Pocket Guide to All-Grain Brewing

Moving from extract to all grain is an important step in brewing. Not only does all grain give you more control over your beer, it opens up new avenues of recipe formulation, experiments, and flavors. The following guide will give you the rudimentary pieces of brewing an all grain batch, and hopefully help you through a brew day or two! We will go forth without covering recipe formulation, and only delve shallowly into the science of why everything is happening.

Step 1- Water Volumes

You can cut miles of heart-ache and guess work out of your brew day by just doing some simple calculations on brew day morning. For these calculations, courtesy of Ray Daniels in *Designing Great Beers*, you will need to know the evaporation rate of your system, how much grain is going into your batch, the amount of beer you want in your fermentor, what your system losses are (i.e. how much is left over in the bottom of the mash tun, sparge tank, or in any transfer hoses, etc.) and what your mashing rate is.

Most of these numbers are easy, despite some being variables. Let's use a 5 gallon batch as an example. For 5 gallons, you want to end up with 5.5 gallons in your fermentor so you end with 5 gallons of beer into packaging (bottles or kegs).

How much grain is going in your batch depends on your recipe, but for this example, let's say 12 lbs. It doesn't matter what kind of grain, just the total amount.

Mashing rate is also easy, generally 1.1-1.5 quarts per pound of grain.

System losses can be measured by 'brewing' a batch of water and calculating what's left over, all together, after each vessel stops pouring through the ball valves, and what's left over that gets stuck anywhere in the system, like in hoses. All this measured together will make your system losses. Let's say our system losses for our hypothetical system are 1.5 gallons (a great starting place).

For evaporation rate, you will simply add 1 gallon of water to your kettle, then boil like you would on brew day for 60 minutes. Afterward, simply measure what's left. If you have .8 gallons left, boil off is 20%, etc.

Ok, down to math. As previously cited, refer to Ray Daniels *Designing Great Beers* for a more complete explanation for all of this math.

Step 1- How much wort will go into the fermentor?

- 5.5 gallons

Step 2 – Shrinkage - Shrinkage is a constant figure, always divide by .96

- 5.5 / .96 = 5.729 (I generally keep the number at 3 decimal points until the end, when I round to the nearest quarter gallon.

Step 3 – Evaporation - Take your now calculated evaporation rate and plug it into this equation, using the time you plan to boil: 1-(PercentEvaporation x (MinutesBoiled / 60))

- 1 - (.20 x (60 / 60)) = .80
- Take this number, and divide it by the answer from Step 2
  - 5.729 divided by .8 = 7.161

Step 4 – System Losses – Take the answer from Step 3 and simply add your system losses to it.

- 1.5 gallons losses + 7.161 = 8.661

Step 5 – Grain Losses – Water loss from grain absorption always needs to be calculated, as it can be a significant amount. Simply multiply how many pounds of grain in the batch, in this case 12 lbs, by .14, which is a constant number, then add that number to the running water total from Step 4.

- 12 lbs grain x .14 gallons water absorption = 1.68
- 1.68 water absorption by grain + 8.661 = 10.34

Total Water needed for Brew Day = 10.34 gallons

Now that we have calculated all of our water losses, we have a fairly exact number of total water needed for brew day. Now, we calculate mash and sparge water in one easy step.

Step 6 – Mash and Sparge Volumes – This is where we decide what our mashing rate is. Everything you read will say somewhere between 1.1 quarts of water per pound of grain to 1.5 quarts of water per pound of grain. For this example, we will use 1.5.

- 1.5 quarts of water x 12 lbs of grain = 18 quarts of water, or 4.5 gallons (18 divided by 4).
- 10.34 gallons for brew day minus 4.5 gallons for sparge leaves us 5.84 gallons for sparge water

Simplifying the numbers – Unless we break out the measuring cup and calculator, measuring out 5.84 gallons of water is unwieldy and somewhat unreasonable. It is easier to round to the nearest quarter, that way it is easy to measuring with a fermentation bucket or similar tool. So we will round 10.34 down to 10.25, and 5.84 up to 6.

Now that we have gone through the equation the long way, here is the quick and dirty version for reference:
Batch size into Fermentor: 5.5 gal
Shrinkage: 5.5 divided by .96 = 5.729
Evaporation: 5.729 divided by .8 = 7.161
Equipment Losses and Trub: 7.161 + 1.5 = 8.661
Grain Losses: 12 lbs x .14 gal = 1.68
1.68 + 8.661 = 10.34
Total Water for Brew Day = 10.25 Gal
Mash: 1.5 q x 12 lbs = 18
18 q / 4 qts/gal = 4.5 gal
Sparge: 10.25 gal total water minus 4.5 gal Mash water = 5.75 gal sparge water, which we rounded up to 6.

