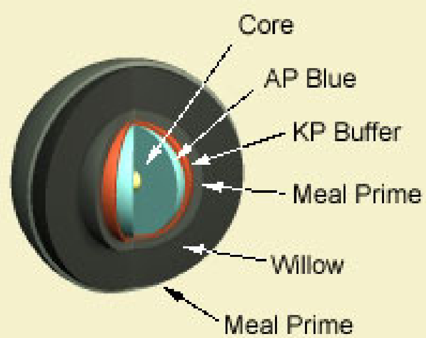
Design Notes...

Round Stars, Part I

by Mitch Piatt and Kyle Kepley

Introduction:
The art of making round stars is perhaps one of the most difficult aspects of pyrotechnics to master. Poorly designed and manufactured stars will ruin a shell regardless of how well it is was assembled. Getting all your stars to ignite does not help when they burn too long, contrast poorly, fail to switch colors simultaneously or fail to all burn out at the same time. It is for this reason that shell competitions do not allow purchased stars except in the most entry level categories, as the quality of the stars play a large role in making a good shell.



This two part article will focus first on the planning and design of round stars, then on the star rolling techniques used for manufacturing them. This article will focus on the "what," while part 2 will describe the "how."

Before you can begin rolling, you must first design your star by answering the following questions:

1) What type of effect is desired?
2) What formulas are required for the effect?
3) Are the formulas compatible?
4) What types of prime are required?
5) What size should the stars be?

Design the Shell First
Star design begins with a good mental image of the shell you wish to make. You may want to imitate something you saw in a show, or you may have a unique design of your own. Either way, you must be able to visualize the entire sequence of effects and timing required by your shell. You are an artist at this point, not a scientist or technician. Do not think about the practical, only the color, sound and motion of animated fire.

A beginner shell builder will be more inclined to try various stars of different sizes and effects in order to get a feel for what they do. This is only natural, and quite a necessary part of the learning curve. Once the builder gets a feel for the visual effect and burn rate of different formulas, he may begin the real challenge of bringing a shell design from imagination to reality. Often the road to success is littered with trial and aggravating error, but such is the challenge that makes success in the end so rewarding.

More...

Round Stars, Part I...

Know Your Formulas

Having a good library of familiar formulas to choose from is critical when designing stars. Most builders have a relatively small set of formulas they regularly use. These include deep and pastel versions of all the basic colors, various charcoal streamers and firefly effects, gold and silver glitters, gold and silver flitter, metal based special effect streamers and strobe formulas.

Building up your personal set of stock formulas will take time and lots of experimentation. It is best to test new formulas with small 300g quantities of pumped or cut stars before rolling stars with a new formula. Round stars are actually more difficult to make in small quantities compared to other types of stars. However, there are some types of formulas or effects that can only be done with round stars, so testing with other types of stars would not give the same results.

It is also necessary to test new formulas by shooting them from a star gun or shell rather than just lighting stars on the ground. A green that appears pale on the ground often looks much better 300 feet up in the air. The same holds true for purples and blues, while streamer formulas must also be moving through the air for the effect to be judged. Nothing is more frustrating than finishing a large batch of round stars only to burn them or shoot them out of a mine because they didn't perform the way you thought they would.

Once you have your working formulas picked out, you will start to become familiar with their burn rates, light output, color purity etc. You will figure out that AP stars have to be made slightly smaller than KP stars in order to burn for the same duration, or that silver flitter stars must be rolled larger because they burn very fast. You become familiar with the tradeoff between color saturation and light output for the various colors.

Last but not least, you become familiar with the way each composition rolls. Different compositions present different problems when rolling, and it becomes necessary to develop the techniques for dealing with these quirks. The most common rolling problems will be addressed in Part II of this article.

Chemical Compatibility

Chemical compatibility has long been a problem in fireworks manufacturing. Round stars typically have several different types of compositions layered on top of each other, and care must be taken to insure that hazardous chemical combinations do not occur. As a general rule of thumb, potassium perchlorate is compatible with all other standard oxidizers. This makes it good for intermediate buffer compositions between incompatible star mixes.

