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NOVEMBER 2003, VOL.9, NO.7

THE HOW-TO HOMEBREW BEER MAGAZINE

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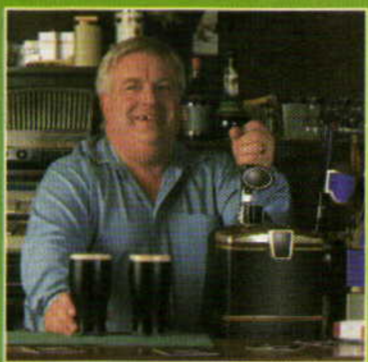


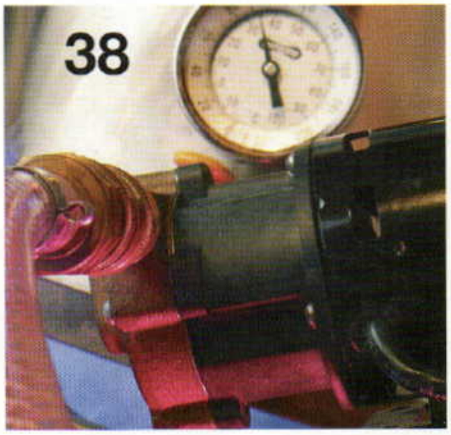
MOUNTMELLICK BEERKITS
THE GENUINE ARTICLE

NOVEMBER 2003
Volume 9 Number 7

Departments

COVER photography: **Charles A. Parker**

Features



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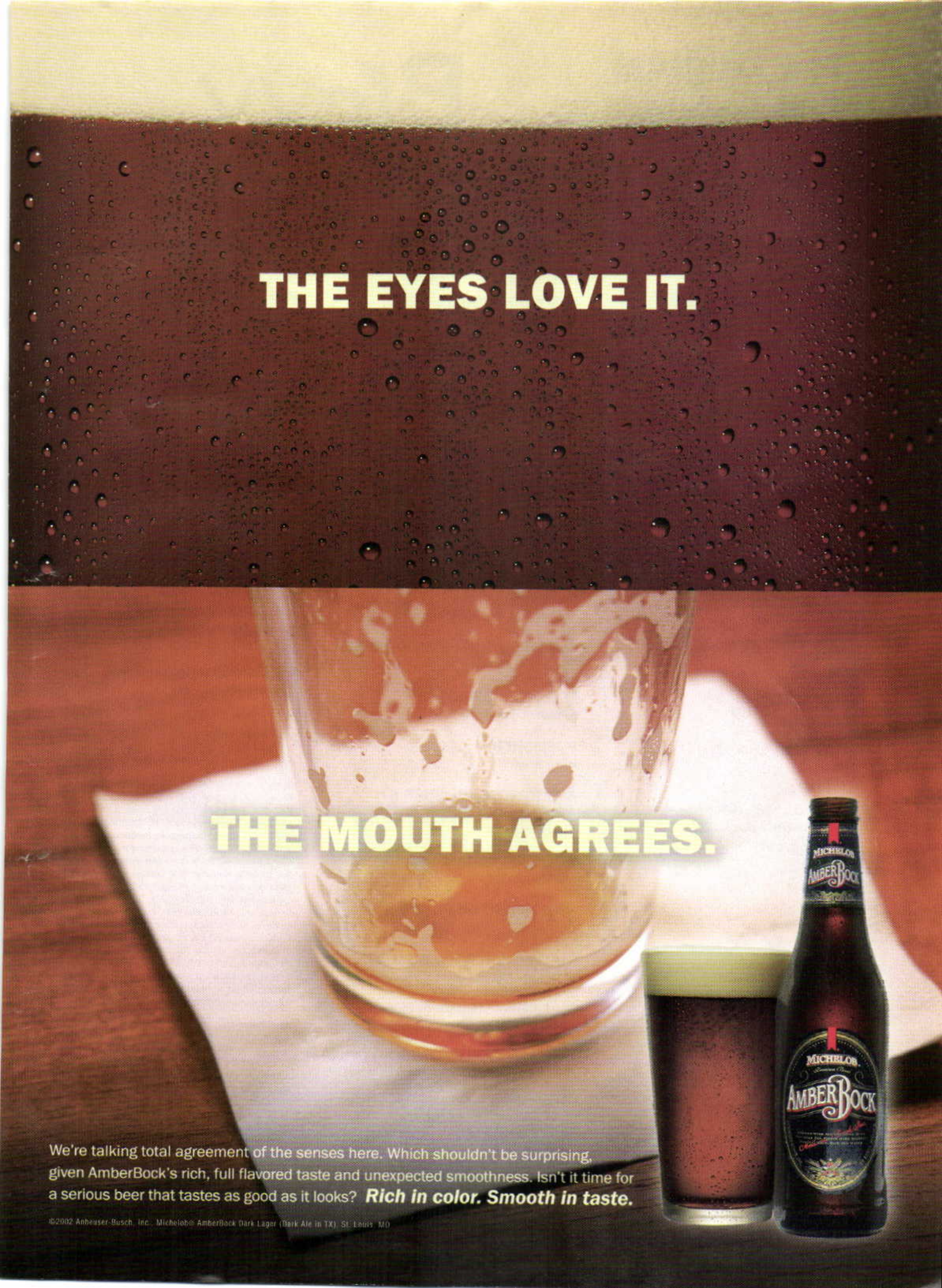

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Brew Your Own

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EDITOR
Chris Colby

ART DIRECTOR
Coleen Jewett Heingartner

ASSOCIATE EDITOR
Garrett Heaney

TECHNICAL EDITOR
Ashton Lewis

EDITORIAL INTERN
Michael Parker

CONTRIBUTING WRITERS
Steve Bader, Thom Cannell, Chris Colby, Horst Dornbusch, Joe and Dennis Fisher, Colin Kaminski, Ashton Lewis, Thomas Miller, Steve Parkes, Tess and Mark Szamatulski

CONTRIBUTING ARTISTS
Don Martin, Ian Mackenzie, Shawn Turner, Jim Woodward

CONTRIBUTING PHOTOGRAPHER
Charles A. Parker

EDITORIAL DIRECTOR
Kathleen James Ring

PUBLISHER
Brad Ring

ASSOCIATE PUBLISHER & ADVERTISING DIRECTOR
Kiev Rattee

ADVERTISING MANAGER
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NEWSSTAND DIRECTOR
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How to reach us

Editorial and Advertising Office
Brew Your Own
5053 Main Street, Suite A
Manchester Center, VT 05255

Tel: (802) 362-3981
Fax: (802) 362-2377
E-Mail: BYO@byo.com

Advertising Contact
Kiev Rattee
kiev@byo.com

Editorial Contact
Chris Colby
chris@byo.com

Subscriptions Only
Brew Your Own
P.O. Box 469121
Escondido, CA 92046

Tel: (800) 900-7594
M-F 8:30-5:00 PST
E-mail: byo@pcspublink.com
Fax: (760) 738-4805

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Volume 9, Number 7: November 2003

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- Instructions

RECIPE INDEX

BYO RECIPE STANDARDIZATION

Extract efficiency: 65%
(i.e. — 1 pound of 2-row malt, which has a potential extract value of 1.037 in one gallon of water, would yield a wort of 1.024.)

Extract values for malt extract:
liquid malt extract (LME) = 1.037
dried malt extract (DME) = 1.045

Potential extract for grains:
2-row base malts = 1.037
wheat malt = 1.037
6-row base malts = 1.035
Munich malt = 1.035
Vienna malt = 1.035
crystal malts = 1.033-1.035
chocolate malts = 1.034
dark roasted grains = 1.024-1.026
flaked maize and rice = 1.037-1.038

Hops:
We calculate IBU's based on 25% hop utilization for a one hour boil at specific gravities less than 1.050.

Contributors

Why is this man smiling? Because Thom Cannell — author of *BYO's* "Projects" column — is now a recognized BJCP certified judge. "It took months of effort, both drinking great beer and learning the history of brewing and brewhouses world wide. I'm really proud to have passed the test."

In daily life Cannell is an automotive writer whose stories have appeared in virtually every major U.S. automotive enthusiast publication. Cannell began home brewing at the prodding of best friend Mike Allen, Assistant Automotive Editor of Popular Mechanics.

"Mike kept hounding me, and astonishing me with the great beers he was making. So I started lurking on the CompuServe Wine and Beer Forum and accumulating knowledge. Then I brewed with Jay and Francie Todd, friends in Lansing, Michigan, and discovered that it wasn't much more difficult than whipping up a good bar-b-q sauce." He switched to all-grain brewing a few months before writing the "Build a Mash Tun for $50" project that appeared in September 1999, *BYO*. Thom — a member of the Red Ledges Home Brew Club in Grand Ledge, Michigan — is all pumped up about his latest feature article on . . . pumps. It starts on page 38. And, in the "Projects" department on page 61, he builds a device for drying carboys.

Colin Kaminski has been working in the brewing industry for five years and lives in Napa, California. He was promoted to Master Brewer at Downtown Joe's Brewpub in June of this year after working four years as the assistant brewer. He is responsible for brewing 750 barrels a year on a 7-barrel system. He is also a product designer for Beer, Beer and More Beer. His products include the Peltier cooled conical fermenters, the grain mills and the new three-barrel brewing system.

Colin has had a varied career working as an assembly language programmer, wedding cake baker, motorcycle mechanic, luthier (making guitars and doing repairs on string instruments), theatrical lighting designer, tooling designer for an electric violin manufacturer, product designer for both lutherie and brewing as well as brewer.

Drawing on his diverse interests, Colin shows us where brewing and the speed of light converge in his article (on page 46) on how to use a Brix refractomer to measure specific gravity.

Although not a Cajun, Marlon Lang was born in Louisiana and lives in Baton Rouge. Marlon graduated from LSU and is a degreed electrical engineer. He specializes in both power systems and instrumentation and control of chemical processes. He holds some patents and has published several technical papers regarding the control of chemical processes.

Marlon started brewing in 1990 with his neighbor. At the time they brewed with malt extract, but he switched to all-grain around 1993. As you can see in the picture, he has a homemade HERMS rig and brews 10-gallon batches almost every other weekend. He's won several local first-place awards for his stout and IPA in the annual Redstick Brewmasters Spring Brew-Off.

He and his wife have traveled and drank beer in England, Belgium, Germany, Austria and Finland.

In his article on page 32, he takes homebrewers on a journey to understanding how PID controllers work and how to tune them on your own RIMS or HERMS home brewery.

Wayward Wizardly Warblings

Mr. Wizard usually provides accurate and detailed answers, but I feel he may have blown it when it came to his answer in the October 2003 issue regarding Sam Wenger's foaming problem. Sam's problem is too much foam, not too much carbonation. You can have a keg of beer that is perfectly carbonated, but still fills your glass with foam when dispensed. While the procedure for bleeding off his cornies excess head pressure is accurate, I would have focused on Sam's dispensing procedures. Using a five-foot length of 3/16-inch ID tubing instead of a short run of 1/4-inch tubing can make all the difference. If I had to guess, I'd bet he has a stubby length of 1/4-inch tubing attached to a cobra head faucet. I'll give you three to one odds that if he maintains 10 to 13 psi on the keg as the Wizard recommends, he will continue to have foaming problems unless he makes a change in his tap configuration.

Shaun Vickers
Jamestown, North Dakota

Mr. Wizard speaks: "Excellent point! When I read a problem I tend to focus in a particular direction and in Sam's case I directed my Wizardly Wand toward over-carbonation. As a self-fashioned dispense nut, I am surprised that I did not concentrate my response towards beer pouring. I completely agree that foamy draught beer is frequently caused by faulty line diameters and lengths. I like to provide enough line loss (pressure drop) to reduce the beer pressure from the keg to the tap almost completely. For a beer pushed from a keg at 12 psi, this requires about 6 feet of 3/16" beer line. Thanks for the great input!"

It's the Yeast We Could Do

I have been enjoying *BYO* for over a year now. You always have timely articles that answer my questions as I try to brew here on Diego Garcia. I cannot tell how viable the yeast I receive is and I wanted to make a starter to revive the yeast. Don Million's article "Beauty and the Yeast" (September 2003) was very informative and answered my question on the approximate specific gravity for making a starter.

David Derby
Diego Garcia

Don't Know Much About History

In his article "Pale Ale" (September 2003), author Terry Foster says, "The 18th century was an exciting time in Britain. By mid-century the Industrial Revolution was well under way." Then we are told in a later paragraph that "All this was to change in the 19th century. As the Industrial Revolution got under way . . . " Well, which is it? Foster also tells us that "Whitbread and Courage (were) still in business even in the 20th century." While this is not a false statement, I fail to see its relevance, especially since the brands persist in this century.

John Grimley
Toronto, Canada

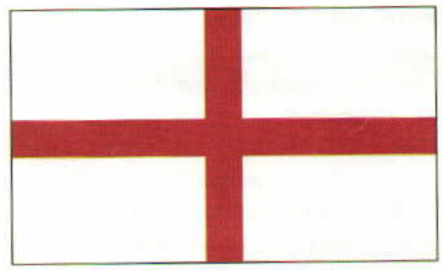
The Industrial Revolution began in the mid 1700s (the 18th Century) and continued into the 1800s (the 19th Century). In the second quote, "got under way" could have been better worded, perhaps as "continued." As for Whitbread and Courage persisting until the 20th Century, you got us. We're still writing "Cold War" on our checks.

Don't Know Much Vexillology

The photos, content and information in your article "Pale Ale" (Terry Foster, September 2003) were great, but I must take issue with the use of the Union flag at the top of each page. The article throughout was the history of *English* ales and yet you insisted on using the *British* flag. I'm sure you would not use the British flag for an article on Scottish ales, you would use the Flag of St. Andrew. So why oh why did you not use the Cross of St. George for England? This may seem a trivial matter to you, but to us displaced Limeys it is a point of pride.

Trev Cox
Reading, Pennsylvania

Editor Chris Colby responds: "We're not vexillologists (people who study flags), so we simply used the flag that flies above government buildings in England and appears on T-shirts of English rock bands. However, since you asked, here's your St. George's Cross:"



Sour Strawberry

I recently brewed a strawberry blonde that turned out a bit sour. It was sour after two weeks in bottles and a bit less sour after a month. It's now been in bottles about six weeks and the flavor has stabilized. How do I get rid of that sour flavor in future batches?

Mike Henry
Portland, Oregon

Sour flavors in beer are often the result of contamination by lactic acid bacteria. However, if your batch was contaminated, the sour flavor should be getting stronger. It's possible the slight sour taste is coming from the strawberries. Strawberries contain about 7% sugar by weight. In the fruit, this sweetness is balanced by an acidity level (1.6% by weight) that is fairly high as fruits go. Your beer is probably not as sweet as fresh strawberries. As such, you may be detecting the acidity of the fruit without the usual sweetness associated with it.

brewer PROFILE

Tiffany Swartz • Lynnwood, Washington

PHOTOS COURTESY OF TIFFANY SWARTZ

Tiffany stumbles in the tub while trying to pose with her carboys. She loves her stout!

I began homebrewing when my fiancé's dad gave me what I thought was a complete beer making kit. I was excited at the thought of starting a new hobby without having to shell out a lot of money for equipment. At most, I thought I might buy a bottle capper, which wouldn't cost more than $20. As it turned out, the dog of my in-laws-to-be (dammit Wanda!) had already helped herself to a good portion of the equipment. Pretty much everything was chewed beyond recognition. The only really usable pieces were a glass carboy (unchewable) and a plastic fermenting bucket (probably next on the lunch menu). I ended up spending about $100 for the remaining equipment and ingredients. At the time, I was working as a water quality chemist. It was pretty neat to be able to adapt concepts I worked with (e.g. specific gravity, fermentation, alkalinity) to something I actually enjoyed.

I started with a pale ale figuring it would be easiest to make. It was only extract with dry yeast, so it wasn't meant to be hard. Alas, I was misguided. I ended up boiling the wort all over the stove twice and it took eight hours to cool down to a pitchable temperature. By the end of the day I was exhausted, but the beer started to ferment, so I was excited.

These days, I brew two batches every four weeks. Dry stout is my favorite to brew . . . and drink. My best beer is the Fat Spider Stout (see recipe below). When it came time to bottle the first batch, I was horrified to discover the fattest black and red spider I had ever seen scurrying amongst the empties. He was about 2 inches in diameter and I swear you could hear him breathing! After a few minutes of screaming, Brian (my beloved fiancé) decided to come to my rescue. However, when he saw the size of the spider he blanched and wouldn't go near it either. After many harsh words and a small argument over whose shoe was going to be used, he finally dispatched the black and red monster.

The rest of the bottling went pretty well. The next day, when we were trying to come up with a name for the beer, we decided on Fat Spider Stout. It turned out delicious! As payment for all the grunt work — spider crunching, heavy lifting, grocery runs and etc. — Brian gets lots of beer. My sister, her husband and my in-laws are also willing guinea pigs. Actually, pretty much anyone who visits the house gets to at least try the beer. I have had lots of surprised people tell me "Why, this actually tastes like beer." (My question to them is, "What did you *think* it was going to taste like?")

My philosophy on brewing is to avoid kitten feet in the mash. We have kittens whom tend to dip their paws into darn near everything when we're not looking. Also, if it's a hobby, calories don't count!

The Fat Spider Stout was named after a fat spider found in the empties at bottling time.

reader RECIPE

Fat Spider Stout

(5 gallons/19 L, extract with grains)

OG = 1.048–1.050 FG = 1.013–1.014
IBU = 33–36 SRM = 29 ABV = 4.5–4.7%

Ingredients

3.3 lbs. (1.5 kg) British pale liquid malt extract
2.5 lbs. (1.1 kg) British pale dried malt extract
1 lb. (0.45 kg) roasted barley
12 AAU Northern Brewer hops (1.33 oz./37 g of 9% alpha acids)
Wyeast 1084 (Irish Ale) or White Labs WLP004 (Irish Ale) yeast
1-2 cups pure maple syrup (the darker the better, amount is to taste)
1/2 cup corn sugar (for priming) (for more carbonation, add an additional 1/4 cup maple syrup with corn sugar)

Step by Step

Bring one gallon (3.8 L) of water to 160 °F (71 °C). Steep grain for 30 minutes. Remove grain bag and let drain into kettle. Add water to grain tea to make 3 gallons (11 L). Bring to boil, then shut off heat and add malt extracts. Bring to a boil again and boil for 45 minutes, adding bittering hops at the beginning of the boil. After the boil, let set for 10 minutes. Cool wort to below 75 °F (24 °C), aerate and pitch yeast. Ferment at 68–72 °F (20–22 °C) for a week to 10 days.

BREWER'S DICTIONARY

C is for . . .

caramel malt: a malt that is prepared by "stewing" (kilning in a moist environment) to produce sugars from starch (the sugars caramelize when the malt is dried to yield color and flavor compounds)

carbonation: injecting or dissolving carbon dioxide gas in a liquid to create a bubbly taste and texture

carboy: a large glass or plastic vessel with a narrow neck

chalk: a term for calcium carbonate, used in brewing dark beers

chill haze: a haziness in beer caused by the precipitate formed when a beer is refrigerated

chillproofing: treating beer to make it more resistant to chill haze, usually by holding beer near freezing for several days of adding polycar and/or silica gel during the second stage of fermentation

clarification: removing suspended particles from the wort or finished beer through mechanical or chemical means

closed fermentation: anaerobic fermentation performed in closed vessels

conditioning: the process of carbonating beer

crystal malt: another name for caramel malt

D is for . . .

decoction mashing: the method of removing some of the mash, boiling it, then returning it to the main kettle to boost the mash temperature (this process is used in all-grain brewing)

dextrose (or glucose): a monosaccharide used to prime bottle-conditions beers

diacetyl: a powerful aroma compound derived from yeast that can impart a butterscotch or buttery flavor to beer

doughing in (or mashing in): mixing ground malt with water, the first step in all-grain brewing

draft (or draught): beer drawn from kegs or casks instead of being bottled

dry hopping: the practice of adding hops to the primary or secondary fermenter (or to finished beer) to increase the aroma and hop flavor of the beer without increasing its bitterness

dry kit: a homebrewing kit that contains dry malt extract, hops, and sometimes specialty malts

dry malt: malt extract in a dried powder form (often called DME)

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If we publish your article, recipe, club news or tip in Homebrew Nation, you'll get a cool messenger bag (compliments of White Labs) and a *BYO* Euro sticker.

reader RECIPE

Anne Whyte • Winooski, VT

00's Checkered Flag Altbier

(5 gallons/19 L, extract with grains)

OG 1.053–1.059 FG 1.013–1.015
IBU 33–45 SRM 20 ABV 5.2–5.7

Ingredients

3.5 lbs. (1.6 kg) light liquid malt extract
3.5 lbs. (1.6 kg) amber liquid malt extract
12 oz. (0.34 kg) of Caramel wheat
12 oz. (0.34 kg) of German CaraMunich III malt
2 oz. (57 g) of Carafa I malt
8 AAU Perle hops (60 minutes) (1 oz./28 g of 8% alpha acids)
5 AAU Spalt hops (30 minutes) (1 oz./28 g of 5% alpha acids)
4 AAU Hallertau Hersbrucker hops (15 minutes) (1 oz./28 g of 4% alpha acids)
Wyeast 1007 (German Ale), White Labs WLP003 (German Ale II), Wyeast 1338 (European Ale) or White Labs WLP011 (European Ale) yeast

Step-by-step

Bring 1 gallon (3.8 L) of water to 165 °F (74 °C). Shut off heat and steep grains for 30–45 minutes. Rinse grains or let drain in bowl. Add malt extract to "grain tea" and enough additional water so you can boil 3–3.5 gallons (11–13 L). Boil wort for 60 minutes and follow the hop schedule in the recipe. Cool and aerate wort; pitch yeast. Ferment in at 60–63 °F (16–17 °C), if possible. After primary fermentation, let beer condition for 3 weeks. Prime and bottle or keg as usual.

homebrew CLUB

The James River Homebrewers

Richmond, Virginia

PHOTOS COURTESY OF DAN MOUER

Some members of the James River Homebrewers club gather for a photo shoot. The club has lasted the test of time, recently celebrating its 20th anniversary.

The James River Homebrewers was once just a handful of guys who liked to brew good beer. Since it was founded in 1983, the club has grown considerably and now consists of about 100 members. Our annual spring party is an affair for people who feel Irish for a couple days in mid-March and want to glug down lots of member-made dry stout. This year, the party had another dimension — it was our 20th anniversary!

In our first year we began the tradition of an annual club competition. The first few were held around my dining room table. To judge, we brought in folks who owned the handful of beer-and-wine shops and restaurants that carried choices beyond Bud, Schlitz, Miller and Pabst. The following year we opened the competition to folks outside the club, and thus began a tradition known as the Dominion Cup, which attracts folks from all over the mid-Atlantic and upper south.

Our sense of "good beer" didn't come from globe-hopping and pub-crawling tours through London, Munich, and the Belgian countryside, nor from "microbrewery" beers available at local gourmet shops. Our knowledge of good beer came from "discovering" Bass, Whitbread, Spaten, DAB, and other European brews. Getting our hands on these beers was not always easy. We used to make clandestine "bootlegging" trips to Central Liquors in Washington, D.C., 100 miles to the north. The Virginia Alcoholic Beverages Control frowns on such illicit imports to the state, and rumors had it that state police were watching D.C. liquor stores for Virginia license plates. Picture this: a VW beetle full of desperate paranoids dashing across the Key Bridge over the Potomac River, looking fervently in their mirrors for state police prowlers, and sweating anxiously over a couple cases of "contraband" beer in the bonnet!

We in the James River Homebrewers have made great beer and friends through the bonds of brew. We are proud of our Website (www.jrhomebrewers.org) and our newsletter, "The Brewsleader," which appears monthly in both electronic and paper versions.

– Dan Mouer

Club members prepare for the BJCP test. Notice the empty study resources.

Here's a club-favorite recipe:

Pre-Prohibition Pilsner

OG = 1.056 FG = 1.012
IBU = 45 SRM = 6 ABV = 5.7

Ingredients

- 9 lbs (4.1 kg) American 2-row pale malt
- 1.8 lbs. (0.81 kg) flaked corn
- 1 lb. (0.45 kg) Carapils malt
- 13.5 AAU US Tettnang leaf hops (3 oz./84 g of 4.5% alpha acids)
- 8.2 AAU Mt. Hood plug hops (2 oz./56 g of 4.1% alpha acids)
- White Labs WLP940 (Mexican Lager) yeast

Step by step

Mash in all grains to 148 °F (64 °C) with approximately 2.5 gallons (9.5 L) of water. After 20 minutes, add boiling water until mash temperature reaches 154 °F (68 °C). Hold at this temperature for 40 minutes or until iodine test shows conversion. Lauter to reach 6 gallons (22.8 L).

After cycling the runoff until clear, add 1 oz. (28 g) U.S. Tettnang whole leaf hops to the brewpot as you lauter. When wort begins to boil add 1 oz. U.S. Tettnang whole leaf hops. After 30 minutes, add ½ oz U.S. Tettnang whole leaf hops and ½ oz. Mt. Hood hop plug. After 50 minutes, add ½ oz. U.S. Tettnang whole leaf hops and ½-oz. Mt. Hood hop plug. After boil, chill and ferment at 52 °F (11 °C) with White Labs Mexican Lager yeast WLP-940. After 14–16 days, transfer to the secondary adding 1 oz. Mt. Hood plugs to dry hop. Lager six weeks at 40–42 °F (5 °C). Bottle with ¾-cup corn sugar and bottle condition at 52 °F (11 °C). Will take about four weeks to carbonate.

replicator WINTER ALE

by **Steve Bader**

Dear Replicator,

Last winter, I tasted Butte Creek's Winter Ale and it was the best beer I've ever tasted. Since then, I've realized that this beer is difficult to find. Since I live in Raleigh, North Carolina, it is a bit of a hassle to drive to California every time I get a craving for my new favorite beer. Could you provide me with a clone?

