, a 3 x 3 inch piece of paper or a 3 x 3 inch piece of plywood? Chemically they're almost the same thing. But the little, bitty edge of the paper is a lot easier and faster to light than the edge of the plywood. And that's what separates the flakes from the atomized - ease of ignition.

Whether you are trying to make a rocket fuel, a flash device, a glitter fountain, a flitter star, or a long-tailed comet (I know, those are fireworks), your success will depend in part on using the right particle shape. So pay careful attention to the type of aluminum (or other metal powder) prescribed in your motor composition. If particle size or shape is not specified, and you are new to making motors, then it's a good idea to ask someone knowledgeable. Using the wrong one might be a waste of time and money, or could even be dangerous.

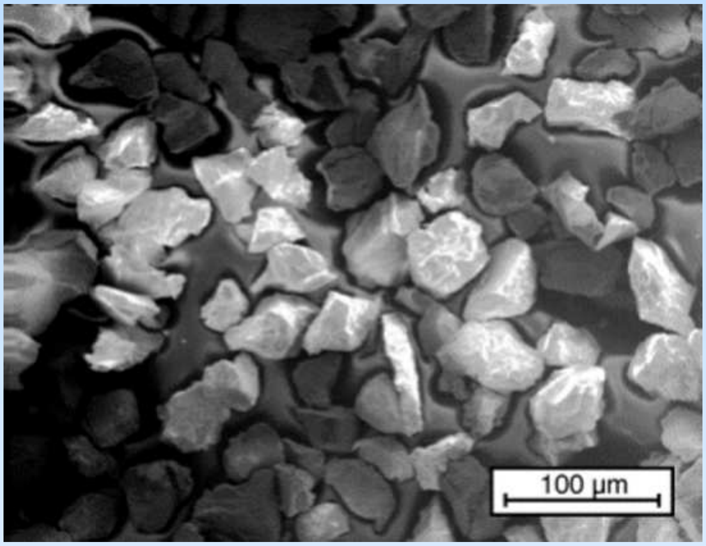
The following photographs show the most common particle shapes used in making fireworks. The scale on the bottom of each photograph shows a 200-micron long scale for your reference (that means 200 millionths of a meter, or a little bigger than a grain of fine, pesky, popcorn salt for all you who insist on watching television and munching popcorn in bed).

In the top right photo notice how "edgy" the aluminum flakes are. These thin edges heat up and ignite faster than the rest of the particles. Flakes, because of this edginess and the fact they offer the greatest surface area, are generally the most reactive particle shape when used in pyrotechnic compositions.

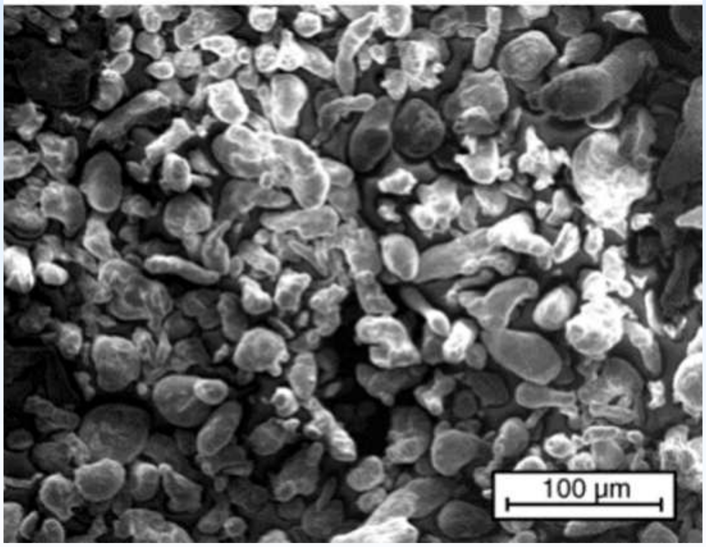
Granular (ground) metal particles, as shown in the second photo down, have a characteristic, gravel-like shape. Like flakes, they have a lot of sharp edges, too. But they do not offer as much surface area, and so will not be quite as reactive as flake powders.