Now that we have our brew day water figured out, we can move on to the mash. Again, it is strongly recommended that you pick up *Designing Great Beers* and look at the more comprehensive version of these equations.

Step 2 – The Mash

First and foremost, this is where you take your yeast out of the fridge and set it out to begin the long process of coming to proper temperature.

The mash is where all the magic happens on brew day. You have infinite control over what kind of sugars you want in your beer, how dry or malty it will be, and what your potential for alcohol will be. Your system doesn't matter as long as you can dial in your process. All you need is a way to heat water, a way to keep that water at a prescribed temperature, and a way to wash the grain. There are only a million different ways to accomplish all of this. Here, we will focus on process, since that will only change slightly system to system.

First, you need to decide what you are brewing. If you are brewing a crisp, dry beer, you will want to target a mash temperature between 147 F and 151 F. In this range, the majority of the active enzymes will be beta-amylase, which will make more simple sugars, which are readily and easily available for yeast to ferment. In this range of temps, your beers will ferment out further, leaving less body, higher alcohol, and a beer with less body.

If you are trying to make a more malty beer, say something English with a big malt profile, or a stout, you will want to be in the range of alpha-amylase, between 154 F and 158 F. This will make a beer with less of the simple and easier to ferment sugars, instead leaving longer chain sugars that will contribute to body, mouth-feel and malt character.

A mash temperature between 152 F and 154 F will give you a beer that is balanced between long and short chain sugars, giving you fermentability and residual sugar. This is a good balance for most beers, adding body and residual sugar, but not sacrificing ABV or balance.

Now that we have an understanding of why we mash, to convert starches to sugars that the yeast are capable of eating, now we can move forward. Select a mash temperature that is appropriate for your beer style or concept, and run with it.

Mashing In

Mashing in is adding your grain to pre-heated water, slowly enough to ensure you don't get any 'dough balls' forming. Dough balls happen when you add the milled grain without breaking it up and the outside gets wet, trapping dry grain on the inside that the enzymes won't be able to get to during the mash.

When heating your water, heat it to about 10 degrees above your mash temperature, as you will lose heat as you add grain to the open vessel. Keep a gallon or so each of boiling and cold water on hand to adjust temperature as necessary once all the grain is wet.

The Mash Itself

Once you mash in, mix everything up with your mash paddle and take a temperature reading. From there, adjust to your proper mash temp. Once you have hit your desired temperature, insulate and walk away. Start a timer for 60 minutes, and check you mash at about 30. . Before you check, mix everything up again, as the temperature will striate, or read warmer on the top, as heat rises. Adjust as necessary. When you start your timer, start your sparge water so it will be ready by the time the mash is done.

If you have a refractometer, check the sugar conversion when you check temperature at 30 minutes.

Step 3 - The Sparge

There are many ways to sparge, or wash the newly converted sugar off of the grain. We will cover both a Fly Sparge, also know as continuous sparge, and a Batch Sparge.

Fly Sparge

Fly Sparging is a continuous sparge, or wash, of the grain by the water from the Sparge Tank, also called the Hot Liquor Tank (HLT). By running the wort out of the bottom of the mash tun at the same rate that the HLT water runs onto the top of the mash, the wort is slowly but effectively washed of grain.

First, you must begin by recirculating the grain bed so that at least an inch, ideally two inches, of water are on top of the grains, and the wort is running clear from the ball valve in the bottom. Recirculating can be done with a standard pitcher, a pump, or anywhere in between. Simply pull wort off of the ball valve in the mash tun and slowly and evenly add it back to the top. Do this until the wort runs clear, with no particulate matter. This may take 2 pitchers or 10, but do it until the wort runs clear.

Once the wort runs clear, open the bottom valve and let it run, about half open, into the boil kettle. Open the HLT ball valve and adjust the flow rate so that water is going into the mash tun at the same rate it leaves. It is good to have a sparge arm that evenly distributes the water over the entire grain bed so that channeling doesn't occur. Channeling is when the wort creates a channel through the grain where all the water goes, leaving out the rest of the grain that is full of sugar. After you get a couple of gallons into the boil kettle, turn the flame on so as to heat the water as it runs in. This will cut back the time it takes to bring the wort to a boil in the next segment of brew day.

Fly Sparging should be done slow and low, generally taking about an hour. This ensures that all the sugars are washed off the grain. The sparge water should be of a temperature to bring the entire volume up to 170 F, so as to ensure all available sugars are dissolved into solution.

Batch Sparging

Batch Sparging is a sparge process where you wash the grains quickly and efficiently in one or two big shots.

