Distillery Design: Producing Vodka and Other Spirits

A Major Qualifying Project

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Chemical Engineering

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Abstract

The goal of our project was to provide the owner of Amherst Farm Winery with an operable distillery design within a tight budget. A growing craft spirits market influenced the owner to pursue a new revenue stream by starting Amherst Farm Distillery, LLC, a locally sourced micro-distillery located in western Massachusetts. Through numerous distillery tours, a hands-on workshop, research, and communication with the owner and numerous vendors, we were able to design a process that will work for the owner and fits her needs. Throughout this project, we gained valuable experience by working with a client and a vendor, and gained practical knowledge associated with creating an operable design.

Executive Summary

The goal of this project was to provide a complete distillery design for the owner of Amherst Farm Winery to expand her business. The owner desired a simple, easy to operate system that was locally made and would fit her $100,000 budget. It would be located in the upstairs loft area in the barn currently used exclusively for the winery. This was accomplished by first researching how batch distilleries operate, and visiting a number of craft distilleries throughout New England to better understand the setup and operation of these facilities. Additionally, by participating in a weekend long workshop at an operating craft distillery, a significant amount was learned about the actual operation, workflow, and overall process. After a thorough examination of the collected data, a design was completed, and summary of operation was compiled.

The design consisted of a process flow diagram, a layout, and a summary of all equipment required for the operation of the distillery. A batch still with a 50 gallon pot, manufactured by Vendome Copper and Brass Works was selected for many, mostly financial, reasons. This still will double as a mash cooker, and its electric heat source eliminates the need for a boiler. Additional equipment such as tanks, pumps, and a grain mill will be purchased from used equipment companies for more savings. New flooring will be installed to isolate any liquids to the distillery area, and protective Plexiglas will be placed around the still to ensure public safety.

The owner was educated in the basic process of distilling and fermenting, and this design was presented to her and accepted, and will be brought forward and installed in the coming years, pending permitting.

Introduction

Amherst Farm Winery is a small business located in Amherst, MA producing a wide variety of wines for the western Massachusetts region. The winery was founded in the fall of 2011 in a historic barn that had been relocated due to the formation of the Quabbin Reservoir. The winery began producing both traditional and fruit wines, which it sold from their location. The production area for the wine is relatively small, and because of that, the quantity of wine produced is not enough for distribution to wine stores and restaurants. While this business model has worked so far, it is important to continue making a variety of new products to keep consumers interested in visiting the location and trying new products. This can include new varieties of wine and similar products, or by diversifying the business to include something new, such as craft spirits.

A growing number of small wineries are showing up across the country, attempting to fill the need for an ever-growing demand for wine across the world. Wine lovers are turning their passion for the drink into a business, creating a flourishing supply of new and interesting varieties of wine to enjoy. The small businesses that are at the heart of this growing wine production trend are restricted by the limited amount of wine grapes that are grown, especially in the northeastern region of the United States. They have diversified into many fruit wines to help increase their variety, but for some small wineries, this may not be enough to satisfy the need to have a wide variety of products available to the consumer.

One way that many of these wineries are attempting to fill that gap is by expanding their business to making craft spirits as well. With a moderate investment, a winery can build a small distillery attached to their winery. With just one still, they can produce a vast assortment of liquors, both in terms of type and flavor. Vodka, brandy, gin, grappa, and many other types of

liquor could be made in a variety of flavors, adding countless options for consumers on top of the already wide variety of wines. A micro-distillery can also be a very financially beneficial option. Typically, a business can make a fairly substantial profit from selling liquor, especially kinds that do not require any kind of aging, as the costs to ferment, distill, and flavor are not tremendously high.

A key aspect to this winery's business model is locally sourced ingredients. While the farm on site can produce some fruits for production, it isn't nearly enough to supply the entire business. As such, the winery sources out to other local farms and orchards to bring in grapes and other fruits and flavors to ensure they can provide a wide variety of products. To start the distillery, the winery would require additional supplies to make a liquor mash. Fortunately, there are many local sources of crops such as potatoes and various grains which can be used to produce vodkas and other liquors which will form the basis for the majority of distillery products.

While the distillery may one day expand to have a large selection of spirits, the initial startup of the distillery should be geared to sell products to existing winery customers. The current customer base is made up of approximately 80% women, most of whom are middle to older aged. A simple yet productive way to market to this group is through selling flavored vodkas. The distillation of vodka is a fairly straight forward process relative to other liquors, which means lower costs for its production. The addition of natural flavorings, which can also be locally sourced, will add a degree of variety to the liquors available and cater more toward the targeted consumers. Today, flavored vodkas are a widely used ingredient in countless mixed drinks, as well as a slightly easier way to drink vodka straight, and have grown in popularity year after year over the past decade. However, most of the currently available options are produced by

large distilleries such as Svedka, Smirnoff, Skyy, Three Olives, Pinnacle, and several others. However, the market for local, smaller batch flavored vodkas remains far from saturated, and the potential of entering this market seems a very logical starting point for the micro-distillery.

Background

Amherst Farm Winery

Located in the town of Amherst, Massachusetts, Amherst Farm Winery LLC is a small winery and vineyard that is owned and operated by Audrey Samek. Amherst Farm Winery produces a wide variety of wines, from their versions of basic reds and whites to a plethora of fruit-flavored blends and dessert wines. Due to its location within the center of Pioneer Valley in western Massachusetts, she is unable to grow many of the fruits necessary for her winemaking. Additionally, because her winery is so new, the trees and vines that she does have are not yet producing enough to meet demand. Currently, she sources all of the other necessary ingredients from nearby farms to supplement what she is able to grow. Open only during the months from March through December, keeping up with demand for her products has been quite the challenge. While Audrey has aid through her hand-picked employees and student workers from local colleges, the New England weather hinders the growth of grapes, making it rather difficult to produce early in the spring.

The winery is located in a wooden barn that consists of two levels. The main entrance is at ground level and contains her winemaking operation, including production, tasting, party room, and the store. The upper level is currently empty in preparation for the micro-distillery business that Audrey is in the process of planning. The design of the actual process of distilling craft spirits for her location will be outlined later in this report. To get to the upper level, there exists only stairs. In order to allow the public upstairs according to local fire code, there will need to be some sort of lift. The copper-topped bar that is located on the second floor will serve as a tasting for the spirits produced there.

The owner is very focused on keeping her business as local as possible. Since she purchases supplemental juices from other local farms, she'd like to continue this trend by getting her raw materials for the distillery from them as well. In addition, all physical labor necessary to get this production off the ground will be locally sourced. She prefers to source all of her products locally to aid her community, as well as to gain more customers through the business connections she makes. Additionally, sourcing locally can help reduce shipping costs, lowering her net spending, and helping to increase her potential profits.

Batch Distillation of Spirits

Spirits are any aqueous solutions of ethanol that are obtained by distillation, such as vodka, brandy, rum, or whisky. These alcoholic liquors can be produced from various raw materials, but all have a similar process to obtain a high alcohol by volume, or ABV. Each type of liquor is produced by the addition of various enzymes to break down the raw material, fermentation to produce the ethanol, and distillation to separate the ethanol for a more pure product. The final steps after distillation to create the finish product depend on the type of spirit desired and also on the recipe created by the distiller. There is a lot of room for creativity in the recipe, and each distiller will have a unique way of producing each spirit. Many types of liquor have their own regulations and if they are not met, then the solution produced cannot be bottled and sold under the name of that liquor. For example, In order to refer to a liquor as "vodka", the ethanol must be distilled to 190 proof, or 95% ethanol. When referring to proof, this is the alcoholic strength of the liquor. In the United States, proof is twice the amount of alcohol by volume (ABV). For instance, if a beverage is 80 proof, then it contains 40% alcohol by volume.

