Next to the cost of grapes, barrels and cooperage products are the most costly recurring expense incurred by most wineries. A "bad" barrel can be doubly costly to a winery, either by the loss of wine through leakage or by imparting bad flavors or characteristics to the wine.

Barrel Builders has sold and maintained barrels for over 20 years. To the best of our knowledge we are the oldest continually operating cooperage in California. We work on thousands of barrels every year - both new and used. Consequently, we know a great deal about how to fix or, conversely, how to ruin a barrel. We continue to learn new approaches and techniques. Treatments that were standard five years ago have been replaced by new more effective treatments today.

This newly updated and revised manual was written to replace the earlier versions of our "Barrel Care and Maintenance Manual" and our "Barrel Repair Manual". It is designed for use by commercial wineries, home winemakers, and anyone else who uses wooden cooperage. Although primarily directed towards oak wine barrels, many of the procedures described herein apply equally well to other woods and wood products. The methods we discuss have been proven to be effective. However, given the nature of wine and oak cooperage, Barrel Builders claims no responsibility for leakage or spoilage caused by the use or misuse of information contained in this manual.

We have divided this manual into three logical sections: 1) how to inspect barrels, 2) how to maintain barrels and 3) how to repair barrels. If you are not familiar with the terms and nomenclature surrounding barrels, we suggest you start with the glossary in the back and review the diagram of a barrel.

We want to thank all the individuals who provided assistance in creating this manual. We also ask that those of you who are working with barrels and who have developed other approaches or techniques not covered in this manual to give us a call and tell us about them! Coopering is an art as well as a trade. We are always willing to learn.

Sincerely,

Phil Burton
President
Barrel Builders, Inc.

St. Helena, CA
June 1995
# TABLE OF CONTENTS

**Section I: Inspecting Barrels**
- 1.1 Inspecting and Testing New Barrels  
- 1.2 Inspecting and Testing Previously Used Barrels  

**Section II: Barrel Maintenance**
- 2.1 Important Key Points  
- 2.2 Chemicals, Supplies and Tools  
- 2.3 Swelling a Barrel  
- 2.4 Maintaining an Empty Barrel  
- 2.5 Sealing a Barrel  
- 2.6 Cleaning with Proxycarb  
- 2.7 Cleaning with Soda Ash  
- 2.8 Citric Acid Wash  
- 2.9 Extending the Useful Life of a Barrel  
  - 2.9.1 Barrel Shaving  
  - 2.9.2 Oak Chips  
  - 2.9.3 Inserts  

**Section III: Barrel Repairs**
- 3.1 Tools and Supplies  
- 3.2 Repair of Bore Bug Leaks  
- 3.3 Repair of Through Wood Leaks  
- 3.4 Repair of Leaks between Staves and Headboards  

**Glossary of Cooperage Terms**  

**Diagram of a Barrel**  

**Table of Solutions**  

**Conversion Table**
Section I: INSPECTING BARRELS

Twenty years ago, when Barrel Builders was just starting out and there was limited selection of cooperage, wineries were willing to put up with problem barrels. Leaks were common, finish was often poor, shapes and sizes varied all over the place. Not so today. The competition in the new cooperage market is fierce. Wineries expect barrels that are perfect - no leaks, fine cosmetics, perfectly uniform toast levels, same dimensions, galvanized hoops and, most importantly, excellent, uniform flavor. If you receive new barrels that you think are inferior, it is time to find a new supplier!

1.1 Inspecting and Testing New Barrels

Given the cost of the barrel and the cost of the wine going into them it is accepted practice for a winery to inspect and test all barrels before filling them. The next section discusses how to inspect and test both new and previously used barrels.

**INSPECTION**

When a new barrel arrives at your winery, what should you do? Many wineries already have a detailed procedure in place. If not, we suggest you use the following as a check list.

☐ Remove all wrapping material and shipping paper if it has not been removed by the distributor. Look for any obvious damage that may have been caused by the shipping company.

**Inspect Exterior**

☐ Barrel should be smooth and well sanded.

☐ There should be no gaps between staves.

☐ No signs of cracking of staves, particularly in the bilge area. ¹

☐ Hoops are evenly spaced and even on barrel. Hoop nails are driven properly.

☐ Hoop rivets are aligned on the same stave.

☐ Galvanizing is uniform (no flakes or chips). Ends of the hoops are galvanized or coated.

☐ Head hoops are flush with or extend just a bit above the top of the chime.

☐ No noticeable bowing in the heads.

☐ The bung hole is smooth, tapered and cauterized.

¹ Cracking of staves at the bilge is often a sign that the wood was not heated sufficiently or properly prior to bending. The staves are heated during the shaping process and water is applied to the barrel. The moisture soaks into the wood and gives it some flexibility. Cracked staves are most common in the stave with the bung hole.
INSPECTING BARRELS

Inspect Inside - use a small flashlight or a light bulb that can be suspended through the bung hole.

☐ Smell the barrel. It should smell like lightly toasted wood. 2 (See Caution box on SO₂!)

☐ The toast level should be even and uniform. No charring or blisters.

☐ There should be no signs of sawdust or molds. 3 (Sawdust will actually not cause any problems, but it is difficult to differentiate from mold!)

<table>
<thead>
<tr>
<th>CAUTION - SO₂!</th>
</tr>
</thead>
<tbody>
<tr>
<td>New barrels, and any barrels that sit empty for more than a few days, should be treated with sulphur dioxide, SO₂, before they are sealed. If you remove the bung and immediately inhale the air from inside a sulphured barrel, you will be extremely unhappy! SO₂ can actually burn the inside of your nasal passages. To be safe, remove the bung, take a small wiff, and if SO₂ is present, remove the bung and let the barrel sit for several hours in a well ventilated space. You can also rinse the barrel with water.</td>
</tr>
</tbody>
</table>

TESTING NEW BARRELS
There are several methods to determine the soundness of new barrels. We at Barrel Builders use the following approach whenever we have completed warranty repairs on a new barrel.

1. Lay the barrel on a testing rack where it can be rotated. If a rack is not available, carefully lay the barrel on its side on a clean, smooth surface.

2. Add 3 to 5 gallons of water to the barrel. (See Caution box on Water.)

3. Replace the bung and rotate the barrel to ensure that the entire inside of the barrel is wet.

---

2 It is difficult to accurately describe the smell of a good barrel. Bad barrels, however, smell like mold or wet earth. Kiln dried oak smells like dill or green wood. Used barrels can develop an aldehyde smell that resembles nail polish remover or vinegar.