Flake-Shaped Aluminum Particles
(Magnified 100times)

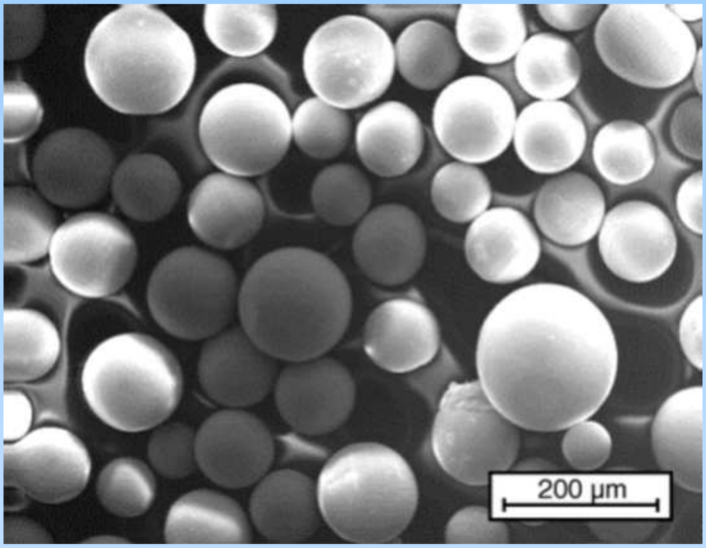


Granular-shaped ferro-aluminum particles
(magnified 100 times)



Atomized, spheroidal aluminum particles
(magnified 200 times)

Atomized particles come in two basic shapes: those that have irregular, rounded shapes, called spheroidal, shown bottom left and those that are almost perfectly round called spherical, as shown below.

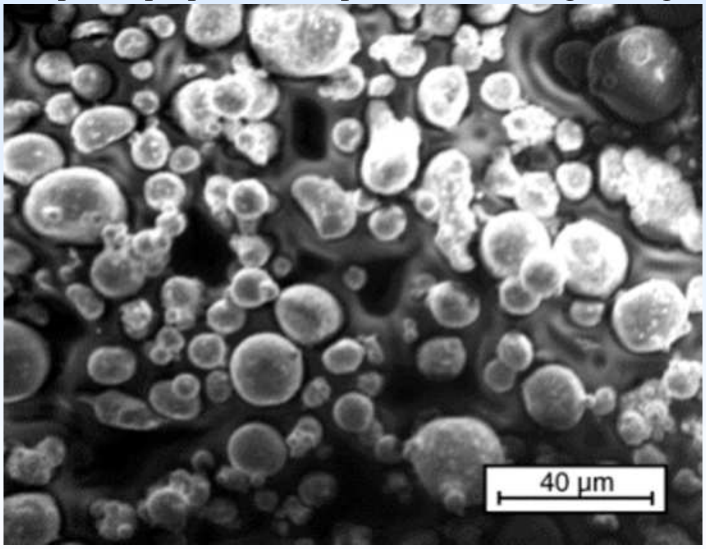


Atomized, spherical titanium
(magnified 100 times)

Notice that the spheroidal particles on the lower left also have "edges", those irregularly shaped extensions you see in the aluminum shown. But because they are rounded, they are not as reactive as the flake and granular material.

Spherical-shaped particles range from being perfectly round, shown in the titanium photo above to almost-round, as shown with the aluminum particles below. These are the least reactive particle shapes of all, with very few, if any edges to take fire.

So, the bottom line is that all metal powders are not created equal. Whenever you are creating a new composite propellant composition, choosing the right



Atomized, spherical aluminum
(magnified 500 times)

metal fuel's particle shape is critical. Spherical shapes are the predominant metals used in composite compositions, however, some have had success with other shapes. Again, if in doubt, ask someone knowledgeable.

US MESH	INCHES	MICRONS	MM
3	0.2650	6730	6/730
4	0.1870	4760	4.766
5	0.1570	4000	4.000
6	0.1320	3360	3.360
7	0.1110	2830	2.830
8	0.0937	2380	2.380
10	0.0787	2000	2.000
12	0.0661	1680	1.680
14	0.0555	1410	1.410
16	0.0469	1190	1.190
18	0.0394	1000	1.000
20	0.0331	841	0.841
25	0.0280	707	0.707
30	0.0232	595	0.595
35	0.0197	500	0.500
40	0.0165	400	0.400
45	0.0138	354	0.354
50	0.0117	297	0.297
60	0.0098	250	0.250
70	0.0083	210	0.210
80	0.0070	177	0.177
100	0.0059	149	0.149
120	0.0049	125	0.125
140	0.0041	105	0.105
170	0.0035	88	0.088
200	0.0029	74	0.074
230	0.0021	53	0.053
325	0.0017	44	0.044
400	0.0015	37	0.037
625	0.0008	20	0.020
1250	0.0004	10	0.010
2500	0.0002	5	0.5