Vodka

Vodka is very high purity liquor. As mentioned earlier, in order to refer to liquor as "vodka", the ethanol must be distilled to 190 proof, or 95% ethanol, then diluted to 70-80 proof for distribution. If the product is not distilled to this high proof, then it is not technically considered vodka. The raw materials for vodka are any type of grain that can be ground, such as corn, potatoes, and whey. Different starting materials will result in a slightly different flavor, which many craft distillers are focused on. The unique starting material is what gives each recipe its distinct flavors. To start off the process, the raw material is ground into a fine powder and mixed with water and various enzymes and bacteria to prepare for fermentation. It is allowed to ferment and then fed to the distillation process to remove the ethanol to increase the proof of the spirit to 190. Then clean water is added for the final product.

Other Spirits

There are many other spirit types that are all produced slightly differently. Whiskey is a very popular liquor which is made exclusively from grains. There are many variations of whiskey, such as Bourbon, Scotch, and Tennessee whiskeys, all of which have their own regulations on what can be given that name. For example, Bourbon whiskey must be put in a new white oak barrel to age at less than 125 proof. All of these whiskeys have their own unique flavors and recipes that distinguish them. Another liquor is rum, which is fermented with a molasses or sugar base, creating a very sweet liquor. Gin is a liquor that is distilled over a basket of mashed fruits including juniper berries, along with potential others such as apples to add

flavor. Every liquor has its own distinct character, and plenty of room for adaptation and creativity.

Regulations

There are a number of regulations pertaining to the distillation of alcohol federally, locally, and by the state. These regulations must be followed to ensure the continued operation of any facility, and the required permits as described in the regulations must be obtained prior to production.

Federal Regulations

The US Alcohol and Tobacco Tax and Trade Bureau regulates the distilled beverage industry. This agency requires a new business to apply for a permit to produce alcohol in the United States that must be approved prior to any production of liquor. There is no fee for this permit to be screened or maintained through the lifetime of the business. There are several permits that this agency gives out to different industries, but the liquor industry applies under the "Distilled Spirits Plant - Beverage" title, which covers any business producing, bottling, or selling distilled beverages.

State Regulations

In Massachusetts, there are more regulations pertaining to distilleries. There is a classification for farm distilleries, which allows farmers to produce small amounts of liquor as an additional source of income. This classification allows the production of up to 5000 proof

gallons (50% ABV) of liquor a year for a licensing fee of $22; additional production induces a larger licensing fee. The farmer-distiller license is required to be renewed yearly, however, there is no need to resubmit the paperwork required in the initial application. Additionally, there are a number of state taxes on the sale of liquor produced in such a facility. A tax of four dollars and five cents shall be collected for every proof gallon as defined above. This is a legal requirement for any alcohol producer, and must be paid to continue production and sale of the product.

Amherst Local Regulations

Locally, there are several regulatory requirements for a distillery. First, there must be approval from the fire chief because of the heating element in the still and the potential fire and explosion hazards associated with alcohol. Additionally, there must be approval from the town or city sewer system to ensure any products going down the drain from the distillery will not adversely affect the water treatment system or the sewer pipes themselves. Also, if the distillery wishes to give samples or sell drinks at the site, they will be required to obtain a liquor license from the necessary local authorities.

Micro-Distilleries

A distillery is a place where alcoholic spirits are made. More specifically, a micro-distillery is a small-scale version of a commercial manufacture distillery. An operation of this size is great for creating craft liquors and is focused more on the taste and quality of a premium spirit rather than producing vast quantities of liquor. Many craft distillers choose to produce flavored spirits, rather than compete for the same customers as larger, well-known companies such as Smirnoff or Svedka. The number of micro-distilleries throughout Massachusetts and the

rest of New England has increased dramatically over the last few years. As seen in Figure 1, Massachusetts has several around the state; however the area surrounding Amherst is quite bare.

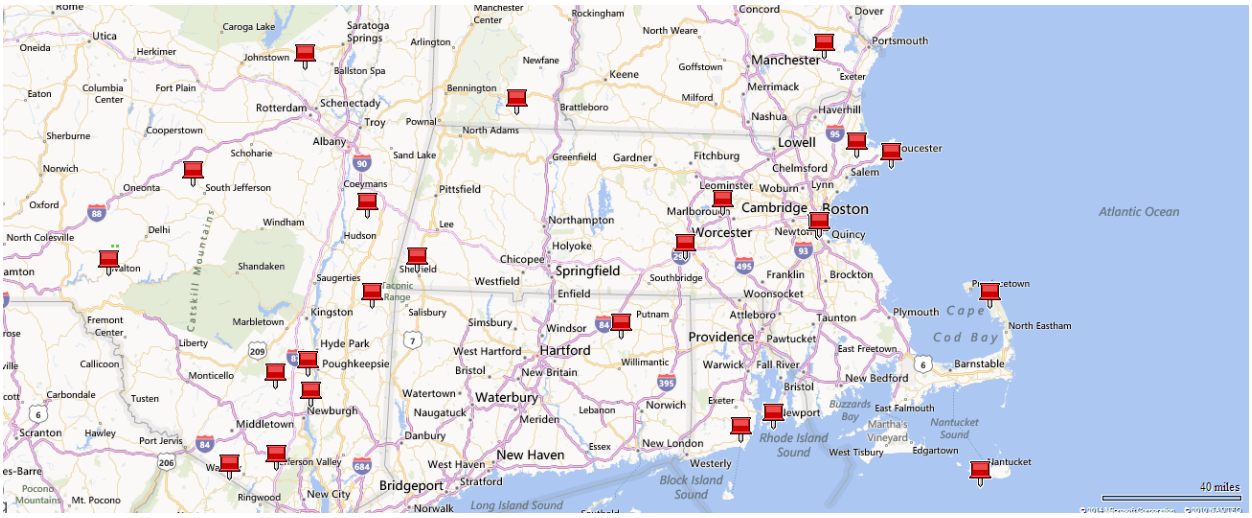


Figure 1: Map of Massachusetts Micro-Distilleries

As craft distilling is a quickly emerging industry, the number of businesses in this area is expected grow. As of July 2013, there were 14 craft distilleries in the state of Massachusetts. The exact number currently in business is unknown due to the constant flux of start-up distilleries.

One nearby distillery is Nashoba Valley Spirits. Nashoba produces grappa, gin, vodka, whiskey, and brandy on site, from growing the raw materials to fermentation and distillation, and the finished product. Their pot still used for distillation of spirits can be seen in Figure 2. This still has a 100 gallon capacity. Amherst Farm is looking to produce approximately the same amount of, or even less, spirits per year as Nashoba and will likely need something of this magnitude.

Figure 2: Nashoba Valley Spirits Still

Figure 3: Cold River Vodka Still

Other micro-distilleries are on a slightly larger scale, such as Cold River Vodka located in Maine or American Crafted Spirits who makes Silo Vodka which is located in Vermont. The still used by Cold River has a 1000 liter, or 264 gallon, capacity, as can be seen in Figure 3. The still used by American Crafted Spirits is about the same size and can be seen in Figure 4, along with separate tray towers for increased separation as seen in Figure 5.

There are many different sizes and options for pot stills when it comes to distilling craft spirits. These companies bought their equipment from Vendome Copper and Brass Works in Kentucky, Kothe Distilling in Germany, and Carl Artisan Distilleries in Germany.