3 Mold can grow inside a barrel if it was not properly treated with sulphur after manufacture and testing. The most typical mold is a penicillium which tends to be green or blue in color and grows at stave joints and the intersection of the head and staves. There are many other types of interesting molds, ranging from orange in color to a fine white webbing. If in doubt, remove the head and inspect the barrel!
4. Add 5 to 10 lbs. of air pressure to the barrel. This is done by taking a recessed silicone bung that has a small hole pressed through it and putting the nozzle of an air compressor in the hole. Compressed air is added, the nozzle is removed from the bung and replaced with a small, tapered wooden plug.

5. Rotate the barrel and inspect for leaks. Use chalk to mark any areas of concern.

**CAUTION - WATER!**

Water quality is perhaps the single most important factor in successfully maintaining sound cooperage. Wood is a porous substance. It is the interaction between the wine and the wood that imparts unique flavors to wine. Be careful about the water you add to the barrel since the water and anything in it will soak into the wood. At Barrel Builder's shop in St. Helena our water is terrible. It comes from a well and contains large amounts of iron and who knows what else. We run it through several filters before using it. A potassium permanganate filter or other ion exchange method will remove most minerals. If you are using water supplied by a city, be sure that it is not heavily chlorinated. If it is, consider using a charcoal filter or other filtering device to remove the chlorine.

Water left in a barrel can stagnate in less than two days, particularly in warm weather. If a barrel needs to be filled with water for more than 2 days, use a citric acid/metabisulfite solution or rinse (described elsewhere in this manual) and refill with fresh water every 2 days.

Particularly with a new barrel, it is not uncommon to have some small leaks appear in the first few minutes. Most will seal relatively quickly as the water soaks into the wood. Within a day, all leaks should stop. If not, a longer soaking may be required. Refer to Section 2.3 for directions on how to soak up a barrel.

If a leak will not seal with an extended soaking, you have three options; 1) Call the supplier and have the barrel replaced or repaired, 2) call Barrel Builders and have us make the repair or, 3) make the repair yourself. This is a judgement call and will depend on the size and nature of the problem and your willingness to take responsibility for making the necessary repair.

---

4 An oil-less air compressor is recommended to avoid adding any contaminates to the barrel.
OTHER TESTING METHODS
If an air compressor is not readily available, the barrel can be filled entirely with water. We at Barrel Builders like the air pressure method because it uses significantly less water, is faster, and allows many barrels to be checked at once.

Another approach used by several cooperages and wineries to test new barrels is to use hot water rather than air pressure. Following the inspection, several gallons of hot water are added to the barrel, the barrel is rotated to coat the inside, and the bung is placed gently back in the bung hole, only tight enough to form a seal. Hot water tends to penetrate the wood faster than cold water. As the hot water cools, it will cause a vacuum to form in the barrel. After an hour, the bung is checked. If it comes out easily, the barrel has leaks. If it is sealed in tight, the barrel is sound. Again, the advantage here is that a minimal amount of water is needed and many barrels can be checked fairly quickly. One shortcoming of this approach is that the source of the leak may not be obvious unless the leak is large. To find the source of the problem, the barrel must be either filled entirely with water or use the air pressure approach described above.

1.2 Inspecting and Testing Previously Used Barrels

Before wine is added or repairs are attempted, the barrel must be tight. Wood is a porous material. If the barrel has been sitting empty for a period of time in low-humidity conditions, it will tend to dry out. Adding liquid to the barrel will cause the staves to swell. If the hoops are in place and relatively snug, then simply add water to the barrel and let the wood swell. Either the compressed air method or the fill-with-water method mentioned in Section 1.1 can be used to check for leaks. If longer soaking is required, refer to Section 2.3 where we discuss a more extended procedure on how to soak up a barrel.

If the hoops are loose or have fallen off, it will be necessary to drive them back into place before soaking. If you do not have a barrel driver, a wide chisel with the edge ground flat will suffice. A chisel will work for a small number of barrels but if you have more than a couple of hoop repairs to make we recommend purchasing a hoop driver. Using whatever tool you choose, drive the hoops back to at least their original position. If the barrel is very dry, you may find you can drive them back much further. After the hoops are in place, add several gallons of water to the barrel and rotate it several times to ensure that all interior surfaces are wet.

In some cases when working with very dry barrels or large tanks, it is not possible to fill them with water. An alternative is to use a hose with a spray or mist attachment. As long as you can get the wood wet, it will swell. You will likely have to spray the barrel several times. Once a barrel begins to swell, try to fill it with water. Ideally, the barrel should be filled for a day or two after the leaks have stopped.

5 A hoop driver is almost a “must have” tool for any operation that has more than a dozen or so barrels. Barrels continually swell and shrink and keeping the hoops tight will do wonders for extending the life and limiting the frequency of repairs.
Occasionally a barrel will get so dry and loose that the staves shift position. While salvageable, repairing such a barrel is difficult. We recommend that you call us at Barrel Builders for advice.

**INSPECTING USED BARRELS**

**Exterior**
- Outside is clean and free of dirt and mold.
- Hoops are tight and equally spaced.
- The heads are flat and show no signs of warpage.
- No signs of cracking in the staves, particularly on bung stave.
- No signs of leakage or heavy, localized staining.
- No signs of bore bug damage, particularly where the headboard meets the staves.
- Bung hole is not chipped or gouged.

**Interior**
- A slight odor of sulphur when bung or seal is removed is a sign that the barrel has been well maintained.
- No "off-odor" smells.
- No signs of mold.
2.3 Swelling a Barrel

Since water is cheap and wine is not we highly recommend that a barrel be "tight" before the introduction of wine. In Section I we discussed the quick and dirty procedure for soaking a barrel and testing it. If the quick and dirty method does not work, an extended soaking may be required. Use the following procedure if you intend to soak a barrel for more than 24 hours.

**PROCEDURE TO SWELL A BARREL**

1. Rinse the barrel to be sure it is free of dust and debris.
2. Fill the barrel half way with cold water.
3. Add citric acid and potassium metabisulfite in a solution of 100 ppm SO₂. (Refer to Table of Solutions for the correct dilutions based on barrel size.) The combination of citric acid and metabi is required to get a sufficient release of SO₂. The release of SO₂ is dependent on the pH of the water. The citric acid lowers the pH and increases the release of SO₂.
4. Fill the remainder of the barrel with water and bung it.

The barrel should be topped up daily with water. If the leakage is substantial, the sweetening solution may have to be renewed. Be sure not to force the bung in too tight since it may form a tight seal and the leaks will stop. When the barrel is completely soaked up and there are no more signs of leakage, empty the barrel and rinse well several times before introducing wine. If leaks continue after 48 hours of soaking it is unlikely that further soaking will be effective.

Even though a barrel is tight and holds water, it may seep a bit when wine is added. If leakage is a problem when wine is in the barrel, an initial use with fermenting must or unfiltered wine with its high solids content will help seal the pores. Keep an eye on the barrel and be sure to keep it topped and clean until you are sure that all seepage has stopped.