HIGH ENERGY DIPPED IGNITERS

CHRIS PEARSON & JIM ROSSON

Is there an alternative to purchasing high-priced pre-made igniters or having to stuff pyrogen into straws if you want reliable ignition for your rocket motors? ***Yes . . . there is!*** *While there are several different companies that sell already made igniters or dipping kits, they seem relatively expensive. For a rather small cash outlay, and, if you make Research motors, using chemicals that you probably already have, you can make a dipping compound that will perform as well, if not better, than any commercially available igniter or dipping mixture.*

WARNING! This igniter formula includes magnesium powder and powdered potassium nitrate. These two chemicals should never be mixed dry as there is the possibility of spontaneous ignition or explosion if they are. Fine magnesium powder itself is very dangerous and if spilled can form an airborne cloud that can flash explosively. Do not attempt to work with these chemicals if you have had no prior experience with them. Remember to follow good lab technique and wear gloves and eye protection. Have a source of water or fire extinguisher handy. It is a good idea for people who are inexperienced in chemical handling to mix the chemicals outside, or in a garage and work with someone else present.

PRELIMINARY INFORMATION

Preliminary Information Please refer to the previous article “How to Make an Igniter” for details concerning construction of a bridge wire-type igniter that will be used in the construction of the dipped igniter.

Carefully mix together the igniter pyrogen formula as follows:

4 parts magnesium powder or mag/aluminum
(Works best with <50u/270-325 mesh powders)
5 parts powdered potassium nitratE
½ part silicon metal powder
6 parts Plasti-Dip binder (red or clear only)
3-4 parts toluene (if needed)

Plasti-Dip is an air-dried rubber coating dip for hand tools and is available at hardware stores such as Ace and True Value. Only the red or clear colors are usable for igniter construction because of changes in the compound chemistry for different colors. The toluene needed to thin the mixture is available at the same hardware stores as the Plasti-Dip or at Sherwin-Williams retail stores. Do not substitute any other solvent for the toluene.

Please note that the above chemical ratios are a “starter” formula. The best ratio for your pyrogen varies a lot on the quality/particle size of your ingredients. If your igniter “pops” or flashes explosively instead of burns, you’ll have to increase the amount of binder to slow the reaction down, starting with twice as much binder. Likewise, you can add potassium nitrate to increase the burn rate if your igniter is too slow. The igniter should have a burn time of about one second. Simply add magnesium for more heat/slag, potassium nitrate for more speed, binder to slow to down the reaction, or solvent to reduce the dip thickness.

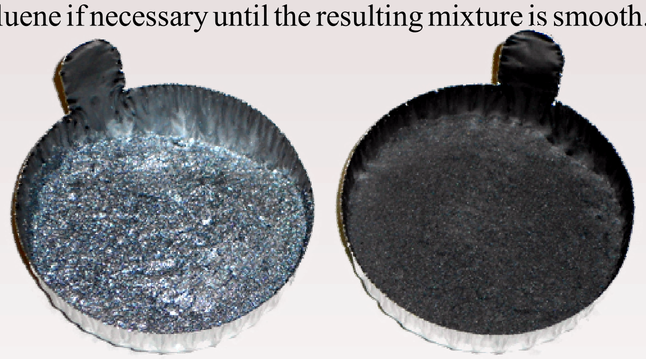
You may ask “Why use Plasti-Dip?” It’s thick and works well as a binder, it’s cheap, and one container of it will last

Various items needed to produce High Energy Ignitors a long time. The silicon fillers in the Plasti-Dip create a glassy oxide that "splutters" during the pyrogen burn. You can duplicate this effect by adding powdered silicon to any other igniter formulation. The burning SiO2 “slag” seems to fuse to the propellant when it hits, and helps the grain ignite. After much testing it was discovered that slow and hot was the only 100% sure fire way to light any motor formulation, even those difficult to ignite green, smoky or sparky propellants. If one is not trying to light an old swollen and oxidized White Lightning motor, or some other improperly stored propellant, there are a lot of formula variations that will work most of the time.

Low ambient temperatures also impacts amount of heat flux required, and this is where long and hot is mandatory. For a pyrogen to use in low ambient temps, you can mix two different particle sizes of magnesium (small flake for easy ignition, and mid-sized spheres for heat retention and slower speed). It can also be helpful to add silicon powder for higher slag content and longer heat flux duration in cold weather.