Figure 4: American Crafted Spirits Still

Figure 5: American Crafted Spirits Distillation Columns and Condenser

Methodology

The goal of this project was to provide the sponsor with a final distillery design to be installed in the provided space at Amherst Farm Winery. We began by meeting with the winery owner to gauge needs, wants, and a budget for the project. We researched distilling to gain a basic knowledge base on the subject, and to help guide the next steps. We contacted four different still manufacturers to get quotes and give the sponsor a general idea of what was available at what price. We visited a number of small distilleries to get a better idea of the operation and functionality of different aspects of the process, and participated in a weekend-long workshop on distilling in Windsor, VT. After we had gained a working knowledge of what was required and the associated costs, we designed the proposed distillery and presented it to the sponsor.

The first step was to meet with the sponsor in order to gauge needs and wants for this design, and to learn what her knowledge base was for this project. At the initial meeting, the sponsor laid out her vision of a small distillery in the upper floor of the barn where Amherst Farm Winery is currently located. She wanted an easy to operate, visually appealing design to help bring attention to the new business. She wanted to keep the total expense to around $100,000, including all necessary installation and infrastructure upgrades for the space. She also outlined her desire to keep everything local where possible, including all potential equipment for the distillery. With these limitations in mind, the space was measured and analyzed help provide a base for the future design.

The next step was to get in contact with distillery equipment manufacturers and get quotes for equipment. After some research, requests for quotes were sent out to four manufacturers. We received quotes from two manufacturers in the United States, one in Chicago,

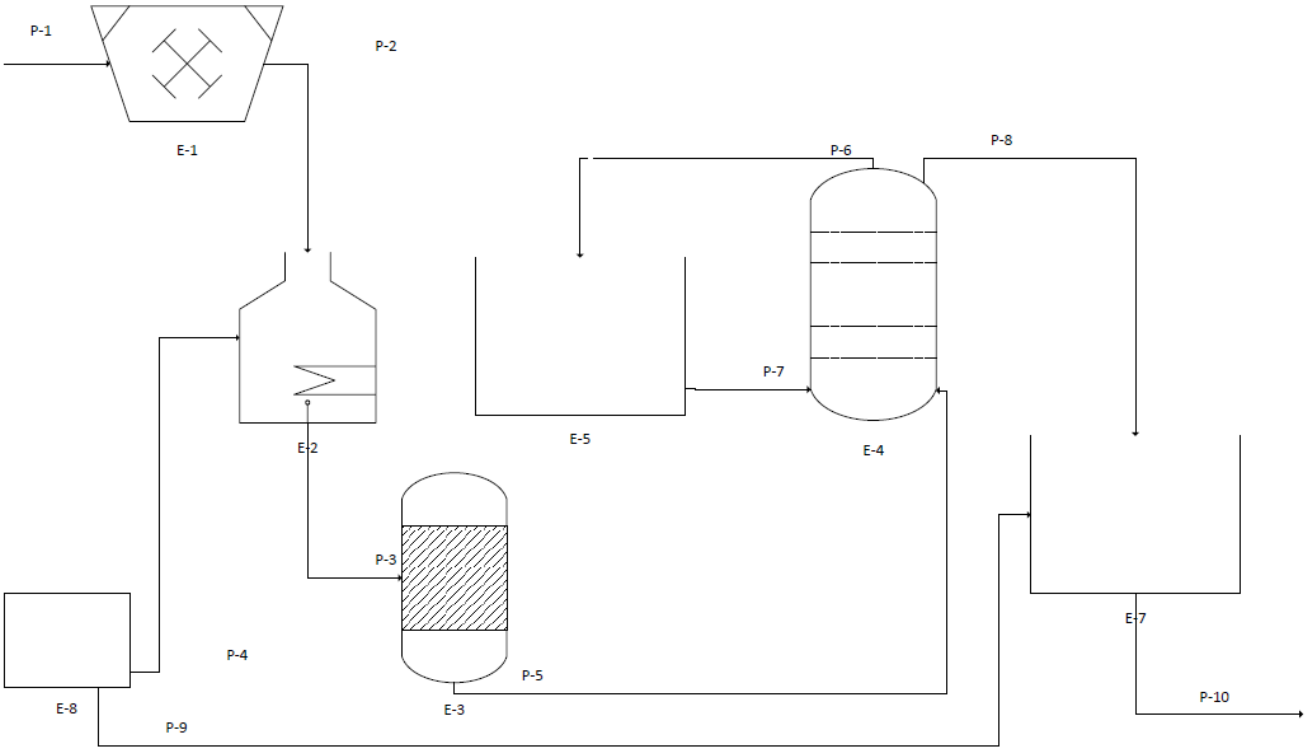
which is German owned, and one in Kentucky. After reviewing the products offered and comparing them to the needs and budget of the distillery, a manufacturer was selected. There was a constant line of communication with the manufacturer, collecting technical details of the products, as well as finding more detailed financial information, confirming the quoted prices, and rough estimates for installation costs. Through this communication we were able to provide the owner of the distillery with all necessary equipment information prior to her purchase.

To better understand how small craft distilleries operate, many distillery tours were taken across New England. While the process of distilling can be explained easily, there are many subtleties about the design that aid the efficient running of a distillery and can help the distiller make more quality product. By visiting many distilleries, similarities in design, as well as specific benefits and inefficiencies of certain setups, were seen. Additionally, the participation in a weekend-long distilling workshop at American Crafted Spirits in Windsor, Vermont provided a look at the actual operation of a distillery. By taking part in the process, and operating all of the machinery, it helped teach many key operational details for a distillery that cannot be found in literature. This information was later applied to ensure the design of the final distillery would be functional and efficient for the owner.

Once all of the necessary information had been collected, and all necessary factors had been considered, a design was completed. The design consisted of selecting all necessary equipment for the efficient operation of the distillery, as well as all necessary upgrades to the space to ensure safe operation of all equipment. All of the components were organized into a layout that will provide a working operation for the owner.

Design

Process Flow Diagram



Process Description

This process is designed to produce craft liquor at Amherst Farm Winery. It will produce small batches of liquor from locally sourced ingredients to be bottled and sold on-site in western Massachusetts.

Approximately 500 pounds of grain or other starch source is ground to a granular texture in the hammer mill. A portion is brought to the still and mixed with enough water to fill the pot. The mixture is brought up to a temperature of 85 C with continuous mixing and allowed to cook for about an hour, varying by recipe. The heating unit is turned off, and enzymes are added at various high temperatures according to the recipe. The mash is allowed to cool further to around 30 C, when the yeasts are added to begin fermentation. Once fully mixed, the mash is transferred via the mash pump to the fermenter. This process is repeated until all grains have been used, and the fermentation tank is full. The pot is cleaned thoroughly to prepare for later use in the process. The fermentation takes place over a period of 5-7 days, at around 30 C and should produce a mash of approximately 10% ABV.

Using the mash pump, the fermented mixture is transferred to the still. A stripping run is performed by heating and stirring the mixture until a 35% ABV vapor is condensed and collected in a receiver tank without the use of the tray column. The run is considered complete when the temperature of the pot reaches 99 C, as most of the alcohol should have been removed by that point. The remaining mash in the pot is discarded as waste or collected for farm use. This is repeated until the entire 10% fermented mixture has been stripped and collected. After the strip process is complete, the still and fermentation tank should be thoroughly cleaned prior to next use.

The stripped liquor is transferred with the clear liquid pump back into the still. The agitator and heating element are turned on to begin the distillation run. At around 80 C, product will begin to flow, and an initial few gallons should be condensed and taken off as waste, as it will contain potentially dangerous amounts of methanol and will have a very foul odor and taste. The dephlegmator is provided with cold water, and the reflux will greatly increase, causing the alcohol percentage to rise. Slowly, more liquor will be fully condensed and taken out of the system as heads. In total, up to 5 gallons could be removed as heads. After the heads have been removed, the flow will begin to reach top quality, and can be taken into the receiving tank as product. The stream must be closely monitored for quality and proof. If the desired proof has not been reached, an increase in the flow of cold water to the dephlegmator will increase reflux and result in a higher proof product. As distillation continues and quality and proof decline, the receiving tank is removed, and the still is shut off and allowed to cool. The waste liquor is drained from the still and the pot and tower are cleaned thoroughly.