There are some chemical combinations so hazardous that the two chemicals should never be used within the same star, even when separated by buffer layers. This is especially true of chlorates in combination with ammonium compounds, which will form the extremely sensitive explosive ammonium chlorate.

Other chemical combinations will simply cause the star to fail, such as nitrates in combination with ammonium compounds, which form the extremely hygroscopic ammonium nitrate and leaves you with soggy stars that will not burn.

Some chemical combinations result in a more sensitive mixture, elevating the level of risk and care that must be taken. These combinations may not present any problems for a long time, giving the builder a false sense of security, then one day result in spontaneous combustion without warning. This is the case when using chlorates with any sulfates, sulfides, sulfur, lampblack or finely powdered metals.

The following table outlines the more common chemical combinations to avoid between two formulas that will be in contact with one another. Some combinations require a buffer between them if used in the same star, while those marked as dangerous should never be used in the same star even if separated with a buffer layer.

Contained in Formula 1	Contained in Formula 2	
	Requires a Buffer	**Dangerous**
Potassium Nitrate Strontium Nitrate Barium Nitrate	Ammonium Perchlorate	
Potassium Chlorate Barium Chlorate	Sulfur Sulfides Sulfates Hexamine Sodium Oxalate Lampblack Naphthalene Calcium Carbonate Chromium or Chromates (never wet with hard water)	Any ammonium compound Red Phosphorus
Ammonium Perchlorate	Potassium Nitrate Strontium Nitrate Barium Nitrate	Any chlorate compound

More...

Round Stars, Part I...

Primes

There is no quicker way to ruin a perfectly good batch of round stars than incorrectly priming them. Once a prime is applied that is incapable of igniting the underlying star, there is no way to undo the damage. Some star formulas require no prime at all, while others require a series of two or three prime layers.

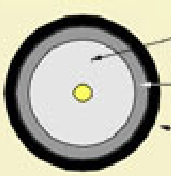
Beginners are often frustrated with the lack of prime specifications for the formulas they encounter. Even when prime specifications are given, it is still a good idea for the builder to verify that the prime is adequate before rolling it onto a batch of stars for the first time. A simple test can be done by flattening down a small amount of prime comp and placing an unprimed star on top of it. If the prime fails to ignite the star when it is burned, then chances are it will not light the star when it is rolled onto it either.

When basic meal powder fails to ignite a star, there are several alternatives that can be used as a "first fire" (the term given to the prime layer that is in contact with the actual star composition).

STEP PRIMES

A step prime is a type of prime made from ratios of the star composition mixed with meal powder. It is typically used with stars containing a lot of metal, which require high ignition temperatures. The meal helps lower the ignition temperature of the prime layer, while the star comp yields the high temperatures needed to ignite the star.

A typical first prime would consist of 2 parts star formula to 1 part meal. If this does not ignite the star, then the percentage of star comp is increased. If straight meal will not ignite this prime, then a second prime layer with a higher percentage of meal is used. The basic idea is to increase the concentration of meal in successive prime layers to the point that pure meal will ignite the last layer, making the final prime layer 100% meal.



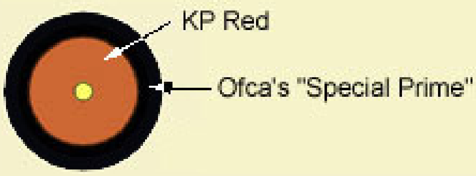
Formula: Silver Flitter

While step primes can result in 2 to 4 layers of prime, this method eliminates the need to mix up special prime formulas. You simply mix enough of the original star comp to account for the amount required for priming. Note that the star comp must be compatible with meal for this method to work. Meal must not be mixed with formulas containing chlorates or ammonium compounds.

