# Hop Bill Calculation

While dealing with malt we have used the term 'L°/kg' to represent the potential extract per kilo of malt. When calculating hop grists, we are obviously not concerned about fermentable extract, but instead with the extraction of bittering compounds known as α-acids. The percentage by weight of α-acids in a hop sample is usually given on the packaging of whichever hop we decide to use in the recipe, and we will need this figure to calculate the weight of those particular hops required.

When developing a recipe we need to decide the desired concentration of these bittering compounds in the finished beer. This can be expressed as mg/hL, but is more often referred to as International Bitterness Units (IBUs) or Bitterness Units (BUs), which are all the same thing. To follow the example of the British bitter used in our malt grist calculations, an average bitterness level might be 35 BUs.

Finally, in the same way as with the mash extract calculations, each brewery functions differently, and we must assign a percentage for the efficiency with which we extract hop α-acids. This is commonly known as **% utilisation**. This percentage is affected by temperature, boil time, gravity and pH. However, by far the largest contributor of these is boil time, to such an extent that it is all we really need to worry about. Hops added at the start of the boil may be utilised at 25%, for example, and 'flame out' hops added at the end of the boil by only 5-10%. Calculating this figure can be difficult and must be partly based on experience in any given brewery, but the chart below is helpful in calculating an estimated % utilisation.

Alpha Acid Utilization vs Time for 1.050 OG
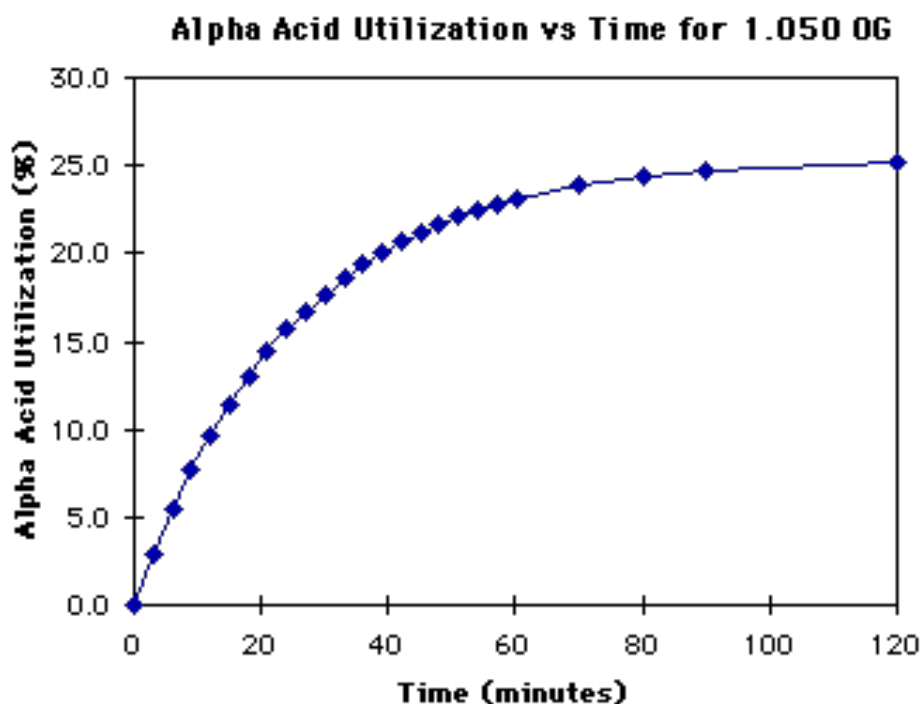
When we know the % α-acid content of the hop variety we wish to brew with, the number of IBUs we want to impart to the beer and the volume of beer we want to brew, and we have estimated a utilisation % based on the chart above, we can calculate the weight of hops needed by our recipe. This is done through the following equation:

$$\text{Weight of hops (g)} = \frac{\text{Desired IBU} \times \text{Batch size (L.)}}{\% \text{ α-acids} \times 1000 \times \% \text{ Utilisation}}$$

*NB all %ages in this equation must be expressed as decimal % - ie 10% = 0.1, 20% = 0.2 etc.

So, say we are brewing our bitter with 35 IBUs and a batch size of 20 litres. If all our hops are added in one go at the start of a 90 minute boil, we can estimate a % utlisation of 25% based on the chart on the last page. As for our hop variety and α-acids, say we use for instance Challenger with 7% α-acids by weight. The weight of these hops required would be calculated like this:

$$\text{Weight of hops (g)} = \frac{35 \times 20}{0.07 \times 1000 \times 0.25}$$

$$\text{Weight of hops (g)} = 40$$

40 grams of Challenger at 7% α-acids would give us the IBU we desired in this beer then. However, as you'll have spotted, we rarely want all our IBUs coming from our pre-boil addition- we may want to add flavour/aroma additions at the end of the boil, or use more than one variety. If this is the case, we must calculate the affect of each hop addition to our total IBU levels. The easiest way to do this is to assign an IBU level first to each addition. So, Say we want the majority of our IBUs in the above example from our pre-boil challenger addition, but we want to add a aroma addition of another hop at flame out. In this instance we would re-calculate the above equation to a lower IBU level of say 30, then calculate the flame out addition to add the extra 5 IBUs required to meet our total bitterness. It is important here that we go back to the utilisation charts- lower boil times drastically reduce hop utilisation, so much larger quantities of hops will be needed to achieve 1 IBU over 10 minutes than over 90. Unfortunately this can mean a lot of separate calculations for low IBU levels if you wish to make many small hop additions, which may put you off trying to break the record for the number of hop varieties used in one beer. Unless you really like using your calculator.

Finally, you may have a set quantity of hops that you wish to use up no matter what IBU they give you. Or you may have a recipe already for which you'd like to estimate the IBU levels. In this

instance, the above equation can be re-arranged to resolve IBUs rather than weight. This equation looks like this:

$$IBU = \frac{\text{Weight (g) x \% } \alpha\text{-acids x 1000 x \% Utilisation}}{\text{Batch size (L.)}}$$