MIXING & COATING PROCEEDURE

1. Measure out the Plasti-Dip and dilute with toluene in a solvent proof plastic mixing cup or glass beaker. Carefully mix in the magnesium powder to the thinned Plasti-Dip. It is very important to first completely mix the magnesium powder into the Plasti-Dip before adding the potassium nitrate, as this will greatly reduce the risk of accidental ignition. This is called “wetting out” the metal, and there should be no powered magnesium anywhere in the mixing cup before adding the potassium nitrate. Use a plastic spoon for measuring the magnesium into the mixing cup and then discard the spoon. Do not use this same spoon to measure the potassium nitrate! You can now add the silicon metal if desired. Add the potassium nitrate with another clean spoon, discarding it immediately afterwards, and stir with a wood stick, adding more toluene if necessary until the resulting mixture is smooth.



Notable difference between flake and powdered magnesium

2. The mixture should have a consistency that is not too thin, as you don’t want it to be dripping off the end of the igniter before it dries. Too thick of a mixture will make it hard to coat the wire and will result in poor bonding between the pyrogen and wire, and might be susceptible to cracking with age.

High Energy Dipped E-Match and Bridge Wire

3. Dip the igniter wire into the mixture, making sure the mixture completely covers the nichrome wire. Hang the dipped igniter head down over a paper towel. If the pyrogen drips off, the mixture is too thin. Let some of the toluene evaporate until the mixture thickens up and try again. Likewise, too thick of a mixture can be thinned with more toluene. Multiple dips of this pyrogen are not recommended because the additional thickness can cause the pyrogen to “pop” rather than burn or blow the top of the pyrogen head off without igniting it. Try to get as thick a coating on the wire as possible with one dip. Don’t worry about the thickness of the coating when dipped, as the pyrogen head will shrink in size as the solvent flashes off.

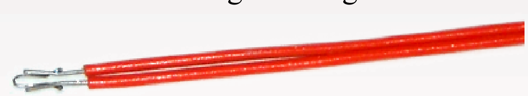
4. After you’ve dipped the igniter wires, let them dry for 24 hours. Because of the nature of the Plasti-Dip binder, the igniter will have a rubbery consistency which is very durable and resistant to drying out or cracking and will not require any sort of “protection” dip to prevent crumbling. It can also be shaved with a razor blade to reduce the diameter of the pyrogen head if necessary to fit it into a small motor nozzle.

5. Check for continuity and resistance of the finished igniter once again using a digital volt-meter. The resistance of the completed igniter shouldn’t have changed. If using these igniters in a cluster, use ones with the same resistance, or ones that are very close. It is usually a good idea to check continuity on the igniter once again at the pad right before you insert it in the motor. Use your own DVM. Don’t rely on the continuity circuits (if they exist) of the launch pads.

USING ELECTRIC MATCHES

Using electric matches as the pyrogen initiator eliminates having to construct the bridge wire-type igniter and can save much time if you are constructing them yourself, or expense, if you are purchasing them pre-made. Electric matches will allow a faster ignition of the igniter pyrogen and propellant which is important when flying clustered motors.

One of the problems that many igniter compositions have is that they are relatively insensitive and can’t be ignited using electric matches so bridge wire igniters must be



Business ends of a commercial bridgewire igniter and electric match used. If you need faster ignition for clusters or upper staging and you're uncomfortable with using thermite for cluster ignition, enhanced e-match igniters are the answer. Adding antimony trisulfide, bismuth trioxide, zirconium hydride or lead tetroxide to the pyrogen composition increases the ignition sensitivity of the mixture enough to be ignited using a "popping" type electric match such as a J-Tec. Although other e-match types may be used, they might not ignite the pyrogen reliably. Testing must be done to check e-match suitability and pyrogen burn time.

Of course, zirconium is also a candidate for this task. One of the most common uses of zirconium in igniters is in a mixture of metallic zirconium and potassium perchlorate, called ZPP. It is also known as a NASA Standard Initiator.

However, both zirconium and zirconium hydride are expensive, about $1-3 per gram in reagent grade and it is not a chemical that is available from pyrotechnic supply companies. Using zirconium hydride is significantly safer to use than metallic zirconium, which when finely divided is pyrophoric, that is, it will spontaneously ignite from the friction in the air. Many professional rocket people and chemists warn against using metallic zirconium for any purpose.

