



# Hop Schedule Guidelines: Award Winning Homebrew and Classic Beer Style Recipes

by Daniel Morey  
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## Introduction

Achieving proper hop and malt balance is essential in brewing award winning homebrew. One fifth of the total score is based on aroma balance and nearly two fifth are based on the flavor balance. Misusing hops can easily upset the balance resulting in beer that while good does not exemplify the style.

I have analyzed the NHC gold medal winning recipes from 1993 through 2000 and the recipes contained in the Classic Beer Style Series to develop a set of guidelines that can be used to select the amount and variety of bittering, flavoring, aroma, and dry hops. This paper will present bittering fractions (percentages), average boil time, and recommended varieties for each addition. Bittering fractions are based on the contribution to the total bitterness in IBUs that the addition provides. Bittering fractions are not a new concept. Bittering fractions have been used by George Fix and Laurie Fix in Vienna Märzen Oktoberfest, Eric Warner in Kölsch, and Byron Burch in Brewing Quality Beers: The Home Brewer's Essential Guidebook.

## Categories of Hop Additions

For the analysis, hop additions were grouped in four categories: Bittering, flavor, aroma, and dry hop. These categories refer to the intended use of the hop and not the varietal grouping of the hop. First wort hopping and mash hopping were omitted in this study due to the limit number of recipes that used these techniques.

### *Bittering Hop Additions:*

Bitterness to offset the malt sweetness is the primary purpose of bittering hop additions. Due to the long boil times only some "hop" flavor remains and nearly no aroma is contributed. Shorter boil times result in more flavor and aroma being retained.

Based on current literature and the results of the BABBLE hop survey, bittering hop additions are boiled for more than 25 minutes and usually greater than 35 minutes. All recipes studied for this paper used bittering hop additions.

### *Flavoring Hop Additions:*

These additions also contribute bitterness to the beer, though to a lesser degree due to lower utilization from shorter boil times. Hop flavor is not just the bitterness in beer. Hop flavor is typically grouped in four categories: Spicy, herbal, floral, and citrus or piney. Flavor additions, depending on their boil length may contribute significant aroma characteristics. Flavor hops are added between 25 and seven minutes from the end of the boil.

*Aroma Hop Additions:*

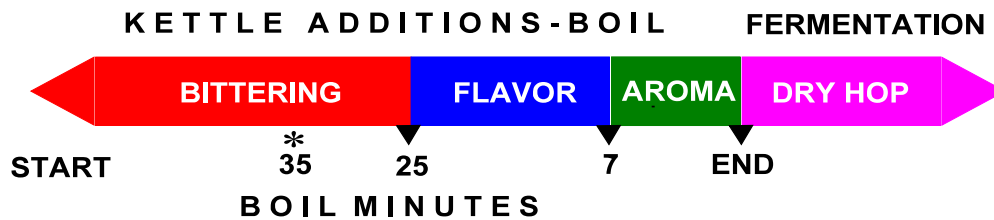
Hop aroma is generally attributed to the essential oils contained in the hops. Since these oils are volatile, they evaporate rapidly from the boiling wort. Consequently aroma hop additions are reserved for the final seven minutes of the boil and may be steeped after the boil is complete. Aroma additions contribute on a minor scale to total bitterness and should be included in the bitterness calculation. For hops that are steeped, I assume the utilization is equivalent to that for one minute boil. Flavor is also extracted from aroma additions.

*Dry Hopping:*

Dry hopping is considered by some as the superior way to develop hop aroma in beer. Most authors believe that dry hop additions do not contribute to actual bitterness. Because these additions do not contribute to the IBU total, the bitterness fraction is not defined for dry hops. Instead, dry hop additions will be quoted in ounces per US gallons. Dry hopping is not suitable for all “classic” styles. Only half of the beer styles analyzed for this paper used dry hopping.

*Summary of Hop Additions:*

Hops are used at different stages during or after the boil to achieve desired hop characteristics. We can divide the time line into four regions to achieve our desired outcome.



