SO_2 Management

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An Introduction to SO_2 Management

If we want to make high quality wines, then one of the most important things we as winemakers need to learn is how to effectively manage the sulfite levels in our wines. When done correctly, maintaining the proper amount of sulfites in a wine protects it from oxidation and microbial contamination during ageing/storage. This allows the wine to continue developing safely throughout its entire lifetime. Yet, for this protection to be effective, the required sulfite levels need to be consistently maintained at all times. This is done by testing the SO_2 levels in our wines at regular intervals and, if we are short of the desired range, by adding additional sulfur to make up the difference.

As straightforward as this seems, however, accurate sulfite management is actually much more of a hands-on process than just adding a generic amount of SO_2 from time to time and letting it ride. Here is the reason why: There are 2 technical concepts that need to be taken into account when making our sulfur additions or we run the risk of getting inaccurate results:

1. **Binding:** Due to the complex way sulfite additions interact with the various chemical compounds and solids naturally present in our wines, the amount of free sulfite remaining in the wine after we make an addition often falls short of our calculated goal. This loss is coming from a binding phenomenon which needs to be taken into account and corrected for or our wines risk not being protected in spite of us making sulfur additions.
2. **The amount of SO_2 needed to protect a wine is pH dependant:** The free SO_2 * levels required to protect wine are pH-dependent: as the pH goes up, higher levels of free SO_2 are needed to protect the wine. In other words, you can have 25 ppm free SO_2 in your wine and think everything was fine, but if your pH is above 3.3 the wine is still not adequately protected! When it comes to sulfite additions, one size definitely does not fit all! *(*Note: a full explanation of "free" and "total" SO_2 is coming!)*

Since understanding these concepts is key to our ability to properly control sulfur levels, the first half of this manual will be spent focused on them. Then, once we have laid this foundation, the second half of the manual will show how to incorporate this knowledge into a technically sound protocol that will allow us to effectively manage our SO_2 levels with confidence. Let's get to it!

Understanding SO_2 Management Theory

What is SO_2?

We'll begin by starting with the basics. *Sulfur Dioxide,* or SO_2, is a chemical compound used by winemakers to help keep their wine protected from the negative effects of oxygen exposure as well as spoilage microorganisms. Sulfur Dioxide is known by a variety of different names to winemakers, the most common being "SO_2", "Metabisulfite", and just plain "Sulfite." In winemaking, the SO_2 concentration in a wine is measured in Parts per Million, or ppm, which refers to the number of **Parts** of Sulfite **per Million** parts of wine. This unit of measure is equivalent to mg/L, or **milligram** of SO_2 per **Liter** of wine.

What is SO_2 Management?

When a wine contains the proper amount of sulfites, a protective buffer is created that helps the wine withstand any accidental oxygen or microbial exposure that may occur during the ageing/storage process. The sulfite does this by acting as an intermediary force that quickly intercepts and reacts with the offending element or organism before it can damage the wine. However, this is a one-way ticket and we will learn that once the sulfite becomes used-up, it is no longer available to react with future threats. It is still part of the "total" amount of SO_2 in the wine, but it is no longer "free" to protect the wine (more in a moment). In its most basic form, SO_2 management simply comes down to understanding how to create and maintain a small, stable reserve of *Free SO_2*.

Each Wine is Unique: Understanding the "Binding" Phenomenon

Many of the solids and chemical compounds in wine (both good and bad) interact with sulfite, and their concentration/presence has a direct effect on how an SO_2 addition behaves. To begin with, no two wines are ever the same; each one possesses a unique ratio of chemical compounds and solids that are present at varying concentrations. Depending on winemaking techniques, handling, or even sanitation issues, these differences can be quite pronounced. It's because of these inherent differences that two seemingly identical wines (ex: both are dry with the same pH and TA) can often end up with different free SO_2 levels after equal sulfite additions.

