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EPA ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Bourbon Distillery

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Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. Waste Minimization Assessment Centers (WMACs) were established at selected universities and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at the University of Louisville performed an assessment at a plant that manufactures bourbon whiskey and distiller dried grains as a byproduct from corn, rye, and malt. The grains are milled, mixed together, and cooked. Then the resulting mixture is allowed to ferment. After fermentation, the mixture is processed in a distillation column. The distillate is diluted to proper proof and placed in charred barrels for aging. After an appropriate storage period, the barrels are emptied and the contents are shipped in tank trailers. The team's report, detailing findings and recommendations, indicated that large quantities of CO_2 and ethanol are vented from the plant and that significant cost savings could be achieved through CO_2 and ethanol recovery.

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from University City Science Center.

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Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste generation is to reduce or eliminate the waste at its source.

University City Science Center (Philadelphia, PA) has begun a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the in-house expertise to do so. Under agreement with EPA's Risk Reduction Engineering Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at the University of Louisville's WMAC. The assessment teams have considerable direct experience with process operations in manufacturing plants and also have the knowledge and skills needed to minimize waste generation.

The waste minimization assessments are done for small and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding $75 million, employ no more than 500 persons, and lack in-house expertise in waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers and reduction of waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

Methodology of Assessments

The waste minimization assessments require several site visits to each client served. In general, the WMACs follow the procedures outlined in the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC staff locate the sources of waste in the plant and identify the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report that details the WMAC's findings and recommendations (including cost savings, implementation costs, and payback times) is prepared for each client.

Plant Background

The plant produces bourbon whiskey and distiller dried grains from corn, rye, and malt. It operates three shifts/day to produce approximately 5 million gal of bourbon and over 16,000 tons of distiller dried grain/yr.

Manufacturing Process

The basic raw materials—corn, rye, and malt—are milled in hammer mills and fed to cookers. Water and setback (thin stillage from the drying of spent grain after the alcohol and large solids have been removed) are added and the resulting mixture is cooked. During cooking, the starch in the corn and rye is converted to sugar. After the conversion has taken place, the mixture (known as mash) is pumped to a fermenter where yeast is added to complete the conversion of sugar to alcohol. Upon completion of the fermentation cycle, the mash (or beer) is pumped to an intermediate tank called the beer well.

The contents of the beer well are pumped to the distillation column where the alcohol is steam stripped from the beer. The steam stripper distillate is condensed and pumped to the doubler for final distillation. Distillate from the doubler is condensed and pumped to the barrel-filling operations; spent grain is pumped to the dry house for processing.

At the barrel-filling facility, the distillate is diluted to proper proof with demineralized water. Barrels (of charred new white oak) are filled with the diluted distillate and transported to the warehouse for aging.

During the storage period (a minimum of four years), the material in the barrel goes through a maturation or aging process by which the distillate is transformed into a bourbon. When the product in the barrel is determined to be of proper quality, the barrel is transported to the dumping area. There the contents of the barrel are poured through steel screens for removal of solids. The product is then pumped to one of two storage tanks from which it is loaded into tank trailers for shipment.

Spent grain from the distillation operations is processed into distiller dried grain (an animal feed additive) in the dry house. The spent grain is processed in centrifuges where the solids are concentrated and the excess water (centrate) is removed. The concentrated solids are fed to an air dryer and the centrate is pumped to an evaporator where the dissolved solids are concentrated. The viscous discharge (syrup) from the evaporator is mixed with a portion of the dried grain stream as it is recycled back to the dryer. The portion of the dried grain stream not used as recycle is conveyed to one of two storage silos if the moisture content is satisfactory.

An abbreviated process flow diagram for this plant is shown in Figure 1.

Waste Management Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of the waste, and the annual waste management cost for each waste stream identified are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team recommended for the plant. The minimization opportunity, the type of waste, the possible waste reduction and associated savings, and the implementation cost along with the payback time are given in the table. The quantities of waste currently generated by the plant and possible waste reduction depend on the production level of the plant. All values should be considered in that context.

It should be noted that the economic savings of the minimization opportunity, in most cases, results from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. Other savings not quantifiable by this study include a wide variety of possible future costs related to changing emissions standards, liability, and employee health. It also should be noted that the savings given for each opportunity reflect the savings achievable when implementing each waste minimization opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, several additional measures were considered. These measures were not completely analyzed because of insufficient data, minimal savings, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to waste reduction may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Seal the grain leaks found throughout the conveying operations.
- Install a shutoff mechanism that provides a tighter seal at the discharge of the milled grain hoppers in order to reduce grain losses.
- Control ethanol emissions from storage tanks.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-814903 by the University City Science Center under the sponsorship of the U.S. Environmental Protection Agency. The EPA Project Officer was **Emma Lou George**.