OXYGEN DEFICIENT PRIMES

An oxygen deficient prime works well for stars that will be used in shells with flash bag breaks. Flash break shells are more common for plastic ball shells, but have a tendency to project the stars at a very high velocity to the point of blowing out the flame and creating "blind" stars. Oxygen deficient primes are black powder type primes with a high charcoal content. While this type of composition barely burns on the ground, it utilizes the increased oxygen from high wind speeds when exiting the shell to keep the star burning.

Bill Ofca has developed a flash/prime system that works similar to the oxygen deficient prime concept. With this system, he takes star ignition one step further by using a flash break that creates potassium and aluminum sulfide droplets which embed themselves into the prime layer of the stars. More on this system can be found in Ofca's Technique in Fire- Volume 3, "The Design and Assembly of the 6 Inch American Crown Chrysanthemum Shell."

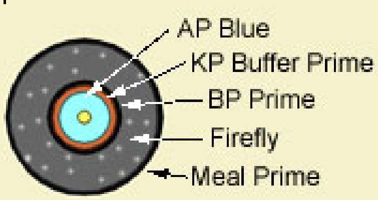


Formulas: Ofca Prime, KP Red

HOT MEAL PRIMES
In many cases an effective prime may be made by using meal with small amounts of metal powder or powdered silicon to increase the burning temperature. This type of prime often does not require a final meal prime layer, as the percentage of metal is not enough to effect the ignitability of the meal. A typical prime might consist of meal and medium flake aluminum in a 40:1 ratio.

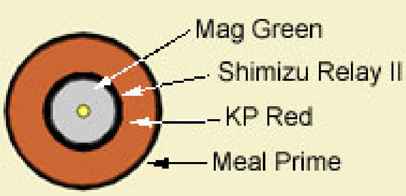
BUFFER PRIMES
Buffer primes are often used in color changing stars that contain incompatible chemicals. If a potassium nitrate glitter mix is being used over an ammonium perchlorate blue, then a buffer would be needed between the two layers. Without the buffer, the nitrate would leech into the AP core and ammonium nitrate would be formed, creating a hygroscopic star that would soon turn to mush.

In most situations, a potassium perchlorate based buffer prime applied with 4-6% NC lacquer will prevent any dissolved nitrate from breeching the buffer prime. This prime is also used between ammonium perchlorate stars and the final meal prime.



Formulas: KP Buffer Prime, AP Blue, Firefly

COLOR CHANGING RELAYS
While not serving the same purpose as a prime, color changing relays consist of a thin prime-like layer of low-light output composition sandwiched between the two color layers. The purpose of this relay is to enhance the effect when transitioning between colors, causing one color to fully extinguish for a split second before the second color flashes back on. Without the color changing relay, there can be a blending of colors during the transition from one color to the next, marring the effect.



Formulas: Shimizu Relay I, Shimizu Relay II, Mag Green, KP Red

FINAL PRIME LAYER
One of the most pleasing effects produced by round stars is a simultaneous shift from one effect or color to another. The more exact the timing of the transition is, the better the effect. While one key to achieving precise timing is to size the stars very accurately when making them, it is also important that the stars be primed with a final layer of fast burning meal. When a good round star is ignited, the flame should race around its entire surface almost instantly so that the star begins a uniform burning progression toward its core.

Stars with a slow outer prime will not be capable of clean effect transitions, as the first point on the star that takes fire will reach the core before the rest of the star, resulting in the inner color bleeding through before the previous color has finished. Even a layer of relay composition can not make up for an outer prime that is too slow. While a star that consists of something like Tiger Tail to green will take fire without a final meal prime, failure to finish the star with a fast prime layer will result in a tiger tail break that slowly fades to green.

More...

Volume 2, Issue 2

Round Stars, Part I...