The discrepancy mentioned above between what we've calculated on paper and the amount of free SO_2 we actually wind up with in the wine is coming from a phenomenon known as "binding". It is based on the fact that when sulfite is added to

a wine, portions of the addition react with and become chemically bound to the aldehydes, acids, furfural, sugars, solids, yeast/bacteria, etc that are naturally present in wine. Binding continues until all of the various reaction-able elements in the wine have either become bound up or there is no more free sulfite to interact with. This binding action actually serves to protect the wine; as long as there is free sulfur present, it is available to react with and effectively neutralize both oxidation and microbial spoilage threats. In effect, free SO_2 can be viewed as an insurance policy that the winemaker takes out in case the wine has any problems during its lifetime: As long as you have the recommended amount of free SO_2 your wine is protected (more on this later).

Judicious is Best!

Maintaining a reserve of free sulfur means that once a wine starts to lose its free SO_2 content, we are obligated to add more sulfite to raise it back up again. Yet, there can be too much of a good thing. If we don't monitor our amounts and blindly keep adding sulfur to the wine in an effort to maintain the required pool of free SO_2, it is possible to add so much that the total amount of sulfur in the wine becomes detectable in taste, negatively impacting the wine. This is one of the fine lines that we as winemakers walk, one more example of the junction between artistry and science that is winemaking. We need to have a sufficient quantity of sulfur present in order to maintain the free SO_2 levels needed to protect the wine, but we don't want the total levels to be so high as to be noticeable when we drink it. Therefore the goal of proper sulfite management in winemaking is learning to create the required amount of free SO_2 in the wine while using the lowest total amount of sulfite possible. In order to help us do this it is important to take a further look into the implications of the binding process.

Three Agents That Bind SO_2

Managing our free SO_2 levels starts as soon as our last fermentation is over (alcoholic or malolactic). When we make our first SO_2 addition (by calculating, testing the results and correcting back up to our desired level if necessary- more on this later) we are establishing our starting point for free SO_2 in the wine. Once this baseline has been established, as long as the wine remains completely sealed and devoid of oxygen contact the level of free SO_2 should remain fairly stable over time. However, as soon as we start to open the vessels up for tasting, testing, blending, fining or topping up (for barrels), we will begin to see a clear drop in the free SO_2. This drop can be slight or quite drastic depending on how the wine is being handled. There are three main causes of the binding phenomenon responsible for this drop in the wine's free SO_2 levels: aldehyde formation, spoilage organisms, and the introduction of solids into the wine.

1. **Aldehydes:** When a wine is exposed to oxygen the alcohol in it oxidizes into chemical compounds called aldehydes. Aldehydes are a class of chemical compound that bind with SO_2, resulting in lower free SO_2 levels. In fact, there is a snowball effect often associated with aldehyde formation: As the aldehydes develop and react with the free SO_2 in the wine, less SO_2 is available to intercept oxygen. As a result, the incoming oxygen then reacts with more alcohol to create more aldehyde – and so on and so forth. This is the most common cause of a drop in a wine's free SO_2 and the most common cause of oxygen-related spoilage that we see in homemade wines. ***Note:*** *Barrels and tanks with headspace tend to lose their free SO_2 more quickly than fully topped inert vessels do. This is due to the wine's interaction with oxygen in the environment/headspace. It's important to note, however, that even if there is no oxygen exposure, free SO_2 levels can still decrease gradually during ageing due to normal chemical reactions taking place in the wine as it continues to evolve (the higher the pH, the higher the level of decrease).*
2. **Spoilage Organisms:** If conditions are favorable and spoilage organisms contaminate the wine, this can create a cell mass that binds with the SO_2. The end result is a lower free sulfur level in a wine. Most commonly these organisms will be *Acetobacter* (vinegar bacteria), *Lactobacillus*, *Pediococcus*, and film yeasts (often if one spoilage organism is present others are as well). Spoilage problems usually gain a foothold when depleted free SO_2 levels – usually due to excessive oxygen exposure - make the wine vulnerable.
3. **Introduction of solids:** Any time we add solids into our wine, such as oak (which, being porous, also brings some oxygen with it), tannins, sugars, specialized yeast products, fining agents, etc. we will have some amount of binding going on, thus lowering the free SO_2.