Occasionally a barrel will begin to leak long after it has been filled. Remove and replace the bung to make sure that residual or secondary fermentation has not built up the pressure in the barrel.

2.4 Maintaining an Empty Barrel

If a barrel is left empty and untreated after wine or water has been introduced, molds and bacteria will begin to grow, eventually making the barrel unusable for wine. By replacing the air in the barrel with an atmosphere that is high in sulphur dioxide, SO₂, microbes cannot survive.
There are three ways to introduce sulphur dioxide into a barrel; sulphur disks, sulphur sticks or sulphur gas. If using disks or sticks we recommend using a sulphur bung which is a wooden bung that has a heavy gauge wire that extends down inside the barrel. At the end of the wire is a hook, for disks, and a basket, for sticks, that keeps them from dripping into the barrel. By burning the disk or wick in the barrel much of the oxygen is replaced by SO₂.

**PROCEDURE TO ADD SULPHUR TO A BARREL**

1. Make sure the barrel is tight. If air can easily enter the barrel, the sulphur will quickly escape.
2. Rinse the barrel with water.
3. Drain well. Any residual water standing in the barrel will combine with SO₂ gas to form sulfurous acid which will soak into the wood.
4. Add sulphur dioxide.
   - **Using sticks:** Place the stick in the basket and light the top. Place the sulphur bung loosely in the bung hole. Allow to burn completely.
     - **Quantity:**
       - 1/3 stick for 50 to 60 gallon barrel
       - 1/4 stick for 20 to 30 gallon barrel
       - 1/5 stick for 5 to 15 gallon barrel
     - (A 1/3 stick will take 3 to 4 minutes to burn.)
   - **Using disks:** Place one disk on the hook and light an edge. Place the sulphur bung loosely in the bung hole. Allow to burn completely. (Disks are sized for use only in 50 to 60 gallon barrels.)
   - **Using gas:** Use a hose from pressurized canister and inject SO₂ gas for 3 to 5 seconds.
5. Bung the barrel. (Refer to next section for suggestions.)
6. Store barrel in a cool, dark, humid location. Check the sulphur level every 3 to 4 weeks and repeat if necessary.
7. Rinse the barrel well with clean water before adding wine.

---

6 If pieces of sulphur drop into the barrel they can contribute to the formation of Hydrogen Sulphide which produces a rotten egg smell.
Section II:
BARREL MAINTENANCE

2.1 Important Key Points

Since wood cooperage, as we mentioned, is porous it can never be absolutely sterile. The treatments described in this manual are to be used to clean, de-tartrate, prevent microbial growth, and reduce the population and retard the growth of undesirable micro-organisms.

When any chemical is introduced into wooden cooperage it will penetrate the wood. The use of hot water will increase penetration. After a barrel is cleaned, it is commonly treated with citric acid. The function of citric acid is to neutralize any residual chemicals and lower pH. The neutralizing step is very important and should be allowed to act as least as long as the cleaning agent to assure deep penetration and neutralization of any chemical residue. If hot water is used initially, use hot water in the neutralizing step. Citric acid is a mild cleaning and bleaching agent and has a "sweetening" effect on the wood.

When adding any powder to a barrel, be sure it is completely dissolved in water first; otherwise some chemicals may fall to the bottom and form a hard insoluble deposit.

Do not use chlorine unless all other cleaning methods have failed and the barrel will otherwise be junked! We use chlorine-based bleaching compounds only as a last resort. Most people feel that due to the formation of 2,4,6-trichloranisole or TCA (a moldy, wet-newspaper odor) when chlorine comes in contact with the barrel, chlorine should never be used. Several prominent wineries have banned the use of any chlorine products in any part of the winery. Chlorine gas can join with lignins in the air to form a compound called TCP. TCP's are not detectable in wine but can be acted on by bacteria, molds and fungi to form TCA's.

If you have ever tasted a bottle of wine that has "cork taint" you know what TCA is all about. For many years it was standard practice to treat all corks with chlorine. TCA is amazingly potent and detectable to the average person in a couple of parts per trillion.

2.2 Chemicals, Supplies and Tools

Below is a list of a few basic chemicals and supplies that you may want to have on hand to maintain your barrels. Most are relatively inexpensive and can be obtained through Barrel Builders. If you decide to shave a barrel to extend its life, you will also need the tools listed below.

**Chemicals and Supplies**
- Metabi - sodium metabisulfite
- Proxicarb™ - sodium percarbonate
- Soda Ash
- Citric Acid
- Sulphur - disks, wicks or gas
- Sulphur bung

**Tools**
- Chalk
- 3 to 5 pound mallet
- Hoop driver
- Smooth-faced hammer
- Bumper
2.5 Sealing a Barrel

It is important that a barrel be properly sealed, whether it is empty and in storage or contains wine. The type of bung used depends on how the barrel is being used.

**SHIPPING BUNGS**

New barrels are generally shipped with a small wooden bung that is held in place by a piece of cloth. These bungs are inexpensive and provide an adequate seal for transport. They are not effected by SO₂ and are effective in keeping unwanted matter out of the barrel. For a proper seal, the bung hole must be clean and relatively smooth.

**SILICONE BUNGS**

Silicone bungs have become the industry standard for use in wine making. Many styles are available on the market. The most important characteristics to look for in a silicone bung are a high silicone content, a correct taper, and an adequate length. Barrel Builders has sold a line of bungs for over 15 years. We own our molds and we use pure silicone, which is a translucent, pearly white. While other bungs are available on the market, many contain fillers. This makes them less expensive but also less resilient. You can tell if a filler is used in a bung if it is tan or cream colored.

Silicone bungs come in both solid and recessed styles. The recessed are slightly cheaper and have an indentation in the bottom which can provide a tighter seal. A drawback is that the recess can be difficult to clean. (Our typical recessed customers are small wineries who do not mind the little extra time it takes to clean a recessed bung.)

The major limitation of a silicone bung is that it may react with raw SO₂, causing it to discolor and harden. A hard silicone bung is useless and pieces may begin to flake off. If you want to use a silicone bung in a sulphured barrel we have several customers who put the bung inside a plastic sandwich bag and then seal the barrel. Seems to work!

The most common method used to clean silicone bungs is a solution of metabi and citric acid. Make a solution and soak the bungs for several hours. Some wineries find that a hot water bath is also an effective cleaning method.