Size Matters

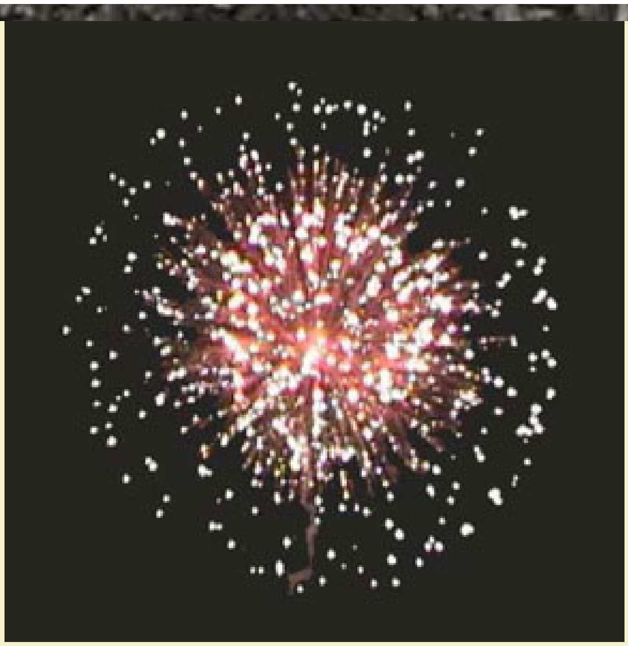
One of the finer aspects of designing round stars is determining the proper thickness of each layer required to achieve the desired effect. For solid color stars the process is pretty straight forward, but color changing stars timed to perform in coordination with other stars in two or more petals can be a challange.

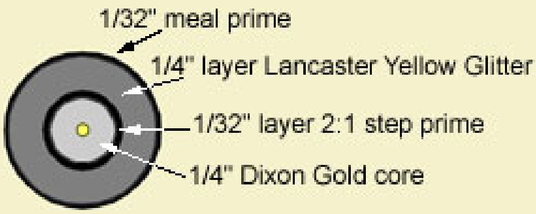
At the most basic level, the size of the stars in a shell will determine both the density and span of the break. Using 3/4" stars in a 6" round shell would produce a rather sparse break with a drooping umbrella effect as the stars continue to burn beyond the short amount of time a spherical break can fight against the effects of gravity. This may be the desired effect in the case of long tailed streamers or bright magnesium stars, but looks rather odd if ordinary color stars are allowed to linger for too long. If the same 6" shell were filled instead with 3/8" color stars, a dense break with a short lifespan would result. If the 3/8" stars were rolled from a slow burning comp and used to completely fill a flash bag type shell, an attractive waterfall effect would result.

The size of individual layers within the star plays an important role in the timing of one or more color changing petals. For example, say you wanted a 6" double petal chrysanthemum with a blue inner petal and an outer petal that transitioned from willow streamer to electric white at the end of its expanse. Due to the smaller space available to the inner petal sphere, the blue stars would need to be as small as possible while still having enough burn time to last close to the point where the outer petal transitions to white. If a slower burning AP blue was used, one could get away with using 1/4" stars, otherwise 3/8" would be a good starting point. The electric white at the core of the outer petal stars would not likely take fire from the willow, thus a prime layer would be required. The white cores would be rolled slightly smaller than 1/4" such that when the prime layer is added the final size would be right at 1/4". Since the star is not really switching from one color to another, rather from a streamer effect to a color, no relay layer is necessary. Depending on the burn rate of the willow comp, the remainder of the star would be rolled out to between 1/2" and 9/16". Since this is a color changing star, it is important that a final prime layer of fast meal is used to insure instantaneous ignition accross the entire surface of the star.

It often helps to draw a cross section of the star you intend to make, with each layer labled as to its thickness and effect. The following illustrations show a double petal break along with the star designs used to create it. Creating this template for a shell design employs all the aspects of star design covered thus far. Next month we will examine the procedure for manufacturing various stars using a star rolling machine.

9/16" Dia. Outer Petal Stars





3/8" Dia. Inner Petal Stars

Formulas: Lancaster Yellow Glitter, Dixon gold, Mag Red

Related Articles:
Round Stars, Part II
Star Roller Reviews

Mail Passfire.com