Techniques to Limit Binding

Now that we have taken a closer look at the elements that can bind-up our free SO_2 levels, we can focus on how to eliminate or at least minimize the unwanted impact they have on our wine. For each of these three problems, there are proactive courses of action we can take to minimize potential ill effects:

- **Aldehyde formation:** Since aldehydes form when alcohol oxidizes, if we eliminate or limit the amount of oxygen the wine comes into contact with then we also effectively eliminate or limit the amount of aldehyde that gets formed in our wines. This can be accomplished by flushing any air spaces that the wine will occupy with inert gas. Examples of these "air spaces" include the headspaces of vessels, transfer lines, pump cavities, filter housings, etc.
- **Spoilage Organisms:** Good sanitization practices and being vigilant about keeping free SO_2 at the required level will help to keep any microbial issues at bay. This not only keeps the wine from developing off flavors from unwanted microbial action, but also limits the total SO_2 additions to a minimum, lessening the risk of a negative

sensory impact from SO_2.

- **Introduction of solids:** Finally, when adding any solids into the wine, realize that a small portion of the sulfite will become bound to the newly introduced element in the wine. Therefore, we will need to add a little bit more SO_2 to compensate for this. After its initial impact on sulfite levels, your oak or other additives should not continue to adsorb portions of future SO_2 additions.

SO_2 Management Theory Summed-Up

In this first section we have learned that the actual quantity of sulfite needed to maintain a desired free SO_2 level is never a fixed, "one size fits all" amount. Depending on your wine, just adding 50 ppm of SO_2 from time to time during ageing may or may not be enough to protect your wine. And we've mentioned how the SO_2 level required to protect a wine is based on its pH and this level needs to be maintained at all times in order for the wine to be protected (we will look closely at this in the next section). However, each time we make a sulfur addition, a portion of our free SO_2 may become bound by a variety of elements naturally found in the wine. When this binding occurs it lowers the amount of free SO_2 that remains in the wine after we make an addition. Therefore, if we want to maintain accurate free SO_2 levels, we need to test our wines after making an addition and make up any losses of free SO_2 that became bound.

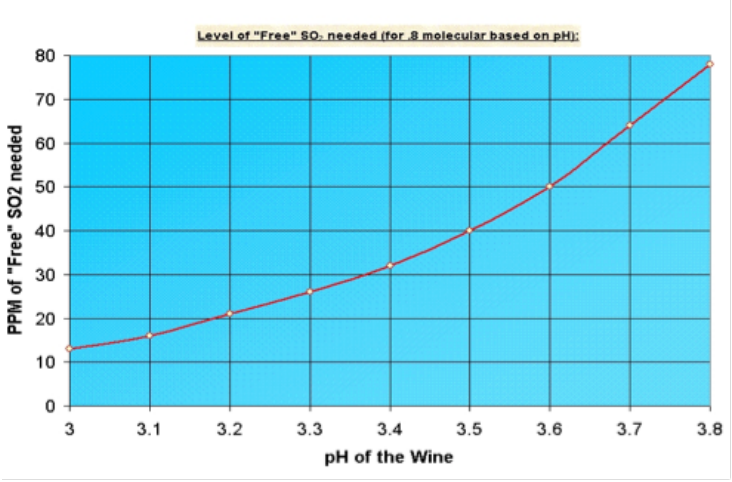
> ***Note:*** *Once you have stable sulfite levels in a wine this doesn't mean you can suddenly become negligent with your handling! As we have seen, improper handling of the wine will only cause the binding reactions we are hoping to avoid and as a result, the free SO_2 will drop and force us to keep adding more and more sulfur into our wines. By knowing how the binding phenomenon works, you are now better to able to prevent this scenario.*

Testing and Calculating SO_2 Additions

Now that we have a better theoretical understanding of what's needed for proper sulfite management, let's put it to use by testing and calculating an actual addition. We'll begin by determining how much sulfite is needed to protect our wine. Then we'll look at how to test the amount of free SO_2 we actually have in the wine. Finally, if the free sulfite level is below our desired range, we'll focus on how to raise it to make-up the difference.

Free SO_2: How Much Do I Need?