Todd French
Raleigh, North Carolina

Butte Creek Brewery is a 4000-barrel brewery located in Chico, California. Winter Ale is a seasonal beer that they have brewed since the brewery opened in 1996. I talked with head brewer Roland Allen, who was a homebrewer for three years before working as a brewer at Sierra Nevada for nine years.

Roland described the Winter Ale as being similar to a brown ale, only with a higher alcohol content to counter the snow and cold. I call the style "winter warmer" — kind of like a brown ale on steroids. The beer has 1–2% more alcohol by volume, a bit more maltiness, and more hop bitterness. Roland says the flavor profile of the Winter Ale consists of a slight nuttiness, a smooth malty flavor and chestnut brown color. Butte Creek does a coarse filtering of this beer to enhance its beautiful color.

Keeping a low fermentation temperature of 67 °F (19 °C) is also important for the flavor profile of this beer. Higher fermentation temperatures create some fruity flavors that you want to avoid in the Winter Ale.

For more information visit the Butte Creek Website at: www.buttecreek.com or call (530) 894-7906.

Butte Creek Brewing – Winter Ale

(5 gallon, extract with grains)

OG = 1.055–1.061 FG = 1.014–1.015
IBU = 32–42 SRM = 21 ABV = 5.4–5.9%

Ingredients

6.6 lbs. (3.0 kg) Briess Light malt extract syrup
1.0 lb. (0.45 kg) Briess Light dry malt extract
7 oz. (196 g) chocolate malt
3 oz. (84 g) Munich malt
1 tsp. Irish moss
11.25 AAU Perle hops (bittering hop) (1.5 oz. of 7.5% alpha acid)
4.5 AAU Fuggle hops (1.0 oz. of 4.5% alpha acid)
White Labs WLP051 (California V Ale) or Wyeast 1272 (American Ale II)
0.75 cup corn sugar (for priming)

Step by step

Steep the two crushed grains in 3 gallons (11.4 L) of water at 150 °F (65 °C) for 30 minutes. Remove grains from wort, add malt syrup, dry malt extract and bring to a boil. Add Perle (bittering) hops, Irish moss and boil for 60 minutes. Add Fuggle aroma hops for the last 3 minutes of the boil.

When done boiling, add wort to 2 gallons (7.6 L) cool water in a sanitary fermenter, and top off with cool water to 5.5 gallons (20.9 L). Cool wort to 80 °F (27 °C), aerate the beer and pitch your yeast. Allow the beer to cool over the next few hours to 65–67 °F (18–19 °C), and hold at these temperatures until the yeast has fermented completely. Bottle your beer, age for 2–3 weeks and enjoy!

All-grain option:

This is a single infusion mash. Replace the light syrup and dry malt extract with 12.0 lbs. (5.4 kg) US pale 2-row malt. This will give an OG of 1.062, assuming an extract efficiency of 65%. Mash your grains at 155 °F (68 °C) for 60 minutes. Collect enough wort to boil for 90 minutes and have a 5.5-gallon (20.9-L) yield. With a full wort boil, 1.5 oz. (35 g) of Perle hops will yield 42 IBU (in conjuction with the late addition hops). (The rest of the recipe follows the extract instructions given above.

homebrew calendar

November 8
Novembeerfest
Kent, Washington

Novembeerfest is the oldest homebrewing competition in the Seattle area. The event is sponsored by the Brews Brothers Homebrewing Club and will be held Saturday, November 8 at Larry's Brewing Supply in Kent, Washington. Judging begins at 10:00 a.m. All BJCP styles, including mead and cider will be accepted. Deadline is November 1st, and the fee is $5.00 per style entry. Entries may be dropped off at Larry's Brewing Supply, Mountain Homebrew and Wine Hobby in Kirkland, or Bob's Homebrew Supply in Seattle. For further information contact Jim Hiken at (425) 483-9324.

December 6
Palmetto State Brewers' Open
Columbia, South Carolina

The 5th annual Palmetto State Brewers' Open will be held at Jaderloon in Columbia, South Carolina. All BJCP styles will be judged along with a "Just Good Beer Brew Off" for those great homebrews that do not match a particular style. Entry fees for the sanctioned competition are $6.00 per entry. Fees for the "Just Good Beer Brew Off" are $5.00 per entry. Multiple-entry discounts are available. Ribbons and prizes will be awarded for winners and a cash prize goes to the best of show. For more information, visit the Palmetto State Brewers' club Website at www.sagecat.com/psb.htm.

homebrew RACECAR

Matt and Anne Whyte • Winooski, Vermont

If you ever find yourself at Thunder Road race track in Barre, Vermont, you might notice a Vermont Homebrew decal flying around the quarter-mile track on driver Joe Steffen's car. The homebrew shop's owner, Matt Whyte, doesn't just sponsor the car — he helps build it. Along with owner Smitty MacKay and Richard "Hac" Bonneau, the team's principal sponsor for 14 years and the official tire buyer, Matt is an integral part of the crew.

The familiar orange and white #00 car races in the Flying Tiger division. This is the second tier of four divisions, and the team is the defending 2002 champion. Popular with both fans and competitors, Steffen is also a two time Sportsmanship Award winner.

On a given night, each division will have between 25 and 40 cars. After preliminary qualifiers, consolation races and a last-shot B-feature race, the final field is around 26 cars. You can be pretty sure that the Vermont Homebrew car will make it to the Tigers' feature race.

Matt and his wife, Anne Whyte, are living a nice life these days. Anne has been homebrewing since 1990, and together they keep the store open seven days a week.

The real brewer in the family, Anne has won more ribbons than Matt can count, and is the past president of the Green Mountain Mashers homebrew club. She recently presented a homebrewing seminar at the Vermont Brewers' Festival. (See her racecar-inspired altbier recipe on page 9.) They just celebrated the store's eighth anniversary with good beer, good customers and a winning race car to play with every Thursday night.

PHOTOS COURTESY OF ANNE WHYTE

Driver Joe Steffen took the checkered flag in this victory for the VT Homebrew car.

Vermont Homebrew Supply owners Matt and Anne Whyte sponsor #00 above.

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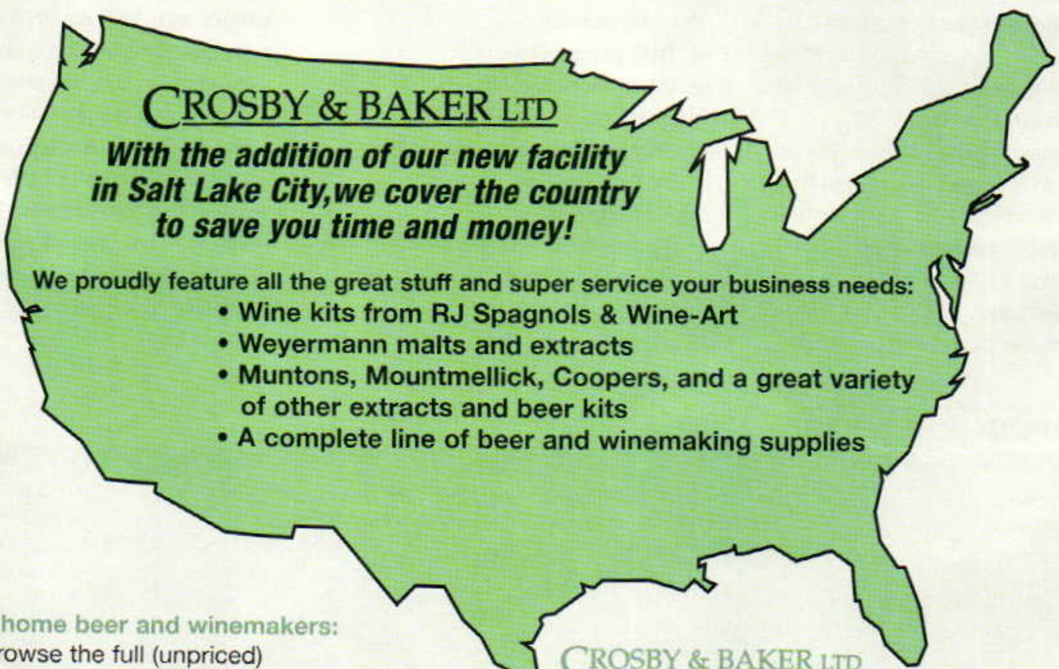

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Yeast Management

Recycle with care for future generations

by Thomas J. Miller

Quality yeast is so accessible these days that homebrewers rarely think twice about chucking yeast after one use. Few realize that reusing yeast for multiple generations means quicker fermentations and, quite possibly, better beer. It all begins with keeping your yeast healthy. Learning to manage your yeast is another step toward expert homebrewing.

Brewer: Steve Dresler is the brewmaster at Sierra Nevada Brewing in Chico, California. He received two Bachelor's degrees — one in biology, the other in chemistry — from California State University at Chico. He studied brewing at U.C. Davis in 1984 and 1985 and studied yeast and fermentation at Siebel in 1997. He has been with Sierra Nevada for the past 20 years.

Our preference is to deal with a single strain of yeast. It makes management of the yeast that much easier. When you have multiple strains, it is more difficult to keep the yeast strains and yeast generations separate. You end up with a considerable danger of cross contamination, which would destroy the integrity of the yeast.

For that reason, we have used a single strain since 1980. We propagate up a lager yeast once or twice a year for our seasonal program, but it is completely isolated in a different section of the plant and always kept in closed containers.

We propagate our yeast from slants, building them up until there is enough to pitch a 200-barrel fermenter. Our ale yeast is used for 15–20 generations. After the twelfth generation, we begin propagating the new batch.

Once we start a new yeast propagation, all of a sudden we are dealing with two yeast batches of the same strain, but of different generations — one is at least twelve generations old, the other is only one. In this instance, despite the fact that they are the same strain, if we mix them up, the new propagation is ruined.

All that said, we have never been able to quantify exactly why we re-propagate our yeast and dispose of the 20th-generation yeast even when it is still performing so well. The first few fermentations with a new yeast tend to be slower. Also, the young yeast imparts a more ester-like flavor (though it ages out pretty quickly). The simple fact is, a long time ago we made a quality control decision to dispose of yeast after twenty batches. It is a policy that works well for us, and we're sticking with it.

Homebrewers would really have to brew like crazy to get 20 generations out of a batch of yeast. Most homebrewers (and brewpubs for that matter) do not have the kind of brewing regimen to overcome the major issue of yeast viability. This is the simple fact that yeast will die if it is not actively being used.

If you do collect yeast, keep it chilled as close to 32 °F (0 °C) as possible. When it comes time to use it, rouse the yeast with a boost of oxygen. This can be done by vigorous stirring. Be sure to use a sterile spoon or whisk to get a bunch of froth going. The object here is to increase the metabolic activity before pitching the yeast.

Yeast aeration creates lots of activity necessary for cellular division. There is actually a pretty extreme view among some brewers that, if you aerate the yeast enough, you will not need to aerate the wort anymore. The idea being, once you give the yeast enough oxygen, it is already in the active growth phase and switches over to the stationary fermentation phase (where it can complete fermentation).

Yeast collection is really not a very big deal if you just remember to be clean about it! If you have an open container (or one that is easily opened) and you are making ales, I would suggest skimming off the yeast when the beer is fermenting at high krausen. Put the yeast in a sterile container and whisk it vigorously. This whisking concentrates the yeast solids by getting the carbon dioxide out (created during fermentation). Removing the carbon dioxide is good for yeast viability.

For brewing lagers, I would suggest scooping the yeast out from the bottom of the fermenter when you transfer from the primary to the secondary fermenter. A flat bottom fermenter means lots of trub and stuff in the yeast, but this problem isn't too hard to deal with.

One way to get all this this trub away from your brew, is to transfer the beer after two or three days of fermentation. The trub and dead yeast would have settled by then in the first tank. When fermentation finishes in the second vessel, mostly good yeast will be left behind.

Once you collect the yeast, I suggest following the advice of Chris White of White Labs. He has written about storing yeast under a layer of sterile, distilled water. This prevents the yeast from being in contact with air. Oxygen prevents yeast from going into the total dormant stage. A bit of beer from your fermenter could also serve as a good replacment for the distilled water in this practice.

Brewer: Jordan Fleetwood brewed for Big River Grill in Chattanooga, Tennessee from 1997–2000. He has been the brewer at The Dogwood Brewing Company in Atlanta, Georgia since September 2003.

There are three essential components to proper yeast management. These are proper sanitation, maintaining an environment that is as sealed as possible and storage temperature.

Proper sanitation is a standard brewing issue that becomes magnified when you start thinking about harvesting yeast and reusing it for multiple generations. If you purchase a sterile batch of Wyeast or White Lab yeast, that yeast is basically perfect at the time of pitching — once you introduce it to your brewing environment however, it immediately becomes subject to contamination.

This means that your entire brewing process must be immaculate if you intend to maintain yeast integrity. More specifically, any surfaces your beer will touch post-kettle must be sanitized as well — think heat exchanger, racking hose, fermenters and carboys.

Maintaining a sealed environment is a tough requirement for most homebrewers to achieve. Still, the concept serves as a good illustration of what professionals try to do. At Dogwood, we ensure the yeast environment is sealed by keeping the yeast under CO_2 pressure at all times — it is under pressure in the fermenters as well as the yeast storage vessel. The pressure protects the yeast and helps transfer the yeast from tank to tank.

For example, a cylindroconical fermenter allows the yeast to collect in the cone. Because that yeast is under pressure, we can blow trub and yeast out of the tank from the bottom valve, then attach a 5-gallon stainless steel tank to the bottom of the cone and push yeast in. We then pressurize the yeast in the smaller tank (the CO_2 prevents bacteria from working) and will use pressure again when we want to push the yeast into the next fermenter.

A complete, enclosed environment is the ultimate goal if you want to protect your yeast. That said, when I worked at Big River we recaptured yeast in what might be described as homebrewer fashion. We used a sanitary stainless steel scoop to retrieve the yeast, put it in a stainless steel bucket and stored the buckets (covered with plastic wrap) in the cellar at around 32 °F (0 °C). You want it as cold as possible without freezing the yeast. Temperatures just above freezing put the yeast to sleep, which tends to make them more vigorous upon repitching.

When re-pitching time came, we poured off the dead yeast that had gathered on top of the bucket until we got to the nice slurry. Be sure to discard the top portion off any collected and stored yeast to eliminate trub and dead yeast cells after storage. This will ensure better beer flavor and a quality yeast harvest the next time around.

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Creepy Crawlies

Scorched stainless and the dynamics of DMS

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Bug off! I'm brewing

I have many back issues and couldn't recall an article specific to my inquiry — it has to do with finding creepy crawly bugs in the grains! I was getting ready to brew one day when I discovered bugs slowly crawling out of a batch of wheat that I had just purchased. Luckily for me, I don't grind my grains at the brew shop, but at home. I didn't notice the bugs until a few days later when I was about to crush. What would have happened if I had ground the grains with the bugs in it and had them processed in my wort? I bring my grains up to 160 °F (71 °C) to steep, but not to a boil. I boil my hops in a totally separate "hop boil." Would the steeping process at 160 °F neutralize any live bug contamination?

Ernest Wakukawa
Kahaluu (Oahu), Hawaii

I am not entirely clear on your brewing process and will get to those pesky bugs in a moment. I am going to assume that you are an extract brewer using some grains. In this case it sounds like the pound of wheat malt was used in addition to some extract. I make this assumption because you are using the word "steep" instead of "mash" and you also mention a separate "hop boil."

Whether an all-grain brewer, partial grain brewer or extract only brewer, the wort boiling step is extremely important. With the exception of extracts specifically designed and marketed as "no-boil," brewers must boil their wort.

The most significant thing accomplished by wort boiling is sterilization. This step allows brewers to determine what sorts of organisms are in the wort because boiling kills nearly everything (spores can survive short boiling periods, but that is a technicality that you are not concerned with at this time) and gives us a clean slate with which to work. Of course, if we contaminate that clean slate with dirty equipment or bad yeast, that is our fault and it's the job of the brewer to keep the wort in a clean and sanitary environment after boiling. Wort boiling also precipitates protein, isomerizes hop acids and drives off certain undesirable malt volatiles like DMS.

Insects in malt is actually a fairly common problem. I am not suggesting that this is by any means acceptable, but it is common. In my experience, flour weevils are the most commonly found bugs in malt. Weevils can cause major problems for commercial brewers if they infest a malt silo. These little critters eat malt and in the process, rob brewers of the important carbohydrates that they have purchased from the maltster. As a biproduct of metabolism, bugs, like other creatures, produce heat, carbon dioxide and water. Insect infestation — and the fecal matter that comes with it — can lead to an increase in the malt moisture content, which in turn can lead to other problems such as mold growth.

Your experience is much more mild than this and that is why I began writing about the normal wort boiling procedure. The fact is that bugs are all around us and we as humans eat lots of them. I heard on Michael Feldman's "Whad'Ya Know" (an NPR program) that a 16-ounce jar of peanut butter can legally contain 100 bug parts. The key with anything we eat is safety. Some people intentionally eat bugs. Most intentionally eaten bugs are fried and this is an effective method of killing bacteria that may be harmful. Harmful bacteria are not killed by steeping at 160 °F (71 °C), but are killed during boiling.

With that said, I wouldn't worry too much about the occasional flour weevil in the malt. Since these bugs are not rooting around in nasty environments like flies and roaches (they usually spend their entire lives in flour, malt or whatever else they are infesting), they do not fall into the "vector" bug category. A vector is something that spreads bad stuff around, like a fly that lands on your grilled Spam sandwich right after it was sunbathing on a stinky pile of . . . well you get the point.

I have seen an odd weevil in malts, as well as flour, and personally believe that a couple of weevils per pound is not a big deal. Other bugs, like roaches are totally unacceptable since they travel around and spread filth. I have also had several bags of raw wheat arrive at our brewery that had numerous insect larvae on the outside of the bags — the wheat was obviously infested. I certainly did not want to spread this problem into my storage room and destroy the rest of my grain. My malt supplier happily replaced the wheat for free. A refund should be expected for malt containing bugs and I would never buy from a shop again that refused one.

I scrubbed and I scrubbed

I use a converted keg for a brew kettle with a stainless false bottom about 8.5 inches in diameter. The kettle sits on a Camp Chef propane burner. The first few batches I brewed with no problem other than a little scorching that cleaned easily. Then I brewed a wheat beer without paying close enough attention and ended up with heavy scorching on the

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bottom inside of the kettle. I cleaned it with a 3M scouring pad attachment on my cordless drill, then re-passivated the metal with Bar Keepers Friend cleanser.

Since that batch I've had scorching problems of various degrees, and it keeps getting worse. Could it be caused by trying to boil too fast or too slow? Could I not be clarifying the wort sufficiently? Is the kettle too close to the burner? Should I passivate the kettle after each batch? Is there something else I can do to avoid the scorching problem in the future? I'm getting tired of cleaning the kettle with a drill each time; can you help?

Rick Davidson
Spanaway, Washington

I've been writing this column for eight years now and have managed to keep my identity a secret. Lately, I have been a bit more open about the fact that I work in a brewery. Another fact about my life is that I have worked for the largest manufacturer of stainless steel processing equipment in the United States for the last six years. This company actually built the brewery where I work as a showcase of our equipment. My job is two fold — I work in the brewery and am part of an equipment design and engineering group. I like these stainless steel questions because they pertain to the area of my life outside of *BYO*.

This is an excellent question with a very simple answer. Unfortunately, you will need to reverse the clock to appreciate the answer to your question. Your biggest problem is the damage you have inflicted upon your brew kettle. Metallic surfaces become more difficult to clean as roughness increases.

In the stainless steel business we refer to the roughness average (or Ra) when discussing the surface of a metal. Metal surfaces have a wavy appearance when viewed under a microscope. A smooth surface has waves that are very close to each other and a rougher surface has waves that are further apart. Most equipment used for beer and milk has a Ra of 25 micro-inches (25 millionths of an inch) or smaller. This means that the waves are no more than 25 micro-inches apart. Material finish on stainless steel is improved by polishing using progressively finer abrasives. In order to obtain a 25 Ra finish, a 180 grit abrasive (similar to sand paper) is used. 180 grit means that there are 180 particles per square inch of abrasive. That's a pretty smooth abrasive.

In stark contrast, that 3M scouring pad attached to your drill motor is a very rough and aggressive abrasive. What you are doing is roughing up the surface of your kettle and progressively making cleaning harder and harder to accomplish. Unfortunately, it will be difficult to restore the finish to your kettle to where it was before you introduced it to Mr. Scratchy.

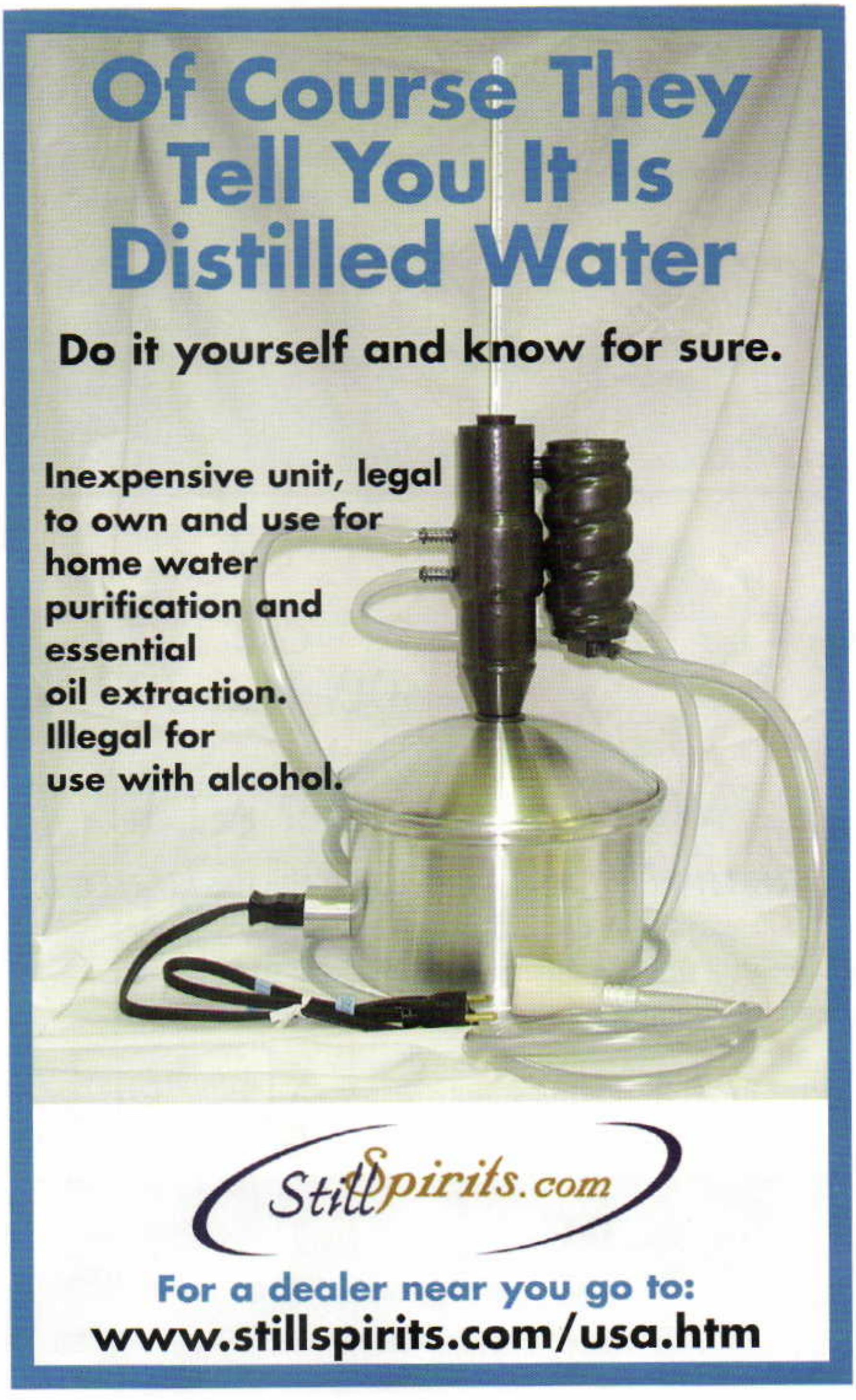
Proper metal polishing requires polishing with the grain of the metal and that requires a belt sander equipped with the proper abrasive. Because the metal grain in the keg most likely goes laterally around the sides of the keg, as opposed to up and down, you would need a very small belt sander in order to polish the inside. This same principle of polishing with the grain was also violated when you scrubbed your kettle in a circular motion with the drill motor. You may need to get a new keg if the problem is really bad.