Approximating Bitterness in IBUs

It is the opinion of the author that home brewers should work with IBUs. Unlike HBU, AAU, or MBU, the IBU method takes in account the batch size and boil time. The bitterness of a 10 gallon batch with 25 IBUs is the same as a 5 gallon batch with 25 IBUs. If you want to maintain bitterness while increasing hop flavor, the IBU method gives the tools to do this while simpler methods such as HBU do not.

There are several approximations available for the home brewer to estimate IBUs. I use a customized variation of the Tinseth form. In my opinion, the Tinseth utilization curve has a logical shape. One of the earliest published approximations was presented by Jackie Rager. Rager’s equation can be found in the 1990 special issue of *Zymurgy*. The reader is encouraged to study Michael Hall’s article in the 1997 Hop Special Issue of *Zymurgy* for details on six of the most popular IBU approximations. Each formula will calculate different hop additions. Because the Garetz utilization curve is equal to zero for the entire aroma range, this approximation is not appropriate for the hop schedules presented in this document. Rager’s equation will tend to give lower bittering hop additions while Mosher’s model will give higher bittering hop additions.

### Using the Guidelines

The following is an example of how to use the data contained in the guidelines.

#### EXAMPLE 1:

Style: California Common

Option: #1: 86% bittering N. Brewer 8% AA 50 minutes  
14% flavoring N. Brewer 8% AA 14 minutes  
0.16 oz/gal Cascade Hops 5% AA Dry hop  
Total Bitterness: 35 IBU  
Target Gravity: 1.048  
Batch Size: 5 gallons

Calculate hop additions using Rager's formula:

$$\text{Bittering} = 0.86 * 35 \text{ IBU} = 30.1 \text{ IBU}$$

$$W = 5 * (1 + 0) * 30.1 / (0.281 * 0.08 * 7462) = \mathbf{0.9 \text{ oz (26 g) N. Brewer 8\% AA or 7.2 HBU}}$$

$$\text{Flavoring} = 0.14 * 35 \text{ IBU} = 4.9 \text{ IBU}$$

$$W = 5 * (1 + 0) * 4.9 / (0.08 * 0.08 * 7462) = \mathbf{0.5 \text{ oz (14 g) N Brewer 8\% AA or 4.0 HBU}}$$

Dry hop:

$$W = 0.16 * 5 = \mathbf{0.8 \text{ oz (23 g) Cascade 5\% AA}}$$

If you convert each addition to HBUs, then you do not need to know the actual alpha acid content when you do the calculation. Doing this, you can adjust the weight of the hops based on the actual alpha acid content later.

As previously mentioned, the different bittering models will calculate different hop additions. Table 1 compares the hop additions calculated using other models for this example.

**TABLE 1: Hop additions calculated using other approximations.**

<b>Addition</b>	<b>Rager</b>	<b>Mosher</b>	<b>Tinseth</b>	<b>Noonan</b>	<b>Daniels</b>
<b>Bittering</b>	0.9 oz	1.6 oz	1.1 oz	1.1 oz	1.1 oz
<b>Flavor</b>	0.5 oz	0.5 oz	0.4 oz	0.5 oz	0.3 oz
<b>Dry</b>	0.8 oz	0.8 oz	0.8 oz	0.8 oz	0.8 oz

### Using Hop Varieties not Listed

The recommended hops are the most commonly used varieties for the given style based on gold medal recipes and from the Classic Beer Style Series. This list is not to suggest that you cannot brew accurate recreations of classic styles without these hops.

Bittering is a result of the isomerization of the alpha acids present in the hops. Alpha acids are grouped according to three major chemicals: Humulone, cohumulone, and adhumulone. Cohumulone has often been cited to give greater bitterness than the other two compounds. Since bittering hop additions have only minor contribution to flavor and aroma there is more flexibility to use alternatives. If you choose to do this, it is recommended that you use hops with similar alpha acid content and cohumulone percentage. The Hop Union USA website is an excellent source for current hop composition data. Ray Daniels' Designing Great Beers, chapter 9 is another source for comparing the alpha acid composition of hops if you wish to make substitutions.