As mentioned previously, the amount of SO_2 needed to protect a wine is based on the wine's pH. To review, the higher the pH the more SO_2 will be needed, and conversely, the lower the pH the less SO_2 will be needed to attain the ideal level. Let's look at the following chart to see how this all comes together:



To use this chart, simply find your wine's pH on the bottom axis, and then follow it up until you hit the red line. From this spot, look all the way to the left of the chart to see the number that corresponds to this height. That number is the ppm of free SO_2 needed to protect your wine at that pH. So, for example, if your wine has a pH of 3.6, you will need 50 ppm free SO_2 to keep it protected.

> ***Note:*** *if your pH falls partway between the values on the chart, just go ahead and make a logical deduction (ex: a pH of 3.65 (1/2 way between 3.6 and 3.7) would need 57 ppm free SO_2 (1/2 way between the 50 and 60 ppm marks).*

Test the Free SO_2: How Much Do I Have?

Once you have referenced the chart and know the amount of SO_2 required for protecting your wine, you will need to test the wine's free SO_2 level to see where it is presently. This will determine whether an addition is required. There are a few ways to do this:

- **"Titrets":** By far the simplest solution for the home winemaker would be to use a kit made by CHEMetrics. It is a Ripper-method titration cell and it's manufactured under the brand name "Titrets" (W510). These are relatively cheap and fairly easy to use, but they are not very accurate. However, reliable SO_2 testing set-ups do require a bit of an investment and as a result many folks choose to accept this inaccuracy. ***Note:*** *if you are making a small amount of wine and will consume it quickly, then taking a risk that the Titrets will be close enough to get the job done is probably fine. However, if you are making larger volumes that will represent a significant amount of time and money we recommend you make the investment in an accurate SO_2 testing set-up or send it out to a wine lab for analysis (such as MoreWine!'s wine testing services).*
- **MoreWine!'s Economy A.O set-up (MT140):** This is a manual, wet lab testing set-up for testing free SO_2. Unlike the Titrets, MT140 is very accurate. The Economy A.O. set-up is just that, economical, and is easy to use. The cost per test comes out to $0.50. The only drawbacks are 1) Some of the reagents expire after 3-4 months and will need to be replenished a few times a

year to ensure accuracy (however, these are cheap to replace), and 2) A single sample takes 15-20 min to prepare and run. ***Note:*** *The MT140 will only allow you to do free SO_2. If you want to run total SO_2 as well, you will need the Hanna SO_2 Titrator (MT680).*

- **Hanna SO_2 Titrator (MT680):** Fully automated, very easy, accurate free + total SO_2 testing out of the box. The reagents for the Hanna SO_2 Titrator are stable for up to 4 years and free SO_2s can be run on an average of 2 min/test. (In our own winery, *www.olinwines.com,* this quick completion time has allowed us to test and adjust the sulfite in each of our 20-barrel vintage lots in a single evening during top-up. What used to take the better part of a day now takes 2 hours!). The only drawbacks of the MT680 is that each test costs $2.00 to run and the probe does require cleaning and maintenance from time to time.

Following the directions, test the wine with your sulfite test kit to determine the level of free SO_2 in your wine. Once you know the results, compare this to the ideal amount that is supposed to be in the wine (that you determined from the chart). If the amount of sulfite is at the desired number then we are done; no addition is necessary. However, if the amount of free SO_2 in the wine is less than our targeted value, then we will need to make up the difference to re-establish/maintain protection in the wine.

Calculating an SO_2 Addition

Let's say we have 5.5 gallons of wine with a pH of 3.65. When we test the SO_2 levels we discover that we have 18 ppm free. If we look at the pH/SO_2 dosage chart we see that at a pH of 3.65 we actually need 55 ppm free SO_2 in order to protect the wine. Since we have 18 ppm but need 55 ppm, we will need to make up the difference. If we subtract 18 from 55 we get 37. Therefore we need to add enough sulfite to add 37 ppm free SO_2 in the wine.