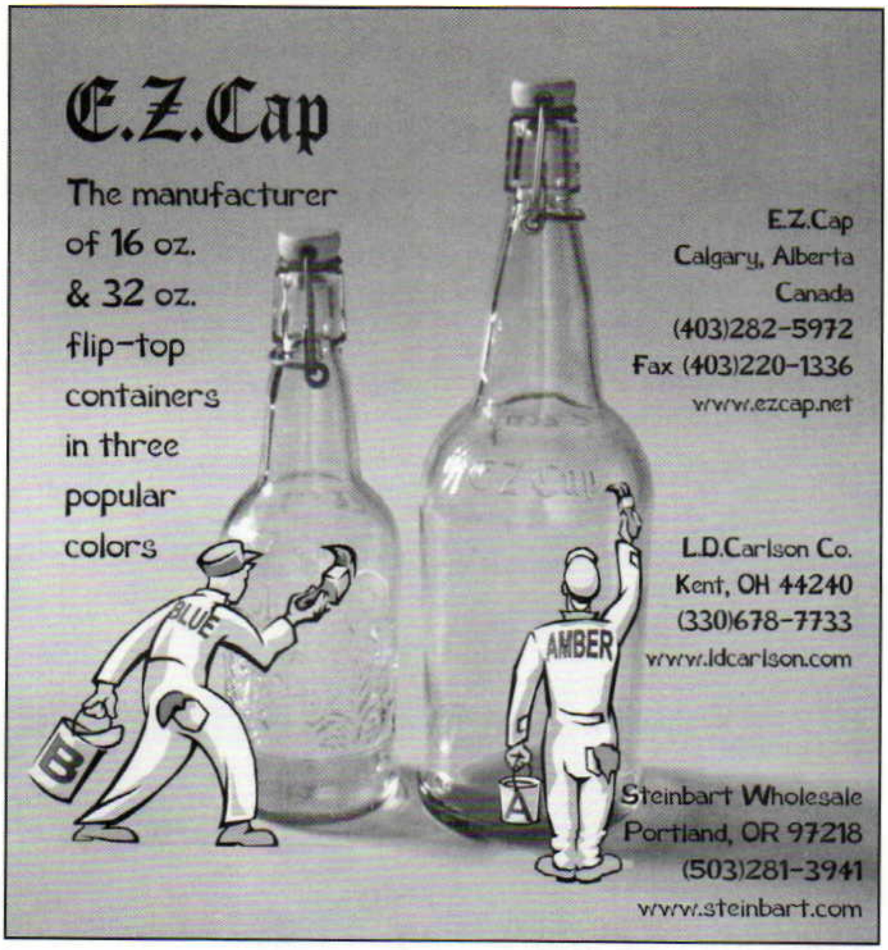
For those of you with expensive stainless steel cookware or brew kettles, here is some money saving advice. DO NOT use any type of metallic abrasive pad when you clean. That includes 3M green scouring pads, copper balls of metal, stainless balls of metal and any metal tool that is handy. (By the way, 3M makes many of the polishing abrasives used by stainless companies, but they are much finer than the pads used to remove cheese from a casserole dish.)

I recommend using Teflon scouring pads that are far too soft to scratch the surface of stainless steel vessels. We use a product made by 3M called a "doodle bug mop" to clean the outside of our fermenters. It's a snazzy tool that has a big pad (which looks like one of those buff puff facial pads) stuck on its end. Again, the key is using something that does not scratch!

So, you've got this smooth kettle surface and burn wort onto it. What's a brewer to do to ensure this type of thing doesn't continue to happen? For starters, you can use a heat diffuser to prevent extreme hot spots in future brews. A heat diffuser is typically made by placing a highly conductive metal, such as aluminum or copper, between the flame and the bottom of the kettle. The other thing you can do is monitor your evaporation rate. Most brewers attempt to reduce wort volume by 8 to 10 percent during the boil. If you are evaporating much more than 10 percent of your wort volume, you are boiling a bit too vigorously and should tune the heat back. This ought to reduce wort burning.

When there is a big cleaning problem, I am a proponent of chemical cleaners. What you want to do is





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select a cleaner that will dissolve the soil and not damage the steel. Although chlorinated cleaners can be used safely on stainless steel, I usually discourage their use because they can cause damage if used inappropriately.

Cleaners like PBW and, my favorite, sodium hydroxide or caustic are good at dissolving soils. The key is to allow the chemicals to do the work for you. It is very important to wear eye and hand protection when working with industrial cleaners. This is even true if you use a brush to do the scrubbing (metal free, of course) since brushes have a way of spitting stuff towards one's face. There is a lot of information about cleaning chemicals, so I will be brief here. My point is that chemicals should be used on dirty equipment — not drills with abrasive scrubbing attachments.

And finally some words on passivation: This is a term used to describe a very particular type of cleaning performed on stainless steel. The main goal of passivation is to remove all contaminants (oils, soils and especially, iron) from the surface of stainless steel in order to allow the "passive" film of chromium oxide (that makes stainless steel "stainless") to spontaneously form. The only chemicals widely used for this task are nitric acid and hot citric acid. Nitric acid is extremely dangerous and the citric acid method is pretty intricate. In any case, you really don't need to worry about passivating stainless steel unless you contaminate the surface with iron. A rusty abrasive or tool is actually one of the best ways to go about contaminating the surface with iron, so this is another good reason not to use metal for cleaning.

I checked Bar Keepers Friend on the net (www.barkeepers.com) and the MSDS (material safety data sheet) for this product lists the main ingredient as oxalic acid. That, coupled with calcium, is the key ingredient of beerstone and I really don't know how it works as a cleaner. This product is mainly advertised as a metal polish and general remover for all sorts of stains. I've never used this on stainless steel, but can guarantee it does not act to passivate the steel. I typically recommend

using cleaners intended for use with food utensils with a known list of ingredients. Good Luck!

DMS exposed

I am using Klages pale malt for all of my brewing. My problem is when I brew lighter beers, like Kölsch, this malt seems to impart a heavy DMS smell. Is it the malt or something else causing this nasty aroma?

Amani Martin
Brooklyn, New York

There are a couple of things I need to clarify before getting into the details of the answer. For starters, I seriously doubt that you are using Klages malt because Klages barley acreage is virtually nonexistent anymore. Many brewers, especially west coast brewers where Klages was very popular, referred to two-row malt as Klages. Although Klages is virtually unavailable, many brewers erroneously assume that U.S. two-row malt is made from Klages barley. Klages was a beloved two-row variety, first introduced in the early 1970's, but like many good varieties has been replaced by varieties with better agronomic qualities. Klages began to fall off of the radar screen in the mid 1990's. I searched for Klages on the internet and all of the hits came from brewing discussions and not organizations who buy and sell barley.

Hits for Harrington, B1202 and AC Metcalf (these are varieties that replaced Klages) are numerous and primarily come from companies dealing with barley farmers. These varieties yield more grain per acre than Klages and AC Metcalf (a fairly new variety from Canada) is especially resistant to lodging, or falling over in the field.

The other point is that all barley varieties produce malt that contains dimethyl sulfide (DMS). DMS is produced by the thermal degradation of an extremely important compound in plants called S-methyl methionine (SMM). All plants contain SMM, which moves sulfur around in them. When plant products are cooked, the SMM is converted to DMS. Cooked corn, green beans, asparagus, parsnips, etc. are all aroma descriptors used to describe DMS (because all of these vegetables contain, and have a strong smell of, DMS).

The strongest correlation between malt type and DMS is color, rather than variety. Pale malts contain more DMS than darker malts because during kilning, SMM is converted to DMS, which in turn is driven from the malt with moisture. Very pale malts often contain high levels of SMM (also known as DMSP, or dimethyl sulfide, in the brewing literature) that convert to DMS during wort boiling. This is key to understand.

The other thing to understand is that DMS is one of those aromas that is easily masked by other aromas. I stated earlier that all cooked veggies contain DMS, but listed only a few

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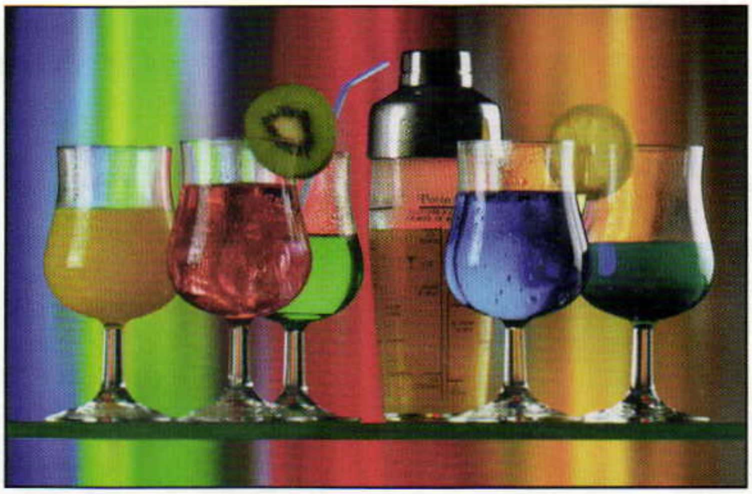

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that are commonly used to describe the aroma. This is because veggies like carrots, celery and peppers have aromas more pungent than DMS (although I detect a fair hint of DMS in cooked peppers).

The same thing happens in beer. DMS is masked in hoppy beers, fruity ales, dark beers with roasted malt aromas and spiced beers — just to name a few.

Beer styles like Kölsch don't have the strong aromas to disguise DMS. In fact, commercial brewers brewing pale lagers are somewhat fixated with DMS because most brewers dislike it. Rolling Rock stands out with its exceptionally high level of DMS and makes one wonder why this beer is so popular. I guess it goes to show that not all consumers agree with us brewers, or that the average beer drinker is not keyed into what should offend his palate! Geez, I sound like a beer snob.

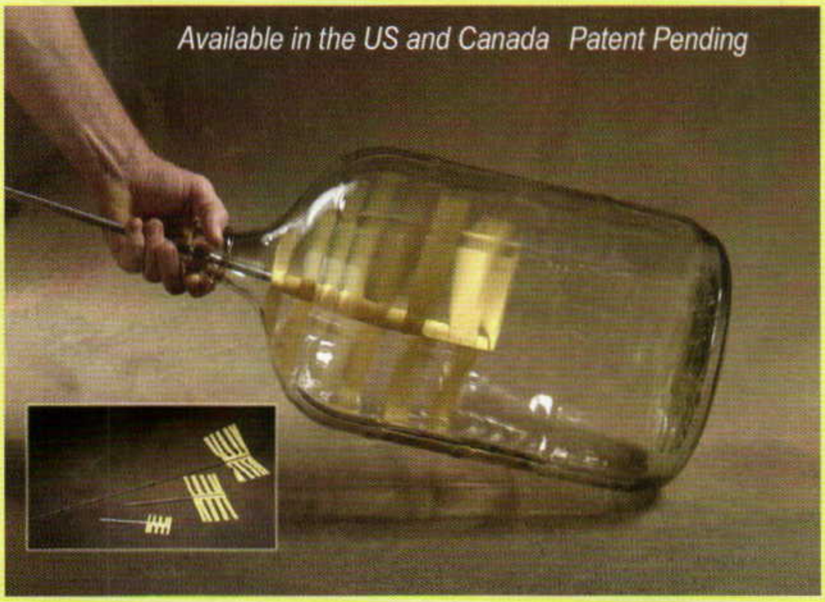
So here's a brief summary. All beer contains DMS and paler beers typically have more than darker beers — because very pale malt is prone to producing DMS-rich beers. DMS comes from SMM and heat is what transforms SMM into DMS. Heat, time and good "stripping" are the keys to DMS removal. Brewers using malt that is high in SMM focus on converting it to DMS and then removing the DMS. Here are some tips to help this reaction:

Extended boiling is very helpful in reducing DMS aromas because it gives DMS more time to leave the wort with steam (this is DMS stripping). I solved a significant DMS problem in the brewery where I work simply by extending the boil from 70 to 90 minutes. Some brewers are afraid that extended boiling will lead to excessive wort darkening. In my experience this is an unfounded concern.

Do not cover your brew kettle during boiling. The idea is to evaporate water during the boil. If you lose too much water during boiling you can always add it back after the boil. Evaporation is good when it comes to DMS removal.

Do not hold hot wort for long periods after the boil. The SMM remaining after the boil will continue converting to DMS in the hot wort. Since the wort is not boiling, the DMS is not evaporated. Cooling the wort as soon as possible following the boil is important with respect to DMS. I answered a similar question to this in the March–April 2003 issue and will avoiding "chewing my cabbage" twice. Cabbage also stinks of DMS to me!

CLEAN IT FAST!



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Mild Ale

An ale for the lady and working man alike

by Horst D. Dornbusch

"Mild ale" has such a gentle and friendly ring. Yet, at one time, this brew was not a beer for the genteel. Rather, it was the beverage of choice of the rough necks of British heavy industry — a real working man's drink, consumed in copious quantities by the steel workers and coal miners of the Midlands and Wales. These toiling chaps needed lots of liquid to replenish the sweat of their brows by which they earned their daily bread. Considering the dangerous rock and the molten metal they had to handle day by day, these fellows just couldn't afford to get drunk on the job. So they imbibed a "mild" ale . . . and the gentle met the tough.

The Partigyle Origins of Mild

The roots of mild ale, however, are not found in heavy industry. Well before the Industrial Revolution of the 19th century — perhaps as early as the 16th century — a milder, weaker version of the regular brown ale was not the drink of the heavy laborer, but of the "fairer" sex, whose members were considered too delicate to handle the rough stuff. Milder, weaker beers were also the preserve of the servants, who were considered too low on the social totem pole to be deserving of the good stuff. Indeed, the forerunner of the mild ale was then a "small" session beer, a brew that one could drink aplenty, without suffering too much harm.

Brew-technically, mild ale probably started out almost inadvertently. Originally, during the old days of partigyle beer-making, mild ale was a brew fermented from the last few, and thus, rather thin runnings of the mash. It was mild and low in strength simply because at the end of the sparge (or after the third, fourth or fifth sparge) there were not too many sugars or flavors left to flush out of the grist. How many runnings a brewer would take, before he called a gyle a mild depended on how the individual brew house was set up.

The grain bed depth and the relative size of the kettle and mash tun plays a role in the number of gyles a brewer can extract from the same mash. In any case, a wort from the final runnings of a mash obviously contains more astringency than normally desired or acceptable. In later years, as mild ale became more firmly established as a separate style, and brewed from scratch for its own sake, the beer also became sweeter in the finish. If brewed in line with the more traditional roots of the style, as we do in our recipes here, the mild ale's malt component, while being somewhat nutty from some amber to dark malts, should also have a slight undercurrent of almost fruity tartness. Because the mild takes its origin as a beer from the final runnings of the partigyle era, as a play on words, we'll call our interpretation of the recipe the End Run Mild.

As a weak beer style, mild ale was clearly a known entity by the time the porter and the pale ale emerged in the 17th and 18th centuries. In fact, some beer historians suggest that mild ale was often one of the foundation "threads" for the early London porters (the other threads often being a middle of the road brown or pale ale and an aged, "stale," and probably slightly oxidized stock ale). Mild ale has always been a relatively cheap brew with a low alcohol content of around 3% ABV — heavier initially and lighter in modern times.

In the evolution of mild ale, color seems to have played less of a defining

Mild Ale by the numbers

OG	1.030–1.032 (7.5–8 °P) rarely up to 1.038 (9.5 °P)
FG	1.008–1.013 (2–3.25 °P) depends on grain bed mix
SRM	approx. 10–25 sometimes darker
IBU	10–20 usually at the lower end
ABV	2.8–3.2% often lower, rarely up to 3.8%

RECIPE

End Run Mild Ale

(5 gallons/19 L, all-grain)
OG = 1.032 FG = 1.008
SRM = 17 IBU = 13–17 ABV = 3.1%

Ingredients

5 lbs. (2.3 kg) pale ale malt (2.5 °L)
0.5 lb. (227 g) CaraPils malt (2 °L)
1 lb. (0.45 kg) amber malt or Munich malt (10 °L)
2 oz. (57 g) chocolate malt (~250 °L)
1 oz. (28 g) black malt (~500 °L)
4.5 AAU Fuggles hops (1.0 oz./17 g of 4.5% AA)
1 tsp Irish moss
Wyeast 1098 (British Ale), White Labs WLP006 (Bedford Ale) or White Labs WLP025 (Southwold Ale)
½-cup priming sugar or DME

Step by Step

For this classic British-style ale use a single step infusion mash of medium thickness at 152 °F (67 °C), which is near the lower end of the diastatic conversion range. This yields more fermentable rather than unfermentable sugars and thus a dryer finish. Let the mash rest for about an hour and then start sparging slowly, for perhaps another hour, until the runnings reach a gravity of about 8 °P (1.008). Sparge with water of roughly 180 °F (82 °C). Check the mash temperature periodically and drop your sparge water temperature if the mash temperature exceeds 170 °F (77 °C).

Boil the wort for about 90 minutes. Add the bittering hops all at once 15 minutes into the boil. You can also split the hops into two equal portions and add the second half anytime between 30 and 60 minutes into the boil. The later you add the second portion of the hops, the more aroma you will get. If you prefer a hoppier brew, you can as much as double any of the hop quantities without harm.

About 10 minutes before shutdown, add 1 teaspoon of Irish moss to the kettle. After shutdown, check the kettle gravity and adjust to reach the beer's original gravity of 8 °P (OG 1.032). Then let the wort rest for about half an hour to allow the trub to settle. Siphon the clarified wort off the debris, heat-exchange it to about 65-70 °F (18-24 °C), aerate the cooled wort and pitch the yeast. Allow the

continued on page 23

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role than other characteristics, which means that mild ales can be almost pale, fairly dark, or anywhere in between. Because of this latitude, I have chosen a middle of the road color value in our recipes of around 16 SRM.

The Modern Mild

Mild ale has been a popular beer style in Britain until roughly the middle of the 20th century, when it started to fall out of favor — in part, because of the growing "invasion" of the British beer market by blond lagers from the continent (namely Europe). Not surprisingly, commercial mild ales now tend to be difficult to find in the New World. Unlike other British ale styles such as pale ale, IPA, porter, Scotch ale and stout, mild ale never acquired much of a market abroad, even during its heyday. Probably the best known and most authentic modern mild — and the one most likely to be distributed in North America — is the slightly dark Highgate Mild from the Bass Highgate Brewery located in Walsall in the English Midlands. This beer has an approximate 3.2% ABV.

Many authors also cite the readily available imported Boddington in a can (with the self-activating nitrogen widget) as a close semblance of a mild, but, subjectively, I find the Boddington's 3.8% ABV just a touch too high. It also has a bit too much hops to be authentic. In addition, its nitro-driven effervescence strikes me as too fine and silky for a true, low-carbonation, "mild" taste. A true mild has its own, gentle carbonation. Boddington does however, have the proper medium body as well as some of the slightly sour, yet nutty, malt flavors that are typical of the style.

The Mild Brewing Process

Depending on the historical sources you consult — and there is no agreement — mild ales should be boiled vigorously. Our mild ale recipes call for a 90-minute boil. If you find your original gravity to be outside the specified range after the boil because of higher than expected evaporation losses, simply liquor down your wort to the proper gravity value (treated

continued from page 21

Mild Ale recipe continued

brew to reach terminal gravity (2–3 days or longer). Let stand for another three days to allow the yeast and cold break to settle out. Rack carefully, prime and package. This beer should condition quickly, within a week to 10 days.

End Run Mild Ale

(5 gallons/19 L, partial mash)
OG = 1.029–1.033 FG = 1.007–1.008
SRM = 16–17 IBU = 13–17
ABV = 2.8–3.2%

Ingredients

- 2.5 lbs. (1.1 kg) pale ale liquid malt extract
- 1.5 lbs. (0.68 kg) dark liquid malt extract
- 0.5 lb. (0.23 kg) amber malt or Munich malt
- 2 oz. (57 g) chocolate malt
- 1 oz. (28 g) black malt
- 1 lb. (0.45 kg) six-row pale malt (optional)
- 4.5 AAU Fuggles hops (1.0 oz./17 g of 4.5% AA)
- 1 tsp Irish moss
- Wyeast 1098 (British Ale), White Labs WLP006 (Bedford Ale) or White Labs WLP025 (Southwold Ale) yeast
- Approx. ½-cup priming sugar or DME

Step by Step

Coarsely mill the 11 oz. (312 g) combination of amber or Munich, chocolate and black malts and place them into a muslin bag. Immerse the bag in cold water and heat slowly, for about 30 minutes to 170–190 °F (77–88 °C).

Discard the bag and mix the liquid with about 4.5 gallons of brewing liquor. Heat the liquor and stir in the two liquid malts. Bring the dissolved malt extract to a boil. Then follow all instructions for the all-grain version.

If you wish to imitate the tannic astringency that would have been present in a traditional partigyle mild from the thin runnings of the mash, boil a pound of un-milled six-row malt in about a gallon (~4 L) of water for about 30 minutes. Strain the grain off the liquid to create an astringent tea. Use the tannic tea as part of the brewing liquor.

End Run Mild Ale

(5 gallons/19 L, extract only)
OG = 1.029–1.033 FG = 1.007–1.008
SRM = 16–17 IBU = 13–17
ABV = 2.8–32%

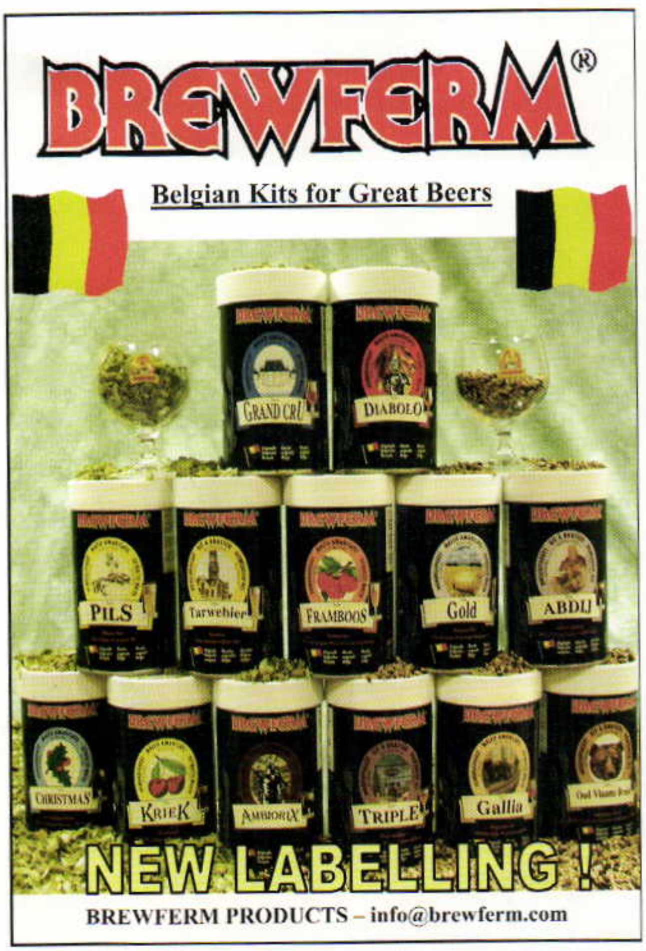
Ingredients

- 3 lbs. (1.36 kg) pale ale liquid malt extract
- 1 lb. (0.45 kg) dark ale liquid malt extract
- 0.4 lb. (180 g) stout malt extract
- 1 lb. (0.45 kg) six-row pale malt (optional)
- 4.5 AAU Fuggles hops (1.0 oz./17 g of 4.5% AA)
- 1 tsp Irish moss
- Wyeast 1098 (British Ale), White Labs WLP006 (Bedford Ale) or White Labs WLP025 (Southwold Ale) yeast
- Approx. ½-cup priming sugar or DME

Step by Step

Heat about 4.5 gallons (~17 L) of brewing liquor. Stir in the three liquid malts. Bring the dissolved malt extract to a boil then follow all instructions for the all-grain version.

If you wish to imitate the tannic astringency that would have been present in a traditional partigyle mild, boil a pound of un-milled six-row malt in about a gallon (~ 4 L) of water for about 30 minutes. Strain the grain off the liquid to create an astringent tea. Use the tannic tea as part of the brewing liquor.



brewing water is referred to as liquor; don't go dumping a bottle of whisky into your kettle — this would certainly throw off your mild ABV!).

Because of the mild's low original gravity, this beer tends to be medium in body, which means it matures fairly quickly. Because of its relative lack of alcohol and hops, the beer does not keep well. After it's been packaged, therefore, consume it within a reasonably short period of time (about a month).

As a low-gravity beer, mild ale must be "mild" in hop bitterness, too. The mild's malt flavor, though not very powerful, must always predominate. This fits well with the mild as an inexpensive brew, because hops have always been a dear commodity in Britain. In the hop department, therefore, the aptly named mild ale bears no surprises: A low dose of East Kent Goldings or Fuggles is the traditional counterpoint to the gentle maltiness. Either hops will do, but if you cannot make up your mind, simply use both (half-and-half). Northern Brewer or Bullion are also suitable. Only a single hop addition, 15 minutes into the boil, is needed for the mild ale. Brewers who wish to experiment with a slightly northwestern touch and a bit more aroma, can split the bittering hops addition. Reduce the initial hops addition of East Kent Goldings and/or Fuggles by one-half and add the remaining hop quantity in the form of Willamette, about 30 and 60 minutes into the boil.

In general, I am all for brewing by the seat of one's pants — it's more fun that way. But when hopping a mild ale, this attitude is inappropriate. Resist the urge to be casual and be precise instead. How often have you measured your hops, grain, or extract, and had just a smidgen left? Not enough to save, really . . . and in it went! "It can't hurt, can it now?" With mild ale, it's different — it really can hurt!

For the mildest milds, you hardly need more than four alpha acid units. With a 4–5% AA Fuggles, for instance (see recipe), you need to measure a mere 1 ounce (28 grams) of hops for a 13–17 IBU, 5-gallon (19-L) brew. If you prefer your mild to be at the hoppier end of the scale, however, simply double the hop amount specified in the recipe.