**WOODEN BUNGS**

Wooden bungs are the traditional way to seal a wine barrel. For small barrels, wood is about the only style available. For standard wine barrels, the use of wooden bungs is declining as more wineries move toward silicone. However, wooden bungs are less expensive than silicone and we still sell several thousand a year. We recommend using redwood or fir, since these woods are softer than oak and are less likely to deform or damage the bung stave. Since a wooden bung will mold to the shape of the bunghole, it is a good idea to mark the bung and barrel so that the bung gets inserted the same way each time. In addition, some wineries attach the bung to the barrel using a string or a fine wire so that the same bung is always used in the same barrel. Some wineries use a sealer such as paraffin to make the bung easier to clean and stop wicking.
**PAPER CUPS**
Since silicone bungs may react with sulphur, many wineries have found that a paper cup works fine when sealing an empty sulphured barrel. Choose a paper cup with a slight taper that will fit in the bung hole. Many wineries secure the cup with a piece of clear package sealing tape. This improves the seal and reduces the chance that the cup will fall out as the barrels are moved around the winery.

**2.6 Cleaning with Proxycarb™**

Sodium Percarbonate (2Na₂CO₃·3H₂O₂) is sold by Barrel Builders under the trade name of Proxycarb and is a white, odorless, crystalline powder. It has become the standard replacement for chlorine-based products in barrels that have "gone-off". Again, Barrel Builders does not recommend the use of chlorine-based cleaners unless all other methods have failed.

While relatively new to the wine industry, Proxycarb has been around for years. It is a common component of "colorsafe" laundry bleaches. As an oxygen-based bleaching agent it provides over 20% available oxygen; the remaining breakdown products are water and sodium carbonate, making it an environmentally friendly product. Other advantages include its long shelf life, it is safe to handle, it dissolves quickly, and it is easy to mix and apply. It is also effective at removing tartrate deposits from barrels.

Sodium percarbonate has a myriad number of uses, but since it is approved for use around food it is a natural choice for use on wooden cooperage. In a concentrated solution we have found it will bleach the exterior of a barrel back to white. We also found it works fine in the dishwasher and to remove stains from the floor!

Remember that any attempt to bring back a barrel that has gone off is just that - an attempt. A stronger solution will be more powerful, but more than 3 cups per barrel may strip some of the oak flavors. Whatever amount you use, be sure to rinse several times and use some citric acid in at least one of the rinses.

**PROCEDURE FOR CLEANING WITH PROXYCARB™**

1. Rinse the barrel to be sure it is free of dust and debris.
2. Fill the barrel half way with cold water.
3. Add Proxycarb (see Table of Solutions for correct dilution) and mix by rolling.
4. Fill the barrel completely with cold water. Hot water releases the oxygen too quickly. Loosely bung.
5. Allow solution to stand for 24 hours.
6. Rinse barrel several times with cold water.
7. Neutralize the barrel with a citric acid solution.
8. Empty the barrel and either add wine or sulphur the barrel.
2.7 Cleaning with Soda Ash

Soda ash (caustic soda) is a caustic chemical and is considered a harsh treatment for barrels (See Caution box!). The primary use of soda ash is to remove tartrates. We do not really recommend it for cleaning a barrel. Our method of choice for cleaning an "off" barrel is Proxycarb (Section 2.6).

Soda ash can be used to clean and leach out undesirable odors and flavors caused by microbial problems. It has also been used to bleach red wine color out of a barrel, but this is next to impossible and is not recommended. Soda ash will leach out the oak flavor of a barrel and is not recommended for use on a new barrel.

CAUTION - SODA ASH!

Soda ash, when used in a strength of over 1/4 ounce per gallon of water has burned oak staves. We highly recommend that soda ash be used in concentrations of less than 1/4 oz. per gallon of water and that 1/4 oz. solutions only be used in the most severe cases. Protective clothing should be worn when using soda ash.

PROCEDURE FOR CLEANING WITH SODA ASH

1. Rinse the barrel to be sure it is free of dust and debris.
2. Fill the barrel half way with hot water - 140 to 180°F.
3. Add soda ash solution (based on rate tables) and mix by rolling.
4. Fill the barrel completely with hot water. Loosely bung.
5. Allow solution to stand for 24 hours.
6. Rinse barrel several times with cold water.
7. Neutralize the barrel with a citric acid solution, again using hot water.
8. Empty the barrel and either add wine or sulphur the barrel.
2.8 Citric Acid Wash

Citric acid is used in a solution to neutralize any residual chemicals in the barrel. It is an essential component to the maintenance of sound cooperage.

**PROCEDURE FOR USING CITRIC ACID**

1. Rinse the barrel to remove as much of the cleaning solution as possible.
2. Fill the barrel half way with water. Use hot water if hot water was used initially; use cold water if cold water was used.
3. Add citric acid solution (see Table of Solutions for amount). Mix by rolling.
4. Fill the barrel completely with water.
5. Allow to stand 24 hours if using hot water, 48 hours if using cold water.
6. Empty and rinse several times with fresh water.
7. Immediately fill the barrel with wine or sulphur the barrel.

2.9 Extending the Useful Life of a Barrel

Due to the cost of new barrels, wineries are seeking ways to optimize their barrel investment. Many experiments have been done to make barrels last longer and other procedures have been used to impart oak flavors to wine.

2.9.1 Barrel Shaving

The two principal reasons for shaving a barrel are to expose fresh oak when the oak flavors have leached out of the surface layer and to attempt to remove molds or undesirable characteristics that have developed in the barrel.

Because we shave a tremendous number of barrels, Barrel Builders has developed and perfected a shaving machine that employs an industrial router and carbide cutters. Our approach requires that both heads be removed. This has its advantages as many wineries are asking us to "flip" the heads, shave, toast, and reinstall them, thereby exposing additional new oak. In addition, removal of both heads allows us to retoast the barrel over an open oak fire. With a crew of three, we can shave and toast 40 or more barrels a day.

If you decide to do your own shaving, it is possible to do a credible job using a sander/grinder, a wire wheel, or a hand scraper. The job can be accomplished by removing only one head.

**If you decide to shave your own barrels wear protective clothing!** This includes safety glasses, gloves, a heavy long-sleeved shirt, and a breathing mask. Shaving is a difficult, messy, messy job!
**PREPARING THE BARREL**

Shaving a perfectly dry barrel can take a long time. Oak is an extremely hard wood when dry. It is recommended that before shaving a barrel, you give it a good soaking, then let it drain for about a day. Having some moisture in the wood will make the job go much faster. If you find it is too wet when you attempt to shave it (a particular problem if using sandpaper), simply let it sit another day.

1. Decide which head to remove. Inspect both heads. If one is bowed or warped it may be best to leave that one in place. If one has a small seep in the croze, take that one out since you will be re-sealing the croze at the end of the job.

2. Using a piece of chalk, mark the chosen head where it meets the bung stave. This will assure that you align the head correctly when it is re-installed.

3. After removing any hoop nails, remove the head hoop and the first quarter hoop. Loosen the bilge hoop just enough for the head to get loose. Using a smooth-faced hammer, gently tap the staves loose from the head, being especially careful around the cants, the outside boards of the head.