The final product is held in a receiving tank, where distilled water is added to dilute the liquor to desired proof. This final product is then put in a storage tank connected to the bottling unit, and then packaged for sale.

Component Descriptions

Still and Mash Cooker

The copper batch still manufactured by Vendome Copper and Brass Works has a capacity of 50 gallons. It has a diameter of 42” and a height of 9’-3”. It will have four bubble cap trays and a dephlegmator to achieve maximum separation. All gauges and safety devices are included, along with an additional touch screen automated system control unit. This batch still doubles as

a mash cooker with an explosion proof agitator to ensure thorough mixing. This unit requires 230 V electric hookup. The insulation jacket will reduce heat loss to conserve energy.

Fermenting Vessels

This design will include two stainless steel fermenting tanks, each with a capacity of 100 gallons, a diameter of 3', and a height of 40". They are open top design and are equipped with 1-½" drain and pipe connections.

Receiving Tanks

This design includes two stainless steel receiving tanks, each with a 55 gallon capacity, a diameter of 2', and a height of 3'. For ease of use, they are wheel mounted to provide mobility to all parts of the process.

Pumps

Two pumps will be required to operate this process. One will be required to move viscous fluids up to 50 gallons at a time. The other pump will transfer clear liquids such as water and ethanol up to 50 gallons at a time. Each pump will require its own set of removable tubing, clamps, and gaskets. The decision of which pumps to purchase will be at the discretion of the business owner; however, it is suggested that they be purchased from W. A. Thompkins, a used equipment distributor located in Massachusetts.

Hammer Mill

A hammer mill will need to be capable of grinding up to 500 pounds of grain, such a potatoes or corn, in under an hour. The decision of which hammer mill to purchase will be at the discretion of the business owner; however, it is recommended that the mill is purchased from Glen Mills, a New Jersey based grinding equipment manufacturer.

Additional Infrastructure

The entire distillery area will be covered in waterproof flooring in order to prevent drips or spilling and to provide for easier cleanup of the equipment. The new flooring will slope to a center point for easier draining. A drain will be installed in the floor to ensure that there is no water build up. 230 volt electric will need to be provided for the still and pumps. An electrician will need to be hired to install this on the upper level of the building. Three sides of the area containing the batch still should be contained by Plexiglas to shield observers from any dangers posed by the equipment.

Operational Details

Pump Operation

Additional considerations must be noted for the safe and effective use of the pumps in this process. In the start-up process for a pump, there is a specific order for opening valves when transferring materials between units. The discharge side must be the first to be opened to prevent a pressure build up. Second, the source valve must be opened to fill the hose and provide something for the pump to move. Once both valves are open, the pump can be turned on, allowing product to flow to the desired location.

As stated earlier, two pumps will be employed in this operation. One will be used for mash and any mealy or thick fluids, while the other will be used for any clear liquids, such as water, or high proof liquor, including the products of the stripping run and any thereafter. It is important to not contaminate the clean pump as it is what is used to transfer the final product, which should be as pure as possible, to the bottling station. Additionally, each pump should have its own set of hoses to prevent contamination, and all hoses should be thoroughly cleaned after each use. Operators should be careful to keep the power line to the pump clear of any liquid, water or otherwise, to prevent shock hazard and damage to the machinery.

Still Operation

The copper batch still will be used for three types of operations: cooking the mash, stripping the ethanol from the fermented mash, and distilling to a high proof ethanol product. Operation of the still for each of these processes is quite different, and they are outlined below.

Mash Cooking

To perform a mash cook, first the still must be filled with the grain that has just been ground by the mill and mixed with water by the agitator. Check that all valves and openings are sealed to prevent leaks and ensure efficient heating. Using the automated controls, set the temperature to 85 C. Once the mash has reached this temperature, add enzymes and yeast at the times and temperatures dictated by the recipe. Once the yeast is added and it is thoroughly mixed, the agitator can be turned off and the mash manually transferred to the fermenting tank by use of the mash pump. After all of the mash has been removed from the pot of the still, it must be thoroughly cleaned by rinsing with water.

Stripping Run

The bubble cap trays in the column are first removed before the stripping run is conducted to prevent build-up of unwanted grain residue. 50 Gallons of the fermented mash is transferred to the pot by use of the mash pump. The agitator is turned on to ensure well-mixed heating, and the temperature of the automated controls is set to 99 C. Next, the condenser water is turned on and the receiving tank is placed under the spirit cup in order to collect the product. The run continues until the rate of product collection has slowed to a slow trickle. The heating element and agitator are both turned off, and the leftover mash is discarded. Again, the still is rinsed with water and the trays are placed back into the column to prepare for future use.

Distillation

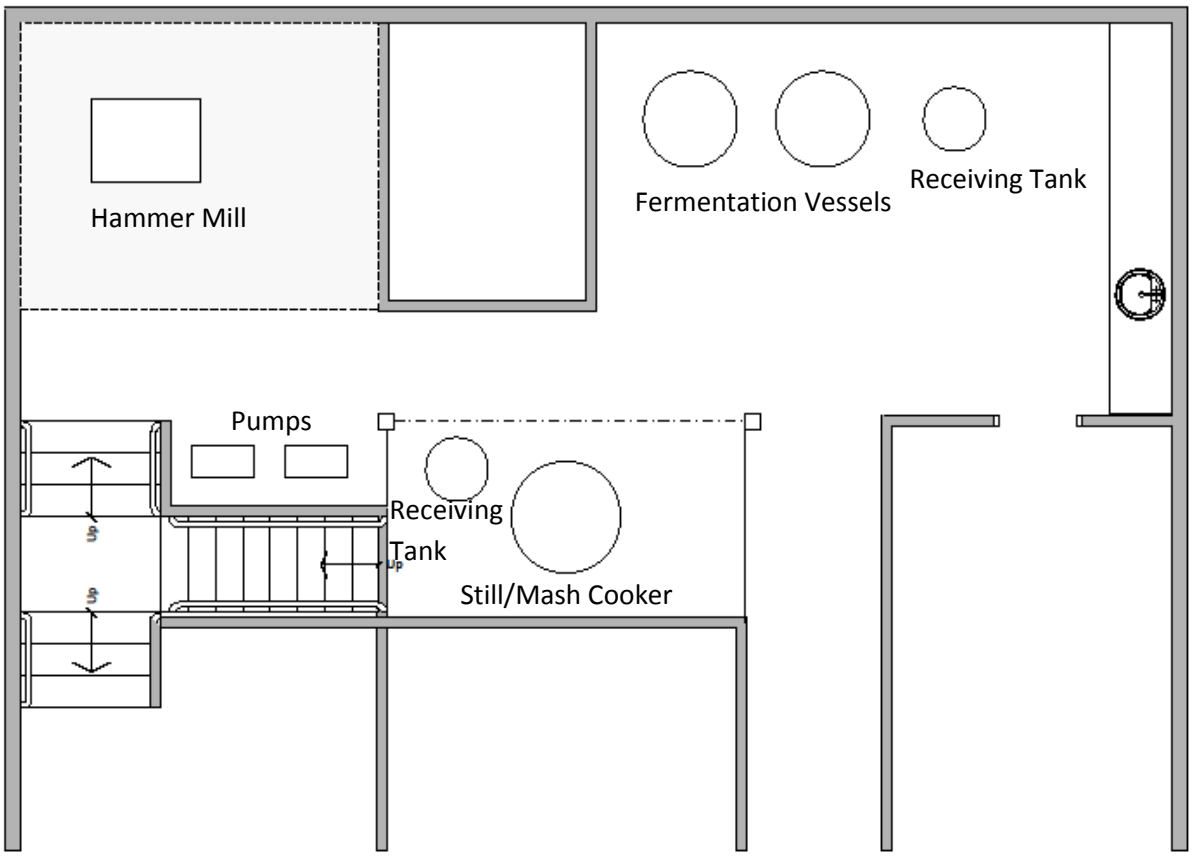
The liquor from the stripping run is put back into the pot of the still and the agitator turned on. The cooling water for the condenser is turned on, and the pot is allowed to heat to 79C, the boiling point of ethanol. This will remove more volatile components, such as methanol, as heads and discarded. Once the initial flow of this is collected, the dephlegmator cooling water is turned on to increase the proof of the product. The heating element is kept on to provide the heat necessary to raise the temperature to match the boiling point of the mixture. Once the desired proof, such as 190 for vodka, is achieved, the liquor is collected as hearts in the receiving tank. The dephlegmator is adjusted throughout the process to maintain the desired proof. Once the distiller is satisfied with the product, the heating element is turned off. Once the remaining product, collected as tails and discarded, has stopped flowing, the cooling water for the condenser and dephlegmator are turned off, as well as the agitator. The remaining low proof liquor in the pot is discarded and the still rinsed with water.