In a nutshell, making a mild ale is very much like making a thin brown ale, but with the added component of tannin astringency from the grain husks (if you wish to emphasize its traditional, partigyle roots). Mild ale brewers, who aim for traditional authenticity, therefore, need to be rather stingy with their mild-ale grain or extract bill. All-grain brewers should probably over-sparge just a tad to recreate that old-time fruity-astringent flavor, which means you should continue to collect wort until your runnings reach a gravity of perhaps 2 °P (1.008). Extract brewers can imitate the same effect by simply boiling a

pound of six-row malt in about a gallon (~4 L) of water for about 30 minutes to create an astringent tea. Be sure you use six-row barley because of its higher ratio of husks to starches. Strain the grain tea through a sieve and use it as part of the brewing liquor.

Because mild ale does not have much body, it's not very effervescent. (This is perhaps one reason why Boddington uses the nitro-widget.)

> "Making a mild ale is very much like making a thin brown ale, but with the added component of tannin astringency from the grain husks."

If naturally carbonated, mild ale has very little head, which makes it an ideal cask conditioned beer. Use no more than a ½-cup of priming sugar for five gallons of beer. A good way to ensure an even distribution of priming sugar is to add a ¼ teaspoon (level) through a small funnel into each 12-ounce bottle.

Because of the slightly tangy flavor component of the weak mild, its yeast can be somewhat fruity as well. A suitable choice is the dry-fermenting Wyeast 1098 (British Ale) yeast from Whitbread, which imparts slightly tart and fruity components to the brew. You can achieve similar results with the White Labs WLP006 (Bedford Ale) or WLP025 (Southwold Ale) yeasts.

The total grain bill of the End Run Mild Ale is roughly 6.75 lbs. (approximately 3.1 kg). The mash is calculated to yield a wort of 8 °P (OG 1.032) in a system with an extract efficiency of 65%. Whether you brew it for your fair lady (or lad) or as a beer to enjoy after a day in the mines, mild ale is an excellent, quaffable session ale.

Horst Dornbusch is BYO's Style profile author. His article on Trappist ales appeared in the October 2003 issue.

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Steeping some crushed grains in your brewing water is a common way for extract brewers to add flavors and colors to their brews. However, not every grain found at your local homebrew shop can be steeped. Some must be **mashed**. **Steeping** and **mashing** are similar processes if a homebrewer performs a partial mash. (A partial mash is a mash that supplies only a portion of a beer's fermentables. The rest is supplied by malt extract.) Steeping and partial mashing are not, however, identical processes and knowing which grains to **steep** and which need to be **mashed** will lead you to produce better malt extract-based beers.

What's the Difference?

Steeping is the process of soaking crushed grains in hot water to extract flavor and color components. Mashing is the process of soaking crushed grains in hot water to activate enzymes within them. The enzymes catalyze the conversion of starches into sugars. In the process, flavor and color components are also extracted. In both cases we soak the grains in hot water. The difference is whether or not we are activating starch-converting enzymes.

It's All About the Grains

Whether or not a grain can be steeped depends on how it was malted. Grains that have been stewed during malting can be steeped. Likewise, grains that have been kilned at high temperatures can also be steeped.

The most commonly steeped malts are the crystal malts (also called caramel malts). These grains are stewed during malting, then kilned to colors ranging from 10–180 °L. They lend a reddish color and sweet caramel-like flavor to your beer. Most of the starch in these grains is converted to sugar during stewing.

Grains that are kilned at higher temperatures or for longer periods — such as chocolate malt — can also be steeped. Roasted malts tend to be darker than crystal malts and give a darker color and sharper flavor.

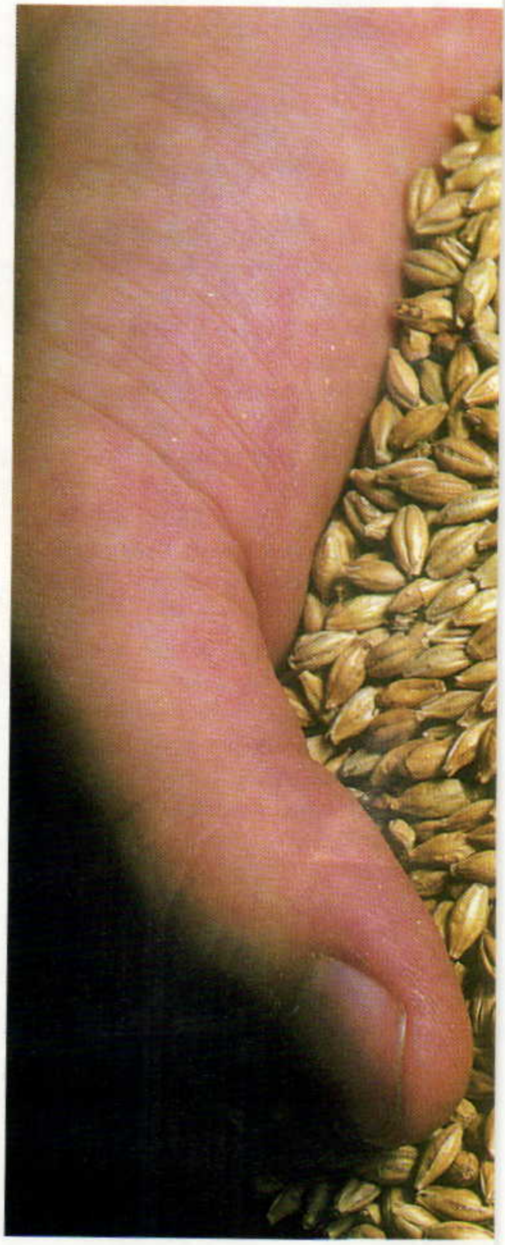
Malts that are not stewed or highly-kilned must be mashed. These malts are called base malts. Base malts require mashing to convert their starches to simpler sugars. If these grains are not mashed, unconverted starches are released into the wort and eventually wind up in your beer. The result is excessive haze and the potential for a "starchy" flavor. Starch can also serve as a potential carbon source for contaminating bacteria or wild yeast strains.

Steeping

When steeping, the temperature of the water is not critical — we are simply soaking the grains to get the color and flavor compounds out. Recipes typically recommend steeping temperatures between 130 °F (54 °C) and 170 °F (77 °C). Anywhere in this range will work, so don't worry about the precise temperature recommended.

The amount of water used is also not critical. As long as there is enough to completely immerse the grains, it doesn't matter if you use a little more or less than recommended. Steeping in larger amounts of water extracts more of the flavor and color from the grains. However, it can also extract tannins and result in an astringent taste in your beer. If you steep your grains in lots of water and taste some astringency in your beers, cut down on the amount of steeping water.

Alternatively, you can steep in the same volume of water if you adjust the pH of the "grain tea" to below 5.8, but



by Don Million

STEEPING vs. Partial Mashing

A guide for extract brewers who use grains

Mmmm . . . grains. They can add color and flavor to your extract-based homebrew. But should you steep this grain or must you mash it? The answer depends on how the grain was treated during malting.

PHOTO BY TODD HAMMOND

not below 5.2, as you steep. Thicker "grain teas" have a better chance of falling into this pH range without any adjustment.

My normal process for steeping grains is this: Heat 3–4 quarts of water per pound of grain (6.3–8.3 L per kg) to 150 °F (65 °C) in your brewpot. Put the grain in a muslin or nylon bag. Soak the grain in the hot water for 15–45 minutes. Remove the bag and place in a large colander. Rinse the bag with 150–170 °F (65–77 °C) brewing water, allowing the runoff to fill the brewpot to the correct amount for boiling. Bring the wort in the kettle to near boiling, add malt extract and proceed boiling.

Cold Steeping

Cold steeping is a variant of the usual homebrew steeping procedure. In cold steeping, specialty grains are steeped between 40–55 °F (4.4–13 °C) for several hours to overnight. Cold steeping is most often used on dark grains and supposedly results in a less

Should I STEEP or should I MASH?

Steep me!

Maltsters have either stewed or roasted these specialty grains. Steep them to add color and flavor to your homebrew.

Crystal malt (10–180 °L)
Caramel malt (10–120 °L)
Special B malt
Chocolate malt
Black patent malt
Roasted barley
Roasted wheat
Roasted rye

Mash me!

These malts contain starch and must be mashed. Mashing — including partial mashing — converts the starches to sugars.

2-row or 6-row pale malt
2-row or 6-row pale ale malt
Pilsner malt
Vienna malt
Munich malt
Wheat malt

If you are unsure what to do with a grain, follow the procedure for partial mashing.

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aggressive flavor from these grains. The "grain tea" from a cold steep can be added at any time during the boil, including late in the boil.

Partial Mashing

Performing a full mash requires equipment beyond that used in normal extract-with-grains brewing. (See "Infusion Mashing" in the March-April 2003 issue for an introduction to full-scale mashing.) However, you can partial mash in your brewpot with just a grain bag.

When you steep grains, the temperature is not that important. In mashing it is critical. A few degrees variation can cause a noticeable difference in the beer. Most mashes rest between 150–158 °F (66–70 °C). (In a single infusion mash, this will be the only rest.) As such, follow the rest temperatures in the recipe exactly, or be sure you understand how to choose your own rest temperatures. Either way, you must carefully control the temperature of the mash.

The volume of water is also more critical when mashing. Recipes typically recommend 1–2 quarts of water per pound of grain (2–4 L per kg). More water results in a mash that converts slower, but produces a more fermentable wort. Less water results in a mash that converts faster but produces less fermentable wort. Again, follow the recipe or be sure you understand the consequences of changes.

When partial mashing, I usually heat 1.5 quarts of water per pound of grain (3.1 L per kg) to about 12 °F (6.7 °C) above the intended rest temperature. As with steeping, I put the crushed grain in a muslin bag and immerse it in the hot water in my brewpot. Unlike with steeping, I monitor the temperature to keep it within a couple degrees of the target. If it is off, I adjust up or down by adding small amounts of boiling water or cold water. You can also heat your brewpot. To do so, add heat for 15–45 seconds then stir the mash and check its temperature in two or three places.

Let the partial mash rest for 45–60 minutes, then lift the grain bag out and rinse with hot (170 °F/77 °C) water. Use approximately as much water for rinsing the grains as you did for mashing them. (The process of rinsing the grains in a mash is called sparging.)

If your partial mash consists of more than a few pounds of grain per 5-gallon (19-L) batch, it will be worth your while to check the pH. You can do so with pH papers or a pH meter. A cooled sample of your wort should register a pH between 5.2 and 5.6.

Mixed Grains

If the recipe calls for both grains that require mashing and grains that can be steeped, mix all the grains together in the mash. There's no need to steep some of the grains and mash others separately, although you can if you wish.

Don Million wrote "Beauty and the Yeast" in the September 2003 issue.

DREW AVIS Merrickville • Ontario

PHOTOS COURTESY OF DREW AVIS

KERMIT

Here is the basic setup pictured in the laundry room/brewery. Every inch of space is utilized with the major appliances serving as stands for the brew kettles. In this particular setup, a GOTT picnic cooler serves as the hot liquor tank (HLT). It's perched atop the dryer along with the control box. The converted keg with the green stripe is being used as the mash/lauter tun, while the other keg is the boiling kettle. Depending on the size of the mash, Drew may use the cooler as the mash/lauter tun and the green striped keg as the HLT. The pump that serves as the heart of the system is placed on an inverted pot placed on the floor.

Drew Avis has gone to great lengths to brew year round in his sometimes frigid home in Ontario. He has your basic big setup, complete with propane burners and converted keg brew kettles. But there are times, too many by his account, when the outside temperature prevents him using the big outdoor rig.

Readers of *BYO* may remember Drew's Split Wort of Increased Gravity (SWIG) method (*BYO* October 2002), where he described a method to brew two different beers at once using a simple setup. He confesses that part of the inspiration behind developing the SWIG method was a need to brew during the colder Canadian months. In keeping with that goal, Drew converted his propane setup into a portable electric brewery that he can set up in the laundry room when needed, and tuck away when he's not brewing.

He calls the setup KERMIT, for Kanadian Electric Recirculating Mash Infusion Technology. By adding a few components, this rimsical system allows Drew to brew in a limited space with many of the components remaining from his bigger setup.

Couplings and Elements
Water in the boiling kettle is heated by a pair of 3000-watt heating elements originally designed for use in a home hot water heater. Drew uses this single kettle in both mashing and sparging, with the pump and plastic tubing carrying the hot water to the HLT and mash tun. Drew sometimes places the mash/lauter tun on the second tier (the dryer) and uses the pump to send hot water from the HLT to the mash/lauter/tun. Wort is then runoff by gravity from the mash/lauter tun to the boiling kettle.

Control Elements
With the help of an experienced electrician, Drew put together a system where the boiling kettle temperature is maintained by heating elements under control of a PID controller. Included in this water resistant boat box are the three main components of the control system: the PID, a solid state relay (SSR), and an RTD temperature sensor. Temperature measurements from the RTD in the kettle are relayed to the PID controller, which trigger the heating elements. The PID provides electricity to the heating elements when an increase in temperature is required. The PID has manual and automatic settings, allowing the brewer to set a target temperature and forget about it, or manually increase power to the heater.

Control Box
With miles of multicolored electrical wire safely stuffed inside the box, the system is ready to monitor and modify temperature in the boiling kettle. The PID, a steal on eBay, is seen on the right. Drew uses a digital thermometer as a backup to the RTD mounted on the keg. A pair of outlets located on the control box is used for powering the pump and Drew's state-of-the-art ventilation system (a box fan pointed toward the bathroom). In a recent upgrade, Drew replaced the stiff household electric wire with more flexible wire for easier storage.

Grain Mill
Drew modified his grain mill by adding a motor to make grinding the grain an easier task.The addition of a wooden box to collect the grist is also a common practice used by many of his club members. What good is speeding up the grinding process with a motor if you end up wasting time sweeping dust and crushed grain off the floor?

Chiller
Seen here is a counterflow chiller, which is used to cool the hot wort prior to pitching the yeast. The tube within a tube design of the chiller allows hot wort to travel in one direction within an inner tube while cold water travels in the opposite direction in the outer tube. Boiling wort is quickly cooled to pitching temperature and is never exposed to air during the cooling process. Drew built this model based on a design by fellow homebrewer Patrick Brochu.

A Place for Everything
What's the use of having a portable electric brewery if you can't stuff it in a box and move it around? The chiller, control box, and rat's nest of wiring fit neatly into a recycling tub. Brewing beer, saving the environment, they are both good things.

Cheers!
Another successful brewing session, with only minor damage to the laundry room carpet. We'd get into innovations in stain removal, but carpet cleaning is not so interesting.

by **Marlon Lang**

BREWING ON Autopilot

The art of CONTROLLING PID controllers

Among avid homebrewers, the true equipment junkies (you know who you are) typically drive an automated system like a RIMS (*R*ecirculating *I*nfusion *M*ash System) or a HERMS (*H*eat *E*xchanger *R*ecirculating *M*ash System). These brewing rigs have pumps that circulate the wort from the mash tun, through a heating device and then back to the tun. The heater is usually either an electric heater, coils immersed in water or a propane burner. The budget conscious brewer can control the wort temperature by manually adjusting the heater. The epitome of automation, however, is a rig that saves effort and adds precision with a PID controller (Proportional Integral Derivative).

If you're thinking about taking the next step and automating your manually controlled rig, then you'll want to know how to get the most use out of your shiny new PID controller box. Unfortunately (and despite what some present-day equipment makers would have you believe) PID tuning is an art, not a science.

Exactly how does changing the amount of P, I or D affect your system? Luckily, you don't need to be a rocket scientist to understand the theory behind PID and, much more importantly, make that knowledge work in your home brewery.


PV 999
SV 250
ENTER
WATLOW
250°F
MICROMEGA
430.6 PV
430.6 SV
Chromalox
80 °F
°C
1000
AUX

Range of Tuning Settings for Some Typical PID TEMPERATURE CONTROLLERS

Brand/Model	P	I	D	Action	Cycle time
Watlow F4S	0-100%	0.1-50 repeats/min 0-999 seconds (alt)	0-999 seconds	Select Heat/Cool	0.1 to 600 seconds
Chromalox 2104 P	0-100%	0.1-50 repeats/min	0-999 seconds,	Select relay contact	0 to 60.0 seconds
SenSource TZN4S	0-100%	0-3600 seconds	0-3600 seconds	Select relay contact	1 to 120 seconds
Omega CN77000	0.5-100%	0-99 repeats/minute	0-999 seconds	Select Heat/Cool	1 to 199 seconds
Love Controls	1-9999	0.1-99 minutes	0.01-99 minutes	Select Heat/Cool	(none)
Brighton AccuCon	0.5-9999	0-999 seconds	0-2500	Select Heat/Cool	(none)

For P settings in percent, a smaller number will increase the P effect. Start with 50%
For P settings not in percent, a larger number will increase the P effect. Start with 2.0
For I settings in seconds/minutes, a larger number will increase the I effect. Start with 0.
For I settings in minutes per repeat, a smaller number will increase the I effect. Start with the largest number available.
For D settings in seconds/minutes, a larger number will increase the D effect. Start with 0.
For Action selection based on Heat/Cool
Use Heat for RIMS heaters run on solid state relays that energize to add heat.
Use Heat for HERMS if you energize the solenoid valve to direct flow into the coil.
For Action selection based on relay contact:
Use Normally Open (NO) for RIMS heaters run on solid state relays that energize to add heat.
Use Normally Open (NO) for HERMS if you energize the solenoid valve to direct flow into the coil.
Cycle times for RIMS heaters with solid state relays should start at 1 minute, and decrease for more precision.
Cycle times for HERMS solenoid valves should start at 5 minutes, but not decrease to less than 30 seconds.

Words to Live By

But first, what exactly is PID? Short for *P*roportional-*I*ntegral-*D*erivative, this term describes the algorithms which the temperature controller uses. To accurately describe the way PID works, we need to be familiar with the following terms:

Process Variable The aspect of the process to be monitored and controlled at a certain value. Also referred to as the process. For this article, the process is your wort's temperature.

Set Point The desired value of the process; also called set. Here the set is your wort's target temperature.

Error The difference between the process value and the set point.

Final Control Element The device that the controller will manipulate to raise or lower the process value. In other words, the heater or the solenoid valve in your rig.

Output The signal from the controller to the final control element.

According to these terms, the automatic controller (your shiny new box) measures the process value (the wort's temperature), compares it to the set (the target temperature), determines the amount of change required and administers it to the final control element (turns the heat on or closes the bypass solenoid valve).

Now, for ideal automated control in home brewing, you want the process to ramp up and slowly settle in at the set without overshooting and overheating the wort. Controllers tuned to achieve this are said to be critically damped. If you're interested in the technical aspect of how that happens, read on. If you just want the practical advice, skip ahead to "Putting It All Into Practice."

A Brief History of Automation

Equipment to perform automatic controls of chemical processes came into use shortly before World War II. The industry soon developed its own argot of acronyms to describe the equipment and its actions. The order of P, I and D reflects successive waves of innovation to these controllers.

Gimme a "P"

One of the earliest terms was proportional band. Abbreviated to PB, it makes up the "P" in PID. Loosely defined, PB means the amount the output of the controller would change to counteract a change of the process. Expressed as a percentage, a 100% PB equals a gain of 1.00. A smaller PB means greater reaction to change, so PB's actions are counter-intuitive. Gain — defined as output change over input change — is now the preferred term.

Pure "P" control action, referred to as P-only, is the simplest and most easily implemented mode. Most early controllers were P-only. One example of P-only control is a basic off/on control system. An electric hot water heater works by P-only, off/on. When the temperature drops below the setting on the thermostat (the controller), the heater turns on until the water temperature exceeds the setting and the heater turns off. Thus, the temperature cycles above and below — but never exactly on — the set.

Gimme an "I"

P-only control will hold the process within a narrow range, but never exactly on the set. Some old operators found that if they reset the set after the controller had settled out, they could get the temperature exactly where it was needed. This "re-setting" led to the term reset. This was the next refinement developed for automatic controllers — integral control, the "I" in PID. Integral control keeps track of the error (the difference between process and set) and compensates by tweaking the output.

Imagine that you are driving a car at 45 mph. As long as you are on a level road, your speed will stay constant. But if you start up a hill without moving your foot (the controller), your car will slow down on the ascent and speed up on the descent. In control theory, that hill is a load change — a disturbance in the conditions under which your process operates. The resulting change in speed is called a droop. Integral control compensates for the droop in P-only controls by keeping track of the change in output when the disturbance first occurred and "integrating the error" into the controller's tuning values. If the hill is sustained, your foot presses constantly harder, adding additional output to bring the speed back to 45 mph.

The integral action will eventually get the process to the set value. However, if the process decides to perversely change in the opposite direction to the previous changes (you go down the hill), the amount of integral action that was affecting the output must be cancelled out before it can be re-set in the right direction. This adverse effect is called wind-up. Slow processes such as temperature control are most always adversely affected by integral action. Integral action causes overshoot and too much integral will cause oscillation.

Gimme a "D"

Early PI controllers would eventually conquer wind-up. But in order to speed up the compensation and keep the process as close to its set value as possible, engineers came up with one final improvement: a control mode that would pre-adjust to load changes.

Let's go back to our car example. You are driving at 45 mph on a level road, but you see a hill coming. You press the accelerator down so that you speed up before reaching the hill; you compensate so exactly that when you crest the hill, you are again going 45 mph. In other words, you anticipated a situation that would change your car's speed and you pre-adjusted to it.

Since the way you adjusted was a function of time and the rate at which the slope of the hill changed, your adjustment was a derivative — the "D" of PID.

Putting it All Into Practice

When you are ready to tune your PID controller, be sure that your rig is functioning correctly. If it is, this method will result in good PID tuning.

Make sure you have paper and a pencil at hand, plus a calculator if you're bad at math, and note your settings for future brewing reference.

Load up your system with water. Set the gain at around 15% of the maximum available. Disable the "I" and "D" parts of your controller. Consult the manufacturer's instructions for your PID controller; if the way to disable "I" and "D" is not clear, then set them to the highest number of seconds. Some controllers have a cycle rate setting. If yours does, set it to 1 minute.

Turn on the pump and start circulating. Put your controller in auto and rapidly raise the set 10 degrees from its current level. Watch the response. If you are using RIMS, the heater should have turned on. If you are using HERMS, the output should have changed the bypass solenoid valve to direct water through the HERMS coil. If it did not do this, the action is reversed. On some units, this is changed by using a positive or negative gain. On other units, there is direction setting. Whichever you have, change it so that heat is added when the set is raised. If the action was correct, did the temperature exceed the set when the temperature stabilized? If not, then double the gain value, cycle the controller to manual then back to auto and try the 10 degree raise again. If it exceeded the set temperature, then halve the gain value, briefly cycle the controller to manual then back to auto and make another 10-degree increase in set. Did the temperature exceed the set? If not, double the gain value. If it did, halve the last gain increase. Repeat this procedure until the temperature exceeds the set by two degrees. The idea here is to slowly increase gain until the response tends to overshoot the set by an amount that you are uncomfortable with.

Now, reduce the gain by half the amount of the last increase. Put the "I" and "D" settings at about 20 minutes. The resulting gain, I and D will be very close. As you brew future batches, gradually tweak the gain up until the overshoot at your final mash temperature is at a level you can tolerate.

My temperature sensor is about halfway down the grain bed. If you are measuring wort liquid in the line, then you will find that a higher setting is necessary to achieve a specific grain temperature. Remember the "Ole Tuner's" mantra: Gain is good; integral is evil.

A Final Word

Don't expect the settings for your brewing buddy's Super Whiz-Bang Temp-o-Matic to work with the same settings as your Maxi-Troll 9000, and vice versa. Each rig has different responses and time constants, so take with a large dose of salt any recommendations made by your equipment junkie friend based on how his system performed. Be very suspicious of settings that have large doses of "I" and "D" and small doses of "P". After all, isn't fine-tuning your personal brewing process a large part of the fun of homebrewing?

Marlon Lang has been a home brewer for 13 years. He works as a control systems consultant.

JUSTIN BRUETT

Lomita • California

Justin's CHEM Setup

Many of the components of the CHEM setup were obtained from industrial salvage yards or conventional retailers and later adapted for brewing. The three half-barrel kegs that make up the backbone of the system are mounted on a piece of kitchen countertop that has been attached to a sturdy, portable frame made of wood. A large ceramic tile under each burner protects the countertop from heat damage, and all brewing vessels are at eye level for safety reasons. A single propane tank located under the counter provides gas to burners located under the hot liquor tank (HLT; left) and the brew kettle (right). Justin plans to add a second tank so that both the HLT and brew kettle will have an independent propane source.

PHOTOS COURTESY OF JUSTIN BRUETT

Justin Bruett has come a long way since his first beer making experience earned him banishment from the kitchen. He still brews, but now uses an eye-popping, custom built rig that he rolls out of the garage when needed. Justin came up with his design for a half barrel modified HERMS setup during a three year stint at a California microbrewery. He calls his single tiered brewing system CHEM, for *C*irculating *H*eat *E*xchanged *M*ash.

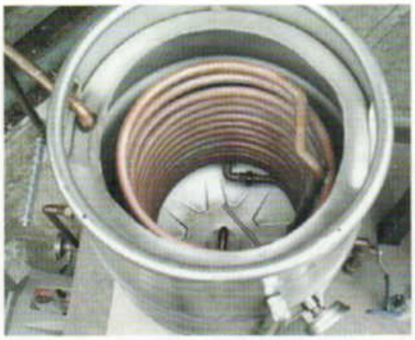
Most RIMS systems have a separate pump and heater to maintain the correct temperature of circulating wort during mashing. This additional heating unit is absent from the CHEM system, as recirculating wort flows through a coil of copper tubing located within the hot liquor tank before returning to the mash/lauter tun. Always looking to improve his brewing system, Justin has several upgrades planned and invites readers to follow his progress at http://just-brew-it.com.