Other chemicals that are cheaper and not as sensitive are usable. Bismuth trioxide can be used and is a safer, non-toxic replacement for lead tetroxide. That and antimony tri-sulfide are all are used in fireworks and therefore can both be purchased from pyro or hobby chemical supply companies. You'll have to experiment with the amount of additional chemicals in your particular mixture, but generally if you mix one part of any of them to every two parts magnesium, you will have a pyrogen mixture that is sensitive enough to fire from an electric match.

Coat the electric match in the normal fashion and allow to dry overnight. No additional precautions are needed for this igniter compared to the traditional pyrogen-tipped igniter. This pyrogen will easily fire with an electric match, providing a much quicker motor ignition and the addition of all but the bismuth trioxide causes the pyrogen to burn at a much higher temperature, making for faster ignition of those binder-rich smoky or sparky motors or other difficult to ignite propellants. You can also use this dip with a bridgewire type igniter.

STORING PLASTI-DIP

After the can of Plasti-Dip has been opened, it will slowly dry out even if the container is sealed. In time it will appear rubbery and cracked. To refresh the mixture, simply pour toluene up to the level of the material and let it sit for a couple of days and stir. You can do this as many times as needed until the Plastic-Dip is used up. However it will be thinner than it was when first opened, and you probably won't have to thin the pryogen mixture when making future batches. You'll also have to increase your Plasti-Dip amount to compensate for the thinning.

HOW TO MAKE AN IGNITOR

An in depth article on the basics of making Standard Ignitors was published in *TRIPOLI GERLACH NEWS* Vol.2 No.2 March 2012.It covers everything from wire wrapping to pyrogen composition. It can be retrieved free of charge by visiting our WebSite:

www.tripoligerlach.org

COMING SOON. . .

HOW TO MAKE ELECTRIC MATCHES

All you need to know about making your own E-Matches. Covers compositions and how to make your own E-Match Blanks really inexpensively! Don't Miss This!

THERMITE BASIC USAGE PRIMER

CHRIS PEARSON

THE THERMITE (THERMIT) REACTION WAS DISCOVERED IN 1893, AND PATENTED IN 1895, BY GERMAN CHEMIST HANS GOLDSCHMIT. CONSEQUENTLY THE REACTION IS SOMETIMES CALLED THE "GOLDSCHMIT REACTION" OR "GOLDSCHMIT PROCESS". GOLDSCHMIT WAS WAS ORIGINALLY INTERETED IN PRODUCING VERY PURE METALS BY AVOIDING THE USE OF CARBON IN SMELTING BUT HE SOON DISCOVERED THE VALUE OF THERMITE IN WELDING. THE FIRST COMMERCIAL APPLICATION OF THERMITE WAS THE WELDING OF RAILROAD TRACKS IN ESSEN, GERMANY IN 1899.

Thermite holds a major usage factor. If improperly pursued much damage to property and body can be created. This is not exaggerated. Use total caution when preparing and using this. This information, like all research information we provide, is for knowledge base only.

Thermite, when properly used, is a great way to get almost instant ignition of composite rocket motors, which is useful when flying clusters or staged motors. However, thermite, in particular, iron thermite, has a bad rap because of its sensitivity and from some well-publicized accidents. It seems that everyone knows "somebody who got hurt making thermite." Copper thermite has many advantages over iron thermite, and manganese dioxide thermite is the best candidate for composite rocket motor ignition.

Some safety procedures need to be observed when making thermite. Of course, as when doing any kind of Research rocketry motor propellant work, eye protection is mandatory, as well as wearing latex or nitryl gloves and make sure to have a fire extinguisher or water source handy.

Mix the chemicals carefully on a sheet of paper by placing them side by side and mix by picking up one end of the paper at a time until the chemical are mixed. Do not stand over the chemicals when mixing. Use anti-static procedures such as grounding yourself and anything you might be using before pouring chemicals. This can be done simply by touching a grounded AC outlet several times during the mixing process. If you are really worried about static discharge, you can use an electronic grounding strap that attaches to your wrist. Do not use metal utensils for measuring chemicals or metal containers for storing the finished product. Use weighing paper or a plastic weigh bowl on the scale.

