Directions for the final week of on-site brewing training For Working Brewers Program

During the final week of residence at the host brewery students perform the following tasks

Brew a batch of beer
Filter a batch of beer
Count and stain yeast under a microscope
Receive a demonstration of microbiological plating
Receive a QC lecture
Evaluate hop and malt samples
Sit for a final exam
Receive sensory training

Obviously some compromises need to be made when a student qualifies to perform the final week activities at their own workplace brewery. For example if the brewery doesn't have a laboratory it may be possible to arrange for the students to experience the cell counting and microbiology work at a nearby facility that does have that ability. The sensory training will have to be left out unless the brewery has access to some flavor and aroma standards. I've included a guide for teaching each part of the final week's activities and of the subjects to be discussed and explained by the head brewer during brewing days. I've also included a copy of the final exam to be taken once the brewer has completed the other activities.

The brewing breaks down into explanations of the following tasks

1. Examine the recipe and discuss the role of the various ingredients as well as discuss the ingredient properties and alternatives that are available.
   Mill the grains and examine a sample from the mill to evaluate the quality of the grind and discuss the appropriateness of the grind for the type of separation system in use. Discuss how the grind would be different for another separation system. We generally sieve test the grist but not every brewery owns the screens.
2. Demonstrate how hot water is prepared and discuss the properties the water for brewing should have or does have. Discuss how water is stored, measured and treated in your brewery and in others you have experienced or seen.
3. Mash in discussing the hydration technique in use, and the grain bed mixing and leveling technique used and how it would differ for other systems.
4. Remove a sample and perform an iodine test to demonstrate enzymic activity on the dissolved starch. Repeat after 10 minutes and again after 20 minutes.
5. Measure the mash pH and temperature. Discuss why each is important and what effects variations will have on the wort properties and the final beer.

6. Discuss recirculating the wort, or vorlaufing, concentrating on wort clarity and dilution of first runnings under the plates. Discuss wort clarity and its importance to wort and beer quality.
7. Collect the wort explaining how best to perform this efficiently and how it might be achieved in other brewing systems. Discuss sparging, rate of run off, the use of a grant, number of collection ports, wort clarity, dilution with sparge water, bed compaction and avoiding set mashes. Talk about discretionary issues such as when to stop the run off (ie kettle full, last running gravity, kettle gravity etc). Take samples of run off and measure gravities at regular intervals. Talk about saving water, energy and effluent charges by stopping sparging at the appropriate time
8. Perform spent grain removal and discuss methods of removal and uses for the spent grain.
9. Look at hops and compare the characteristics of some different varieties. Discuss the chemistry of the soft resins and the difference between pellets and whole flower. Mention extract and their properties as alternatives. Discuss aging of hops and correct storage. Talk about purchasing of hops and the brewer, broker, farmer three tier system and what that means.
10. Collect the correct amount of wort and discuss how and why it is brought to a boil. Compare boiling methods, steam vs direct fired, open vs closed door. Discuss the reasons for boiling wort and the chemical reactions likely to be occurring in the wort during boiling. Discuss the various hop additions, how efficiencies are estimated and how to choose appropriate varieties for those additions. Discuss the option of hot break removal prior to boiling. Demonstrate the condensation ring on the stack and its role in reducing DMS. Discuss operating the kettle safely paying attention to avoiding boilovers.
11. Talk about the generation of steam and demonstrate the operation of the kettle heating system, including routine boiler maintenance, blowdown, water treatment etc.
12. Demonstrate and explain the importance of wort clarification prior to chilling. Mention hot break formation as well as cold break formation. Describe the addition and activity of kettle finings and their role in wort and beer clarification.
13. Describe the operation of the whirlpool, paying attention to issues such as velocity of wort, pump cavitation, formation of the trub pile, collapse of the trub pile during cooling etc.
14. Demonstrate hot break and spent hop removal.
15. Demonstrate wort cooling. Discuss appropriate sizing of the exchange, show the path through the process. Show how the water is recovered and discuss how the unit is cleaned and sterilized before use. Demonstrate the wort aeration method and discuss other options. Talk about the relative merits of bottled oxygen and compressed air. Discuss the reasons for wort clarity. Talk about the need for sterility and mention possible lab tests to check this. Discuss the various temperatures wort should be cooled to for the appropriate fermentation to occur.
16. Demonstrate the preparation of a fermenter to receive the cooled wort. Discuss alternatives for cleaning and sanitation of the vessel. Describe the operation of the temperature control system, the safety features, the CIP system, the sample ports

etc. Discuss why the vessel is shaped that way and what advantages that provides the brewer or the yeast strain.