Waste Removal

The distillation of liquor produces a large amount of waste, as is the nature of a separation process. There are three types of waste produced in this process, and they all need to be dealt with in a responsible manner. After a stripping run is performed, the mash left in the pot will be a thick, soupy mash with a low alcohol content. This waste can be dealt with in several ways: It can be collected and fed to local farm animals since the raw material is a grain, it can be dumped outside to be used as a fertilizer, or it can be disposed of through the drain, provided it is thinned down with enough water. The other two main waste products are the heads and tails of the final distillation. Both of these are high in alcohol content, but can be disposed of down the

drain. Additionally, the heads may be used as a floor cleaner, as they are nearly pure ethanol, and will sanitize the floors, and evaporate.

Layout


Hammer Mill
Fermentation Vessels
Receiving Tank
Pumps
Receiving
Tank
Still/Mash Cooker

Economics

The design of this distillery was very much focused on accommodating a small budget of $100,000. This limit includes purchase and installation of all equipment, and any necessary modifications to the building. The approximate costs of the equipment along with installation are outlined in Table 1.

Table 1: Economic Summary

	Economics Summary				
	Unit	Subunit	Price ($)	Number	Total ($)
	Still		39542	1	39542
		Dephlegmator & Trays	3980	1	3980
		Controls	~7000	1	7000
		Agitator	4950	1	4950
	Fermenter, 100 gal		2690	2	5380
	Receivers, 50 gal		~250	2	500
	Pumps		~2000	2	4000
	Hammer Mill		~2500	1	2500
	Grain Silo		500	1	500
Equipment Subtotal					$ 68,352.00
	Installation		~7000	1	7000
	Building upgrades	Drain, Flooring, Plexiglas, walls	~20000	1	20000
Building and installation subtotal					$ 27,000.00
Total					**$ 95,352.00**

All building modifications are not included and will incur additional costs, such as an electrician and plumber, flooring, bottling station, lift, and Plexiglas walls.

Environmental Health and Safety

With the installation of a piece of equipment such as a still, it is important to take into consideration some environmental and safety concerns associated with the project. One key element is the risk associated with the high temperature vapors that are associated with distilling. It is possible that with a vapor cloud of ethanol in the still, there could be an explosion with metal shards being flung across the building. The building at this site is very open, and will often have customers wandering throughout the building. To help prevent possible injury, it is recommended that the area being used for the distillery be enclosed by a Plexiglas wall to protect customers from potential accidents. In addition, the hammer mill can produce both loud noise and dust. It is suggested that the operator wear ear protection and only operate the mill while the building is closed to the public. To prevent the grain dust from settling on the other parts of the building, it is recommended that some method to keep the dust contained be installed.

One key environmental consideration that needs to be made is what will be done with the waste from the process. The high proof heads and tails of the main distillation can be put down the drain, however the leftover mash is a much larger quantity and is much more viscous, and should not be discarded in that manner. There are two environmentally friendly and money-saving methods to use such waste. One way is to collect the mash in tanks and bring it to a farm for animal consumption. There is a plethora of edible grain in the mash that animals will love. Although there is a bit of alcohol left over, the small amount, less than 5% ABV, will not harm the animals. Another option is to use the grains as fertilizer. There are several nutrients in the mash, and it can be used to aid in growing more grains to feed the process.

Marketing

In order for this micro-distillery to be successful from the beginning, there are some marketing tools that the owner, Audrey Samek, has been very interested in pursuing. Audrey is very passionate about keeping all of her raw materials locally sourced for her emerging business. These raw materials may include, but are not limited to, potatoes, corn, whey, and natural fruit flavorings. There are several farms in the towns surrounding Amherst that produce these ingredients. As a sort of trade or business proposition, the left over mash from the process could be used to feed the animals also found on these farms, creating a sort of mutually beneficial relationship between the farms in the Berkshires. In addition, all pieces of equipment designed for this process are made in America, in keeping with her ideal of locally sourced products as much as possible.

Amherst Farm Winery has kept with these local ideals from the beginning, and by keeping that tradition, the owner hopes to carry over her current customer base to the new distillery. In order to take advantage of the branding she has already developed, her emerging business will be named Amherst Farm Distillery, similar to that of the winery. Since the two businesses will be in the same building, it is expected that her current wine tastings will lead to interest in the new spirits as the installation takes place. Once installed, the pot still will be visible from the tasting area, creating curiosity and interest for the new products.

Current customers consist of approximately 80% women who are above the age of 35. Their tastes coincide with flavorful, fruity drinks. One way to provide this with the distillery is by producing a line of flavored vodkas to build immediate interest. In order for her customers to taste her vodka spirits, there is a separate tasting bar on the second floor of the barn, in close proximity to the equipment. This will provide an opportunity for tasting mixed drinks, while

simultaneously viewing and learning about the spirit-making process. While customers will not be able to enter the equipment area while the process is running, the full-length Plexiglas window will allow for adequate viewing.

An idea that the owner had was to assist in selling the spirits by marketing them in distinct packaging. While she plans to sell both 375 mL and 750 mL bottles, she would ideally like to have custom glass blown bottles that have the imprint of two hands holding the bottle. Spirits in these bottles will be sold at a slightly inflated cost, as they cost more to make and could then be used as décor. The products of the distillery will only be sold on-site, keeping with the tradition of the winery. This will also aid in branding the new line of products because customers will need to visit the distillery in order to purchase.

Conclusions and Recommendations

With any sort of design work, there are always obstacles that lead to valuable learning experiences in the classroom and in industry. In the design curriculum, the focus is on technical details and creating a process that results in the desired specifications without regard for efficiency or cost. Through this project, the experience led to a more realistic design problem. Working with a tight budget, the design was very limited in scale, including only essential elements of the process. The owner of Amherst Farm Distillery was forced to realize that some of her wants were not feasible due to the high cost and that there were some necessities that she fought against. Once she realized how the operation would work, it was obvious to her that this design would be the most cost effective, and that it would work best for her location.

By far, the most difficult part of this project was getting in touch with the owner. Over the course of about two months, we were not able to get in contact with her to discuss any aspect of the design. Since it is her business and she makes all final decisions, it was not possible to move forward with the design and continue speaking with vendors. Eventually contact was made, however the owner was not available to meet for a further three weeks. Once the meeting took place, the project was able to move forward, only slightly behind schedule.

