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Issue 3, Volume 2  
 3/19/13

## GRAIN BILL CALCULATIONS

This issue is dedicated to helping brewers to become comfortable with extract calculations. Grains: the grains we use have a certain amount of extract available. This value is expressed as a percent. The table below illustrates the coarse grind extract, as is, for several malts in common use. We are grateful to Cargill for providing these values.

Malt Type	Coarse Grind Extract, as is
Two Row Base malt	77.30%
20 Lovibond Hi Dry malt	69.20%
Chocolate malt	63.80%
Cara malt	67.30%
Crystal malts	72.20%
Black malt	55.00%

The coarse grind values simply tell us how much extract we can expect to get into the process. One hundred pounds of two-row malt can be expected to deliver as much as 77.3 lbs of extract into the process for example (100 x 77.3%). This becomes quite important for the grain bill calculation, as we define our product parameters.

In the brewery we have to deal with both dry measures (% Extract) and with liquid values, meaning the pounds of extract per bbl, expressed as Balling (°B), and use both values constructively.

The problem with extract is that we lose it during processing. We lose extract during transfers; leave some in the Lauter Tub; and lose more during hop removal and trub settling.

As brewers, we have at least two main measurement points for extract recovery: The amount we recover to the brew kettle is generally considered to be our lautering efficiency. Our second measuring point is in the cellars. Here we look at the volume and the Balling, calculating the net extract recovery rate for each brew. The net extract recovery rate is the value used when back calculating grain bills.

At either point in the process, we are comparing the amount of extract received at a particular point to the amount of extract that was available in the grain bill for that particular brew. We express that ratio as a percentage and refer to it as the yield or the extract recovery rate. If the brew has several grain types, with varying amounts of extract availability, we need to summarize the total extract available from each type in



order to know how much extract was available from the grain bill. Once a brewery is in operation the recovery rates will stabilize and then can be used effectively for the calculations shown on the following pages.

The need to back calculate a grain bill can happen because we are brewing a new product, because our Ballings are too high or too low, or because we are making process changes that impact the cold wort Balling and Barrels. The system shown in the illustration allows for grain bill adjustments for all grains in a product formulation, helping to keep the formulation percentages accurate.

The basis for calculations is an algorithm from the “Old Practical Brewer”. This simple algorithm has been used as a basis for costing systems in breweries, since it facilitates calculating pounds of extract per bbl without having to load extract tables into the computer. In the algorithm there is one constant: The weight of water per bbl, and that is simply 259 lbs per bbl. The actual algorithm is as follows: Pounds Extract Per BBL =  $((259 + \beta) \times (\beta \div 100))$ .

Placing a value of  $15^\beta$  into this formula would indicate that we have 41.1 lbs of extract per bbl. The extract tables indicate that  $15^\beta$  is 41.06 lbs per bbl.

Back calculating a grain bill is done in five steps:

1. Calculate the weighted average coarse grind extract available in the product formulation. Note: this step is necessary when there are several malts in the formulation, with widely varying percentages of coarse grind extract.
2. Define the products cold wort production parameters. This example assumes a cold wort target of 100 bbl at  $15^\beta$ .
3. Back calculate the amount of extract needed from the brewhouse to net the amount of extract received in the cellars. This requires selecting a net recovery rate or yield percentage. It is a simple summary method for dealing with process losses.
4. Calculate the **total** amount of grain required for the formulation. This is done by dividing the extract required in the brewhouse by the weighted average extract available in the desired grain bill.
5. Finally, apply the percentages from each grain type the grain bill formulation to the gross total pounds of grain calculated in step four. This completes the calculation so that you know how many pounds of grain, by type, are needed to produce the product.

An estimated cost of the process loss is provided. Projects to improve extract recovery, especially where it is very low, as in this illustration, are often fully justified. Such projects can also help to fund increases in quality and capacity, while reducing the cost of the product, improving profits. **If your brewery is operating at low efficiencies contact us to discuss potential improvements.**

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## Back Calculating a Grain Bill for a "New Product"

### STEP 1: "New Product" Formulation and Calculation of the Weighted Average Extract in its Grain Bill

Our 'New Product' Formula	Percent of Grain type in this Formula	Coarse Grind extract Available, Each Grain*	extract contribution from each grain (BxC)
Two Row Malt	50%	77%	38.5%
Caramel Malt	20%	67%	13.4%
Chocolate Malt	20%	64%	12.8%
Black Malt	10%	55%	5.5%
<b>Total</b>	100%		<b>70.2%</b>
<b>Weighted Average CG extract for this brew</b>			<b>70.2%</b>