Flavor and aroma hops require greater attention. Flavor and aroma compounds are not necessarily proportional to alpha acid content. Look for hops with similar oil profiles (humulene, myrcene, and caryophyllene) and content. Humulene, myrcene, and caryophyllene are usually present in trace amounts due to late hop addition. More important are the oxidation products that can be produced during the boil: Humulene epoxides and diepoxides, humulol, linalool, geraniol, citral, etc . . . As a generalization, humulene products produce spicy or European flavors and aromas while myrcene products have floral, piney, or citrus like flavors and aromas. Again, Hop Union USA website and Ray Daniels' book Designing Great Beers are excellent resources if you wish to substitute hop varieties.

Table 2 compares the average key components of commonly available hops. For selecting alternative bittering additions the percentage cohumulone of alpha acid column is useful. The weight ratio of essential oils are expressed per weight of the alpha acids. Remember we are trying to achieve a specific alpha acid addition and oil addition with flavor and aroma hops. Hops with similar ratios should produce acceptable results.

Since dry hop additions are quoted in ounces per gallon, we need to compare the total essential oil content per ounce between the recommended hop variety and the substitution. Table 3 provides average essential oil content per ounce of hop.

**TABLE 2: Kettle Addition Substitution Chart - Cohumulone and Essential Oil per Alpha Acid Unit**

<b>Hop</b>	<b>Cohumulone % (w/wAA)</b>	<b>Humulene oz/oz AA</b>	<b>Myrcene oz/oz AA</b>	<b>Caryophyllene oz/oz AA</b>
Bramling Cross	27	0.051	0.063	0.027
Brewers Gold	43	0.071	0.140	0.019
Bullion	39	0.070	0.176	0.030
Cascade	37	0.030	0.120	0.010
Centennial	30	0.030	0.106	0.014
Chinook	32	0.036	0.060	0.016
Cluster	39	0.014	0.043	0.006
Columbus	33	0.022	0.041	0.012
Eroica	41	0.001	0.063	0.010
Fuggle	27	0.067	0.081	0.022
Galena	40	0.011	0.050	0.004
Golding (US)	23	0.060	0.045	0.019
Hallertauer (US)	21	0.060	0.070	0.020
Hallertauer (GR)	23	0.100	0.050	0.027
Hersbrucker	20	0.053	0.044	0.020
Kent Golding	25	0.065	0.033	0.020
Liberty	27	0.075	0.065	0.021
Mount Hood	23	0.058	0.184	0.026
Northern Brewer	25	0.055	0.120	0.016
Nugget	27	0.035	0.113	0.017
Perle	29	0.048	0.061	0.016
Saaz (US)	25	0.058	0.054	0.016
Saaz (CZ)	25	0.062	0.034	0.016
Spalt	25	0.040	0.037	0.021
Styrian Golding	28	0.051	0.043	0/014
Tettnanger	26	0.037	0.051	0.013
Willamette	32	0.063	0.125	0.019