In many scientific processes, there is a rigid and established method for creating a product. Conversely, making craft spirits, such as vodka or whiskey, has a lot of room for creativity. There will never be two batches that are exactly the same, and no two recipes will produce the same product. There are certain requirements for various liquors to be labeled under a certain name, but the recipe to obtain those specifications could be anything within reason.

Designing the recipe is an art form; it requires a lot of passion and dedication to come up with a product that is enjoyable. This will be left to the owner of Amherst Farm Distillery so that

she may craft her liquor to her customers' tastes. It is a recommendation that she continue to build relationships with other distillers in order to further her knowledge about spirit making and their unique flavors. In addition, she must know what her equipment is capable of. Dialog between her and Vendome Copper and Brass Works, Incorporated will be crucial to her continued success as she develops her new business.

References

Audrey Samek, Personal Communication. Sep. 2013 - May 2014.

"Distilled Spirits Industry." *TTB*. 2014. Web. 24 Apr. 2014.

http://www.ttb.gov/spirits/index.shtml

Kyle Grant. Personal Communication. May 11, 2014

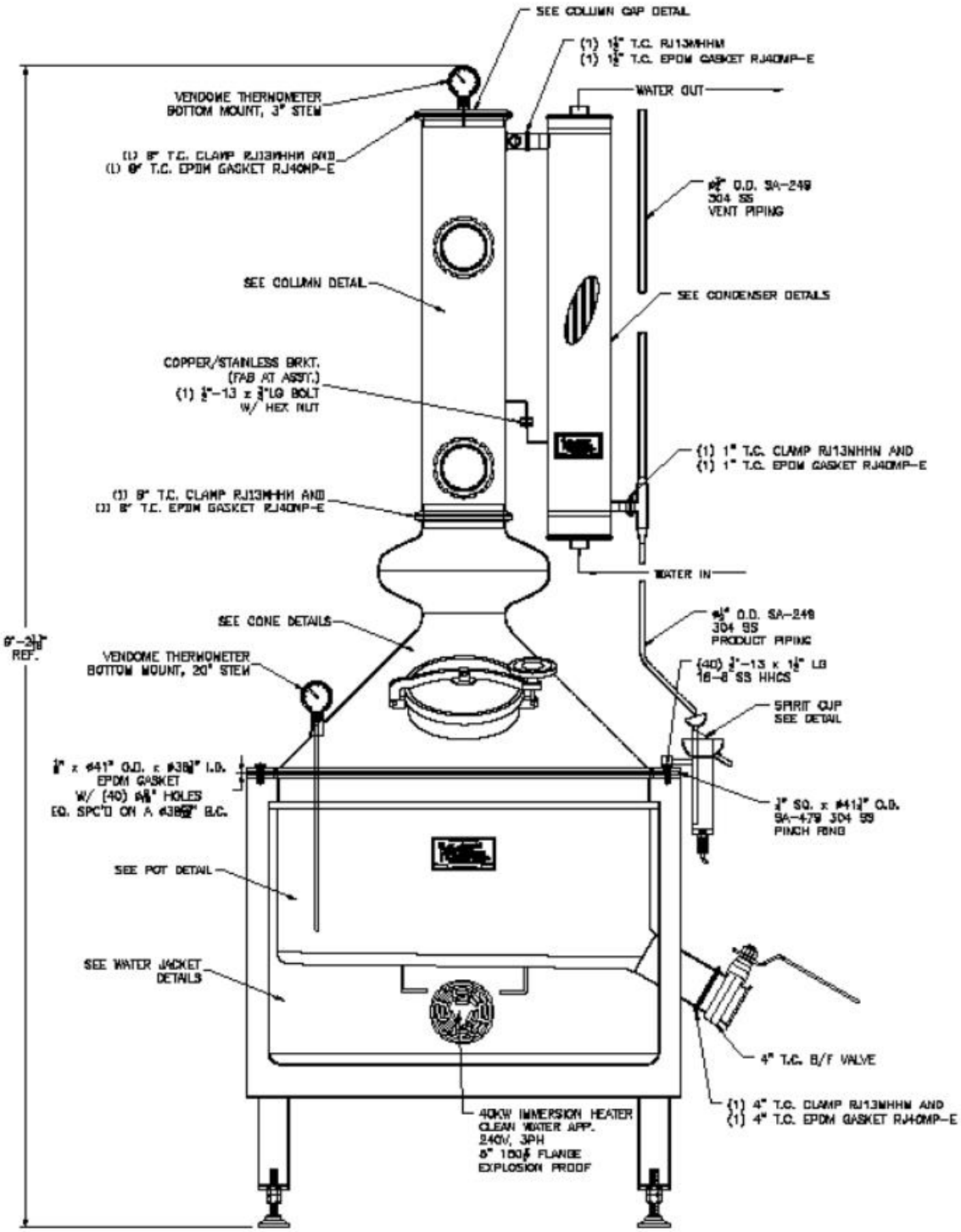
Massachusetts general laws. Part I, title XX, ch. 138: Alcoholic Liquors. (2014)

https://malegislature.gov/Laws/GeneralLaws/PartI/TitleXX/Chapter138

Ray Parker, Personal Communication. March 29, 2014

Appendices

Appendix A: Copper Batch Still Diagram



Appendix B: Quote from Vendome Copper and Brass Works

502-587-1930
FAX 502-589-0039

VENDOME COPPER & BRASS WORKS
INCORPORATED
DISTILLERY EQUIPMENT ● STAINLESS STEEL TANKS
BREWERY EQUIPMENT ● PROCESS SYSTEMS
729 EAST FRANKLIN STREET
LOUISVILLE, KENTUCKY 40202
www.vendomecopper.com

Customer: Danielle Dechaine & Jack Besse
Address: Worcester Polytechnic Institute
Massachusetts

Email: d_c_dechaine@WPI.EDU
Phone:
Cell:
Fax:

Date Sent: 11/6/2013
Price Updated: 5/30/2013
Quoted By: Kyle Grant
Phone: 502-587-1930
Email: KyleG@vendomecopper.c

The systems listed on the following page are designed for low to middle proof whiskey, rum, brandy, or single distillation of GNS, for gins and vodkas. All of the systems are capable of producing 190 proof in multiple runs. A vodka column is highly recommended if vodka is the desired product and will be produced from raw materials. Any custom pot still systems that are not listed or continuous distillation systems please inquire and pricing will be provided once the design has been established.

All of the batch still systems are custom designed and fabricated upon order. All equipment is for heavy industrial use and is fabricated in Louisville, Kentucky, USA by fourth generation coppersmiths. Vendome can fabricate any size or shape to meet your needs including partial systems. Any other related stainless steel or copper equipment can also be supplied, such as, fermenters, cookers, whiskey tanks, bottling tanks, etc. Delivery is usually 10 to 16 weeks depending on work load and material availability at the time of the order. Shipping can be quoted once the design, delivery date, and destination are established.

Terms are 30% down, 60% prior to shipment, remainder net 30 with established credit. Prices do not include taxes, if any apply. After receipt of down payment, fabrication drawings will be supplied to customer for approval prior to start of fabrication. Pricing is subject to change once final design drawings are approved. Installation of systems by Vendome personnel is available with pricing provided upon request.

Vendome will supply serial numbers for all equipment prior to final shipping. It is the customer's responsibility to obtain all required permits and abide by all state and federal regulations.

