The 'Mixology' of Stock Mixes

How to turn mixture 'A' into mixture 'B' without magic or a math degree.

by

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Have you ever had a leftover batch of star composition that you wanted to use for something else? Did you ever notice that a lot of formulae calling for KNO3, sulfur, and charcoal call for meal powder, instead of the individual ingredients? Did you ever wonder why, or how you might use that method yourself?

The meal powder used in those mixes is what's often called a '**stock mix**'. It's a mixture which is handled as a single ingredient. Using stock mixes offers the pyrotechnician several advantages over mixing individual ingredients.

One advantage to stock mixes accrues to you when you have lots of formulae with nearly the same ingredients, or with a common subset of ingredients. Pre-mixing and full incorporation of the stock mix means less work, and fewer ingredients to handle to create the final mixtures.

Less work isn't the only advantage. A pyrotechnician may have several formulae which vary only by the percentage of one ingredient. In that case, the version of the mix with the least of that one component becomes a stock mix for the other variants. That method means less mixed material to store, while still providing all the variants quickly and easily.

We've all been faced with having a couple of pounds of 'mixture A', and wishing not to waste it, trying to 'tweak' it up to mixture 'B'; sometimes without success. The mathematics of stock mixes can become confusing.

When you're faced with two mixtures which have the same ingredients, but where *every ingredient is in different percentages* in the two mixtures, it is a little daunting to figure out how much of each to add to mixture 'A' to turn it into mixture 'B'. That confusion is only compounded when the ingredients in mixture 'A' not only change percentages, but have other, new ingredients added to them to become mixture 'B'.

There might be mathematical formulae to express those relationships (there are, in fact), but using them is difficult. The math of simultaneous solution of multiple equations in three, four, or five variables is intimidating to the person of average mathematical abilities. I sure don't want to work that hard just to avoid wasting a couple of pounds of star composition. There *must* be a simpler way to figure it out!

It turns out that there is a simpler way. Rather than a mathematical formula (or several), we can use a very simple **algorithm**. An algorithm is nothing more than a predefined list of simple steps, which when followed, yields the desired (often complex) results. I'm going to present *two* algorithms; one which turns a predefined quantity of mixture 'A' into X (larger) amount of mixture 'B', and another which turns X-amount of 'A' into a predefined target amount of 'B'. The two methods are essentially the same, with only a couple of steps added to yield the desired end. There is a little arithmetic involved in the methods; ***Arithmetic***, not higher math!

Let's start with the first method, which turns a known quantity of mixture 'A' into a larger quantity of the target mixture, 'B'.

For simplicity, the two examples will be with the same stock mix, and yielding the same target mix. We'll turn ordinary 75-15-10 meal powder into a 'Spiderweb' star mix.
The mixtures are:

	MEAL		**Spiderweb**
KNO_3	**75%**		**46.6%**
Charcoal #1	**15%**	(Willow air-float)	**20.0%**
Charcoal #2	(none)	(80 mesh hardwood)	**16.3%**
Sulfur	**10%**		**11.4%**
Dextrin	(none)		**5.7%**

We'll turn 500 grams of meal into X grams of Spiderweb.

- Step 1 -- Record the proportions of the stock mix, and the target mix. (see above)

- Step 2 -- Identify which ingredient will make the *least positive* change in **actual quantity** from the stock mix to the new mix (or the most negative change, if any ingredients change to the negative). As a prerequisite, you **must** make sure both lists of proportions are in *actual* percentages, and not 'plus' percentages. More about that later. The two lists in this example **are** in actual percentages (parts in 100). This is a seemingly perverse relationship. You calculate the relative change of an ingredient by taking the reciprocal of its actual percentage of the new mix, and multiplying that result by the percentage change, retaining the signs. The formula is:

$$(1/\text{actual\_percent}) * \text{change\_in\_percentage}$$

If only ONE ingredient changes to the negative, then that's the base, and there is no computation to be done. But if two or more make negative changes from the old to the new mixture, then you have to grind out the numbers. So… we'll do it here:

- The two 'new' ingredients, Charcoal #2 and Dextrin increase by 16.3% and 5.7%, respectively. They didn't exist in the old mixture, so we can ignore them. .

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- Charcoal #1 increases from 15% to 20% -- a +5% change.
  (1 / 0.20) * .05 = .25

- Sulfur increases from 10% to 11.4% -- a good candidate at only +1.4%.
  (1 / 0.114) * .014 = .1228

- KNO3 *decreases* from 75% to 46.6%, so it's the winner at -28.4%. But let's run the numbers, anyway:
  (1 / 0.466) * -.284 = -0.609 … the **least positive** result!

The winner of this percentage contest (in this case, the KNO3) is your 'base' ingredient. You will add other materials to the stock mix to create the new mix, but you will not add any more of this 'base' material; its **percentage** will change, by virtue of the other ingredients being added, but its amount will not change. If there exist more than one 'base' ingredient - in other words, if there is a "tie" in the percentages contest - then *just pick one.* The other one won't change quantities, either.

- Step 3 -- Find and record the actual weights of each ingredient in the stock mix in grams (or pounds, or tons), by multiplying the total weight of mix on hand by each ingredient's percentage in the mix.

KNO3 -- 500g x .75 = 375g
C -- 500g x .15 = 75g
S -- 500g x .10 = 50g
Total 500g
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Now, knowing that the KNO3 is our base ingredient, we know that the target mixture 'B' will have 375 grams of KNO3 in it. **That is a revelation**! Using that figure, we can find out exactly what weight of mixture 'B' we will create when we add ingredients.