You begin by first recirculating the wort, just like in a Fly Sparge, until it runs clear. From there, you drain the ENTIRE VOLUME into your boil kettle. Turn on the flame so you can begin bringing the wort to a boil.

After you drain it into the kettle, refill the mash tun with the hot water you have standing by in the HLT. You can do a single batch sparge, which is using the entire sparge volume in one shot, or a double batch sparge, where you would use half the water in the HLT to refill the mash, twice. Either way, you want to make sure your HLT water is hot enough to bring the entire mash volume to 170 F after temperature losses. We will use the double batch sparge as a model here.

Use approximately half of the volume of your HLT and ensure that the grain is all submerged. Mix well with the mash paddle, then allow a 5-10 minute rest. Recirculate again until the wort is clear, then again drain the entire volume into the boil kettle.

Do the exact same thing with the rest of the water in the HLT, and you're done! Check and note pre-boil gravity here.

Step 4 - The Boil

The boil is pretty straight forward, and maybe the easiest part of the process. Here, you are just boiling and adding hops. The accepted boil rate is a roiling boil. I like to maintain a medium to medium high boil to ensure that all of the off flavors (chlorine, dms, etc) are boiled off.

The amount of time you boil is generally 60 minutes, unless you are using any Pilsner malt, then you will need an extra 30 minutes to boil off the compounds that can create DMS, or dimethyl sulfides, which can lend your beer an awful cooked vegetable flavor.

Hop Additions

Depending on your recipe, you may have many different hop additions throughout the boil. The longer you boil the hops, say a 90 or 60 minute addition, the more bitter and less aroma you will create. If you are making a malt forward beer, and are only using hops for balance, in general a solid 60 minute addition, or maybe a 60 and a 30 minute addition will work just fine. If you are looking for a more hop forward beer, plan on using more late addition hops to add hop aroma.

Start your timer as soon as the hot break, the first part of the boil where the wort tries it's best to boil up out of the pot, stops. From here, you add hops according to your recipe, beginning with your 60 minute addition, meaning 60 minutes left in the boil.

Preparing for the End of the Boil

With 15 minutes left in your boil, you should begin to add clarifiers, extra sugars, and anything else your recipe calls for. Also, this is where you put in your immersion wort chiller to sterilize it.

If using irish moss or whirlfloc, create a vortex in the middle of the wort and add the prescribed amount, per manufacturers instructions. Allow the vortex to settle naturally. This is called vorlauf, and will settle the majority of the particulate matter in the middle of your kettle, making it easier to rack clear wort off of the edge by the ball valve.

Step 5 – Cooling the Wort

Cooling the wort can be done in many forms, including immersion chillers, a length of copper tubing you set inside the wort and run cold water through, counterflow chillers, a length of tubing within another length of tubing where you run the wort through the inner most tubing and cold water through the outer most tubing, and plate chillers, where you run the beer through stainless steel plates one direction and water through a second set of stainless steel plates that run opposite and against the first set of plates. All are great methods, with infinite upgrades, tips and tricks. For this example, we will use the immersion model.

As stated above, insert your clean immersion chiller in the boil at 15 minutes left. Boiling the 25' or 50' length of copper will be enough to sterilize it. At the end of the boil, turn on the water and allow it to run through the coils and out, picking up heat as it goes. If possible, try to utilize the water coming out (it will be hot, then warm) for cleaning.

The idea here is to cool the wort down as quickly as possible to decrease the chances of wild yeast and bugs from getting into the wort.

Step 6 – Transferring to the Fermentor and Pitching Yeast

During this step, you will transfer the wort from the boil kettle, now that it's a pitchable 65-70 F, into your fermentation device. Let it splash around so that your wort is aerated, or you can aerate your wort by more sophisticated means, either a pure oxygen tank and aeration stone, or a small air pump with an aeration stone.

Pitch your yeast starter or package, already warm from being out of the fridge during brew day, about halfway through the transfer so as to mix and aerate. Cover and put in a fermentation chamber, and that's it! Now all you have left is cleaning...

Recommended Reading:

Designing Great Beers by Ray Daniels

This book contains all of the numbers, and why they are what they are. Great for learning how to calculate volumes, AAU's (Alpha Acid Units, which will tell you how hoppy your beers are), and any other calculations you need before, on and after brew day.

How to Brew by John Palmer

How to Brew will cover many of the numbers, but really focuses on different processes, how to keep off flavors out of your beer, how to taste them in your beer, as well as a ton of information on every aspect of brewing.

Brewing Classic Styles by Jamil Zainasheff and John Palmer

This lexicon of winning homebrew recipes, organized by style, is a perfect place to start to both understand the origin of the style that you're brewing, and brew a tried and true recipe. With every style represented, and tips and tricks on each, you can't go wrong.