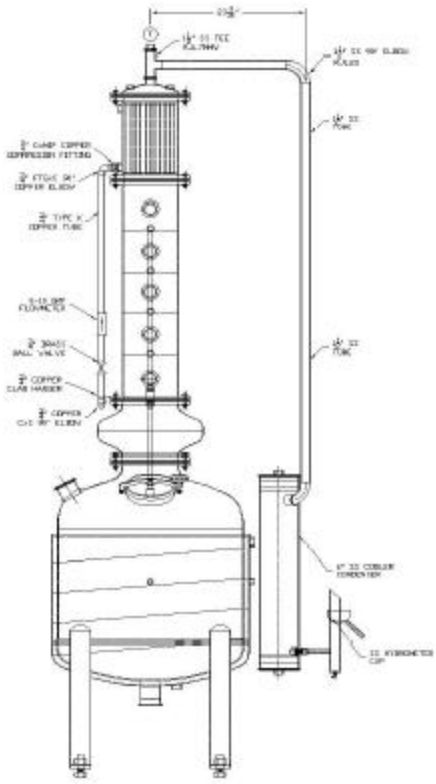
Upon request, we can refer a consultant to help you with all of your startup and recipe development needs. We also can provide contacts if you require equipment leasing.

POT STILL SYSTEM				
		Gallon Charge		
Item	Qty	50 Gallon Steam or Hot Oil Jacketed	"NEW" 50 Gallon Electric Hot Water Bath	30 Gallon Electric Oil Jacketed
Copper Batch Still	1	$45,330	$39,542	$38,600
One (1) 8" stainless steel glass ornate manway. (6" on 30 gal)		x		x
One (1) additional sightport for viewing pot contents		x		
One (1) bottom outlet with drain valve		x		x
All couplings for heating, temperature, safety, CIP, spares		x		x
All gauges and safety devices included		x	x	x
Four (4) 3" pipe legs		x		
Adjustable feet				
All brass or stainless steel hardware		x		
One (1) copper lid with vapor outlet piping		x	x	x
One (1) ss vertical condenser/product cooler with ss hardware		x		
One (1) Spirit Cup		x	x	x
All piping for tray drains, washout, and cooling water		x		
8" dia pot mount copper column with four (4) bubble cap trays and four (4) easy open sightports		x		
8" dia pot mount copper column with easy open lid set up for trays, gin basket, dephlegmator, or structured packing. "Shown as option below"			x	
4" tube style column with stainless structured packing				x
Copper reflux onion below column		x	x	
Insulation jacket			x	x
Dephlegmator		x		x
Ornate design with all machined hardware		x		x
Economy desiged with cost over function. Welds left as welded.			x	
Can double as a Cooker			x	
Clamp in Options for the "New" 50 Gallon Elec HWB				
Dephlegmator for controlable reflux			$2,950	
Structured Sulzer Chemtech Packing			$3,240	
4 Bubble cap trays with dephlegmator			$3,980	
Drop in Gin Basket			$1,680	
Required but Not Included in Price				
**Requires hot oil heater or 15 psi steam boiler" Approx $7800.00		x		
**Requires 230 electric, single or three phase			x	x
Mirror Finish On All	1	$4,350	$3,275	$2,800
Explosion Proof Agitator	1	$4,950	$4,950	$4,950
Explosion Proof electrical agitator with mounting port.				

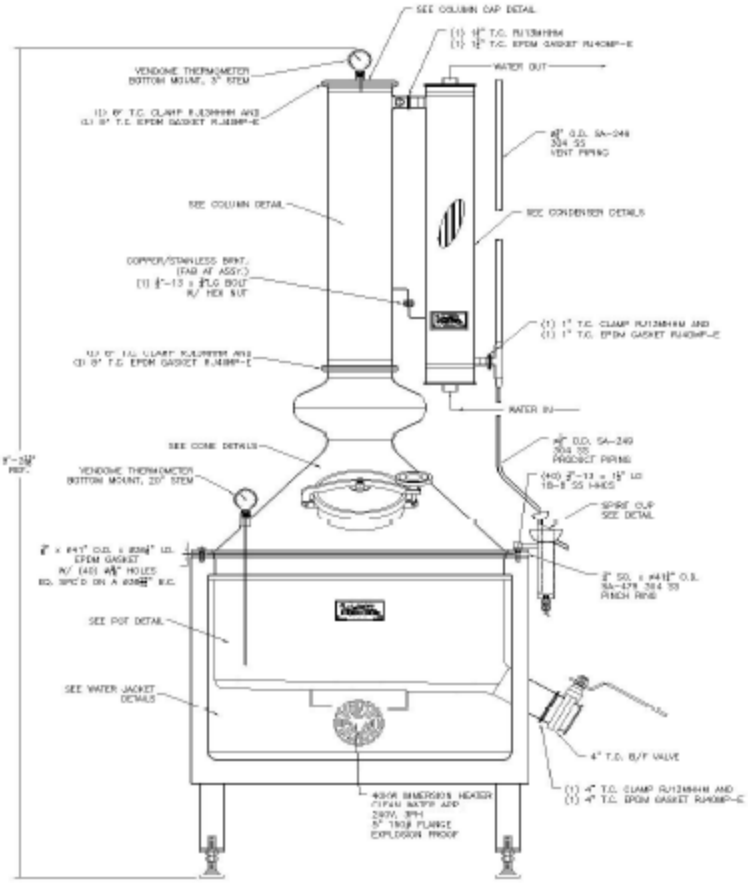
OPTIONAL EQUIPMENT				
		Gallon Charge		
Item	Qty	50	50	50
Mash Cooker 50 gallon	1	$11,500	$11,500	$11,500
All Stainless steel, dished heads top and bottom				
Live steam sparger for cooking. Internal coils for cooling				
3" drain with valve. top mount electrical Agitator.				
18" top manway				
Roll Around Transfer Pump	1	$4,790	$4,790	$4,790
Moves raw materials between hot water tank, cooker, fermenters, and batch still				
Stainless steel APV 110/230v 1ph electric roll around carriage.				
10' PVC intake and 20' delivery hose with ss camlocks couplings.				
Economy air driven Air driven also availble $3350.00				
Economy Fermenter Vessels				
1-1/2" drain with valve and camlock connector, open top.				
50 gallon $1,690.00	0	$0		
100 gallon $2,690.00	0	$0		
Stainless Receiving Tanks				
50 gallon $1,790.00	0	$0		
100 gallon $2,790.00	0	$0		
Touch Screen Automated System Control Unit		$7,000	$7,000	$7,000
This can be priced after plant design and layout has been established				
Field Installation				
This can be priced after plant design and layout has been established				
Optional Totals:				
Grand Total:				

Package Boiler -Electric, propane or natural gas driven			
We recommend you purchase boiler and have installed locally	(BTU/hr)		
Minimum recommended boiler sizing for batch still only	75,000		
Minimum recommended boiler sizing for batch still and mash cooker running simultaneously	125,000		