4. Continue to loosen the remaining hoops until the head can be pushed into the barrel (for most new American and European barrels) or lifted straight out (for old style American barrels). The headboards are held together with either wooden dowels or double-pointed nails. The head should stay together if you handle it carefully.
5. Once the head is removed, drive the head hoop back on the barrel to re-snug the staves and keep dust and other particles from getting trapped between them. You should reset the bilge hoop as well.

6. Drive an awl or a small nail (12d-16d) into the edge of the center board of the head to a depth of about 1/4 inch so that it can act as a handle. This will make it easier to reinstall the head after the shaving is completed.

**SHAVING THE BARREL**

The age and condition of the barrel will dictate the amount of wood that needs to be removed. A rule of thumb is to remove at least 1/16" off the old surface. The color of the wood can serve as an indicator of the depth of wine penetration. Ideally, you want to remove at least 1/8 of an inch beyond where the color has penetrated. We at Barrel Builders often shave older barrels as deep as 1/4 of an inch if the thickness of the stave is sufficient.

1. Shave the barrel.
   - If using a sander, use coarse paper; 16 or 25 grit is recommended.
   - If using a wire wheel, use a coarse heavy wheel. A stainless steel wheel is recommended.
   - If using a hand scraper, use a heavy one with a curved blade.
   - Whichever method you employ, start at the far end of the barrel and work on an area that covers several staves. When enough wood has been removed, rotate the barrel and continue shaving. Work from the back to the front.

2. Use care in the area of the croze. Leave 3/4 of an inch or more unshaved to ensure that the sealing surfaces of the barrel are not disturbed.

3. Re-toasting is best accomplished using a toasting basket and scraps of oak. The ideal is to create a relatively hot fire and toast the barrel for at least 20 minutes. If a toasting basket cannot be borrowed or fabricated a propane torch can be used. A propane torch will "brown up" the interior surface, but provides only a superficial toast.
REASSEMBLING THE BARREL

1. Make a very thick paste of ordinary flour and water. Lightly apply a bead of this paste to the edge of the croze. Use a blunt pointed stick to be sure that the paste gets inside the croze.

2. Replace the head: *Old American Style barrels*:
   
   2.1a Loosen the hoops until the head will just tap down into position in the croze.

   2.1b Make sure the head is correctly oriented using the mark you made on the head and the bung stave.

2. Replace the head: *European Style barrels*

   2.2a Loosen the hoops until the head can be jammed down inside the barrel.

   2.2b Hold the head in the barrel and seat the marked end of the head into the croze at the bung stave.
2.3b
Lift the head up into place as far as possible, using the awl or nail as a handle. Tap the staves where the head sticks. You should be able to "jimmy" the head into place. At Barrel Builders we use a bent piece of pipe called a bumper which we insert through the bung hole and use it to tap the head into place. This makes the job pretty easy for one person but it's not absolutely necessary.

3. Reseat the hoops back into place while keeping an eye on the head to make sure that it is correctly aligned and seats properly. Be sure that the rivets on the hoops are correctly aligned on the bung stave.

4. Clean off any excess flour paste and clean up the outside of the barrel.
5. Rinse the inside of the barrel to remove any flour residue. Flour is an excellent medium for mold growth!
6. Test the barrel for soundness using the procedures listed under Section 1.2, INSPECTING A PREVIOUSLY USED BARREL.

7 If the barrel is damp, it may be difficult to get the head hoop to seat - as you pound one side, the other side pops up. Use a piece of chalk and rub the area where the hoop will sit and then also chalk the inside of the hoop. This will dry the wood and help the hoop "stick".
7. Either fill the barrel with wine or add sulphur dioxide.

2.9.2 Oak Chips

Oak chips are a fixture of the wine industry due to their ease of use and the cost of new cooperage. The use of oak chips can add a significant amount of oak character at a tiny fraction of the cost of new barrels. (We have several winemakers who refer to chips as "micro-barrels"!) Chips have become a staple, particularly in the fighting varietal category where they can add much complexity at an affordable price. There are hundreds of tons of chips used annually - we know, because Barrel Builders is a major supplier - but very few wineries will admit usage.

Two reasons why wineries are averse to advertising the use of chips are: 1) the use of chips is considered "cheating" - a sign of low quality and: 2) for years the legality of chips was in doubt. In 1993 this second issue was resolved. The Bureau of Alcohol, Tobacco and Firearms (BATF) has ruled that chips no darker than the "color of American cigarette tobacco" are acceptable. To the best of our knowledge, no one from BATF has ever investigated either suppliers or wineries to see that the standards are being met!

Chips are one of the cleanest ways to get a decent oak flavor into bulk wines since it can be easily done in a tank. Clearly, there remains much debate regarding the complex interplays between air, oak and wine and potential loss of character with short duration contact times, particularly in stainless steel tanks.

WHAT TO LOOK FOR IN CHIPS

Generally, American and French oak chips are available from several suppliers, including Barrel Builders. A variety of toast levels are available although most manufacturers have a house toast which has proven most successful for them. At
Barrel Builders our house toast for French oak chips is a light golden-brown; what we would classify as a medium toast. Our American oak chips are toasted slightly darker since this seems to mellow the extractives somewhat. The toasting for both is done slowly so that the color is uniform throughout the chip and all the chips are about the same color. We do, occasionally, get requests for lighter or darker toast levels which we can fill if given adequate lead time.

When shopping for chips, look for uniformity of color and size. Be careful not to buy chips that are really shavings or sweepings from the cooperage! The chances are high that they will be contaminated with dirt, oil and who knows what. Quality oak chips will be made from wood that is a byproduct of the barrel manufacturing process; stave ends, rejects, and other scrap. Consequently the wood will have gone through the same aging process as the manufacturer’s barrels - hopefully with extended air drying. Wet or kiln-dried wood will impart the same characters as kiln-dried wood used in barrels and is particularly noticeable in American oak.

**HOW CHIPS ARE USED**
For the past five years or so we have discussed use patterns, amounts, durations, and results with numerous wine makers. It would be nice to be able to publish a consensus, but like winemaking in general, there is a wide variety of opinions. Consequently, the best we can do is provide some general guidelines.

A range of 10 to 15 pounds of chips per thousand gallons of wine appears to be a common dosage. When customers are first experimenting with chips, we often recommend using 8 to 10 ounces for one barrel - start light, you can always add more. Published literature suggests that that extraction is largely complete in a couple of days. However, in the real world many winemakers extract for a week or more while sometimes also wait several months. One large user swears that a subtle change in flavors occurs between weeks 3 and 5.