It's a good idea to mix only the amount that you are planning to use. The mixed composition will degrade over time, and it isn't usually a good idea to have any large amount of mixed thermite sitting on your shelf next to other chemicals. Package in a delicate tissue paper or saran wrap "burrito" with an e-match. Use in motors with large cores and nozzle throats to prevent clogging. Do not use a home dipped match (using a composition such as MagnaLite) or commercially available dipped match like a Quickburst to try to ignite thermite. The e-matches you need must be the type of that "pops" and does not simply burn. Make sure that the ignition leads of the matches are shorted together before beginning assembly of the igniter, and remain shorted until the igniter is installed in the motor. Don't use on motors smaller than a J or K, as the nozzle throats are generally too small to install the completed igniter. And of course, following basic igniter safety protocol, you do not want to install the igniters until the rocket is loaded on the launch rail.

When using thermite igniters it's a good safety practice to carry an extra e-match or igniter, a digital volt-meter or even something as simple as a 12v light bulb with wires attached when going out to the launch pad. Connect it to the launch pad ignition leads to confirm that they are not hot before you install the igniter into the motor. This is actually a good protocol when using any type of igniters. If using an e-match or igniter, make sure to do this away from the motor(s), the thermite igniter, your eyes or anything else flammable. Make sure that your hands or anything else that you want to keep are not underneath the motor(s) when you hook up the igniter, just in case the igniter accidently fires.

Insert the igniter all the way to the top of the motor, and then back it off slightly, so that it is positioned centered within the core of the top grain of the motor.

Properly made and installed, a thermite igniter will provide almost instantaneous ignition of your motors.

Most common Thermites are based on iron or copper. For ignitor applications a Manganese based Thermite seems to work very well. As with all Thermite formulations and applications extreme care and attention must be at front at all times. This can not be expressed enough. Any lax has the potential to really bite you big time!

MANGANESE THERMITE FORMULATION

CHRIS PEARSON

The most energetic thermite mixture that one can come up with (aside from exotic, expensive and unobtainable ingredients) is a manganese thermite. This variety of thermite can be easily made by using a mixture of very fine powdered manganese dioxide and ~100-200 mesh magnesium at a ratio of 1.5 parts MnO_2 to one part Mg by weight. The mixture lights easily with an electric match, and seems to put out noticeably more heat than a Cupric Oxide/Aluminum, CuO/Al mix. It also doesn't seem overly sensitive to electrostatic discharge, as it is difficult to light with an open flame, and it is not shock sensitive

The reason a MnO_2 based thermatic composition is preferable to a CuO based thermatic composition in this application is because the heat of formation is about 35% higher: 1.15 kcal/g for MnO_2 based versus 0.74 kcal/g for CuO based thermite. As a result the reaction temperature for the MnO_2 based composition is above the boiling point of both MgO and Al_2O_3 so the thermite creates a high temperature gas cloud which easily lights more of the motor surface and at a faster rate. But this MnO_2 mixture is hard to light.

This can be solved easily as Shidokovsky, a Russian chemist, notes that a mixture of the following is significantly easier to ignite and still has a reaction temperature above the boiling points of both the oxides

$$68\%\ MnO_2 + 17\%\ Mg + 15\%\ Al$$

experimentation has shown that using as fine a grade Al and Mg as possible is essential to lowering the ignition temperature. This can be a problem as fine Mg can't be readily obtained because of shipping restrictions.

When lighting a motor to reduce the ignition time you have to increase the heat flux at the grain surface. There are three important variables here:

1) the amount of material
2) the burning rate of the material, and
3) gas generation that could carry the heat away.

The Shidokovsky thermatic composition reaction is near gasless (other than the flux state of the oxides) so you are not going to exceed the loading pressure of the motor by using a more aggressively matched thermite charge than you would using a CuO/Al based composition.

The way to calculate the optimal amount of charge is to calculate the amount of engine surface you want to light (the area of the core of the motor is a good approximation for this purpose) and use enough composition to get 150 cal heat flux per square centimeter of motor surface.

2Al + 3CuO has a flame temperature of 2843 K and contains 974 cal/g,

4Al + $3MnO_2$ has a flame temperature of 2918 K and contains 1159 cal/g.

2Mg + $1MnO_2$ has a flame temperature of 3271 K and contains 1322 cal/g.

This data comes from a long list of thermites in: *Theoretical Energy Release of Thermites, Intermetallics, and Combustible Metals*, by S. H. Fischer and M. C. Grubelich

CARL GUSTAF PATRIK DE LAVAL

The Man of High Speeds

He was born in the Swedish province of Dalecarlia (Dalarna) in 1845. He was a descendant of a French family that came to Sweden in the seventeenth century. Even as a child he was unusually clever and ahead of his time. His studies were very successful and he got a degree in engineering and also became a Ph.D. At the time of his invention of the separator he was employed at the Kloster works in Dalecarlia, an important industrial estate.