Calculating Grams of Metabisulfite for the Desired PPM

PPM stands for "parts per million" and is a measure of concentration that can be expressed as 1mg/L. When we say 20 ppm of SO_2 in our wine, we are saying for every million parts of wine we have 20 mg of SO_2. The way we find out how much Potassium Metabisulfite is needed to add the desired ppm of SO_2 into a specific volume of wine (in this case 37 ppm SO_2 into our 5.5 gallons) is by using the following equation:

$$\frac{\text{PPM of free } SO_2 \text{ desired* x 3.785 x Gallons (US) of wine you are adjusting}}{0.57 \text{ (the actual \% of } SO_2 \text{ that is contained in Metabisulfite by weight)}}$$

(*Note: *It is important that the number you get for the " ppm of free SO_2 desired" for your adjustment needs to have its decimal point moved three places to the left before you plug it in to the equation! In this example, the 37 ppm of free SO_2 needed goes into the equation as* ***.037****).*

Since **37** ppm is the amount of SO_2 we want to add, let's plug it in to the equation:

.037 x 3.785 x 5.5 (we have 5.5 gallons of wine) = **1.35** grams.

0.57

So, the amount of Potassium Metabisulfite needed to add 37 ppm of free SO_2 into our 5.5 gallons (to bring you up from the 18 ppm to the 55 ppm that you needed), is **1.35** grams.

Compensate for Binding Reactions: 2-Steps for Accuracy:

Since you never know how much of the 37 ppm SO_2 you are adding will become bound (and therefore lower the amount of free SO_2 you think you are adding your wine), getting our 55 ppm free will be a two-step process:

1. First we'll perform our calculation to determine how many grams of SO_2 are needed to add 37 ppm free SO_2 to our 5.5 gallons and add this to the wine (taking care to gently but thoroughly mix it in).
2. Then, once the addition is made we recommend checking the free SO_2 in a few days to see how much of our added sulfite became bound. At that point if the free SO_2 is lower than our targeted level we just add the amount needed to get us back up to our desired 55 ppm free. ***Note:*** *Once you have made this correction you are good to go until the next time you are adjusting the SO_2.*

If you don't have a scale:

¼ tsp SO_2 per 5 gallons (US) = 50 ppm. Fudge accordingly.

1 tsp SO_2 = 5.9 grams.

Note: *Since it's easier to measure with a pipette than to keep weighing out SO_2 each time you need it, you can also make a 10% stock solution and add your SO_2 via a graduated 5 ml pipette (: In a 750 ml bottle (standard wine bottle size), put in 75 grams (circa: 12 tsp) of Potassium Metabisulfite. Fill the bottle ½ full with warm water shake until crystals are dissolved, then top up with cold water. Add it according to the following table:*

Amount of 10% SO_2 Solution Needed to Add:

Desired Dose	10 ppm:	30 ppm:	50 ppm:
Per Liter:	.18 ml	.53 ml	.88 ml
Per Gallon (US)**:**	.67 ml	2.00 ml	3.33 ml

If you don't have a pH meter or an SO_2 test kit:

Typically, you can just add 50 ppm (1/4 tsp per 5 gallons) of SO_2 at the crush. On the other hand, if there were rotted or blistered clusters mixed in with your grapes, or you run your tests and find that you have a high sugar/low acid/high pH must, then you may want to add as much as 80-100 ppm for this first addition. True, this sounds like a lot to add, but keep in mind that the must just after the crush will have a lot of sol-

ids in solution, so a good portion of the 80-100 ppm SO_2 will become bound at this stage. (However, you will want to keep the SO_2 levels low if you will be doing a MLF. In this case, do not add more than 50 ppm before you ferment).

Post-ferment (once the MLF is done), you will want to augment the SO_2 level during your transfers by another 25-50 ppm. Finally, you will add another 40-50 ppm at bottling time. By doing this you will only be maintaining a generic level of SO_2, and you obviously run the risk of having it be too much or too little*. Still, this is far better than not doing it at all.

***Note:** these generic levels of SO_2 are based on a wine with a pH of around 3.5-3.6. If your wine has a pH that is higher than this, your wine will require more SO_2 to keep it safe. Refer back to the SO_2/ pH dosage chart and adjust accordingly.*

Just an important reminder:

With all the benefits of potassium metabisulfite comes a need to respect its nature. Its fumes are highly caustic and care should be used when handling it (depending on how sensitive you are to it, you may want to use rubber gloves). You should avoid breathing it and do not get it in your mouth, or eyes.