**TABLE 3: Dry Hop Substitution Chart - Essential Oils per Ounce**

<b>Hop</b>	<b>AA%</b>	<b>Humulene % oz/oz (w/wt)</b>	<b>Myrcene % oz/oz (w/wt)</b>	<b>Caryophyllene % oz/oz (w/wt)</b>
Bramling Cross	6.0	0.31	0.38	0.16
Brewers Gold	6.8	0.48	0.95	0.13
Bullion	7.8	0.54	1.37	0.23
Cascade	5.0	0.15	0.60	0.05
Centennial	9.0	0.27	0.95	0.12
Chinook	12.5	0.45	0.75	0.20
Cluster	7.0	0.10	0.30	0.04
Columbus	15.0	0.33	0.61	0.18
Eroica	10.5	0.01	0.66	0.11
Fuggle	4.5	0.30	0.36	0.10
Galena	12.0	0.13	0.60	0.04
Golding (US)	5.0	0.30	0.23	0.09
Hallertauer (US)	4.5	0.27	0.32	0.09
Hallertauer (GR)	4.5	0.45	0.22	0.12
Hersbrucker	3.8	0.20	0.16	0.08
Kent Golding	5.5	0.36	0.18	0.11
Liberty	4.5	0.34	0.29	0.09
Mount Hood	3.8	0.22	0.69	0.10
Northern Brewer	8.0	0.44	0.96	0.13
Nugget	9.8	0.34	1.10	0.17
Perle	6.3	0.30	0.38	0.10
Saaz (US)	4.3	0.25	0.23	0.07
Saaz (CZ)	3.8	0.23	0.13	0.06
Spalt	4.5	0.18	0.17	0.09
Styrian Golding	5.3	0.27	0.23	0.08
Tettnanger	4.3	0.16	0.21	0.05
Willamette	5.0	0.31	0.63	0.09

EXAMPLE 2:

Continuing with the first example, we can use tables 2 and 3 to make hop substitutions and then calculate new additions.

Style: California Common

Substitutions

Using Table 2 (cohumulone percentage and essential oil content per alpha acid unit):

Nugget 27% cohumulone for N. Brewer 25% cohumulone

Willamette 0.063 humulene and 0.125 myrcene for N. Brewer 0.055 and 0.120 respectively.

Using Table 3 (essential oils per ounce):

Galena 0.13% humulene, 0.60% myrcene, and 0.04 % caryophyllene for Cascade 0.15%, 0.60%, 0.05% respectively.

Option: #1:                   86% bittering Nugget 9.8% AA 50 minutes  
                                   14% flavoring Willamette 5% AA 14 minutes  
                                   0.16 oz/gal Galena Hops 12.0% AA Dry hop  
 Total Bitterness:        35 IBU  
 Target Gravity:           1.048  
 Batch Size:               5 gallons

Calculate hop additions using Rager’s formula:

$$\text{Bittering} = 0.86 * 35 \text{ IBU} = 30.1 \text{ IBU}$$

$$W = 5 * (1 + 0) * 30.1 / (0.281 * 0.098 * 7462) = \mathbf{0.7 \text{ oz (20 g) Nugget 9.8\% AA or 6.9 HBU}}$$

$$\text{Flavoring} = 0.14 * 35 \text{ IBU} = 4.9 \text{ IBU}$$

$$W = 5 * (1 + 0) * 4.9 / (0.08 * 0.05 * 7462) = \mathbf{0.8 \text{ oz (23 g) Willamette 5\% AA or 4.0 HBU}}$$

Dry hop:

$$W = 0.16 * 5 = \mathbf{0.8 \text{ oz (23 g) Galena 12\% AA}}$$

Note the essential oil profiles are similar between the two versions. Since most essential oils will be lost during the long boil of bittering additions the important comparison is in the flavor and dry hop additions.

**TABLE 4: Comparing essential oil profiles of the two examples**

Example	Hop additions	Humulene oz	Myrcene oz	Caryophyllene oz
#1 N. Brewer and Cascade	All	<b>0.0074</b>	<b>0.0182</b>	<b>0.0023</b>
	Flavor and Dry	<b>0.0034</b>	<b>0.0096</b>	<b>0.0011</b>
#2 Nugget, Willamette, and Galena	All	<b>0.0059</b>	<b>0.0175</b>	<b>0.0023</b>
	Flavor and Dry	<b>0.0035</b>	<b>0.0098</b>	<b>0.0011</b>

Style Guidelines

**CALIFORNIA COMMON**

Bitterness: Medium to High  
 Flavor: Medium to High  
 Aroma: Medium

Recommended Hops:            Bittering: N. Brewer, Cluster, and Cascade  
    Flavor: N. Brewer and Cascade  
    Aroma: N. Brewer, Liberty, and Cascade  
    Dry Hop: Cascade and N. Brewer