Hot Liquor Tank

The hot liquor tank is the workhorse of the brewing system. Here, water is heated to use in mashing, sparging, to maintain temperature of the heat exchange unit, and for sanitizing many of the brewing components. On the right is one of three handmade sight glasses, used to monitor flow rate.

Heat Exchanger

Within the HLT is a forty foot coil of ⅜" copper tubing that acts as a heat exchange unit during mashing. During the mash, water is once again added to the HLT and heat is applied to ensure that circulating wort returns to the mash tun at the appropriate temperature.

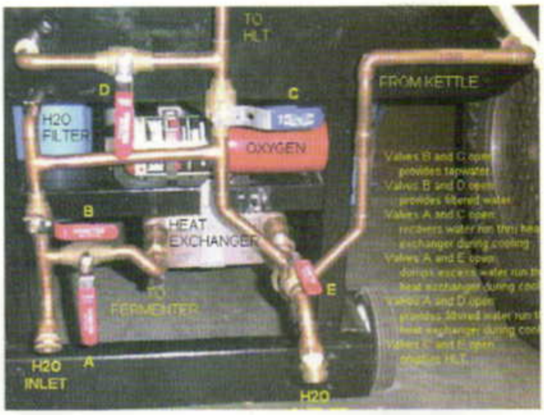


Mash/Lauter Tun

Hot water is pumped from the HLT to the mash tun and allowed to run through the grain bed. A quick disconnect valve inside the mash tun allows for a "spray ball" used to pre-heat the tun during mash-in. A recirculating head can also be attached and submerged to avoid hot side aeration.

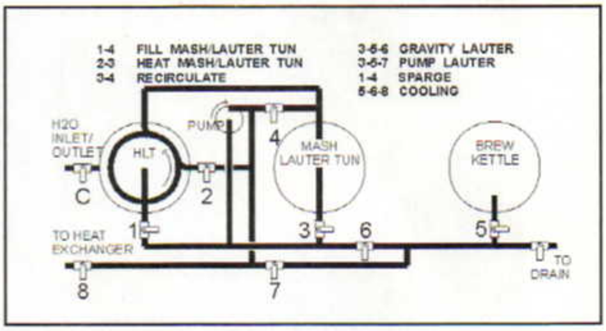
Sight Glass

Justin has incorporated three sight glasses into his setup. This particular homemade device allows him to view the clarity of the hot liquid as it recirculates through the mash tun. A second sight glass lets him monitor the amount of grain passing from the lauter tun to the brew kettle. The third sight glass is located adjacent to the aeration unit and the heat exchanger, and is used to check aeration and flow rate of cooled wort heading to the fermenter. Aeration level is estimated by noting the size and quantity of bubbles passing through the sight glass.



The Works

With the aeration unit removed, you can see the oxygen bottle used for aeration, the heat exchanger used in cooling the wort, and part of the water filtration system. A host of valves, when set correctly, can send water or wort just about anywhere. Excess cooling water can even be used to water nearby plants.



Plumbing Diagram

One way to understand how the system works is to follow the flow of liquid from one brewing vessel to another. For example, to fill the mash tun with hot water from the HLT, turn on the pump and open valves number 1 and 4. To cool the hot wort, open valves 5, 6, and 8 to send the hot liquid from the brew kettle to the heat exchanger located underneath the countertop.

Dumping the Grain

You may have wondered about the large, stainless steel scoop attached to the top of the mash/lauter tun. At the end of the lauter, Justin disconnects the mash/lauter tun plumbing and swings the entire kettle back on a pivot to dump used grains into the trash. He's made a special squeegee that mirrors the shape of the kettle to help facilitate cleaning.

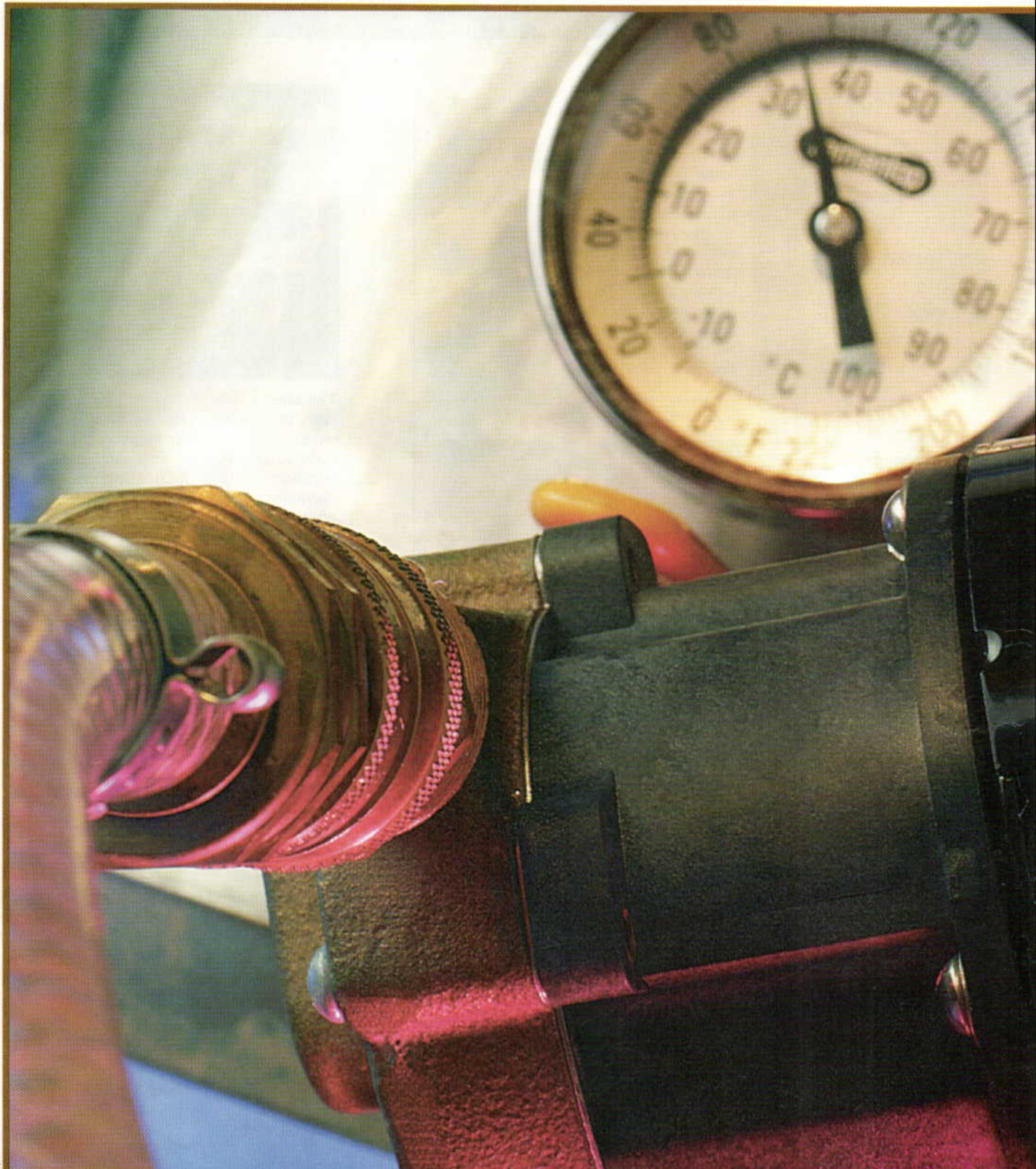


PHOTO BY CHARLES A. PARKER/IMAGES PLUS

MOVE IT!

Transfer water and wort quickly and safely with a **PUMP**

by **THOM CANNELL**

Sumerians, Egyptians and even Sir Isaac Newton approved of gravity as an inexhaustible force for moving things from point "A" to point "B." So, why would homebrewers want to contravene the forces of nature, particularly when nature is free? Well, gravity works only "downhill" and pumps are a labor-saving (and safe) way of moving liquids around your brewery.

Sumerians and Egyptians, brewers that they were, would have loved modern pumps to move beer around the brewhouse instead of buckets. Having a pump means you can move liquids from where they are to where you want them, regardless of elevation. In a homebrewery, pumps are not only a convenience, they can also increase safety because they eliminate the need to lug vessels of hot water or wort around. (And, if you have a bad back or for some other reason shouldn't be lifting heavy loads, they can keep you brewing.)

Homebrew Applications

There are a wide variety of uses for a pump in a homebrewery. If you have a three-tier brewery — a brewery with a hot liquor tank (HLT) above the mash tun, which itself is above the kettle — a pump can move water from ground level to your HLT. If your brewing vessels are all on one level, a pump can move water or wort between them — it can pump hot water from your HLT to your sparge arm and wort from the mash tun to the kettle. A pump is also the "heart" of recirculating homebrew systems such as RIMS and HERMS. Pumps can force beer through filters. Having a pump means you can clean your kettle and other equipment without moving it. This is called clean-in-place (CIP) operation. (See the Projects column in the October 2002, March-April 2003 and September 2003 issues for more uses for a pump.) When using your pump, always ensure that the input and output tubing are securely connected before you start pumping. (Also, prime your pump if required.) If you are pumping hot liquids, ensure that the output end is secured (and not pointing in your direction).

Making the $125-plus commitment to purchase a pump is a serious commitment to brewing whether you are an extract brewer or the most advanced all-grain RIMS-HERMS brewer. But what pump to use? Let BYO give you a guiding hand.

There are many kinds of pumps and they fall into two large families: positive displacement pumps and centrifugal pumps.

Positive Displacement Pumps

Positive displacement (PD) pumps, — whether they move a liquid via vanes, a diaphragm, screws, pistons, gears, tubes or lobes — move their cargo in a similar manner. Liquid flows into the suction (input) side as a cavity expands in size. The liquid is then is forced out as the cavity grows smaller. (As Bart Simpson might say,

In commercial breweries, pumps move liquid through fixed (immovable) pipes. Frequently, professional brewers use clover fittings to connect their pipes.

A typical assembly of stainless steel tubes and clear sight glass. Every commercial brew house I've seen features a sight glass just after the counterflow chiller and filter. The red lever controls inlet of pure oxygen and the sight glass shows the mix of gas and wort.

"These pumps both suck and blow.") By their design, PD pumps are self-priming. Depending on the action of the pump, the output might be continuous or pulsing. If your outlet is far enough from the pump, the pulses will even out.

If you restrict output, a positive displacement pump will try to continue to flow, increasing pressure until something breaks. Large commercial breweries typically use this type of pump, as do some craft breweries and brewpubs. New Belgium brewery, to pick one example, has many peristaltic pumps. (In a peristaltic pump, rotating rollers "massage" liquid through a flexible tube situated around the roller rotor.)

Centrifugal Pumps

Small brewers are more likely to use centrifugal pumps. A centrifugal pump uses an impeller inside a chamber called the volute, with the impeller converting its velocity (spin) into pressure. The shape of the volute forces the liquid to discharge from the pump. While it's tempting to imagine a tiny ox-driven water wheel, the impeller throws liquid out the discharge, it does not "bucket" or "cup" the liquid and lift the liquid out.

A basic centrifugal pump is not self-priming, but additional features can be added to make it so. Some pumps have a method of air elimination. For examples, they may have a valve that allows air to leave, but closes once the pump is primed. Others have bleeder valves to allow manual air bleeding. Self-priming pumps can start a liquid flow, sucking the air out of the line and pulling liquid from a source. For instance, pumping water from a hot liquor tank to a mash tun on the same level. Not having to start a siphon action sucking 170 °F (77 °C) liquid can be a good thing for your lips.

Self-priming pumps are, however, likely to be so tightly constructed that bits of brewing matter — coagulated protein, hops, grains — can jam the pump. Some pumps overcome this by using flexible vanes.

Direct Drive

Most small pumps are usually direct drive. Direct drive means that the motor shaft is connected directly to the impeller. A few types of direct drive pumps don't like to have their output restricted. Low or no flow can result in the motor burning up. But restricting output to prevent a stuck mash is a necessity in a RIMS (*R*ecirculating *I*nfusion *M*ashing *S*ystem). Fortunately, most direct drive pumps are quite happy to run restricted. However, be absolutely certain of this feature should you decide to purchase this kind of pump (I use this type of pump, purchased from a homebrew dealer.)

Magnetic Coupling

Another kind of centrifugal pump mates the impeller to the motor with magnetic force. Magnetically coupled pumps are usually not self-priming; you must fill their inlet line and pump-house with a liquid before applying power. Most brewers say "no problem" and simply locate their pump below the lowest point in their system. Because magnetic pumps do not have the motor physically connected to the pump impeller, they are not harmed by restricting output — for instance a closed ball valve or by debris jamming the impeller. If this happens, the magnetic drive acts as a clutch to prevent overloading and motor burnouts.

Pump Materials

Most pumps are constructed to move commercial fluids like water, oil, corrosives, and other chemicals. Wort is heavier than water (runoff can be up to 1.120+ SG) and acidic with a pH of 5.2. The pump you select should not incorporate cast iron, carbon steel, rubber, or silicone (unless food grade

Buna-N rubber or food grade silicone) in pump house construction. Buna-N rubber cannot, however, be cleaned or sanitized with bleach. Some of these materials give off flavors. Others will not withstand the heat. One good choice would be a pump with a stainless steel impeller and EPDM (Ethylene Propylene Diene Monomer), Viton or silicone elastomers. Most pump seals are made from graphite and use EPDM. That is the sanitary norm.

Two materials are favorites for heat resistant pump construction, stainless steel and polysulfone. Polysulfone is less expensive, but stainless steel is more enduring and more expensive. Look for pumps rated as "food grade" or NSF rated, or USDA rated for food production. However, be aware that these ratings refer only to the impeller, not the seal.

Temperature

Temperature rating is critical in selecting your pump. It must be rated to withstand boiling water (212 °F/ 100 °C). Many pump housings are rated to 150–190 °F (66–88 °C) and are therefore less expensive. Don't be tempted to save 10% and lose the whole investment in your first brewing session.

Power and Head

Horsepower is not really an issue in choosing a pump. Most are powered by electric motors well under ½ horsepower. What is important is the relationship between flow rate (expressed in gallons or liters per minute or hour) and the distance above the pump it can deliver its payload. This is called head.

Head is also the "shut-off-height," the distance above the pump when it no longer delivers liquid. Before purchasing your pump, measure from lowest point in your system, typically the pump itself, to the highest to calculate your needs. For instance, a pump may have a shutoff height of 12.1 feet (3.7 m) and deliver 7.2 gallons per minute (27.25 liters/minute) when the outlet is only 12 inches (304 mm) above the inlet. Required head also must include all sources of pressure drop downstream from the pump. Nozzles, small lines and line length all contribute to head. Calculating the head can be difficult. Just to be safe, add a few feet to your head to account for these things.

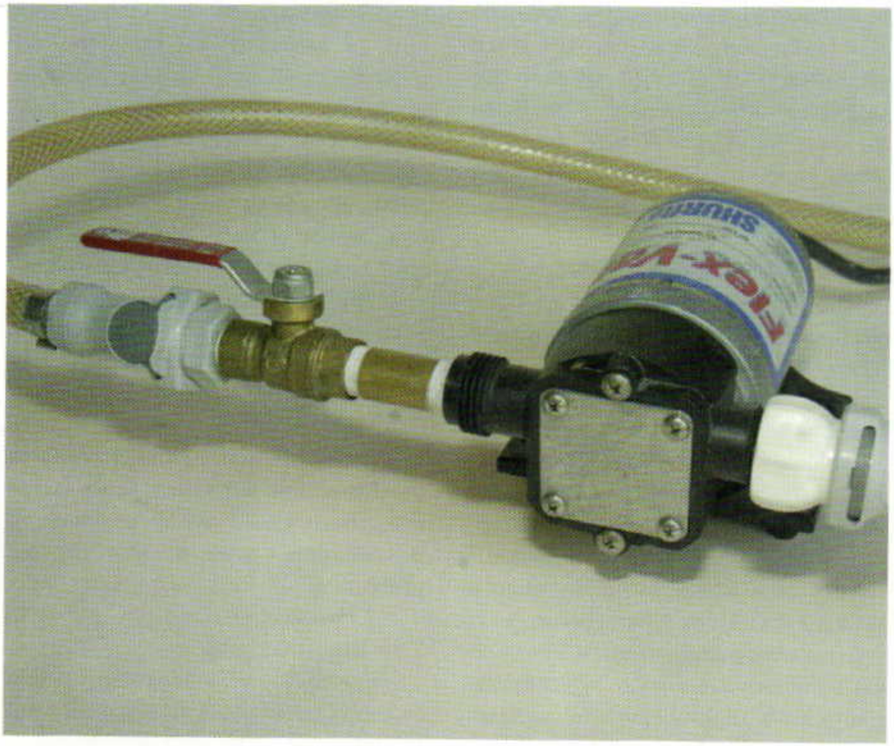
Flow rate and head are inversely proportional; the nearer your outlet is to the pump's shutoff height, the less the flow. For example, if your brewing tree or sculpture measures 12 feet from a bottom-mounted pump to the lip of the hot liquor tank at the top, there could be a problem. If the distance were 8' (2.4 m), no problem at all.

The Ins and Outs

Another consideration when selecting your pump is the location of the inlet and outlet, and how they connect to your hoses. Most pump houses have the inlet 180° opposite the outlet

Scott Isham of Harper's Brew Pub and Restaurant transfers a molasses-infused stout into a conical fermenter. A variety of fittings permit him to redirect the flow around the brewery. Here the first bit of wort is spilled into drains until sanitizing fluids have run out of the transfer tube.

A commercial one-horsepower pump with a center mounted inlet. Unlike with most homebreweries, the vessels and pipes in a commercial brewery never move. This pump is mounted on wheels so it can be moved around the brewhouse and used for different purposes.

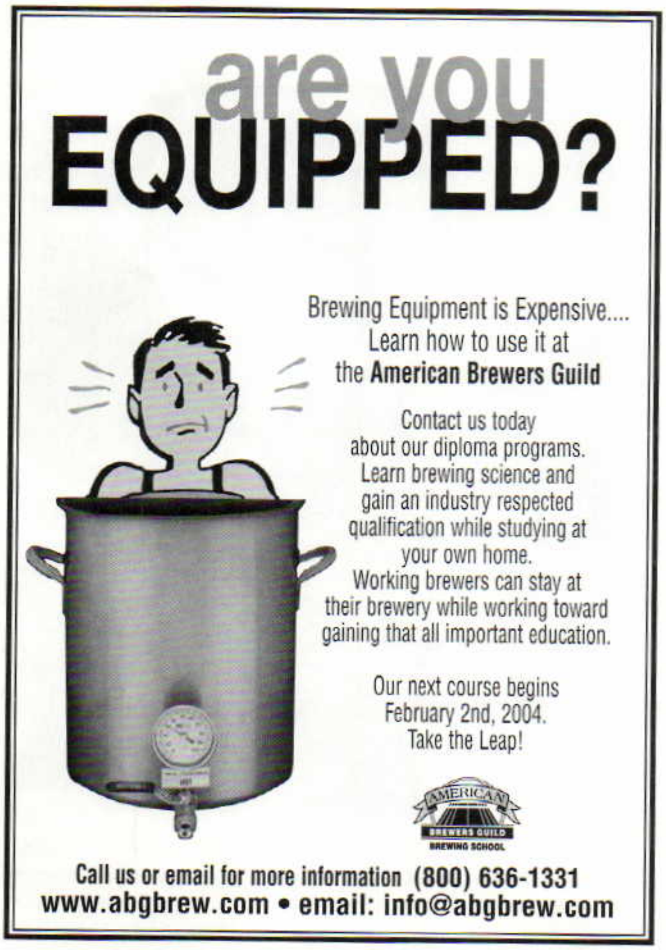


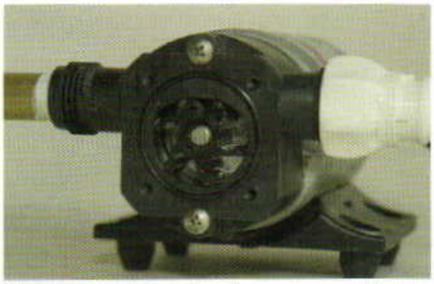
My pump with quick disconnects. Note that on the outlet (ball valve) side a brass nipple is used while at the inlet side a garden hose adapter was chosen. Quick disconnects are very handy, but you will need to use more attention to their cleaning and sanitation.

and can be rotated in 90° increments. Other pumps have inlets mounted directly on the front of the pump house. Most U.S.-sourced pumps have (½") male pipe thread (tapered) inlets and outlets, though some have garden hose threads or smooth surfaces. Professional brewers prefer "tri-clover fittings," which are threadless connectors.

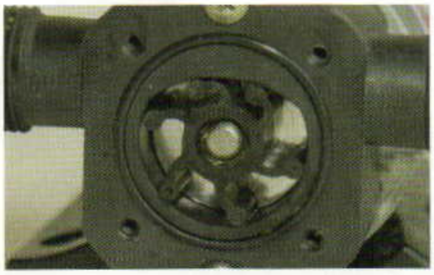
Pumps with tri-clover fittings are considerably more expensive, as are the fittings themselves. Instead of clover fittings, consider using quick disconnects. Be aware, however, that these pose real cleaning problems and may not be sanitary. Quick connect fittings have springs and crevices for wort to hide in and support bacterial growth.

A variety of quick disconnects in either stainless steel or polysulfone are available from home brew stores at a reasonable price. And you'll quickly discover that pumps are most valuable when you can change their use quickly.





Here is my homebrewing pump with the cover removed. Both inlet and outlet are equipped with ½" (13 mm) NPT and garden hose connectors. One of each was used to suit my system.



The impeller (the "spinner" in the middle) and the volute (the space the impeller resides in) are clearly seen once the pump's cover is removed. Note that the rotor is off-center in the volute.

Unscrewing a boiling hot fitting is dangerous as well as painful. If you don't use quick disconnect fittings, be sure to install a drain valve before the pump. Quick disconnects may have automatic shutoff valves; these quickly clog with ordinary brewing debris. Don't purchase this kind of QD. Most polysulfone quick disconnects — the kind I use — have a cross-shaped center support. These, too, clog easily. Like most brewers, I've used a drill to remove this impediment.

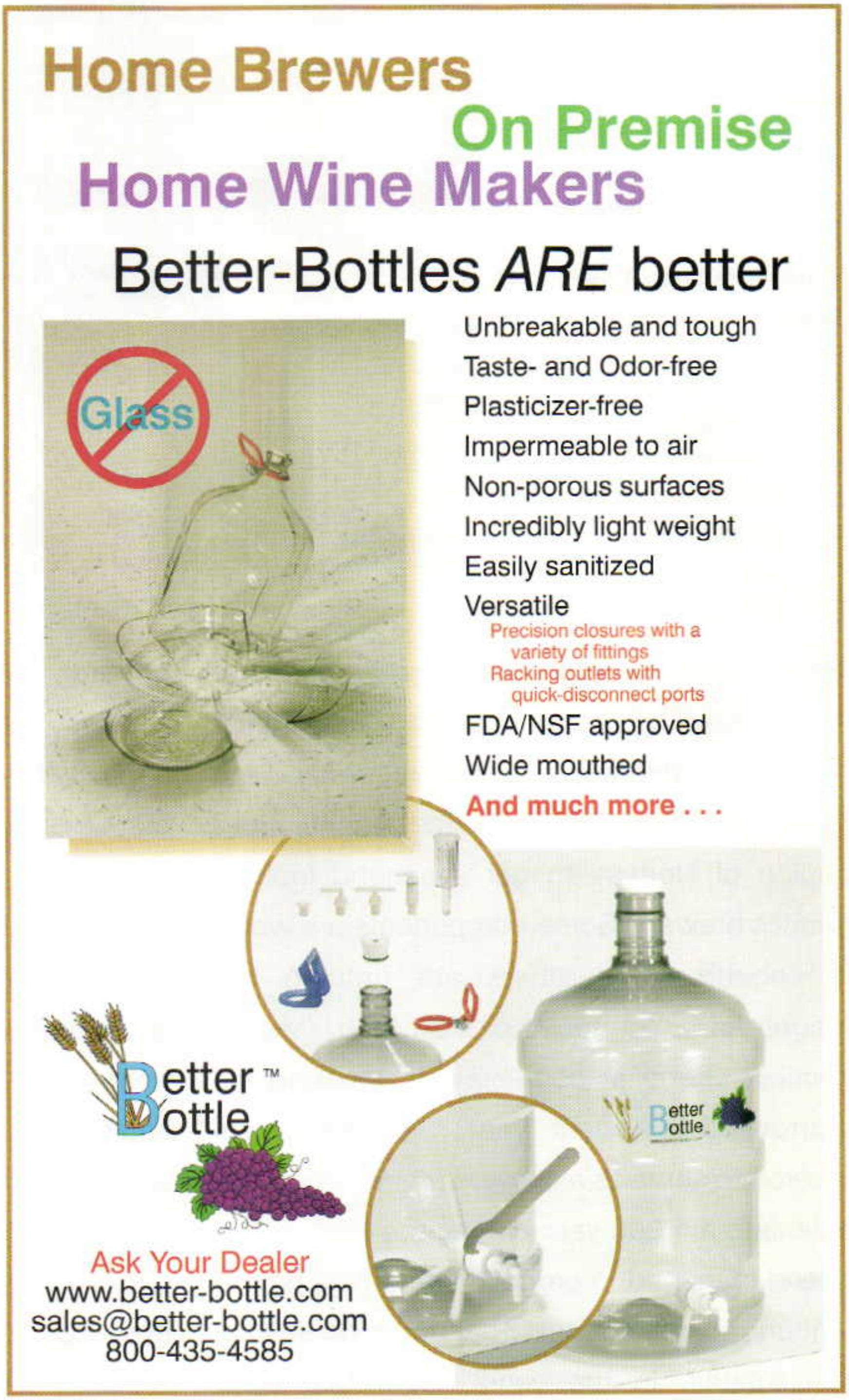
Pumps are available in voltages from 12 VDC to 408 VAC, you should have no problem finding one suited to your voltage. Wash-down duty motors are extremely common and the only type used in most commercial settings. Some pump motors, however, are not in the least water resistant. If you use this type of pump, they should be shielded from water and wort, and the motor should be used on a grounded ground fault interruptive (GFI) circuit to protect your life.