17. Look at the yeast being pitched. Describe how it was stored, and where it came from. Describe how you decided how much to add and what temperature it is being pitched at. How did you evaluate its health and what are its sensory properties. How is it to be added and mixed with the wort. How will you check the correct amount is present and what you are expecting for a lag phase.
18. Demonstrate how we accomplish brewery clean up at the end of the day. Discuss cleaning options and tidying.
19. Collect the information needed for accurate record keeping and complete all paperwork. Discuss why this is being done

The following overview questions could also be addressed

1. Talk about the difference between a system designed for a brewpub, where vessels do double duty, single brew days are normal, everything is crammed into a small space etc compared to a microbrewery system where each vessel is specialized and multiple brews are done each day.
2. Discuss multiple brews into the same fermenter and discuss the aerate/not aerate batches question, and how much to pitch, batch mixing etc.
3. Show them the refrigeration system describing in detail how every part works and what it does. Point out the condenser, describe the evaporator, discuss why glycol is used and how to check it etc
4. Discuss pumps and their operation, talk about sizing, seals, cavitation etc
5. Show them how to keep the brewery clean and tidy, how to roll a hose, how to pour and measure chemicals, how to protect themselves from chemical and steam burns.
6. Show them shipping and receiving and demonstrate the correct storage and inventory control of ingredients and product.

Enjoy a well earned beer and talk about the day.

The filtration breaks down into explanations of the following tasks

1. Describe how the beer arrived at the point where it is ready for filtration. Describe the primary fermentation, how we decided that it was finished, how we monitored the progress of fermentation, the growth of yeast and when or if to cap the fermenter. Describe the maturation process, why you're doing it, what is happening during it, what flavors are being created or removed. Explain the temperature regime used to prepare the beer for final serving.
2. Demonstrate how the beer is prepared for filtration with regards to solid settling and removal, fining, or absortion pretreatments.
3. Demonstrate the practical aspects of beer clarification using whichever method you use in your brewery. Explain why it was chosen and why the method is effective. Discuss the alternatives and their relative strengths and weaknesses. Use the scientific references of Darcy's law and Stoke's laws to explain filtration and

natural sedimentation respectively. Demonstrate the practical set up of hoses, backflushing techniques, head space connection, and manifolds.
4. Describe and demonstrate how you consistently achieve the desired carbonation in you final product with reference to the relationship between temperature and pressure and the solubility of carbon dioxide.
5. Explain the quality control and lab testing aspects of beer stabilization, including the steps taken to exclude oxygen and bacteria.
6. Explain record keeping and beer loss tracking and reporting procedures.