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	84 - 93	46 - 60	7 - 16	10 - 20	n/a	n/a	0.10-0.20
	86	50	14	14	---	---	0.16
2	84 - 93	46 - 60	7 - 16	10 - 20	n/a	n/a	n/a
	86	50	14	14	---	---	---
3	90 - 98	60 +	n/a	n/a	2 - 9	2 - 5	0.10-0.20
	94	65	---	---	6	4	0.16
4	90 - 98	60 +	n/a	n/a	2 - 9	2 - 5	n/a
	94	65	---	---	6	3	---
5	80 - 90	60+	8 - 16	10 - 20	2 - 4	2 - 5	0.10-0.20
	85	60	12	10	3	2	0.16

**AMERICAN PALE ALE**

Bitterness: High  
 Flavor: High  
 Aroma: High

Recommended Hops:            Bittering: Chinook, Cascade, and Perle  
    Flavor: Columbus and Centennial  
    Aroma: Cascade and Columbus  
    Dry Hop: Cascade and Centennial

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	93 - 97	36 - 46	n/a	n/a	3 - 7	1 - 2	0.17-0.40
	96	40	---	---	4	2	0.31
2	77 - 86	50+	10 - 16	10 - 15	4 - 7	1 - 5	0.17-0.40
	82	60	12	10	6	5	0.31
3	70 - 78	40+	22 - 30	10 - 15	n/a	n/a	0.17-0.40
	74	55	26	15	---	---	0.31

## ENGLISH BROWN AND MILD ALES

Bitterness: Low  
 Flavor: Low  
 Aroma: Low

Recommended Hops:            Bittering: Kent Golding, Willamette, and Fuggle  
    Flavor: Kent Golding, Willamette, and Fuggle  
    Aroma: Cascade, Fuggle, and Kent Golding  
    Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	100	35+	n/a	n/a	n/a	n/a	n/a
	100	60	---	---	---	---	---
2	95 - 97	48 - 51	n/a	n/a	3 - 5	2 - 4	n/a
	96	50	---	---	4	3	---
3	54 - 84	60+	11 - 37	10 - 15	5 - 9	1 - 3	n/a
	69	60	24	13	7	2	---
4	83 - 92	35+	8 - 17	15 - 20	n/a	n/a	n/a
	88	50	12	20	---	---	---

**PILSNER**

Bitterness: Medium to High

Flavor: Medium

Aroma: Medium

Recommended Hops:            Bittering: Saaz, Hallertauer, Tettnanger, and Perle  
    Flavor: Saaz, Hallertauer, and Styrian Golding  
    Aroma: Saaz, Hallertauer, and Styrian Golding  
    Dry Hop: Saaz

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	100	45+	n/a	n/a	n/a	n/a	0.10-0.30
	100	55	---	---	---	---	0.21
2	75 - 92	60+	6 - 24	15 - 20	2	1 - 2	n/a
	83	60	15	17	2	2	---
3	90 - 97	50+	n/a	n/a	3 - 10	1 - 5	n/a
	94	60	---	---	6	3	---
4	75 - 85	60+	15 - 25	15 - 20	n/a	n/a	n/a
	81	60	19	15	---	---	---

**ENGLISH BITTERS AND PALE ALES**

Bitterness: Medium to High  
 Flavor: Medium to High (brewer’s discretion)  
 Aroma: Low to High (brewer’s discretion)

Recommended Hops:            Bittering: Kent Golding, Fuggle, N. Brewer, and Chinook  
    Flavor: Kent Golding, Fuggle, Cascade, and Hallertauer  
    Aroma: Kent Golding, Cascade, Hallertauer, and Tettnanger  
    Dry Hop: Kent Golding and Cascade