Selecting a Pump

Either a positive displacement pump or centrifugal pump will work in a homebrewery. If you purchase your pump from a homebrew store, they will be aware of the needs of homebrewers. (If the store serves both home brewers and winemakers, make sure you specify the pump is for brewing. Winemakers don't require high-temperature capabilities.)

If you buy your pump from a hardware store or industrial supply catalog, be sure to consider all your requirements — you need a food grade pump that can be used on liquids up to 215 °F (102 °C). The pump should be able to withstand output restriction (be "dead-headed") and handle small amounts of solids (grain bits) without jamming.

Thom Cannell writes the Projects column in each issue of BYO.



MARK BROOKS

Laerdal • Norway

Brewery overview

Mark has managed to pack a lot of equipment into a relatively small brewery. Against the far wall in the center is the mash tun; to the right are three 1000-L (264-gallon) stainless tanks for fermentation and lagering. On the left is his insulated boiling kettle, which began its life as a milk cooler on a dairy farm some thirty years ago. Three 25-kw propane burners within the brew kettle are used to heat the wort to boiling. By using propane burners, Mark can adjust the color and tastes of his beer by letting some of the wort caramelize.

PHOTOS COURTESY OF MARK BROOKS

Regular readers may remember the profile of Mark and his brewery that appeared earlier this year (Homebrew Nation, May-June 2003). We now return to the Sogne Fjord region of Norway to get a second look at Mark's brewery. Some components are worth a second look, others are gracing the pages of *BYO* for the first time. Mark's earliest efforts at beer brewing involved his borrowing an ancient "yeast log" from a local church to serve as a starter culture. Using this relic and a 1,200 year old recipe, Mark and a friend managed to produce something potent enough to inflict a nasty hangover on several classmates. In the years since that early brewing adventure, he has constructed a nearly all-stainless, 1000-L (264 gallon) capacity brewery. Many of the components of Mark's brewery are cast offs from dairies and other food service facilities. Ever the crafty brewer, Mark traded the promise of future beer for materials and services. By his account (see www.Brooks.no), Mark used his homemade beer to barter for various equipment, delivery and welding services, welding supplies, and even a pair of 1000-L (264-gallon) high pressure tanks. His careful design and hard work is paying off. Mark has certainly constructed an impressive brewery, which is sure to make you drool.

Mash Vessel

Seen here is the 800-L (211-gallon) brewing vessel that Mark uses as a mash tun. An auxiliary tank, located just to the right of the mash tun, uses electric heating elements and digital thermostat to generate and control a 120 °C (248 °F) mixture of water and glycol. This mixture is then circulated under pressure through a steam jacket located on the exterior of the mash tun. A second pump clarifies the wort at mash out, as it draws the hot wort from the bottom of the tank and gently returns it to the top of the mash tun through a circular manifold with slotted holes on top. Also seen here is the integrated stirrer which mixes grain and water during the

Wort Collector and Hop Back

The wort collector and the hop back are both nifty peices of equipment to have in your brewery. They are located between the boiling kettle and the plate heat exchanger. Using a hop back allows the brewer to introduce fresh hop aroma at the end of the boil. From here, the hot wort is pumped through the heat exchanger for cooling.

Plate Heat Exchanger

This used heat exchanger, which was another valuable find at a local dairy, is used to cool the hot wort prior to fermentation. Wort from the boiling kettle also passes through a filter at this time. This filter allows Mark to further clarify his wort as it heads into the fermenter.

Oxygen Injector

Like many home brewers and commercial beer makers, Mark aerates the cooled wort prior to fermentation. Using a homemade aerator, sterile oxygen bubbles through a stainless steel air stone and into the cooled wort. Saturating the wort with oxygen is necessary to produce a healthy, vigorously growing yeast culture. An additional benefit from vigorous aeration is the removal of some of the cold trub as it rises to the top of the fermenter and overflows the tank.

Fermenter

This 1000-L (264-gallon) double-walled tank is the site of primary fermentation. Fermentation takes place within the confines of the inner chamber while the outer chamber aids in temperature regulation. Temperature sensors within the fermenter relay information to a PID controller, which can then activate a solenoid valve resulting in the flow of cooled water throughout the outer chamber. In short, when you have a fermenter like this in your home brewery, you know you're on the way to making a lot of good beer.

Three Pressure Tanks

The large steel tanks seen here are used in the production of the finished product from the cooled wort. As primary fermentation starts to slow, beer is pumped from the tank on the right (fermenter) to the secondary fermenter (upper left). The secondary fermenter and bright beer tank use Mylar beer liners. This keeps the beer in a sterile environment and lets you move the beer with air pressure.

The Brewmaster

Mark poses, mash paddle in hand, with his brewery. His kettle is to the left and the mash tun on the right. With all the beer he's promised to people in the dairy industry around Norway, that paddle must get a lot of use.

By COLIN KAMINSKI

REFRACTOmeters

BREWING and the Speed of Light

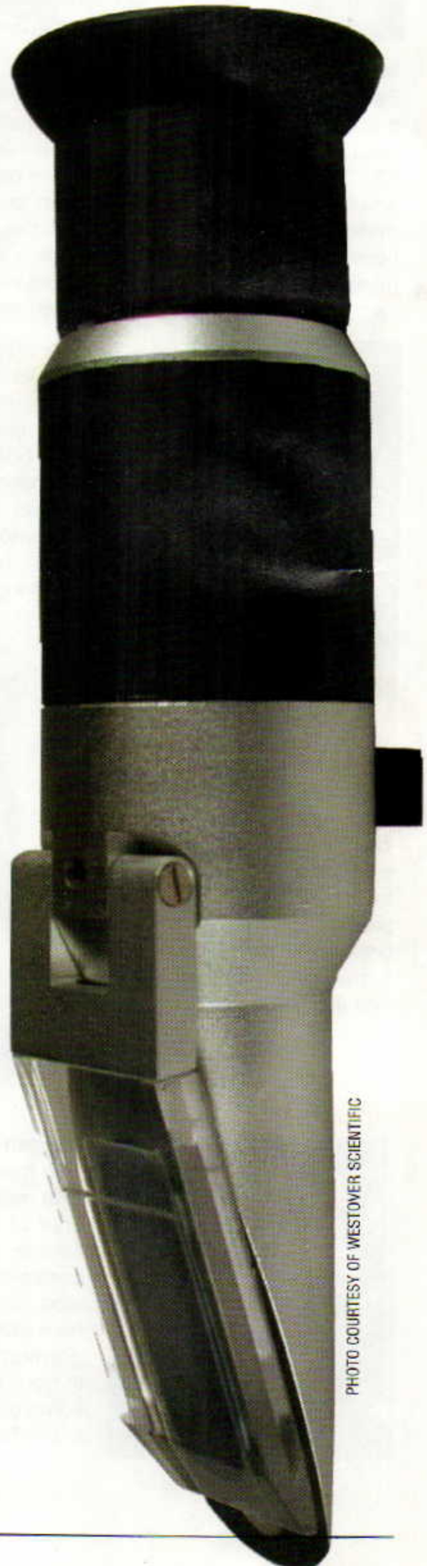


PHOTO COURTESY OF WESTOVER SCIENTIFIC

WHEN LOOKING for consistency in brewing, one of the hardest things to achieve is a reproducible starting gravity. Variations in mill gap, mash temperature, mash thickness, water pH and water salts all play an important role in hitting a consistent starting gravity. One problem with measuring wort gravity during the sparge or boil with a hydrometer is the need to quickly cool a sample large enough for your hydrometer. I was using a one-liter flask in an ice water bath when a friend suggested trying a refractometer. I thought this would be the magic bullet because I only needed a couple of drops of wort to make it work. I quickly found out that while refractometers are very convenient, they require a few mathematical corrections in order to be accurate.

Refractometers are most often used in brewing to obtain quick measures of the specific gravity of unfermented wort. With a little more effort, however, you can obtain information about fermented worts — including finding the alcohol level in your beer and the original gravity from a finished beer! The math involved can be challenging, but there are software programs available that will do the math for you.

Fortunately I found there were many people before me that had done all of the homework in order to make this a convenient instrument to use. Jeffrey Donovan of Sausalito Brewing Company has written a wonderful program called ProMash that — along with numerous other things — includes a refractometer calculator for brewers. I use this program all of the time. Louis Bonham has also searched the professional literature and disseminated a lot of information on refractometry to the homebrewing community.

What is a Refractometer?

A Brix refractometer is an optical instrument that measures the sucrose concentration in a sucrose and water solution as a function of the index of refraction of the solution. The kind of Brix refractometer that most brewers use does not contain any electronic components.

Refraction is what makes a pencil look bent when it is dipped in a glass of water at an angle. The index of refraction is technically the ratio of the speed of light in a vacuum divided by the speed of light in the sample. It is equal to the sine of the angle of incidence (the angle that the light enters the water) divided by the sine of the angle of refraction (the degree to which the light appears bent) of a beam of light. In equation form it is: $RI = \sin(I)/\sin(r)$

If you were to stick a pencil in a series of glasses holding increasingly concentrated sugar water, you would see the pencil apparently bent to a greater degree as the sugar content rose. A refractometer makes this measurement very easy and converts the index of refraction to Brix, which is equal to percent sucrose. The refractometer uses the sample to bend light, projecting a line onto a reticule made up of lines and numbers, allowing us to measure of the angle in which the light was bent.

A refractometer looks like a little telescope. You lift a window and place a drop of fluid inside, wait 30 seconds to allow the refractometer to become thermally stable (also letting the sample spread across the plate uniformly) then read the result in Brix. Brix can be approximately converted to specific gravity (SG) by a simple equation:

$$SG = 1 + (0.004 \times Brix)$$

Most people just remember the multiply by four rule. Take the Brix reading, multiply by 4 and this will give you specific gravity in "gravity points." For example, if you read 11 Brix, multiplying that by 4 yields 44, which corresponds to a specific gravity of 1.044.

A slightly more accurate conversion formula is:

$$SG = 1.000019 + [0.003865613(Brix) + 0.00001296425(Brix) + 0.00000005701128(Brix)]$$

Using this formula, a Brix reading of 11 yields a specific gravity of 1.043.

Choosing a Refractometer

There are many types of refractometers. The type brewers use is the type fruit growers use to measure the sugar concentration in fruit to see if it is ripe. It usually measures 0 to 30 Brix (1.000 to 1.120 SG) and this is a useful range for homebrewing applications. It is important not to get one that measures battery acid or some other chemical solution as it will require unavailable equations to convert to Brix and will likely measure the wrong range of refractive indeces.

Refractometers are available with or without automatic temperature compensation (ATC). ATC is a nice luxury, but not necessary if you use a temperature compensation chart. (In simple refractometers, ATC is done optically — it is not an electronic effect.) They cost anywhere from $75 to $300 depending on quality and features as well as country of origin. I have used the less expensive models with good results. Since the sample has a very small mass compared with the refractometer, it is only the temperature of the refractometer that is important in getting an accurate reading.

Using a Refractometer

Using a refractometer is very simple. You calibrate the refractometer by cleaning the window and placing a drop of distilled or RO water on the glass. Close the cover and make sure the glass has no dry spots or air bubbles. Wait 30 seconds. Hold the refractometer level with the window pointed toward a light source and look into the eyepiece. The meter will show a line between blue and clear. This line will correspond with a scale on the side of the viewing screen. This is where the reading is taken. Then adjust the calibration screw until the meter reads 0 Brix. Once the meter is calibrated, clean the window, place a drop or two of the sample on the window and read the value through the eyepiece.

Temperature Calibration

If you are using a model with ATC, you can simply use the reading you have. If you do not have ATC, then you must use a chart included with the refractometer to get the compensated reading. You simply use the ambient temperature and the reading to get a value that must be added or subtracted from the reading to make the compensation. Do not use any temperature corrections when calibrating your refractometer. Instead, ensure that the calibration is made when the meter is at the correct temperature, 68 °F (20 °C) for most meters.

Understanding the Reading

If a sample is simply sucrose and water, you can take a refractometer reading directly. If, however, you are testing wort — which is mostly maltose — you must make a correction that I call wort calibration.

Wort Calibration

Measurements of the specific gravity of wort using a refractometer will not agree with the measurements of gravity using a hydrometer. Brix refractometers are meant to measure the percentage of sugar in a pure sucrose solution. Since wort is not simply sugar and water, you need to make

PHOTO COURTESY OF VALLEY VINTNERS

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Handheld digital refractometers: These electronic refractometers have a larger range and better precision than standard optical refractometers, but cost more.

Standard optical refractometer: A standard refractometer has a sample window (right) and an eyepiece (left) in which you read your Brix measurement.

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a small correction because of the non-sugar components of the wort. The correction factor is different for different breweries. Beers that are very dark or have a very high starting gravity may also require a different correction factor. To calculate your correction value, measure the specific gravity with your refractometer. Then chill a sample of your wort and measure the gravity with a hydrometer. Convert the hydrometer reading to Brix using the equation: Brix = (SG-1)/0.004. Then divide the reading of the refractometer by your actual hydrometer reading. You should have a number between 1.02 and 1.06. If you do this for several worts and average them, you will get a number that you can use for your brewery. ProMash defaults to 1.04 and this is the number I use. Once you have this number, divide all of your subsequent refractometer readings by your calibration number to get the actual reading. For example, if your reading is 14.6 Brix then your corrected reading is 14.04 Brix (14.6/1.04=14.04). Then, we can convert the measurement in Brix to specific gravity.

Once you've calibrated your refractometer and measured your wort correction factor, you can obtain a measurement of your specific gravity quickly, without having to cool enough wort for a hydrometer sample. You can use the refractometer to measure the gravity of your wort during run-off to help you to decide when to stop sparging. Likewise, you can quickly obtain your gravity anytime during the boil to determine if you need to keep boiling your barleywine or if adding water to your best bitter is in order.

With careful use, a 0–30 Brix refractometer is precise to within 0.2–0.3 Brix. As such, it is less precise than a good hydrometer. However, it can provide a quick measurement of gravity to within about one "gravity point" at times when cooling the wort for a hydrometer sample would take too much time.

Measurement of ABV

This is where it starts to get complicated. Fortunately Louis Bonham did a great job of researching this method for homebrewers. You need to take a reading with the refractometer as well as a hydrometer and use this equation:

$$ABV = [277.8851 - 277.4(SG) + 0.9956(Brix) + 0.00523(Brix^2) + 0.000013(Brix^3)] \times (SG/0.79)$$

In this equation, Brix is the Brix reading of your refractometer and SG is the specific gravity reading from your hydrometer.

If you try this, it is important to take very careful readings. Degas the sample in a blender or by pouring it between two glasses until it does not foam. Make your reading at as close to 68 °F (20 °C) as possible. If your hydrometer is calibrated in Brix, use the longer formula I cited earlier to convert it to SG. This equation fits very well with the data points. Measurement of ABV can be made to within 0.3% if you are careful.

Apparent and Real Extract

What your hydrometer reads is the apparent extract (AE) of your beer. The real extract (RE) is the actual percentage of sugar unfermented. You can measure this by taking the refractometer reading and converting it to refractive index with this equation:

$$RI = 1.33302 + 0.1427193(Brix) + 0.000005791157(Brix^2)$$

Then you need to plug the refractive index (RI) into this equation:

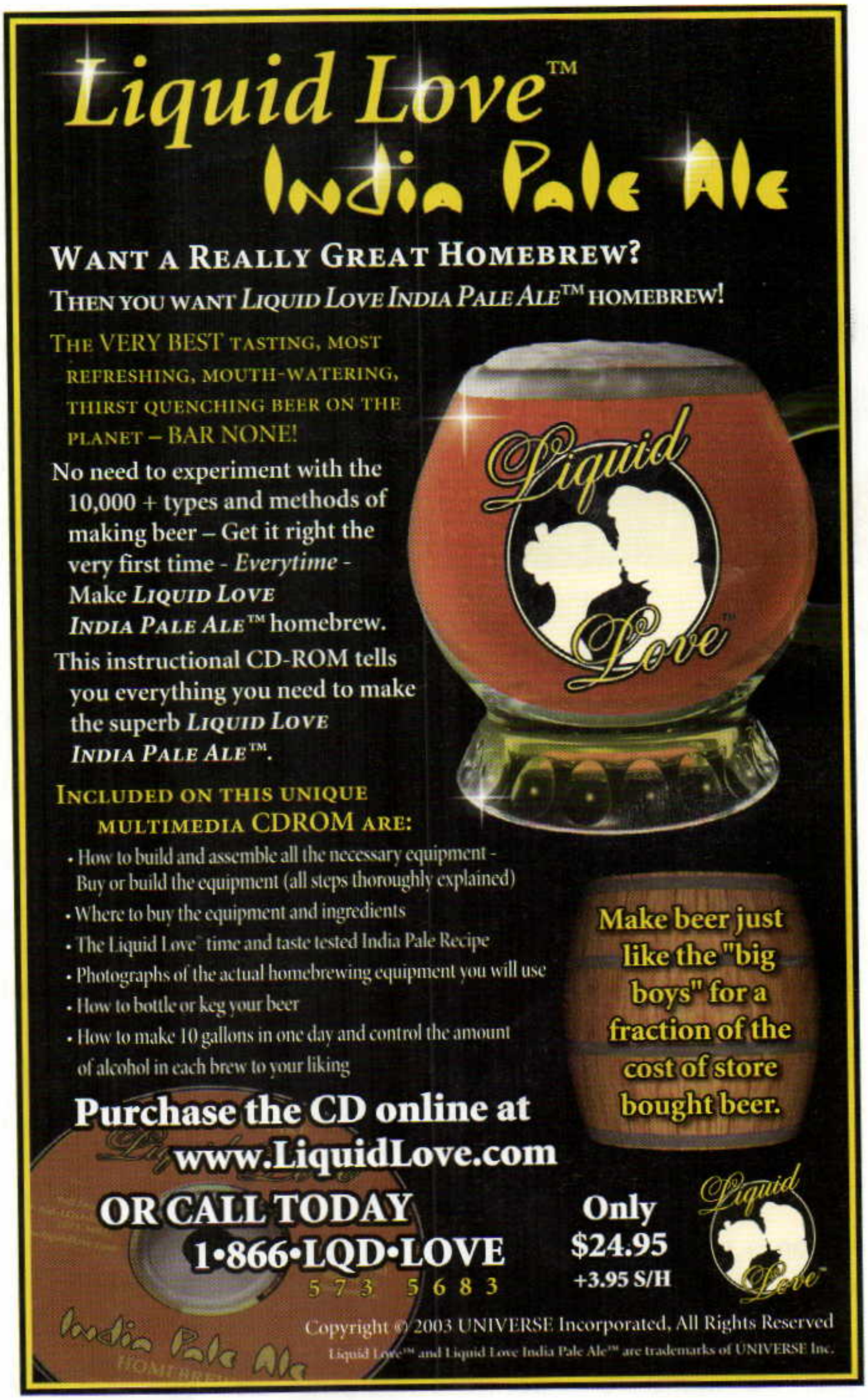
$$RE = 194.5935 + 129.8(SG) + RI[410.8815(RI) - 790.8732]$$

I like to know the RE as I find it correlates better with the perceived sweetness than the AE. If you want to find out the gravity of a fermenting wort and you have previously measured the OG, you can take a refractometer reading from just a couple of drops of fermenting beer and put the results into an equation to get the specific gravity of the beer. This has the advantage of allowing you to find if fermentation is complete without having to gather enough for a hydrometer reading.

It is also possible to find the starting gravity of a fermented beer. Say you have a bottle of Samuel Smith's IPA and you are looking for the starting gravity. You can take a refractometer reading and plug the value into yet another formula. (I use ProMash to make these two calculations.)

I would highly recommend a refractometer as a way to read wort gravity quickly while sparging and boiling — and measuring the ABV of your finished beer. While the equations can be daunting at first, they can be undertaken by anyone with a little high school math. Alternatively one can use brewing software like ProMash or make a spreadsheet to solve them.

Colin Kaminski recently became the Master Brewer at Downtown Joe's Brewpub in Napa, California.



MIKE WHITE

Stillwater • Oklahoma

PHOTOS COURTESY OF MIKE WHITE

Mike's computer-controlled RIMS

Pictured here are the three main brewing vessels used in wort preparation. Mike salvaged four stainless steel Sanke kegs from a local scrapyard in Oklahoma and used a Dremel rotary tool to remove the tops of the kegs. To the left is the boiling kettle, on the right is the hot liquor tank (HLT), and the mash/lauter tun is in the center. The boiling kettle has a pair of 5500-watt (240 volt) heating elements while two 1200-watt (120 volt) elements in the HLT. All heating elements are actually operated at 120 volts, reducing required electricity and minimizing chances of scorching the wort.

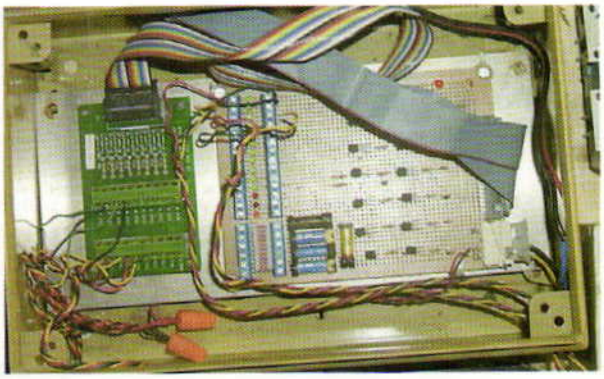
Mike White has realized the dream of college students everywhere; he's found a way to receive academic credits for brewing beer. During the spring semester at Oklahoma State University, this engineer somehow managed to convince his instructor that constructing a brewery was a suitable project for an advanced research course. The goal of his research project was to design and build a recirculating infusion mash system (RIMS) where temperature is controlled through an automated control system. A secondary goal was, of course, to produce some fine homebrew. Mike started brewing just a few years ago. One of his first batches was a memorable brew he simply refers to as "Nasty Ass Ale." With his new brewing system, the days of "nasty" beer are long gone. He put his modest woodworking skills and experience in electrical engineering to the test in constructing his computer controlled RIMS brewery.

Inline RIMS heater
The advantage of using a RIMS system is that wort is clarified by recirculating it through the mash/lauter tun. Liquid drawn from the bottom of the mash/lauter tun is returned to the top of the grain bed several times, producing a clearer wort. For best results, wort temperature should be maintained by either using an independent heating element or a heat exchanger. A pump circulates the wort through this inline heating element. Sensors before and after the RIMS heating element maintain the target temperature.

System Sensors and Controls
Above the three brewing vessels are the various components of the control system. An analog digital input output (ADIO) control board allows the user to automatically monitor and adjust mash temperature using a PC. Input to the ADIO board comes from a control interface board, and output to the heaters passes through a solid state relay. The wood-framed box pictured on the left is a switch box, which allows manual control of pumps, lights and all heating elements.

The Brains of the System
The opened white box to the left contains the solid state relay; to the right are the control interface board and the computer CPU. The small gray box in the foreground is a 12-volt computer power supply used to run one of the pumps and the control interface board.

Solid State Relay Box
Temperature sensors located in the brewing vessels and in the RIMS circuit continually send temperature data to the ADIO board by way of the control interface. When additional heat is needed, the ADIO board directs one or more heating elements to be activated. Temperatures higher than the target temperature will prompt the ADIO board to deactivate heating elements. Since the ADIO board itself cannot handle the heavy voltage load needed to power the heating elements, it controls the elements through a solid state relay. Safely tucked within this nest of wires are the solid state relay, many hazardous 120 volt and 240 volt connections, and a small fan to keep things cool.



Control Interface Board
The low voltage output from the ADIO control board cannot trigger the solid state relay, so an amplifier in this control interface unit boosts the signal. Indicator lights signal when the relay is active, and help in troubleshooting the system.

Old Fridges Never Die
Mike rescued a second-hand fridge and encased it in red oak to make this beautiful kegerator. A hole drilled between the freezer and the main compartment and an added fan keep both sections at around 40 °F. The refrigerator's main compartment can easily fit up to six 5-gallon kegs while the former freezer provides space for bottle storage.

Step Mashing

Multiple rests yield more mash control

Story by Don Million

A single infusion mash is a mash with only one rest, usually between 150–158 °F (65–70 °C), for the conversion of starches into sugar. A rest is simply a span of time during which the mash sits at a (relatively) constant temperature. Step mashing is a mash program in which you rest at multiple temperatures, starting at lower temperatures and moving higher. In step mashing, different enzymes are allowed to work at or near their maximum rate at each step. Doing multiple steps increases the complexity of the mashing process and causes the brew day to take longer. However, step mashing is a more traditional mash program for some styles of beer, for example American lagers. In addition, step mashing can influence mash and wort characteristics such as lauterability and fermentability.

Step mashing: step by step

Malt contains enzymes. If a barley grain was not malted and then mashed, these enzymes would catalyze reactions that would allow the barley grain to grow into a barley plant. (This assumes that environmental conditions were suitable and the barley grain was not from a sterile hybrid.) Different enzymes are most active within different temperatures and pH ranges. (It's interesting to note in passing that the optimal temperatures for many of these enzymes occur in ranges far outside of the range that living barley ever encounters.) Enzymes also have a temperature at which they denature ("unravel" and stop working). The denaturing process is — for most proteins — permanent. Once the mash is heated beyond the denaturing point for a particular enzyme, cooling the mash will not re-activate that enzyme. That is why we step from the lowest temperature to the highest.