- Step 4 -- Take the weight of the base ingredient, and **divide** by the fraction it will constitute of the *new* mix. The result is the total (target) weight of the batch of new mix.
  375g of KNO3 / .466 (portion of KNO3 in mix 'B') = 804.72g

So, our total batch size of mixture 'B' will be 804.72 grams. OK; it's an odd number… but it will be, by this algorithm. The second method will yield better 'batches', but both methods will render identical mixtures.

Now that we know how large batch 'B' will be, it's simple to calculate what the other additions need to be to get from 'A' to 'B'.

- Step 5 -- Multiply the fractions of each of the other ingredients in the new mixture by the new mix's target weight. Record the amounts. These are the target weights of each ingredient in the new mix.

Charcoal #1 -- 804.72g x .200 = 160.94g
Charcoal #2 -- 804.72g x .163 = 131.17g
Sulfur -- 804.72g x .114 = 91.74g
Dextrin -- 804.72g x .057 = 45.87g
subtotal 429.72g
plus our 'base' material, KNO3 375.00g
Total 804.72g
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Now, all we have to do is figure out how much of each ingredient to *add* to the stock mix, to get those target amounts.

- Step 6 -- Subtract the old *weights* of each ingredient in the stock mix from the new target weight of each ingredient in the new mix to find how much of each to add .

	Spiderweb	**(minus)**	**Meal**	**(equals)**	**additional**
KNO3	375g	-	375g	=	none
Charcoal #1	160.94g	-	75g	=	85.94g
Charcoal #2	131.17g	-	0g	=	131.17g
Sulfur	91.74g	-	50g	=	41.74g
Dextrin	45.87g	-	0g	=	45.87g

Add the amounts of ingredients in the 'additional' column to 500 grams of mixture 'A', and -- *Voila…* Meal to Spiderweb in six easy steps!

It's just as simple to produce a target amount of 'B' from an calculable amount of 'A', by a simple variation of the algorithm. Let's say we want exactly 1 kg of mixture 'B' when we're finished.

- Steps 1 - 2 -- Find the 'base' ingredient, just like above.
  KNO3, again.

- Step 2.a -- Calculate the weight of the base ingredient in the desired amount of 'B'.
  .466 x 1000g = 466g

- Step 2.b – Figure out how much of mixture 'A' you need to provide that amount of the base ingredient.
  466g / .75 = 621.33g
  (note, we *divide* the desired amount by its percentage of mixture 'A')

- Step 3, 5, and 6 as above, and *eliminate step 4*, since we already know how much of mixture 'B' we'll end up with!

So -- instead of starting with 500g of meal, and ending up with 804.72g of Spiderweb, we start with 621.33g of meal, and end up with 1000g of Spiderweb.

Here's another example, using the first algorithm to transform 200 grams of leftover flitter star mix (Bleser) into 'spin' flash cores for stars. (With deference to Dave Bleser, I prefer the effect of bright aluminum over dark in this flitter.)

Step 1 -

proportions	**flitter**	**'spin' (stated)**	**'spin' (actual)**	**change**
KClO4	33%	70%	66.67%	+33.67%
Aluminum #808	61%	30%	28.57%	- 32.43%
Dextrin	6%	+5%	4.76%	- 1.24%

Note that we had to derive an *actual percentages* list for the 'spin' core mix, since it was stated with a 'plus' percentage of dextrin. That's done simply by totaling up **all** the percentages including the 'plus' amounts, then dividing each individual percentage by that total. (i.e. – for the KClO4, 70% / 105%(total) = 66.67%)

Step 2 - Inspecting the changes, we note that there are two ingredients making negative changes, so we'll have to calculate the winner.

Dextrin (1 / .0476) * -0.0124 = -0.2605
Aluminum(1 / .2857) * -0.3243 = -1.1358

Aluminum becomes our 'base' (Hey, *neat*! The *expensive material* doesn't change!)

Step 3 - Determine what weights of ingredients we have in the original flitter mix.

KClO4 200g x .33 = 66g
Aluminum 200g x .61 = 122g
Dextrin 200g x .06 = 12g
Total 200g

Step 4 - Determine what weight of finished mix 'B' we'll create.

Aluminum (base) 122g / .2857 = 427.02g

Step 5 - Determine what the target weights of the other ingredients will be in mix 'B'.

KClO4 .6667 x 427.02g = 284.69g
Dextrin .0476 x 427.02g = 20.33g
305.02g
Plus our 'base' aluminum 122.00g
check total 427.02g
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Step 6 - Determine how much of each ingredient to add to 'A' to arrive at 'B'.

ingredient	**'spin'(actual)**	**(minus)**	**flitter**	**(equals)**	**additional**
Aluminum	122g	-	122g	=	none
KClO4	284.69g	-	66g	=	218.69g
Dextrin	20.33g	-	12g	=	8.33g

Add 218.69g of KClO4 and 8.33g of Dextrin to 200g of flitter to yield 427.02g of 'spin'.

Do a couple of your own examples on paper, to see how easy it is! I hope you find the methods presented here useful.

If you'd like a free copy of a Windows and Windows95 compatible computer program to do these computations, visit my worldwide web site at ***http://www.Bridge-City.com***. Visit the software page, and download "**stokmix1.exe**". That file is a self-dissolving archive containing **stockmix.exe** and **vbrun300.dll**, which is needed for Windows to run the **.exe** file.

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(ed. -- The software should be available by the time you read this article.)