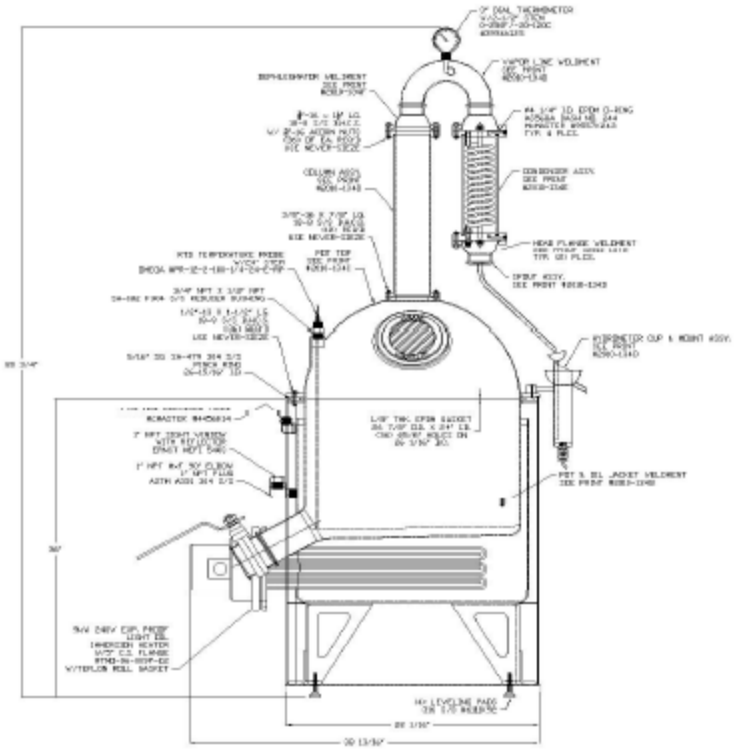
Estimated Product Output (based on 8% ABV Charge with 5 hour run time)	Gallon Charge		
	30	50	
80 Proof	18	30	
100 Proof	14.5	24	
120 Proof	12	20	
140 Proof	10	17	
(*multiple runs) 190 Proof	7.5	12.5	
	*production liters after heads and t		



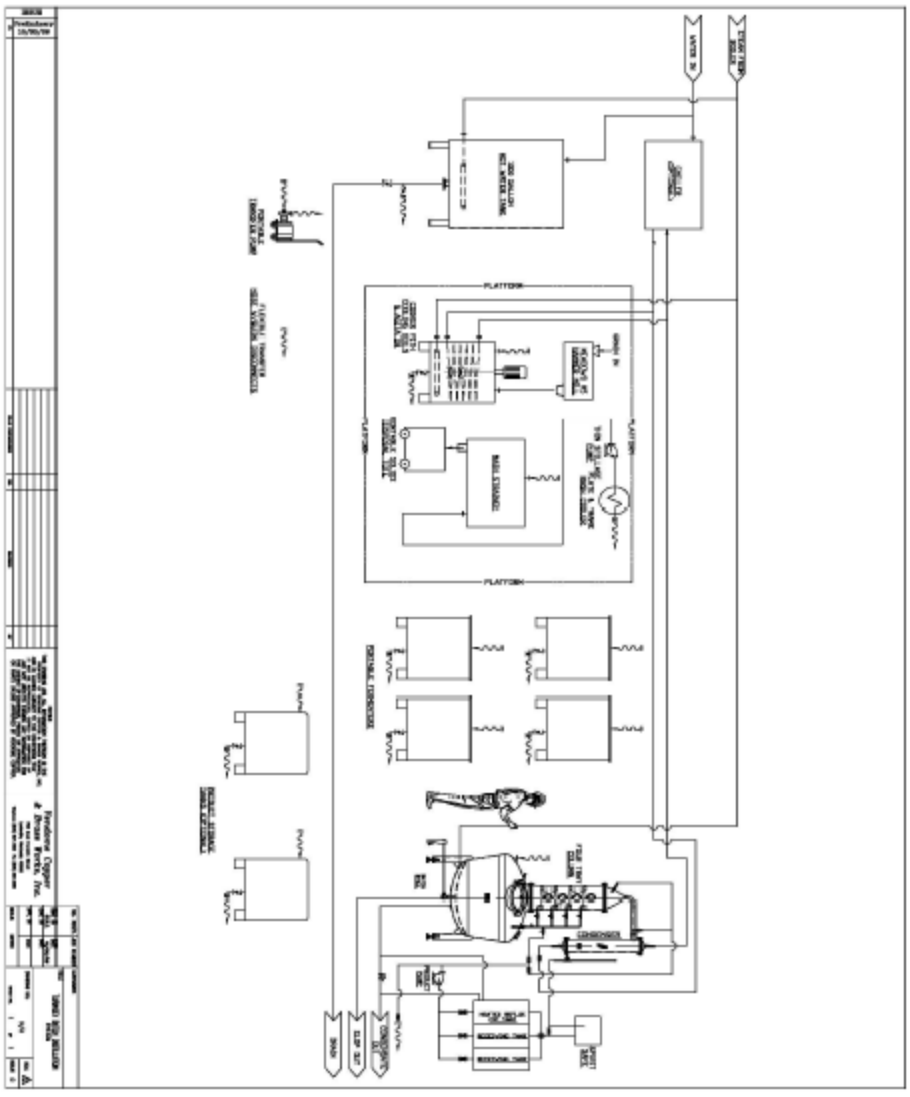
50 GALLON STEAM OR OIL



"NEW" 50 GAL. ELECTRIC

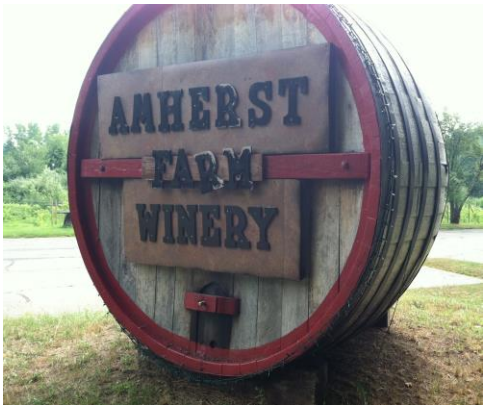


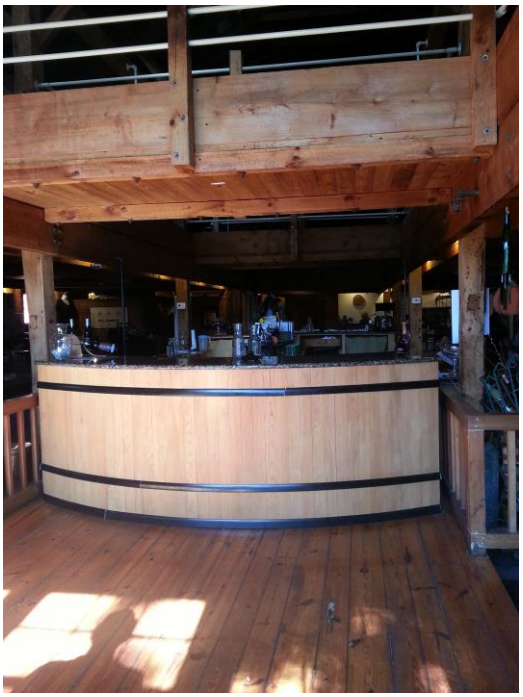
30 GALLON ELECTRIC



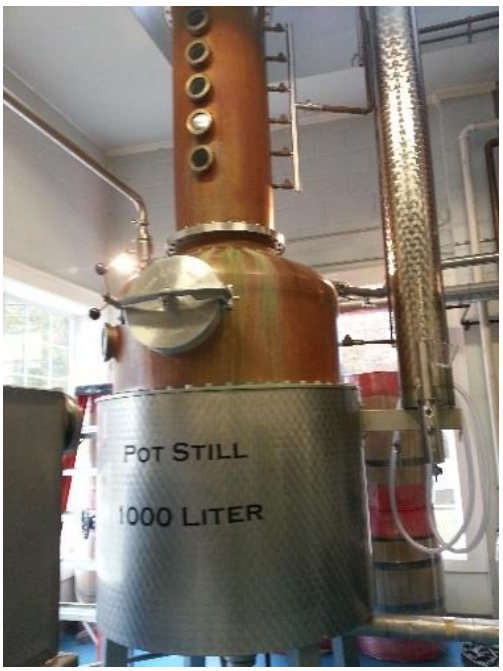
Appendix C: Pictures

Amherst Farm Winery





Distillery Tours


POT STILL
1000 LITER

Workshop


MX 1600
RAD


1000 Ltr.


SILO
SILO


SILO