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 <u>dry measures</u> (% Extract) and with <u>liquid values</u>, meaning the pounds of extract per bbl, expressed as Balling (°ß), 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= $((259+°ß)x(°ß÷100))$.

Placing a value of 15°ß into this formula would indicate that we have 41.1 lbs of extract per bbl. The extract tables indicate that 15°ß is 41.06 lbs per bbl.

Back calculating a grain bill is done in five steps:
1. Calculate the <u>weighted average coarse grind extract</u> 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°ß.
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.**

David Kapral
Brewing Consulting Services, LLC
208-938-2064

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%
Total	100%		**70.2%**
Weighted Average CG extract for this brew			**70.2%**

STEP 2: Define "New Product" Parameters		
Cellars Targets, This Brew		
Brew size received or expected	100	bbls cold wort
Balling target	15°ß	Plato or Balling
Lbs extract received in the cellars	4110	100*((259+15)x(15/100))
Yield estimate (extract recovered in Cellars vs extract available)	**87.0%**	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°ß	41.10	Lb extract / Bbl at 15°ß
Calculation Used:	((259+15)x15/100))=41.1 lbs / bbl	
Lb of extract in the Cellars	**4,110**	lbs extract in 100 bbl brew @ 15°ß
Divide cellars extract by selected NET YIELD	**87%**	net recovery rate
Equals Lbs extract needed from brewhouse	**4,724**	Lbs extract from brewhouse

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

Step 5: Finishing up: Calculating Individual Grain Weights		
"New Product" Formula	Percent of Grain type in Example Formula	Calculated lbs grain, by individual grain type
Two Row Malt (50%x6730)	50%	3365
Caramel Malt (20%x6730)	20%	1346
Chocolate Malt (20%x6730)	20%	1346
Black Malt (10%x6730)	10%	673
Total Grain Required , by type	100%	6,730

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°ß
Pounds extract lost in the process: 4724 lb --- 4110 lbs (represents an 87% extract recovery rate)	**614.14**	Lbs lost from mash in to cellars
Equivalent bbl lost @15°ß (614.4/41.1)	14.94	Equivalent bbls @ 15°ß
Approx $$ value per bbl of wort	$10.00	Est. production cost per bbl
Approx cost of lost wort per brew:	**$149**	$$ 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**

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

The author, David Kapral, has over thirty years of brewing experience.
Some of hiscredentials are:
- Experienced Brewmaster, with 8 years consulting experience to craft brewersacross 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:

> (208) 938-2064
> **kbrewconsult@q.com**
> **www.davidkapral.com**

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

Ed Michalski, CEO
PRO Engineering and Manufacturing, Inc

PRO Engineeringhas been providing equipment and engineering services to the Brewing industry for over 40 years.

PRO Engineering and Manufacturing, Inc has a commitment to serving theCraft Brewing industry through [tunnel pasteurizers](#) and [batch pasteurizers](#) specifically tailored to craft brewers.

Edward A. Michalski Bio

Ed Michalski started his career in the beverage industry by designing stainless steel, higher flow, spray headers for Pabst Brewing. Along with the header design he also developed a process to produce the new headers.

Ed, along with his brother David, formed PRO Engineering/Manufacturing, Inc.
Based on what they learned by re-designing and refurbishing other manufacturers' pasteurizers, Ed and PRO started to offer the pasteurizer marketplace superior new pasteurizers.

Contact Ed Michalski, CEO, at:
(414) 362-1500
ed.michalski@prowm.com
[Click Here for more information](#)

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