Gustaf de Laval had manifold technical talents and produced a number of inventions. Apart from the centrifugal separator, the operational steam turbine is the best-known. He came to acquire quite a reputation as both an inventor and an industrialist, and he was also able to influence many other contemporary inventors. Unfortunately his genius for technical innovation did not extend to economics.

In 1875 he took a job as an engineer at Klosterverken Iron Works and shortly thereafter he developed a centrifugal device for separating cream. Needing more time to perfect his device he resigned his position at Klosterverken, and after much persistence was able to obtain a small loan that enabled him to manufacture his device. The device proved to be such a success that it was not long before Separator Company, Limited was on secure financial footing. For his invention of this separator device and other labor saving devices for dairy farmers, de Laval has been called "the Edison of dairying".

In search of a method to drive the centrifugal separator, which required high speeds, de Laval developed a steam turbine. The turbine was driven by high pressure steam shooting through a cone shaped nozzle developed by de Laval, that is now used on rocket engines. Able to turn, at what at the time was a frightening speed of 24,000 rpm, the turbine had to be reduced to one-tenth speed to drive the separator and did not prove to be useful for this purpose. However there were many other uses for the turbine and a separate industry developed.

Not content to rest on his laurels de Laval was constantly seeking new inventions, including milking machines and a process for treating low grade Swedish zinc ores, none of which were as successful as his cream separator. During his lifetime he received many honors, including from the King of Sweden, the Cross of Commander of the Order of Wasa and that of Knight in the Order of the North Star and he was made a member of the Royal Swedish Academy of Sciences in 1886 and received its gold medal in 1892.

In 1887, de Laval developed a small, high-speed turbine with a speed of 42,000 revolutions per minute. He is credited with being the first to use a convergent-divergent type of nozzle in a steam turbine in order to realize the full potential energy of the expanding steam in a single-stage machine, completed 1890. He also invented various devices for the dairy industry, including a high-speed centrifugal cream separator 1878 and a vacuum milking machine, perfected 1913.

De Laval's other interests ranged from electric lighting to electrometallurgy in aerodynamics. In the 1890s he employed more than 100 engineers in developing his devices and inventions, which are exactly described in the 1,000 or more diaries he kept.

Also unfortunately the only thing we as rocket scientist have come to appreciate from de Laval is the rocket nozzle which bears his name. While the mathematics of the de Laval nozzle is a crucial part of our rocket technology it seems de Laval will go down in history, not as a rocket scientist, but a milk man who found away to separate cream from cows.

During his lifetime Gustaf de Laval acquired 92 Swedish patents and founded 37 companies. His inventions were to create work for millions of people.
Gustaf de Laval died on February 2, 1913. His memorial was engraved with the inscription: "The Man of High Speeds".

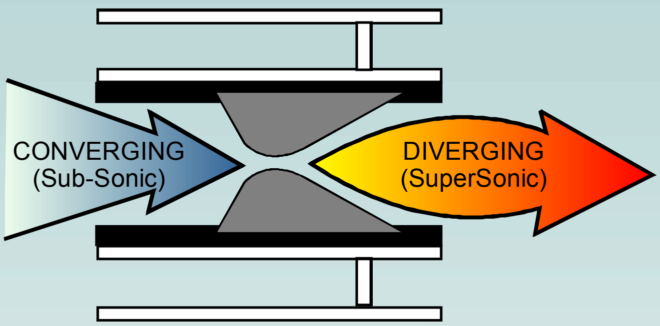
The de Laval Nozzle

A de Laval Nozzle (or convergent-divergent nozzle, CD nozzle or con-di nozzle) consist of two sections. The first is called the Converging Section, the area closest to the propellant. This section's cross-sectional area decreases to a minimum. The second area is called the Diverging Section. It faces the rear of the motor and it's cross-sectional area increases from a minimum. The point of minimum area is called the Throat.

It is used to accelerate a hot, pressurised gas passing through it to a supersonic speed, and upon expansion, to shape the exhaust flow so that the heat energy propelling the flow is maximally converted into directed kinetic energy. Because of this, the nozzle is widely used in some types of steam turbine, it is an essential part of the modern rocket engine, and it also sees use in supersonic jet engines

In rocketry applications the purpose of the nozzle is to direct the exhaust gases and increase their velocity.