### STEP 2: Define "New Product" Parameters

#### Cellars Targets, This Brew

Brew size received or expected	100	bbls cold wort
Balling target	15°B	Plato or Balling
Lbs extract received in the cellars	4110	$100 * ((259+15) * (15/100))$
Yield estimate (extract recovered in Cellars vs extract available)	<b>87.0%</b>	Expected extract recovery rate

### STEP 3: Back Calculating the Extract Required From the Brewhouse

Brew size received (cold wort volume )	100	bbl
extract per bbl at 15°B	41.10	Lb extract / Bbl at 15°B
Calculation Used:	$((259+15) * (15/100)) = 41.1 \text{ lbs / bbl}$	
Lb of extract in the Cellars	<b>4,110</b>	lbs extract in 100 bbl brew @ 15°B
Divide cellars extract by selected NET YIELD	<b>87%</b>	net recovery rate
<b>Equals Lbs extract needed from brewhouse</b>	<b>4,724</b>	Lbs extract from brewhouse



**STEP 4: Calculate Total Grain Required for this Brew:**

<b>Lbs extract needed from the Brewhouse:</b>	<b>4,724</b>	lbs extract
<b>÷ Brewhouse Extract lbs by weighted average CG extract for this product</b>	<b>70.2%</b>	Weighted Average extract in this formula
<b><u>Total Grain</u> required for this product = 4724 ÷ 70.2%</b>	<b>6,730</b>	Back Calculated TOTAL Grain weight

**Step 5: Finishing up: Calculating Individual Grain Weights**

<b>"New Product" Formula</b>	<b>Percent of Grain type in Example Formula</b>	<b>Calculated lbs grain, by individual grain type</b>
<b>Two Row Malt (50%x6730)</b>	<b>50%</b>	<b>3365</b>
<b>Caramel Malt (20%x6730)</b>	<b>20%</b>	<b>1346</b>
<b>Chocolate Malt (20%x6730)</b>	<b>20%</b>	<b>1346</b>
<b>Black Malt (10%x6730)</b>	<b>10%</b>	<b>673</b>
<b>Total Grain Required , by type</b>	<b>100%</b>	<b>6,730</b>



Extract Loss Calculations		
Starting Grain Weight	6,730	Starting Grain Weight
x weighted average extract	70.2%	Weighted CG as is value, all grains
extract available from the grain	4,724	Gross extract in this grain bill
extract received as cold wort	4,110	extract in 100 bbl cold wort @ 15°B
Pounds extract lost in the process: 4724 lb - 4110 lbs (represents an 87% extract recovery rate)	<b>614.14</b>	Lbs lost from mash in to cellars
Equivalent bbl lost @15°B (614.4/41.1)	14.94	Equivalent bbls @ 15°B
Approx \$\$ value per bbl of wort	\$10.00	Est. production cost per bbl
Approx cost of lost wort per brew:	<b>\$149</b>	\$\$ lost per brew @ 87% extract recovery rate

If you would like to discuss any aspect of this article or if you would like to engage the assistance of David Kapral of Brewing Consulting Services, LLC or Edward Michalski of PRO Engineering and Manufacturing, Inc., **please contact either or both gentlemen using the contact information listed below.**



- Mr. Kapral will be available to discuss brewing issues with you at the PRO Engineering booth (7034) at Brew Expo 2013 from 10:00 a.m. to Noon, both days, March 27<sup>th</sup> and March 28<sup>th</sup>.
- Mr. Kapral can help you solve your brewing process problems.
- Also, Ed Michalski, CEO of PRO Engineering, will be at the booth both days.
- Mr. Michalski can help you by repairing your equipment, supervising equipment installation and providing new equipment.
- Bring us your issues, problems, ideas and dreams and we will discuss them with you for FREE!





**David Kapral, Founder of  
Brewing Consulting Services, LLC**

The author, David Kapral, has over thirty years of brewing experience. Some of his credentials are:

- Experienced Brewmaster, with 8 years consulting experience to craft brewers across the U.S.
- Beer Steward Certification Trainer for the MBAA
- Practical Brewing lecturer at MBAA's annual Brewing course in Madison, WI
- Member of the InTota Expert network
- Received the "Inge Russell Best Paper Award" for a complex fermentation topic

Additionally, Mr. Kapral founded Brewing Consulting Services, LLC.

**The company provides a wide range of practical [operational advice](#) and [solutions](#) to clients in the Craft Brewing industry.** The group includes the David Kapral and Associates Mark Sammartino and Pat Frost. Collectively this group has 100 years of experience in the industry.

Contact David Kapral if you would like to discuss the issues raised in the article or if you want to explore further assistance from his firm:

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**Ed Michalski (left) with brother Dave, checking specs for a customer**

**Ed Michalski, CEO**

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