Chips can be introduced in several ways. They can simply be dumped into the wine where they will sink in a couple of days and the wine can be racked off (although the thought of chips going through impellers makes most winemakers nervous!) Several wineries have developed sophisticated methods using stainless steel screens that can fit over drain fittings. After the wine is drained from the tank, the door is opened, the screen is removed and the chips, lees and residues are hosed out. The most common method is to use "tea bags". A bag of cheesecloth, paint straining or other porous material is made up to hold the chips. These bags can be found in several sizes, are reusable, and easy to sterilize. Attaching a rope makes it easy to get the bag in and out of the tank.

Yet another method is to add a large quantity of chips to a small amount of wine to create an oak extract. The extract is then used to add flavor during the blending process.

---

8 We recently were introduced to "game bags" which are used for hanging deer or elk. These are relatively large mesh bags that are light-weight, easy to tie, food grade and can be purchased in sporting goods stores.
2.9.3 Inserts

Inserts are toasted oak boards that are inserted in barrels or tanks. Several manufacturers have tried various techniques that are designed to replicate the slow extraction that takes place in a barrel. There appears to be a great deal of interest in inserts and how they perform. While Barrel Builders does installation work for one of the insert manufacturers, we do not directly sell the product.

In brief, barrel insert systems use rejected wood from the manufacturing process; therefore it has gone through the same curing process as the wood used in barrels. The typical insert contains about 20 toasted wooden slats about 1/4 inch thick that are held in place by nylon or stainless steel retainers. Currently, most suppliers offer either American or French oak. A typical system will run between $50 and $100 per barrel. This includes the cost of the system and the cost of installation, which requires the removal of one head.

The major selling point of inserts is that they mimic the oak, air, wine interaction that takes place in a barrel. Because the boards are thicker than chips, the extraction is somewhat slower. There are claims that the inserts will last up to 5 years. However, since wine can easily penetrate an 1/8 of an inch of wood in a few months, it seems reasonable to assume that a 1/4 inch board that is exposed to wine on both sides will be substantially used up in one or two years.

Insert systems are also being used in tanks. The installation generally involves welding a system on the inside of the tank that is used to hold the inserts. The inserts are then added and the wine is put in the tank. A relatively new approach is to build a hexagon stack of inserts inside the tank before adding wine. This provides a much higher percentage of oak to wine, but installation and removal is more difficult.
Section III: BARREL REPAIRS

3.1 Tools and Supplies

For the vast majority of repairs you will only need a few tools. Most are readily available at your local hardware store; others are more specialized and you may need to shop around. Barrel Builder's carries some products which may make your repairs go more smoothly. We can also direct you to sources for items that are harder to find.

Before you attempt making repairs we suggest that you have the following tools available:

To repair leaks:
- Smooth-faced finishing hammer
- 1 inch chisel
- Pocket knife
- Piece of white chalk

To replace staves:
- Hoop driver *
- 3 to 5 lb. short handled mallet

To remove and replace heads:
- Bumper *
- Head tool *

* available through Barrel Builders

Depending on the repair, you may need one or more of the following chemicals or supplies, all of which are available through Barrel Builders:

- Epoxy - Food grade
- Spiles
- Wedges
- Hoop Nails
- Flagging
- Sulphur - disks, wicks or gas
- Wet Surface Liner
- Mildewcide
- Balance scale
3.2 Repair of Bore Bug Leaks

There are several types of bore bugs that can cause problems with wine barrels. The most common is *Scobicia declivis* of the Bostrichid family of beetles. The common name for *S. declivis* is the Lead Cable Borer. It bores a hole about the size of a pencil lead.

Abundant on the Pacific Coast below 6000 feet, the Lead Cable Borer infests Oak, Acacia, Eucalyptus, California Laurel and other hardwoods. While more of a problem in the Spring and Summer, they can cause problems at any time of the year. They are highly attracted to wine-soaked cooperage and will attack redwood and even corks in filled bottles. On barrels, bore bug holes are often found at the junction of two boards or where the head meets the staves.

*Scobicia delivis* is a true beetle and the adult resembles a dark hunchbacked grain of rice. Slow flyers, their seemingly random pattern of flight is very distinctive. After mating, the female finds a suitable spot and excavates a tunnel 10 to 15 mm. in length where she lays a single egg. The larva hatches in about 2 to 3 weeks and begins to tunnel parallel with the grain for about nine months, leaving a tunnel up to 45 mm. long. The larva then pupates for several weeks and finally emerges as an adult. Without access to wood the adults die quickly, but otherwise will live for about a month.

### CONTROL OF BORE BUGS

1. Keep the borer away from your cooperage! This is the only way to stop borers. Keep doors and windows screened or closed. Remove dead trees and wood piles from the winery site.
2. Keep barrels full. The borer will tend to make a shorter tunnel and not penetrate wine-soaked wood.
3. Fill the barrel with hot water to kill both the larva and adult beetles.
4. Rotenone is a relatively benign insecticide that has been used with limited success in spot treatment. Ongoing control is important since the borer will continue to infest the same barrels over again.
5. UV lights (buglights) or mildewcide will not stop borers.

### REPAIR OF BORE BUG DAMAGE

1. Take a round toothpick, cut it in half, and gently pound it into the hole. This is the cheapest method and round toothpicks seem to be just about the right size. (Some brands are too small, however.)
2. Fill the hole with a spile. Spiles are small, conical dowels. While more expensive than toothpicks, they are more effective on larger borer holes. If the hole is at the junction of two pieces of wood, be sure that the barrel is soaked and tight since a spile will act as a wedge; in a dry barrel, the spile can cause the pieces to separate.
3.3 Repair of Through Wood Leaks

Wood is honeycombed with small capillary tubes which make up the grain of the wood; this is what makes it so porous. Even though the tubes are partially blocked by crossmembers called tyloses, the openings are generally not large enough to wick both water and wine.

One of the differences between an American and French barrel is that the oak used in an American barrel tends to be sawn where oak in a French barrel tends to be split. The reason American oak can be sawn and not leak is that it has a relatively large number of tyloses that block the grain. French oak, on the other hand, has fewer tyloses and a more open grain pattern. To avoid cutting across the grain, the French split the oak logs into blanks or moraines. While effective, splitting of oak logs into blanks produces a significant amount of waste - up to 70%. This is another reason why French barrels tend to cost more than American. Oak barrels from Central and Eastern Europe (Hungary, Rumania, Slovakia, Czech, Slovenia, etc.) have traditionally been sawn and were known to have problems with through wood leaks. However, careful selection of tight grained wood, even if it is sawn, can eliminate the leakage problem. Some Central and Eastern Europe cooperages are beginning to experiment with splitting logs into quarters or eighths prior to sawing.

Whether split or sawn, grain patterns, knots or other vagaries of growth occasionally permit leaks or seeps. Most major leaks are caught during the testing and quality control procedure at the cooperage. Problem staves are removed and replaced. Occasionally you may receive a barrel that has a through wood leak that must be repaired.