Over time, brewers have employed various rests in their mashes. (Incidentally, brewing texts differ on the exact upper and lower ranges of these rests. However, more importantly, enzymes don't read brewing texts — some activity of these enzymes is found outside these ranges.) Here's a quick rundown of different rests:

Forgotten phytase

A rest in the 95–104 °F (35–40 °C) temperature range is called an acid rest. Rests in this range can activate the enzyme phytase, if it is present. However, in many modern malts, it is destroyed during kilning. When present, phytase acts to slowly, produce acid and lower the pH of the mash. Unfortunately, it may take 2–3 hours to do so. These days, commercial breweries have mostly abandoned the acid rest in favor of direct addition of acids, including — in the case of Reinheitsgebot-observant breweries — acids derived from sour mashes.

Chewing on gums

A rest in the 104–122 °F (40–50 °C) range activates the enzyme beta-glucanase. Beta-glucanase breaks down the compounds (beta glucans) that can cause a mash to be gummy. So, a rest in this range is useful if you're using malts that might gum up the mash or if you have encountered troubles during lautering. If resting in this range, brewers will usually rest for 15–30 minutes.

Protein rest in peace

Historically, rests in or around the beta-glucanase range were called the protein rest. The enzymes carboxypeptidase and endopeptidase were thought to be active in the mash within this range. Collectively, these enzymes were called proteases or proteolytic enzymes because they degrade proteins. These days, most commercial brewers do not believe significant protein degradation occurs in mashes held in this range. And, most modern malts have all the necessary protein modification accomplished during malting.

Amazing amylases

Two enzymes — alpha amylase and beta amylase — degrade the large starch molecules found in malted base grains into simpler sugars. Beta amylase's optimal temperature range is 140–149 °F (60–65 °C). Beta amylase

Equation 1 — Correct temperature for strikewater at mash-in

$$T_{strikewater} = \frac{B1+[B3 \times 0.3822 \times (B1-B2)]}{B4 \times 8.3}$$

Given:
B1=desired temperature of first rest (°F)
B2=temperature of dry grist (°F)
B3=weight of grist (lbs.)
B4=volume of strike water desired (gals.)

Equation 2 — Boosting temperature to the next rest

$$Volume_{(qts.)} = \frac{(B1-B2) \times [(0.2 \times B3)+(B4 \times 4)]}{212-B1}$$

Given:
B1=desired temperature of next rest (°F)
B2=current temperature of mash (°F)
B3=weight of grist (lbs.) (same as B3 in Fig. 1)
B4=current volume of water in mash (gals.)

attacks the end of starch molecules. The primary product of beta amylase action on starch is maltose. Alpha amylase is most active at 154–162 °F (68–72 °C) and essentially chops large starch molecules into smaller starch molecules.

The usual temperature for a single infusion mash falls between the optimal ranges for beta-amylase and alpha-amylase. A rest in this range, which usually lasts 45–90 minutes, is often called a saccharification ("sugar making") rest. These enzymes work over a broad range of temperatures and a rest between the optimum ranges of each will result in some activity for both. Since these are the enzymes that produce the sugar that is required for fermentation, a rest somewhere in the range of these two enzymes is the only one that is absolutely required.

A rest in the beta-amylase range encourages highly fermentable wort and a light-bodied, dry-tasting beer. Conversely, skipping the beta-amylase range and resting only in the alpha-amylase range results in less fermentable wort and a fuller-bodied beer. So, depending on the results you want, you can rest once somewhere within the range of both of the saccharification enzymes, or do separate steps for each of them.

Up and out

Finally, raising the temperature of the mash above the saccharification rest — commonly to 168 °F (76 °C) — stops enzyme activity and is called "mash-out." This temperature may be maintained during lautering. A mash-out is not required, but it heats and thins the wort to make lautering easier. It also deactivates the saccharification enzymes so they won't come back into play if the mash cools during lautering.

Get with the program

A mash program can be very simple. For example, a two step mash with a rest in the beta glucanase range followed by a rest in the saccharification range is fairly common. Alternately, brewers can rest at every step detailed earlier. (Some even mash in at around 104 °F (40 °C) and slowly ramp up to 158 °F (70 °C).) The benefits and drawbacks of the myriad of possibilities of

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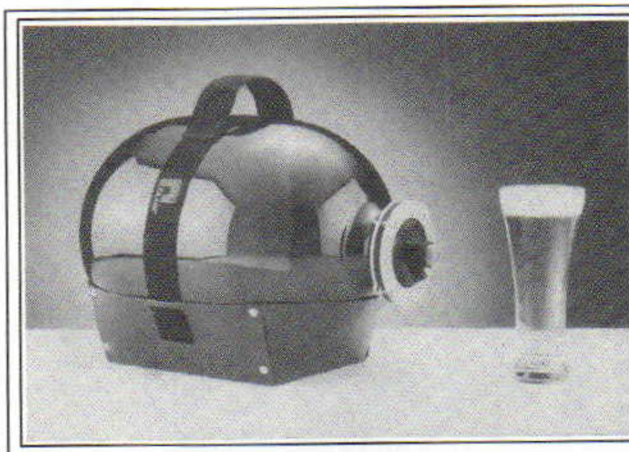

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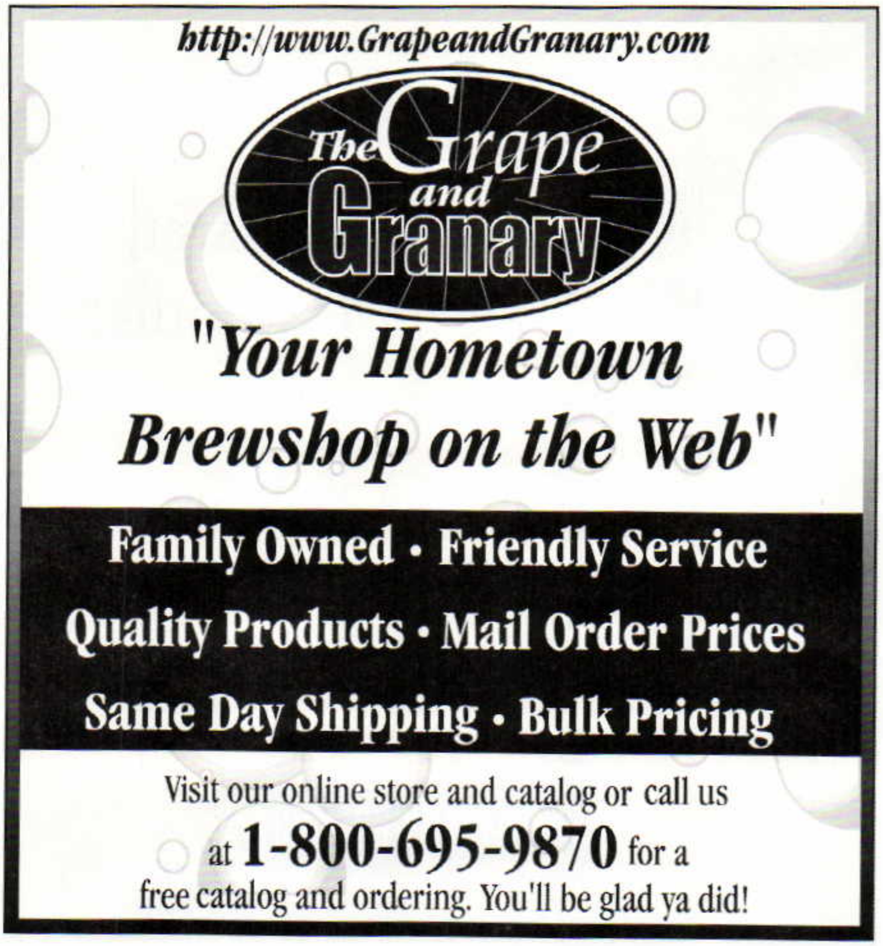
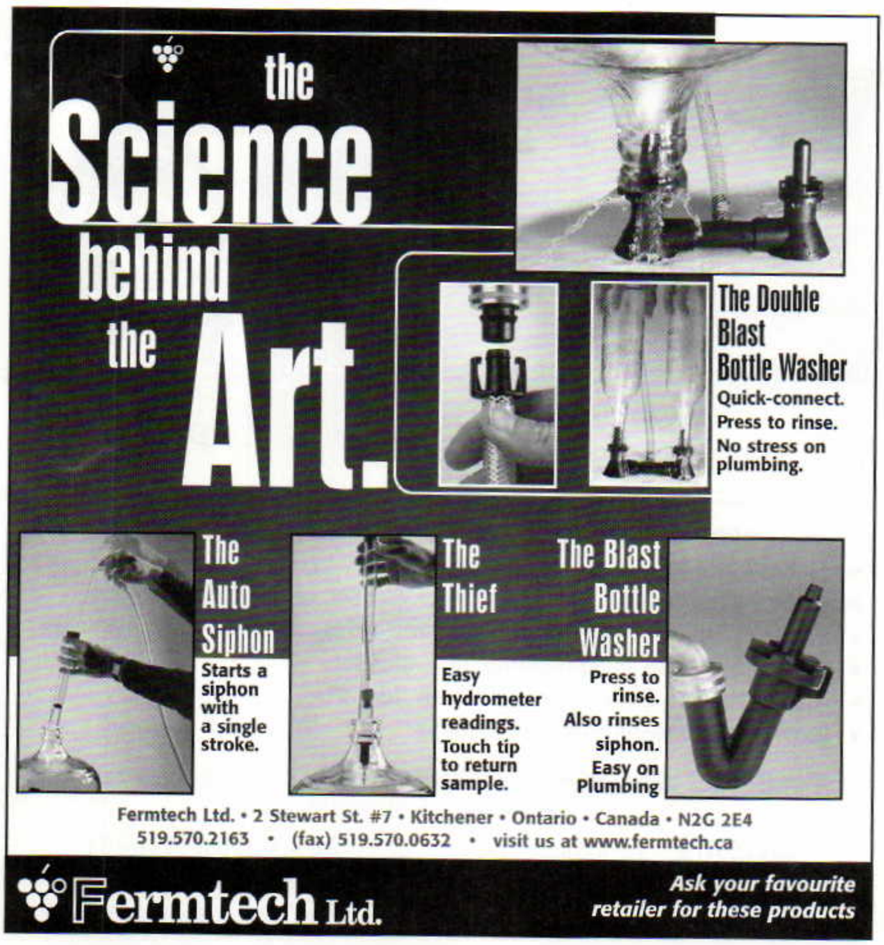




step combinations is beyond the scope of this article.

Step by step

Once you decide on your mash schedule, the next question is how you accomplish the steps. One way is with a process known as a "decoction." Decoction mashing involves boiling a portion of the mash (including the grist) and is complicated enough to need an article of its own (See, for example, "Double Dipping: A Double-Decoction Lesson," February 2001). For that reason, we'll focus on different methods of infusion mashing, in which you increase the temperature by applying direct heat to the mash tun or by adding hot liquor to the mash. (Liquor here means brewing water.)

Step mashing is easy if your mash tun can be heated directly — for instance, if it is a converted keg or metal kettle. These can be equipped with a false bottom or manifold to allow them to serve for both mashing and lautering. Alternately, you can mash in one container and then transfer the mash to a separate lauter tun. Some homebrewers mash in their kettle, then transfer the mash to their lauter tun. Thin mash can be slurry pumped or you can simply use the scoop and dump method.

Either way, directly heating the mash tun is as simple as setting it on the stove or propane burner, raising the temperature to a couple of degrees below your target then turning down the heat. The residual heat in the metal will continue to raise the temperature of the mash for a short time after turning off the heat.

Remember that enzymes are denatured if they get too hot and, once denatured, they cannot be reactivated. For that reason, be careful not to overshoot your target temperatures. Raise the temperature slowly. Your rate of temperature increase should only be a few degrees per minute. Check the temperature frequently at different points in the mash to ensure even heating. Stirring constantly with a mash paddle or large, sturdy spoon will help keep your mash temperature uniform. Once you reach your target temperature, an insulating jacket for the mash tun can be helpful for maintaining that temperature. This can be as simple as a blanket tossed over the tun, or it could be a custom-fit insulating wrap. If your mash tun will fit in your kitchen oven, and if the oven temperature can be turned down low enough, setting the tun in the oven for the duration of the rest will also maintain its temperature.

RIMS/HERMS

Another method for step mashing using direct heating is to use a Recirculating Infusion Mash System (RIMS) or a Heat Exchange Recirculating Mash System (HERMS). These systems use a pump to circulate wort from the bottom of the mash tun (either from under a false bottom or through a manifold), past heating elements to raise or maintain the temperature and then back onto the top of the mash.

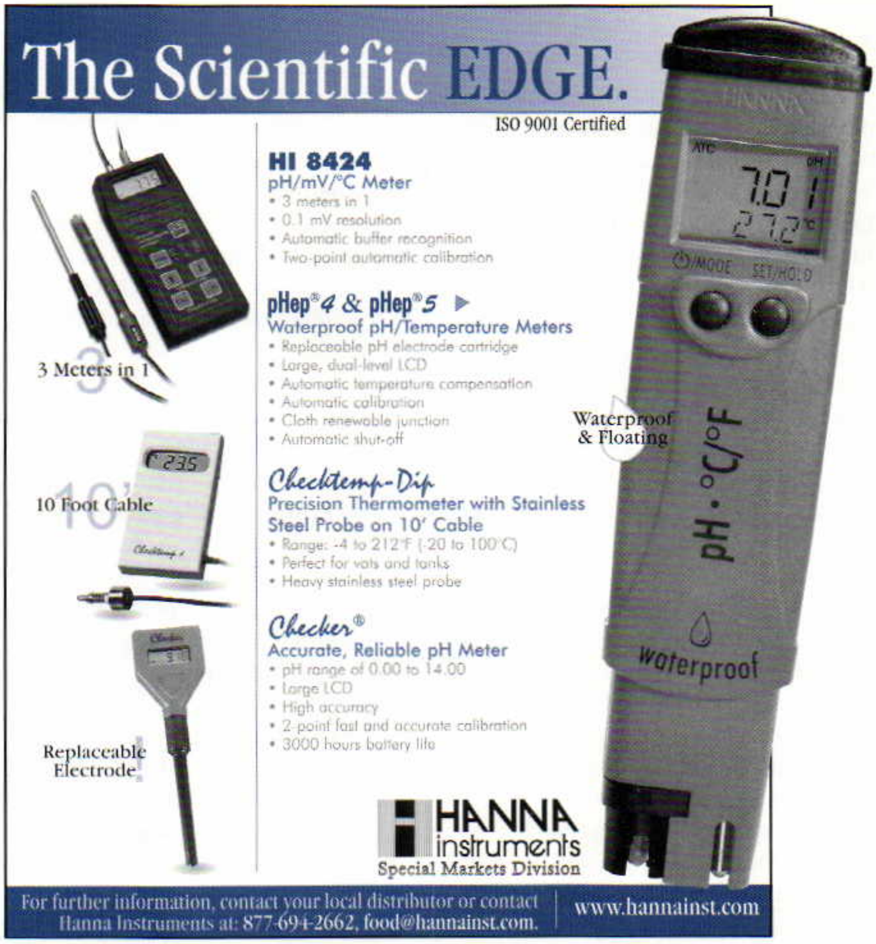
If your mash tun cannot be heated

If you mash in an insulated cooler, a plastic bucket or any container that can't be directly heated, then stepping up the temperature requires you to add just the right amount of hot water to the mash to raise its temperature. A drawback to this method is that your mash becomes progressively thinner as you add more and more water.

Many of the software packages for brewing (like ProMash and SUDS) include calculators to help you determine what "just the right amount" is and the formulas can be easily put into a spreadsheet. First you need to determine the correct temperature for the strike water when doughing-in. This will establish the temperature of your first rest. Equation 1 shows the formula for that calculation.

Once you've doughed-in the grains and stirred them well, check the temperature to make sure it is correct. The formula will get you close, but your mash may end up slightly hot or cold. It is a good idea to have some boiling water and some ice handy for quickly adjusting the temperature up or down.

To raise the mash temperature to the next step, you add a measured amount of boiling water and stir it in



well. Equation 2 shows the formula for determining how much boiling water to add. There are a couple of things to be aware of about the formula in Equation 2. First, the final portion of the formula has you dividing by 212-B1. If you live at an altitude where water does not boil at 212 °F then you have to adjust that. For instance, I live near Denver at about 5,500 ft. of altitude (where water boils at 203 °F), so in my spreadsheet the final division is by 203-B1.

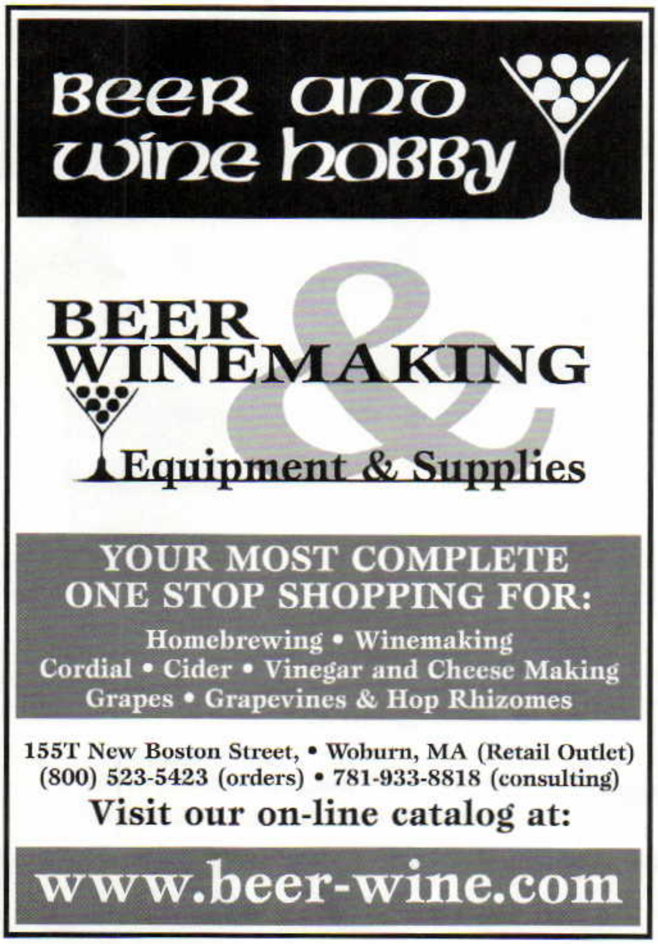
Also, this formula works for any step as long as you adjust all the variables. For instance, when stepping from your initial dough-in to the second rest, the volume of water in the mash (B4) will be whatever your strike water was. For the third rest, though, you have to add your initial strike water plus the volume of boiling water you added to get to your second rest, in order to determine your current volume of water. Likewise, you have to change the value in B2 for the current temperature as you step up. In general, you can assume that the mash will lose only one or two degrees during a rest when you're mashing in an insulated cooler. You may lose another degree or two more if you mash in a plastic bucket. If you open the top to stir and check the temperature too frequently, though, you may lose more than that.

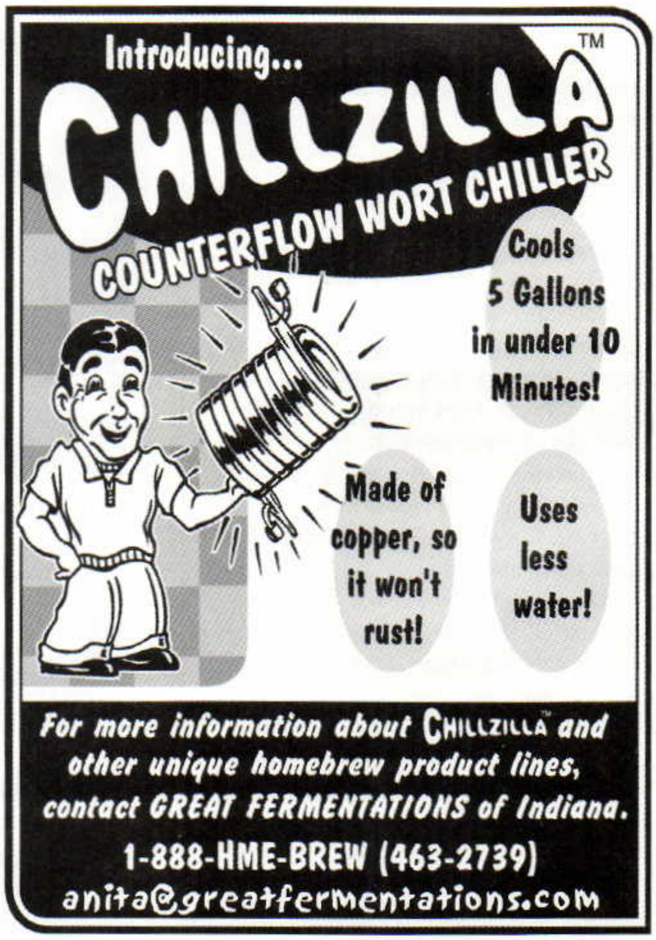
This brings up the question of how to add the boiling water — should you dump in all the water and stir quickly or add slowly, stirring as you go? The second method ends up in a more uniform temperature, but takes longer and risks losing more heat. My personal preference is to dump in all the water and stir quickly, but what's important is what works for you.

As mentioned before, adding water progressively thins the mash. The thickness of the mash, especially at the saccharification stage, affects the fermentability of the wort. Generally speaking, a thinner mash yields more fermentable wort. Also, after several additions of boiling water, the mash tun may become over-filled.

Two solutions exist. Some brewers drain wort from the mash, boil that, and add it back to bring the mash up to the next temperature step. This is not decoction mashing, since you are only boiling liquid wort and not any of the grist. Doing this, however, requires you to subtract the volume of wort that you drain from the previous volume in order to determine how much you have in the mash, which determines how much you should add back and therefore how much you should drain. This is a circular calculation that may require some experimentation to get right. Another approach is to mash in a kettle that can be directly heated, but transfer to a separate lauter tun and raise the temperature with boiling water for mash-out.

Don Million also wrote "Steeping vs. Mashing" on page 26 of this issue.





A Matter of Degrees

Temperature measurement and control

HoMeBreW ScIencE

by Steve Parkes

Brewers long ago realized the important role temperature plays in brewing beer, and have taken steps to measure and control it. Long before the first thermometer was available, early brewers were able to determine the readiness of the brewing liquor by observing their reflection on the surface of the heating liquid. When they could no longer see their face the water was hot enough.

Decoction mashing: early temperature control in mashing

The standard story is that the earliest decoction mashing systems arose out of the need for precise temperature control in the absence of instruments. Mashing at ambient temperature then removing ⅓ of the mash and boiling it before adding it back, and repeating this three times takes the mash through a series of rests that correspond roughly to the temperature optima for the various barley enzymes.

Seasonal brewing: early temperature control in fermentation

In Europe brewing had a season, as warm summer temperatures made the fermentation of lager styles impossible. In the late spring, beers were placed in underground caves packed with ice cut from lakes to keep them fresh throughout the long hot summer. The early history of the United States witnessed many pioneer businessmen who thought it a good idea to ship ice from cold to warm climates. Obviously losses were a huge issue, but many designed and built effective insulated containers.

The rise of refrigeration

In 1842, the American physician John Gorrie, responding to a need to cool sickrooms in a Florida hospital, designed and built an air-cooling apparatus for treating yellow-fever patients. His basic principle which involved compressing a gas, cooling it by sending it through radiating coils, and then expanding it to lower the temperature further, is the one most often used in refrigerators today. Giving up his medical practice to engage in time-consuming experimentation with ice making, he was granted the first U.S. patent for mechanical refrigeration in 1851.

Commercial refrigeration is believed to have been initiated by an American businessperson, Alexander C. Twinning, in 1856 Shortly afterward, an Australian, James Harrison, examined the refrigerators used by Twinning and introduced vapor-compression refrigeration to the brewing and meatpacking industries. Brewing was the first activity in the northern states to use mechanical refrigeration extensively, beginning with an absorption machine used by S. Liebmann's Sons Brewing Company in Brooklyn, New York in 1870. Commercial refrigeration was primarily directed at breweries in the 1870s and by 1891, nearly every brewery was equipped with refrigerating machines. This prompted the spread of lager style beers across the United States as the frontier moved West. In San Francisco an anomaly developed. Popularity of lager style beer outstripped the availability of commercial refrigeration, but the naturally cool climate of the northern California coast led to the development of Steam beers, which are lagers brewed at ale temperatures.

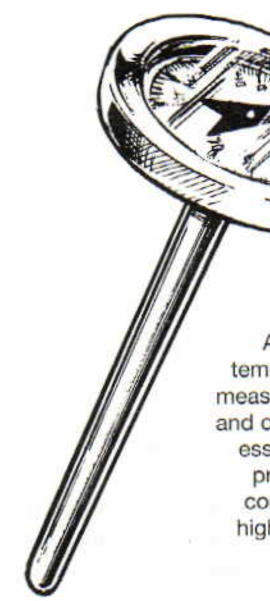
In modern breweries, heating and cooling mechanisms are tightly controlled by various controllers. A first step towards controlling temperature is finding a way to measure it.

What is temperature?

Temperature is technically a property that determines the direction thermal energy will be transferred when an object contacts another object. Thermal energy spontaneously moves from objects of higher temperature to objects of lower temperature. Defining temperature this way is necessary for chemists and physicists. However, as brewers we can use a more colloquial definition of temperature as a measure of how hot something is. A thermometer is, of course, a device which measures temperature.