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	79 - 91	48 - 60	7 - 16	10 - 16	1 - 5	1 - 2	n/a
	88	55	10	13	2	1	---
2	100	47 - 60	n/a	n/a	n/a	n/a	0.15-0.40
	100	55	---	---	---	---	0.24
3	67 - 82	60 +	16 - 26	10 - 20	2 - 7	1 - 5	0.16-0.30
	74	70	21	14	5	3	0.22
4	98 - 99	45 - 60	n/a	n/a	1 - 2	1	n/a
	98	55	---	---	2	1	---
5	79 - 94	42 - 60	6 - 21	10 - 15	n/a	n/a	0.03-0.20
	87	50	13	10	---	---	0.12

## VIENNA, OKTOBERFEST, AND MÄRZEN (VOM)

Bitterness: Low to Medium

Flavor: Low to Medium

Aroma: Low to Medium

Recommended Hops: Bittering: Tettnanger, Styrian Golding, and Hallertauer

Flavor: Saaz and Hallertauer

Aroma: Saaz, Liberty, and Hallertauer

Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	72 - 85	35+	15 - 28	10 - 15	n/a	n/a	n/a
	82	40	18	14	---	---	---
2	89 - 95	46+	n/a	n/a	5 - 11	5	n/a
	92	60	---	---	8	5	---
3	100	45+	n/a	n/a	n/a	n/a	n/a
	100	50	---	---	---	---	---

**PORTER**

Bitterness: Medium to High  
 Flavor: Medium to High  
 Aroma: Medium

Recommended Hops:            Bittering: Kent Golding, Fuggle, Cluster, and N. Brewer  
    Flavor: Cascade, Fuggle, N. Brewer, and Bramling Cross  
    Aroma: Kent Golding, Hallertauer, and Cascade  
    Dry Hop: Kent Golding and Styrian Golding

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	97 - 99	45+	n/a	n/a	1 - 3	1	n/a
	98	65	---	---	2	1	---
2	84 - 91	40+	9 - 16	10 - 15	n/a	n/a	n/a
	88	60	12	13	---	---	---
3	81 - 95	45+	4 - 16	10 - 20	1 - 3	1 - 5	n/a
	90	75	8	13	2	2	---
4	97 - 99	60 +	n/a	n/a	1 - 3	1 - 5	0.10
	99	60	---	---	1	1	0.10
5	81 - 95	60+	4 - 16	10 - 20	1 - 3	1 - 5	0.10
	89	60	9	15	2	1	0.10

**GERMAN WHEAT**

Bitterness: Low  
 Flavor: Not perceived to Low  
 Aroma: Not perceived to Low

Recommended Hops:            Bittering: Perle, Hallertauer, Saaz, and Cascade  
    Flavor: Saaz, Hallertauer, and Perle  
    Aroma: n/a  
    Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	45 - 90	60 - 105	10 - 55	10- 15	n/a	n/a	n/a
	78	90	22	14	---	---	---
2	100	60 - 90	n/a	n/a	n/a	n/a	n/a
	100	75	---	---	---	---	---

**ALTBIER**

Bitterness: Medium to High  
 Flavor: Medium “may be evident”  
 Aroma: Low to Medium???

Recommended Hops:            Bittering: Perle, Hallertauer, Tettnanger, and Spalt  
    Flavor: Tettnanger, Perle, and Cluster  
    Aroma: Saaz, Tettnanger, and Hallertauer  
    Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	76 - 81	40+	11 - 19	17 - 23	5 - 11	3 - 5	n/a
	79	50	14	18	7	3	---
2	93 - 99	45+	n/a	n/a	1 - 7	1 - 3	n/a
	96	50	---	---	4	2	---

**SCOTCH ALE**

Bitterness: Low to Medium  
 Flavor: Low (Should not be perceived)  
 Aroma: Low (Should not be perceived)

Recommended Hops:            Bittering: Kent Golding, Fuggle, and Cascade  
    Flavor: Fuggle, Kent Golding, and Tettnanger  
    Aroma: Kent Golding  
    Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	100	45+	n/a	n/a	n/a	n/a	n/a
	100	50	---	---	---	---	---
2	80 - 94	60+	6 - 20	15	n/a	n/a	n/a
	87	60	13	15	---	---	---
3	82 - 84	60 +	n/a	n/a	18 - 19	5	n/a
	83	65	---	---	17	5	---