**REPAIR PROCEDURES FOR THROUGH WOOD LEAKS**

**Method 1 - for tiny leaks**

Try soaking the barrel with either a bentonite solution or with unfined wine. This will often stop small seeps by plugging any open pores with particulates.

**Method 2 - for small leaks**

The use of garlic and chalk is a trick of many oldtimers and one that works remarkably well! Clean off the leaking area to pinpoint the leak. Take a clove of garlic and grind it into the leak. Tap it into the wood using a smooth-faced hammer. Next, take a piece of writing chalk and force it into the wood - further driving in the garlic. Let the mixture sit for a couple of hours then clean off the residue. (If the leak is really small, sometimes chalk alone will do the job.)

**Method 3 - for multiple small stave end leaks**

Barrels constructed from sawn wood may continue to have multiple stave-end leaks even after hours or days of soaking. One solution is to paint the chime.

---

9 We used to qualify this statement since up until recently almost all sawn European oak was prone to leak. However, for the past two years we have been selling barrels made from sawn wood that are produced in Hungary that are as tight as any split wood barrels we know of.
The barrel must be emptied, rinsed, sulfured and left to dry for a couple of days. The chime can then be painted; oil based paints seem to work best. The paint can be clear or colored. Most Yugoslavian cooperage has red paint on its chime. This is done primarily to minimize leaks, not for cosmetic reasons.

Method 4 - for moderate sized leaks

The application of epoxy is an effective means to stop most leaks. The advantage to epoxy over paint is that it can be used on damp (not wet) wood. Empty the barrel to relieve the pressure on the leak. Clean the area around the leak and apply the sealer. We use and sell O’Sullivans Wet Surface Liner. It is food grade, adheres to damp surfaces, and dries to a brown, “wood-like” color. Curing time is heat dependent. In a cool, damp cellar, curing may take several days.

Method 5 - for large stave end leaks

Large seeps and outright leaks can often be effectively plugged with spiles. To pinpoint the leak, scrape the area with the edge of a knife blade. The exact site of the leak should become obvious. Using a large nail (12d or 16d), make a pilot hole about 1/4 inch deep at the site of the leak. Angle this hole so it heads towards the outside of the barrel, not in towards the head. Using a hammer, drive the spile in as far as it will go, taking care not to break or split the surrounding wood. The object is to crush the wood around the leak. In addition, the spiles will swell in a few days. In the case of a large leak, several spiles may be needed. After the leak has stopped, any protruding spiles may be cleaned off with a chisel or a sharp knife.

Method 6 - for large through-stave leaks

First, try to use a spile to stop the leak, using the procedure described in Method 5. If this fails to stop the leak, or it simply appears somewhere in the same vicinity, you will likely need to use a wedge.

A note of explanation about through wood leaks. A leak that appears in the middle of a headboard or stave is generally caused by liquid seeping the length of a capillary tube. It is possible that the liquid is entering the capillary tube on the inside of the barrel several inches from where it is leaking on the outside of the barrel. To stop the leak, a blockage must be made across the tube. To do so, take a small chisel or a screwdriver and drive it about 1/4 inch into the stave above the point of the leak.

Picture R-1.

A cross-section of a stave showing how a wedge is used to stop a through wood leak. The line on the stave traces a capillary tube from the inside surface to the outside surface.
leak. Then take a small wooden wedge and drive it into the wood. The wedge crushes the tube and stops the flow. The wedge will also eventually swell, tightening the seal. It may be necessary to "bracket" the leak, driving one or more wedges on each side of the leak. Sometimes you can feel the nap of the grain on a stave to determine which way the grain flows and then try to predict which direction the water or wine is moving.

3.4 Repair of Leaks between Staves and Headboards

Leaks between staves or headboards are most common in a barrel that has been allowed to dry out. If you suspect this is the case, it is important to soak the barrel as described in Section II of this manual.

If the leak persists after soaking, the gap, or joint, between the boards will need to be "flagged". Flagging material is made from reeds. The most typical plant used for flagging is *Typha latifolia*. The reed material swells up and acts as a gasket material in the joint. 10

REPAIR OF BETWEEN STAVE LEAKS

1. Mark the location of the leak using a piece of chalk.

10 Barrel Builders carries flagging material. We generally sell it in "bundles" of 10 to 12 plants where each plant contains multiple reeds. If you only have need for a little, we will gladly send you some.
2. Place a mark on the head where it meets the bung stave so that if the head drops out you will be able to return it to its original position.

3. Remove the hoop nails (if used) from the hoops. Drive the head hoop off the barrel, followed by the quarter hoop.

---

**CAUTION - USING A HOOP DRIVER!**

Be sure that you do not wrap your fingers around the driver. The driver should be held relatively loosely so that if it is not seated correctly on the hoop when it is struck with the mallet it will glance off and fall to the floor. Make sure your feet are positioned so they will not be hit by the driver.
4. After the first two hoops are removed, work your way around the area of the leak, gently tapping the stave ends with a hammer. This will help to "unglue" the staves from the head.

5. As you remove the hoops, keep checking the head and tapping the staves. **You want the head to be loose, but not so loose that it drops out.** Loosen the bilge hoop not at all or only as much as necessary.

6. As soon as the head becomes loose in the croze, stop loosening the hoops.\(^{11}\)

7. Using a chisel, tap gently between the two leaking staves, just enough to spread them slightly apart.

8. Take a small length of flagging and prepare it. Peel the flag to separate it into individual pieces. (Soaking sometimes makes this easier.) Using a sharp knife, remove the pith from the edge. You should have a piece of flagging that is about the width of the stave, perfectly flat and will extend from the top of the stave down past the quarter hoop.

\(^{11}\) If the head falls out, you can reinstall it by following the procedures described in Section 2.9.1, BARREL SHAVING.
9. Work the flagging down between the staves until the top of the flagging is in the croze, just touching the head. The other end of the flag should extend at least past the first quarter hoop.

10. Check to see that the head is still seated in the croze and that it aligns with the mark on the bung stave.

11. Replace the hoops. Initially, each hoop should be put on just so it is snug. Check the position of the head once again. Once all hoops are on, they should be tightened, starting with the bilge hoop, at least to the point where they were originally.

12. Secure the hoops using new hoop nails, if desired.

**REPAIR OF HEADBOARD LEAKS**

The procedure we describe below is a bit tricky. It requires that you loosen the staves enough to allow the headboards to be spread, but not enough to allow the head to fall into the barrel. Refer to Section 2.9.7, **BARREL SHAVING**, where we describe how to remove and reinstall the head.

1-6 Are identical to procedures 1 through 6 described above.

7. Once the head is loose, use a wide chisel and tap it gently between the headboards. The boards should spread just slightly.