Measurement of temperature

The measurement of temperature is relatively cheap and easy these days with the wide availability of thermometers. It is wise to understand the limitations of some of the more commonly available thermometers. However, for homebrewers wishing to have better control over their process, the first decision a home brewer should make is what units to use when measuring temperature.



Accurate temperature measurement and control is essential to producing consistent, high-quality beers.

Conversion Factors

Centigrade-Fahrenheit $T_{°C} = T_{°F}(9/5) + 32$

Centrigrade-Raumer $T_{°C} = T_{°R} \times 4/5$

Raumer-Centigrade $T_{°R} = T_{°C} \times 5/4$

Raumer-Fahrenheit $T_{°R} = T_{°F}(9/4) + 32$

Fahrenheit-Centigrade $T_{°F} = -32 \times T_{°C}(5/9)$

Fahrenheit-Raumer $T_{°F} = -32 \times T_{°R}(4/9)$

Various temperature scales

Centigrade Sometimes known as Celsius (after Anders Celsius), this is a metric system that assigns a value of zero to the freezing point of pure water and a value of 100 to the boiling point at sea level of pure water. Each unit between 0 and 100 is called a degree.

Fahrenheit Still used in the U.S. to measure temperature. It assigns values for the boiling point of pure water at sea level at 212° and the freezing point at 32°. Degrees in Fahrenheit are "smaller" as there are 180 degrees between freezing and boiling, compared to 100 in the case of Centigrade.

Kelvin Used in calculations when considering the properties of a physical or engineering system. Absolute zero, the theoretical minimum is 0 K. Freezing point of pure water is 273 K and each individual Kelvin degree is the same as a centigrade degree, $T_K = T_{°C} + 273$. (In the Kelvin scale, the symbol for degree (°) is not used and the unit itself (kelvin) is not capitalized.)

Raumer In central Europe and therefore in some traditional European and North American breweries this scale is still used. Water freezes at 0 degrees and boils at 80 degrees.

Types of thermometers

1. Liquid expansion, in which a liquid (often mercury), iodine, alcohol expands or contracts inside a graduated cylinder

2. Electrical, in which a change in electrical resistance in a small coil of wire is measured. Includes thermocouples, in which the current flowing between two different metals changes relative to the temperature.

3. Metallic expansion, in which differential expansion of two metals causes a metal strip to bend (as in a dial thermometer).

All three types are commonly used in commercial and in home breweries. The liquid in glass is perhaps the most familiar as it is the type most often used around the house. In a commercial brewery and in your home brewery, the accuracy of the mercury in glass thermometer is valuable, but the risk associated with using it directly to measure the brew temperature makes it an unwise choice. These thermometers are fragile and can easily break, so if you are using it to measure the temperature of your mash, your sparge water, your kettle or your fermentation then you risk contaminating the batch with mercury should an accident occur. Of course should this occur the batch should be thrown away immediately and the mercury contained and safely disposed of if possible.

Thermometers must come to thermal equilibrium with the solution they measure before they read accurately. With a mercury thermometer, this may take 15–20 seconds. Electronic thermometers with slim probes ("thermopens") are somewhat expensive, but allow for quick temperature measurements, some within three seconds.

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Calibration

I advocate having a mercury in glass thermometer, and using it to check the accuracy or calibrate the more robust workaday thermometers used in the actual brew. Simply heat some water to the desired temperature range and put both thermometers at a point close to each other in the liquid. Either adjust the bimetal or resistance thermometer until it reads the same as the mercury in glass thermometer, or note the difference and remember to add or subtract it from the reading when using the less accurate thermometer. A glass thermometer that contains a liquid other than mercury may be more useful and slightly safer, but broken glass is still dangerous.

Thermocouples are found in commercial breweries situated in metal housings or "thermowells" in the walls of tanks or pipes. Brewers use them to measure the temperature of the liquid inside the tank or pipework and often link their electrical output to a controller of some kind that can open or close a valve or solenoid. This may allow a heating medium such as steam, or a cooling medium such as iced water or propylene glycol (food grade anti-freeze) to flow through jackets on the tank to heat or cool the liquid inside. More sophisticated home brewing systems may incorporate such devices into the design.

The mash

In previous articles we have discussed at length how temperature will affect the various chemical and biochemical (enzyme) reactions in the brew. The mash temperature is an important part of determining the beer's characteristics as each enzyme responsible for the degradation of the malted barley endosperm material has different optimal temperatures and varying the mash temperature will favor the action of one enzyme over another. For example, in a single temperature infusion mash increasing the mash temperature from 149 to 156 °F (65–69 °C) increased the beer's terminal gravity from 1.008 to 1.014 changing the sensory properties of the beer. The thermometer used to measure the mash temperature should be accurate to at least 1 °F. No use in using the meat thermometer for that task. Also, the temperature in a mash should be checked at more than one spot to ensure that mash temperature is uniform. This is especially important in cases where the mash is not stirred.

The boil

Wort boiling is of slightly less importance when it comes to measuring temperature in that you can see whether it's boiling or it's not. Since wort is a weak sugar solution — or not so weak in the case of some home brews I've tasted — it actually boils a few degrees above the boiling point of water. Of course if you're brewing at altitude elevation, say in Denver, then the boiling point of wort is lower than

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Dealer inquiries welcome. Fax an information request to 562-377-0290, or email sales@zymico.com it is at sea level. The reactions that lead to protein and tannin coagulation are temperature dependent, as are the reactions that lead to DMS volatilization, so it is wise to boil your wort slightly longer. (For example, 2 hours rather than 90 minutes).

Wort cooling

The wort must be cooled to the appropriate temperature for fermentation and maintained there despite the yeast's best efforts to increase the temperature of its surroundings by giving off heat during growth and active fermentation. Again accuracy in measuring the fermentation temperature is key so a thermometer that can measure accurately within 1 °F is a good investment.

Once wort is cooled to around 140 °F (60 °C), it is susceptible to wort-spoiling bacteria. When measuring cooling wort, be sure to use a clean, sanitized thermometer to avoid contaminating it.

Fermentation

It is possible to purchase good quality temperature regulators that can be used in a commercial fridge or freezer to create a consistent temperature fermentation. The one I use has a dial to set the desired temperature, and a bimetal thermometer that goes in the fridge. The fridge plugs into it and the controller plugs into the wall. The fridge simply turns on and off to adjust the temperature as needed.

Less sophisticated methods include using the physics of evaporation to cool fermentation carboys or barrels. Simply wrapping the container in a wet towel and blowing air over it with a fan provides a degree or two of cooling. Fermentation temperature is vital for consistency, which is why commercial brewers really need to focus on temperature control. Wort is collected at the same temperature every time and carefully controlled during primary fermentation. A small increase in temperature can lead to a large increase in some of the metabolic pathways yeast use, for instance one experiment shows increasing fermentation temperature of a lager beer from 46 to 54 °F (8 to 12 °C) almost tripled the ester content of the beer. (Esters are responsible for fruity flavors.) When beer is subsequently aged the ageing temperature is important in determining the beer's flavor and clarity.

If you use a temperature-controlled fermentation — such as a chest freezer or heated box — be aware that the temperature of your beer may be different than the temperature of the chamber. This is especially true early in fermentation or with high-gravity fermentations. Temperature-sensitive strips affixed to carboys aren't very accurate, but they can alert you if the heat of the fermentation is causing wort temperature to greatly exceed ambient temperature in the chamber.

Steve Parkes writes the Homebrew Science column in each issue of BYO.

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Carboy Dryer

Upend your carboys and walk away

story and photos by Thom Cannell

My friend Tom Hughes and I were judging at the World Expo of Beer in Frankenmuth, Michigan this Spring. Tom raised a glass of pale gold and an appropriately cloudy Style 19B, Belgian and French Wit Beer. He took a sniff, a taste, scribbled some notes and said "Thom, I've made something pretty neat that I think would make a good Project for the magazine."

It wasn't the beer that made me perk up my ears, though drinking good beer always makes conversation better. No, Tom's a damn good brewer and a craftsman as well. I was intrigued and between flights of strong Belgian ale, lambic, and German amber lagers asked him to describe his innovation, a carboy drying rack. "I saw some left over 10" PVC pipe, just pieces of scrap, and thought I could devise a good way to safely upend my carboys while they dried," he told me.

Tom had taken 6" tall (150 mm) pieces of 10" diameter (305 mm) PVC pipe, drilled vents into the column with a 4" (200 mm) hole saw, then covered the upper edge with ½" (13 mm) rubber hose. "The holes double as handles while providing plenty of air flow," he explained between judging assignments. "The rubber hose provides a

PARTS LIST

hole saw 4" (200 mm) and mandrill (or cut with saber saw)	$28.57
buckets, 10" diameter	2@ $1.25
plywood base, 12" x 24" x ¾" (305 mm x 610 mm x 20 mm)	$5.50
plywood back, 24" x 24" x ¾" (610 mm x 610 mm x 20 mm)	$5.50
plywood "T" 12" x 24" x ¾" (305 mm x 610 mm x 20 mm)	$5.50
cleat(s) 2 (back) - ¾" x ¾" x 12" (20 mm x 20 mm x 305 mm)	$1.00 (for all)
cleat 1 (T) ¾" x ¾" x 24" (20 mm x 20 mm x 610 mm)	
bungee cord	$1.50

OTHER TOOLS:
½" (13 mm) drill bit, rough file and sandpaper, hammer, saw, drill motor, table saw (or purchase precut), glue, rustproof deck screws

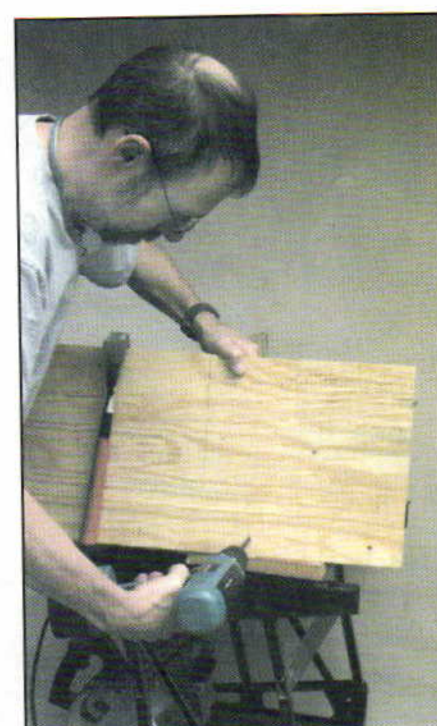
This homebrew innovation allows you to upend two carboys simultaneously and leave them unattended to dry.

These inexpensive buckets that are 10" in diameter provide excellent support and drainage for the carboys.

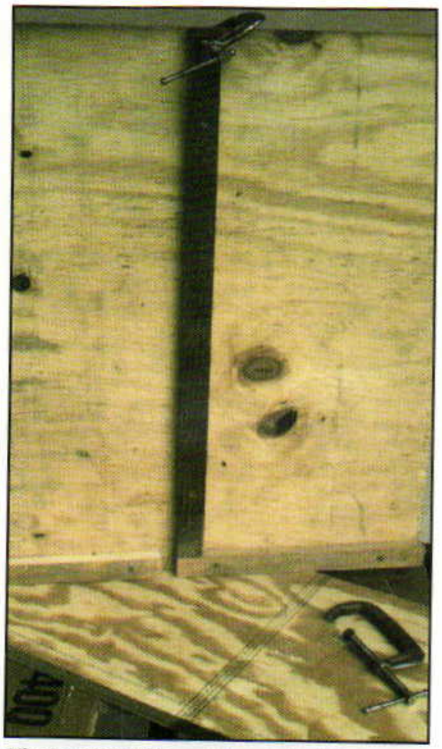
nice soft bump stop and an anti-skid surface to ensure the carboy stays upright. I haven't had any problems with them tottering." The photo he sent convinced me I should present his idea as a *BYO* Project, with our usual modifications.

Modify this easy project? Yep; unless you work in commercial plumbing there's no way to obtain 10" PVC. If you have access to this material (perhaps a subdivision or industrial complex is being built near you) you may be able to negotiate a foot or two in return for a couple of sixers. My local plumbing supply house, the kind that only wholesales to plumbers, doesn't even stock this stuff — they informed me that any scrap big enough to make a joint out of is saved.

A router can be used to round out the edges of the plywood. A light sanding is also recommended.



Predrilling depressions for screw heads (countersinking) insures tight joints and a smooth, snag-free surface.



The back wall is constructed with a vertical cleat (dark) and two cleats attached at the bottom.

What to do? I liked the idea and started combing home stores, kitchen and bath stores, and discount stores for a suitable 10" cylinder. I examined cardboard concrete forms; they were too flimsy. Wastebaskets, which I was sure would provide a solution, were a no-go. There was not a cylindrical wastebasket to be found, and most were woefully thin. But at Target I found the best deal — cleaning buckets that were exactly 10" in interior diameter, had a wide lip, and could be easily shaped or cut. They had walls thinner than I wanted, but have proven to be adequately sturdy.

I wanted to be able to dry two carboys simultaneously, and to ensure they could drain unattended. Who wants to stand around the brewhouse for hours while water drips? I also have a rambunctious male Abyssinian cat who will undoubtedly jump atop anything new and interesting. He's already defenestrated several choice vases, knocked over lamps and tables, and perches atop any open door he can jump to. I needed a reliable, foolproof method of securing the carboys while upended and vulnerable.

The basic concept remains Tom's: a cylinder, ventilation holes and a support lip. I added a "corner" for each of two carboys and a wide base that will hold the entire apparatus. Construction begins after you obtain two buckets or any sturdy 10" cylinder. Why 10"? Most 5-gallon (20 L) carboys are a bit over 10" (250 mm) in diameter (6–7 gallon fermenters measure about 11" (280 mm) in diameter and are firmly and safely supported by the smaller diameter buckets.)

Step One: Cut ½ or ¾" plywood (12-20 mm) into a base large enough for two carboys: 12" x 24" (305 x 610 mm) will suffice. I'd suggest not using any type of particleboard or man-made material as water will inevitably warp and destroy it (unless your chosen material is specifically sold as waterproof). Even

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plywood should be sealed and painted to prevent eventual warping and delamination. If you don't have a power saw, most home stores and lumber yards will cut to size, often for free if you visit when they're not busy. For support, form a corner for each carboy by building a back for the base, and a "T" in the center.

Step Two: Cut another 24" x 24" back and a 12" x 24" piece for the "T." (The actual size would be 11 ¼" if you use a ¾" plywood back. Do the arithmetic, it will be dependent on the thickness of whatever plywood you choose.)

Step Three: Cut or purchase cleat material roughly ¾" square. Cleats will provide a nail/screw surface for the back and "T." You need two cleats for the back, one for the upright T.

Step Four: On the base, draw a line defining the location and thickness of the back wall parallel to the rear edge, and another line that's perpendicular to the rear edge. This defines the position of the T. Remember to allow for the T's thickness. Transfer similar lines to the wall surface; one line defining the cleat, and a center line(s) equal to the T's thickness.

Note: Once all the layout lines were applied to the base, wall, and T, I used a router to round off any edge that would be handled. All surfaces were lightly sanded. I also drilled a ⅜" hole at the corners of the wall and rounded them. Always wear eye and hearing protection and follow safety procedures for your power tools, particularly routers and table saws.

Step Five: Nail and glue one cleat on either side of the center/T line on the back. It's easier to put the necessary cleats on the back rather than the base, and attach the back and T from beneath (it's much easier). Pre-drill screws with a 7/32" drill bit and counter

Use a framing square to ensure right angles. Also, be sure to measure edge-to-center distances accurately.

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All the pieces are dry fit and clamped prior to final attachment. Predrilling will prevent screws from splitting the cleats.

Use a hole saw or saber saw to cut 4" holes in the bucket for ventilation.

sink the heads or the thin cleats will likely split.

Step Six: Attach the long cleat to a tall edge of the "T" with glue and nails or rust proof screws. Let dry. Remember to countersink the heads of the screws here as well to avoid splitting the cleats.

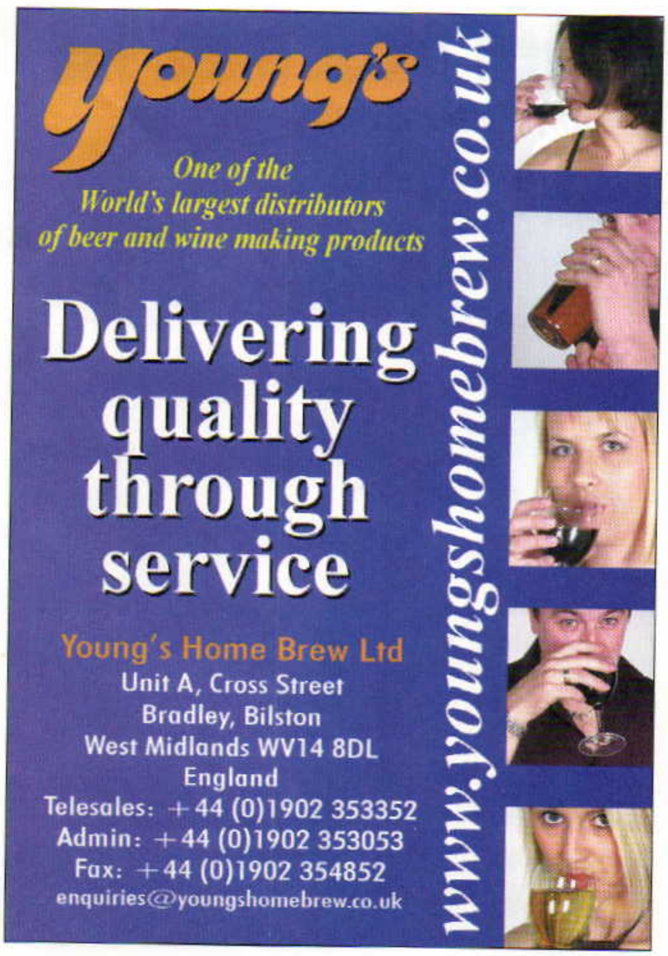
Step Seven: Attach the wall and the T to the base with rust proof screws. Screw the wall's cleats from beneath; clamp the wall, pre-drill 3/32" pilot holes and countersink. Do the same for the T where it meets the wall. Use a framing square to insure that it's squared. Be sure to measure your edge-to-center distances accurately.

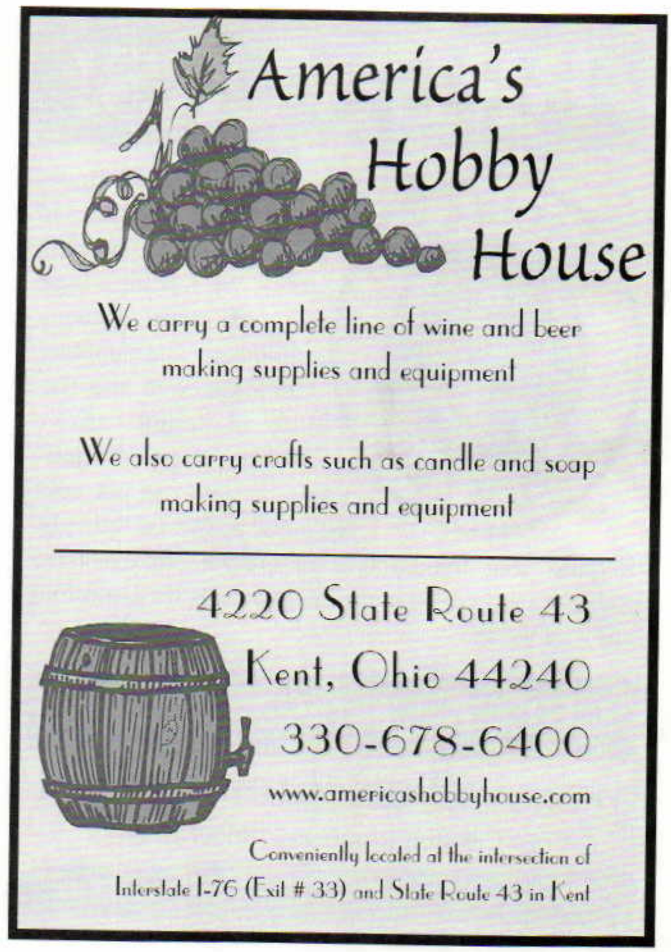
Step Eight: Square up the T where it meets the front of the base and secure it from beneath, pre-drilling and countersinking. If your T is thinner than 1/2" you may want to use 4d (4 penny) finishing nails rather than screws.

Step Nine: Drill 4" holes into the bucket, two just below the top and across from each other. Depending on the strength/thickness of the cylinder you may drill two more holes, each 90° from the others. If you do not have a 4" hole saw, draw a 4" circle on paper, attach the circle to your cylinder, mark the cylinder and cut each hole with a hand saw or saber saw. I purchased a 4" hole saw and didn't even use it. Cutting the thin bucket with a saber saw equipped with a 24 tpi blade was just as fast and nearly as accurate.

Step Ten: To complete the project in style, seal all the wooden surfaces with a penetrating sealer and apply a final coat of varnish or paint. Upend a couple of carboys, attach a bungee cord and Enjoy!

Thom Cannell is a master of trades and writes "Projects," in every issue of BYO. When he's not homebrewing, he writes about cars for a living.





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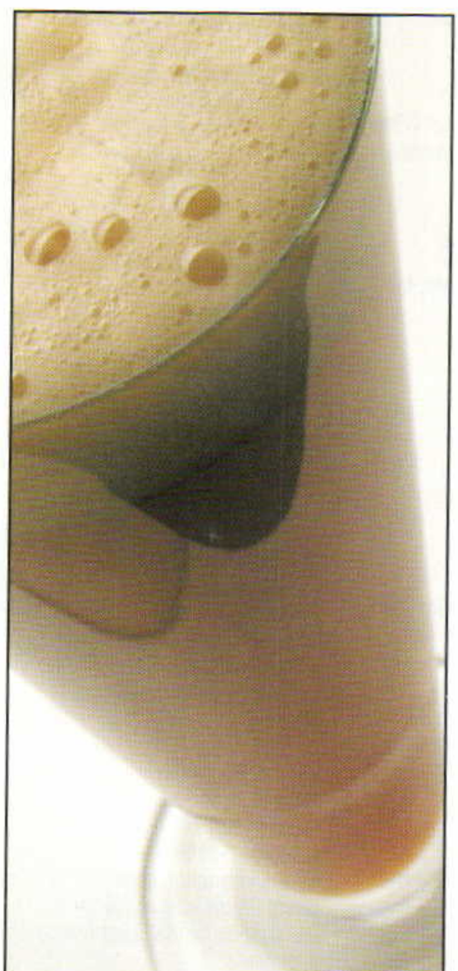
Taste Tester Blues

It's not all fun and games for the panel

by **Henry L. Lefevre**

I used to head the quality engineering function of a certain brewery's can plant. It was an extremely technical job, but our duty was important to the people who consumed and enjoyed the taste of our beer. Some people simply prefer canned beer and they should be able to drink it without the imparted flavor of aluminum. One of our department's missions was to find a can lining that was cheaper, more reliable, and capable of shielding our beer from the can. The best can coatings don't bleed plasticizers that interfere with the taste of the brew. Few beer drinkers like to have their beer tasting metallic or diluted with uncured polymer that was supposed to protect them from an aluminized taste. Who would? We administered screenings of the can liners to ensure that they were up to par.



Can liner screening involves coating the inside of the cans, curing the coating, shipping the cans to the brewery to be filled, aging the beer for a specified time and then having the blue-ribbon panel test the taste.

The "enamel rater test" helped eliminate coatings that formed an imperfect barrier between the can and the beer. These tests helped, but they couldn't compete with the triangular taste tests, where aficionados made sure that the beer met the accepted taste profile. Taste panels tend to use triangular testing to evaluate changes in beer. In triangular testing, each man or woman on the panel is given three samples of beer. Two are identical. The third is similar but not quite the same. If a taste tester fails to identify which samples match, that person's results get rejected. Testers who get too many rejects are likely to be dropped from the panel.

> "You need more self control than a wolf herding sheep. You can't chug-a-lug. You can't gulp. You can't even take a long swig . . ."

When I got involved with taste panels, the brewery's number one screen team needed to check out new hops and other critical raw materials. Therefore, our can-coating testers waited and waited not knowing whether their new liners were good, bad or abysmal. We needed some sort of quick screening.

One of the beer lovers working for me was on a brewery taste panel. He went through months of special testing until his taste buds had been saturated with premium beer and calibrated to the edge of perfection. He could tell the difference between three-week-old beer and five-week-old beer made with the same formulation. He and the quality assurance Vice President arranged for us to develop our own rough-screening taste panel.

Once we had our own testers trained, they helped reduce the load on the experts. Our new arrangement also helped speed up the can-liner acceptance procedures. Can coatings that made the beer taste skunky or gave it an aluminum flavor were screened and rejected. The duds were never submitted to higher authority. For this, they were thankful. Wanting to be in on the fun, I submitted my name to be one of the testers. I wasn't a realist. When I took the qualification test, they found that I could not tell wheat from barley.

Taste testing beer involves tempting your pallet without getting sloshed. Take in the color, swirl the beer, sniff the fragrance, and take a small sip. You need more self-control than a wolf herding sheep. You can't chug-a-lug. You can't gulp. You can't even take a long swig if you want to stay on the panel.

Taste-testing beer is nice work if you can get it, but the job is demanding in both skill and training. I failed more of the qualification tests than anyone east of Seattle. As a matter of fact, I think I must have broken the brewery's record for making wrong guesses.

I love tasting beer. However, I will never make a good taste tester. Neither my ESP nor my taste buds have what it takes to qualify for even a rough-screening taste panel.

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