The Speed of burning propellant exhaust within the propellant chamber is Sub-sonic. Since the nozzle is the only place the gas has to escape it passes thought the converging section of the nozzle and it's velocity is increased. This is because Subsonic gases accelerate when the area decreases.



As it passes thought the nozzle throat this gas is now traveling at Sonic speed.

Entering the second half of the nozzle the exhaust gas is now Super-sonic and increasing velocity in the diverging section. Supersonic gases accelerate as the area increases.

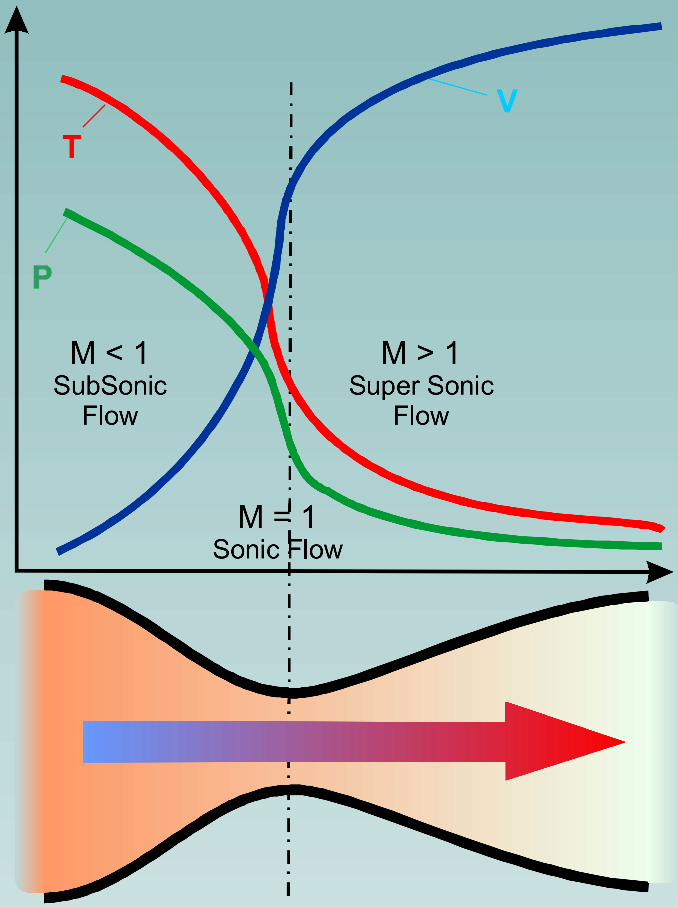


Diagram above of a de Laval nozzle, showing approximate flow velocity (v), together with the effect on temperature (t) and pressure (p)

SIMPLE THINKING

ANTIGRAVITY
When a cat is dropped, it always lands on its feet, and when toast is dropped, it always lands with the buttered side facing down. It is proposed to strap buttered toast to the back of a cat; the two will hover, spinning inches above the ground. With a giant buttered cat array, a high-speed monorail could easily link New York with Chicago.

REDNECKS & BRAILLE
If an infinite number of rednecks riding in an infinite number of pickup trucks fire an infinite number of shotgun rounds at an infinite number of highway signs, they will eventually produce all the worlds great literary works in Braille.

WHY YAWNING IS CONTAGIOUS
You yawn to equalize the pressure on your eardrums. This pressure change outside your eardrums unbalances other people's ear pressures, so they must yawn to even it out.

CHINESE UNDERDEVELOPMENT
Communist China is technologically underdeveloped because they have no alphabet and therefore cannot use acronyms to communicate ideas at a faster rate.

EFFECTS OF DEFORESTATION
The earth may spin faster on its axis due to deforestation. Just as a figure skater's rate of spin increases when the arms are brought in close to the body, the cutting of tall trees may cause our planet to spin dangerously fast.

WHY THE EARTH ROTATES
Birds take off at sunrise. On the opposite side of the world, they are landing at sunset. This causes the earth to spin on its axis.

HOW TO MAKE YOUR CAR GO FASTER
The reason hot-rod owners raise the backs of their cars is that it's easier to go faster when you're always going downhill.

THE CONSTANT CONSONANT THEOREM
The quantity of consonants in the English language is constant. If omitted in one place, they turn up in another. When a Bostonian "pahks" his "cah," the lost r's migrate southwest, causing a Texan to "warsh" his car and invest in "erl wells."

SOMETHING TO WORK ON IN YOUR SPARE TIME