8. Prepare a piece of flagging. (Step 8 above)

9. Trim the end of the flagging so that it matches the shape of the bevel of the head.

10. Slip the flagging into the gap between the headboards and out to the edge of the head. Either run the flagging the entire length of the headboard or "feather" it out several inches past the leaking area.

11-13 Follow steps 10 through 12 under **REPAIR OF BETWEEN STAVE LEAKS** to reseat the head and tighten the hoops.
REPAIR OF CROZE LEAKS
Leaks that occur where the head meets the barrel staves can sometimes be stopped simply by tightening the head hoop or with spiles or wedges. If the seal has been broken, however, the edge of the head may need to be treated with gate tallow or a flour paste and reinstalled (follow removal and head installation procedures described under section 2.9.1, BARREL SHAVING). Flagging can also be used. First, loosen the head as described above. Take a length of flag and tap it gently into the croze using a screwdriver or a chisel. Retighten the hoops and check for leaks.
Glossary of Cooperage Terms

AIR-DRIED: Wood that has been allowed to dry naturally, without the use of a kiln, to reach a proper moisture content (usually between 10-13%) for use in barrels. This usually takes 18 to 24 months.

BARREL PALLET: Metal or wooden racks for storing and stacking barrels that can typically be handled with a forklift.

BARREL TYPES:
Transport: Stout barrel with 6 to 8 galvanized hoops.
Chateau: Thinner staved barrel with head braces held in place by pegs. Often with willow hoops.
Burgundy: A 225 l. barrel that is 35" high and 28" diameter at the bilge (shorter than a Bordeaux style). Can be Transport or Chateau style.
Bordeaux: A 225 l. barrel that is 37" high and 27" diameter at the bilge (taller than a Burgundy style).
Bourbon: A 52 gallon American oak barrel.

BILGE: The curved part of the barrel equi-distant from the two heads.

BLANKS: The boards that are dried and then used to make staves.

BUNG: A plug used for closing the bunghole of the barrel. Can be made of wood, silicone, plastic or paper.

BUNGHOLE: The opening for filling and emptying barrels. The standard opening is 50 to 52 mm and the taper is normally 5 degrees or 1/8" per inch.

CANT: The outside curved board of a barrel head.

CASK: A large oval-shaped barrel.

CHAMFER: The sloping ends of the stave.

CHECKS: Splits or cracks in staves or headboards.

CHIME: The part of the stave from the croze to the end of the stave.

COOPERAGE: A) The factory where barrels are made or B) The product produced by a cooperage. The French word for cooperage is Tonnellerie.

CROZE: The groove near the end of the stave where the head of the barrel fits.

DOWEL PINS: Small, round wooden pegs used to pin the headboards together.

FLAG: A rush or tule which is dried and used as a gasket material to fill gaps and voids.

FLAGGING IRON: A tool to help separate joints of the barrel.

GATE: The manhole in a tank or cask.

HEAD: The round piece that fits into the croze of the barrel and forms the top and bottom ends.

HOGSHEAD: A 300 liter barrel.

HOOP: The circular metal bands that keep the barrel staves together. Can also be made from willow or hickory.

HOOP DRIVER: The tool used to drive down the hoops to force the staves together and make the barrel tight.
GLOSSARY

HOOP NAIL: A small "L" shaped nail driven in next to or through a hoop to keep the hoop from moving.

HOWEL: The portion of the stave which has been hollowed out to cut the croze.

JOINTED: Staves and headboards which have been smoothed on their edges ready to be used to make a barrel.

KEG: A small barrel. Usually under 30 gallon capacity.

KILN-DRIED: A term applied to wood which has been dried in a kiln to lower its moisture content. (see Air-dried)

MORAINES: Another term for blanks.

PUNGEON: A 120 gallon (450 liter) or 135 gallon (500 liter) barrel.

RACKS: Either built-in shelving or a metal rack that holds barrels.

RIVETS: Small metal fasteners used to close hoops.

SPILES: Small wooden conical pegs used to close holes and stop leaks.

STAVE: The vertical pieces of wood forming the walls of a barrel.
# Table of Solutions

<table>
<thead>
<tr>
<th>Barrel Sizes</th>
<th>5 gallons</th>
<th>10 gallons</th>
<th>30 gallons</th>
<th>60 gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium Metabisulfite</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 ppm</td>
<td>3.8 gms</td>
<td>7.5 gms</td>
<td>22.5 gms</td>
<td>45.0 gms</td>
</tr>
<tr>
<td></td>
<td>.1 oz.</td>
<td>.3 oz.</td>
<td>.8 oz.</td>
<td>1.6 oz.</td>
</tr>
<tr>
<td>200 ppm</td>
<td>7.5 gms</td>
<td>15.0 gms</td>
<td>45.0 gms</td>
<td>90.0 gms</td>
</tr>
<tr>
<td></td>
<td>.3 oz.</td>
<td>.5 oz.</td>
<td>1.6 oz.</td>
<td>3.2 oz.</td>
</tr>
<tr>
<td>Proxycarb - Sodium Percarbonate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>18.5 gms</td>
<td>37.5 gms</td>
<td>113.0 gms</td>
<td>226.0 gms</td>
</tr>
<tr>
<td></td>
<td>.7 oz.</td>
<td>1.5 oz.</td>
<td>4.0 oz.</td>
<td>8.0 oz.</td>
</tr>
<tr>
<td>Heavy</td>
<td>56.5 gms</td>
<td>113.0 gms</td>
<td>339.5 gms</td>
<td>679.0 gms</td>
</tr>
<tr>
<td></td>
<td>2.0 oz.</td>
<td>4.5 oz.</td>
<td>12.0 oz.</td>
<td>24.0 oz.</td>
</tr>
<tr>
<td>Citric Acid Solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.0 gms</td>
<td>30.0 gms</td>
<td>90.0 gms</td>
<td>180.0 gms</td>
</tr>
<tr>
<td></td>
<td>.5 oz.</td>
<td>1.0 oz.</td>
<td>3.2 oz.</td>
<td>6.4 oz.</td>
</tr>
<tr>
<td>Soda Ash</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light to medium cleaning</td>
<td>1/8 ounce per gallon of water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy duty cleaning</td>
<td>1/4 ounce per gallon of water</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conversion Table

Weights:

1 ounce = 28.3 grams
1 pound = 454 grams
1 teaspoon = 5 grams = approx .20 ounces
2 teaspoons = 10 grams = approx .40 ounces
1 Tablespoon = 15 grams = approx .60 ounces
10 Tablespoons = 150 grams = approx 5.0 ounces

Volumes:

1 ounce = 29.3 milliliters
1 gallon = 3.785 liters
1 60 gallon barrel = 225 liters