**BOCK**

Bitterness: Low  
 Flavor: Low to Medium  
 Aroma: Low to Medium

Recommended Hops:            Bittering: Tettnanger, Hallertauer, Perle, and Spalt  
    Flavor: Hallertauer, Tettnanger, and Spalt  
    Aroma: Tettnanger, Saaz, and Hallertauer  
    Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	76 - 95	45+	5 - 24	10- 15	n/a	n/a	n/a
	88	60	12	11	---	---	---
2	74 - 81	60+	18 - 22	10	1 - 4	1	n/a
	78	60	20	10	2	1	---
3	100	45+	n/a	n/a	n/a	n/a	n/a
	100	50	---	---	---	---	---
4	90 - 92	60+	n/a	n/a	9 - 10	5	n/a
	91	60	---	---	9	5	---

**STOUT**

Bitterness: Medium to High  
 Flavor: Low (may be low to high for imperial stouts)  
 Aroma: Low (may be low to high for imperial stouts)

Recommended Hops:            Bittering: Kent Golding, N. Brewer, Perle, and Chinook  
    Flavor: Fuggle, Kent Golding, and Styrian Golding  
    Aroma: Cascade, Kent Golding, Hallertauer, and Mt. Hood  
    Dry Hop: Fuggle, Willamette, and Styrian Golding

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	100	60+	n/a	n/a	n/a	n/a	n/a
	100	60	---	---	---	---	---
2	96 - 98	45+	n/a	n/a	2 - 4	1 - 2	n/a
	97	55	---	---	3	1	---
3	96 - 98	45+	n/a	n/a	2 - 4	1 - 2	0.16-0.20
	97	55	---	---	3	1	0.20
4	60 - 90	55+	9 - 39	10 - 20	1 - 2	1 - 2	0.0-0.16
	74	55	25	15	1	1	0.08

NOTE: Options 3 and 4 are more suitable for imperial stout formulations.

## KÖLSCH

Bitterness: Medium

Flavor: Low

Aroma: Low

Recommended Hops:            Bittering: Hallertauer, Perle, Tettnanger, and Spalt  
    Flavor: Tettnanger, Hersbrucker, and Hallertauer  
    Aroma: Hallertauer and Tettnanger  
    Dry Hop: n/a

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	85 - 91	60+	9 -15	10- 20	n/a	n/a	n/a
	88	75	12	15	---	---	---
2	51 - 88	45+	9 - 42	15 - 20	3 - 7	5	n/a
	73	60	22	17	5	5	---
3	100	40 +	n/a	n/a	n/a	n/a	n/a
	100	65	---	---	---	---	---

**BARLEY WINE**

Bitterness: Low to Medium  
 Flavor: Medium to High  
 Aroma: Medium to High

Recommended Hops: Bittering: Chinook, N. Brewer, Cascade, and Galena  
 Flavor: Willamette, Cascade, and Hallertauer  
 Aroma: Cascade, Kent Golding, Tettnanger, and Willamette  
 Dry Hop: Cascade and Kent Golding

Option	Bittering		Flavor		Aroma		Dry
	%	minutes	%	minutes	%	minutes	oz/gal
1	96 - 99	60+	n/a	n/a	1 - 4	1 - 3	n/a
	98	75	---	---	2	1	---
2	94 - 99	45+	n/a	n/a	1 - 6	1 - 5	0.30-0.60
	97	55	---	---	3	4	0.41
3	83 - 96	60 +	4 - 15	10 - 20	1 - 2	1 - 3	0.20-0.40
	91	70	7	15	1	2	0.28
4	80 - 94	60 +	5 - 12	10 - 15	1 - 8	1 - 5	n/a
	87	60	9	13	4	3	---
5	100	60+	n/a	n/a	n/a	n/a	n/a
	100	90	---	---	---	---	---

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