The cell counting and hemocytometer work breaks down as follows

One of the most important controls in fermentation is the population of yeast at the beginning of fermentation (known as pitching rate). The simplest and cheapest means of accurately determining the pitching rate is the use of a hemocytometer and a microscope. A hemocytometer is a specialized slide which has a known volume and a counting chamber. By placing a slurry of diluted pitching yeast on the slide, the amount of cells in the chamber can be counted, giving a concentration of cells/ml in the pitching yeast.
It is also possible to estimate the viability of the pitching yeast, by staining the slurry with methylene blue before counting. This stain is metabolized by viable cells, and hence they will not stain blue, while dead cells will take up the stain and turn blue. Unfortunately this method is only accurate for viabilities above 85-90%, and results indicating a viability below 85% should be considered relatively meaningless.
To use a hemocytometer you will need a microscope with a 40x objective, some pipettes (including graduated pipettes for accurate measurement), glassware for dilutions, methylene blue stain, and a counting device.
The first step in measuring the concentration of your pitching yeast is to get an accurate sample. It is important that you get a sample that is representative of the population you will be pitching. Make sure that the yeast is homogenous by vigorously mixing before sampling, and then carefully pipette 1 ml of the yeast into a 100 ml volumetric flask. By filling this flask with 99 ml of water, you will have a 100:1 dilution. It is also possible to do serial dilutions to achieve the same result (two 10:1 dilutions), and you may need to do more dilutions depending on the concentration of your sample. After your dilution is finished, place a drop of methylene blue into the sample, and allow it to stand for a few minutes.
Place the clean, dry hemocytometer on the stage of the microscope. Place the cover slip carefully on top of the counting chamber, making sure that both sides are resting on the raised area. Draw a homogenous sample of the diluted yeast slurry into a Pasteur pipette and place the tip on the filling notch of the hemocytometer. Allow the counting chamber to fill, avoiding spill over into the overflow area. If the slurry overflows onto the raised area it will raise up the cover glass, changing the volume of the counting chamber and making the count inaccurate.
Focus the microscope at 400x and count five of the areas inside the grid. First count the total number of cells, then the total number of dead cells for each area. Note your count on a grid laid out like the counting chamber, to allow for easier interpretation.
Now that you have a count of the number of cells in the chamber you must determine the concentration of cells in the slurry and then the amount of pitching yeast you will require.

First you must know the volume of the counting chamber, which has dimensions of 1 mm x 1 mm x 0.1 mm. Since the dimensions of 1 ml (also known as a cubic centimeter) are 1 cm x 1 cm x1 cm, (or 10 mm x10 mm x10 mm), you can determine the volume of the chamber with some fairly simple math. Change the dimensions into centimeters and multiply them, and you will have the volume in cubic centimeters (cm^3) or mls.

0.1 cm x 0.1 cm x 0.01 cm = 0.0001 cm^3or 1 $x10^{-4}$ ml

Determine your viability by subtracting the dead cells from the total cells and dividing by the total cells.

To get your viable count, subtract the dead cells from the total cells in the five counting areas.

Total Cells - Dead Cells = Viable Cell Count

Now take your Viable Cell Count of the five areas, and multiply by five to give an average count for the entire chamber. Divide by the volume of the chamber and multiply by your dilution factor to give the total cells per ml.

Next you need to determine the amount of yeast you will pitch into your fermentation. For most yeast, a healthy fermentation is achieved when the population of viable yeast is 1 x 10^6 cells per °Plato of the wort. This accounts for the requirement for increased population in higher gravity worts. So by multiplying the gravity by 1 x 10^6 you can determine your proper pitching rate per ml of wort.

Next convert your volume of wort (probably in barrels) to ml and multiply by your pitching rate to get the total cells needed.

Finally, divide your total cells needed by the viable cells/ml to get your total pitching quantity.

You can also convert this to gallons for easier use.

The microbiological plating and QC training breaks down as follows

Demonstrate and discuss the brewery quality control/assurance techniques. Describe and demonstrate sterile sampling. Demonstrate and discuss media, anaerobic incubation, autoclaving, sterile plating with loops etc. Show sterile filtration of beer samples. Demonstrate carbonation measurement in bulk tank, in package as well as headspace air.

Sensory work

Sensory evaluation is something we must unfortunately leave out. Please provide tastings with descriptive analysis of a selection of your own beers and commercial samples during the training.

Evaluate malt and hop samples

Use your own materials to demonstrate how to evaluate the quality of malt and hops in the brewery.

Report

Students should then write a report of their activities on each formal training day and email/mail it to us at the Guild.

Final Exam

Please proctor the final exam on our behalf. Provide a quiet room for a 3 hr period and present the final. The exam is open book and you aren't allowed to help with the answers. Mail us the completed exam for grading.

Diploma

On receipt of the report and completed exams a diploma will be issued, provided all other responsibilities to the American Brewers Guild are met.