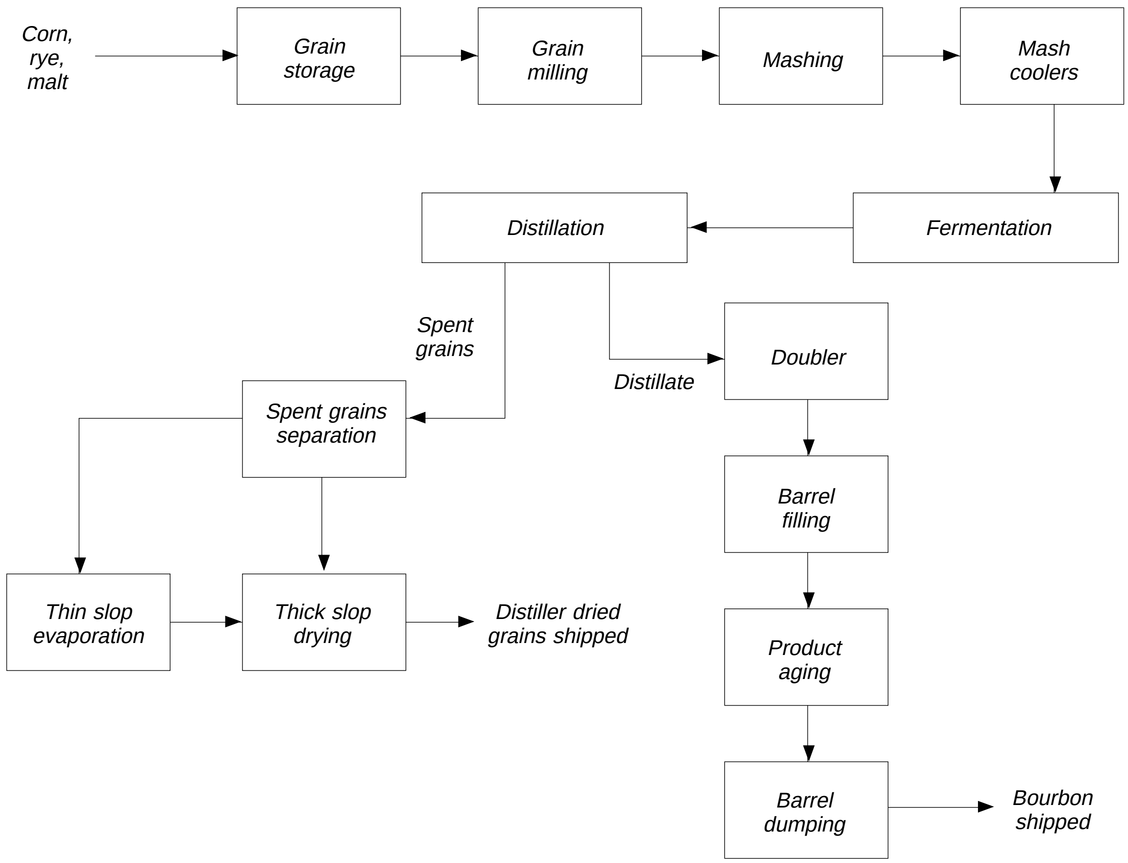

Figure 1. *Abbreviated process flow diagram for bourbon whiskey production.*

Table 1. *Summary of Current Waste Generation*

Waste Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost[1]
Grain losses	Raw material handling	Shipped offsite to landfill	24,000	$6,000
Carbon dioxide	Fermentation	Vented from plant	25,680,000	0
Ethanol	Fermentation	Vented from plant	205,920	43,680
Wastewater	Fermentation tank cleaning	Treated in onsite WWTP; discharged to creek	846,600	—[2]
Ethanol	Distillation	Vented from plant	228,100	48,000
Spent caustic	Cleaning of distillation equipment	Treated in onsite WWTP; discharged to creek	830,000	—[2]
Spilled ethanol	Barrel filling	Evaporates	1,040	660
Char	Charring of new barrels	Shipped offsite to landfill	480 ft^3/yr	40
Ethanol	Warehoused barrels	Vented from plant	3,181,080	1,020,540
Char/bungs	Emptying of barrels and filtering of contents	Mixed with coal; incinerated in onsite boiler	60,000	0
Filter pads	Filtering of barrel contents	Shipped offsite to landfill	3,200 pads/yr	40
Scrubber solids	Dry house air scrubber	Shipped offsite to landfill	3,000	1,090
Scrubber water	Dry house air scrubber	Treated in onsite WWTP; discharged to creek	149,400	—[2]
Spent caustic	Dry house cleaning	Treated in onsite WWTP; discharged to creek	415,000	—[2]
Slop	Dry house `	Sold to farmers	640,000 gal/yr	-7,000 (revenue received)
Distiller dried grain losses	Truck loading, equipment leakage	Shipped offsite to landfill	200,000	17,000
Wastewater	Boiler feedwater treatment	Treated in onsite WWTP; discharged to creek	4,191,500	—[2]
Wastewater	Boiler blowdown	Treated in onsite WWTP; discharged to creek	24,000,000	—[2]
Spent liquids	Demineralizer regeneration	Treated in onsite WWTP; discharged to creek	664,000	—[2]
Ashes	Coal-fired boiler	Shipped offsite to landfill	129,600 ft^3/yr	17,600
Ethanol	Storage tanks	Vented from plant	11,780	5,230
Spent oils	Equipment lubrication	Shipped offsite	275 gal/yr	125
Spent mineral spirits	Parts cleaning	Shipped offsite for recycle	235 gal/yr	1,460
Cloth filters	Dust collectors	Shipped offsite to be cleaned; returned for reuse	110 filters/yr	380

[1] *Includes waste treatment, disposal, and handling costs and applicable lost raw materials value.*
[2] *Cost is included in the annual WWTP operating cost of $118,300/yr.*

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Minimization Opportunity	Waste Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yr)
		Quanity (lb/yr)	Per cent			
Install air ducting from the storage hopper vents to the inlet of an existing pulsating dust collector in order to minimize grain losses from the vent lines.	Grain losses	4,800	20	$1,200	$3,000	2.5
Modify the metal funnel apparatus used during grain unloading from the railcars in order to reduce grain losses.	Grain losses	1,200	5	300	500	1.7
Install a recovery plant to recover CO_2 and ethanol from the fermenters. The recovered liquefied CO_2 can be sold to a distributor or an end-user as a food and beverage grade product. Recovered ethanol can be sold to a fuel alcohol facility or used as supplemental fuel onsite.	Carbon dioxide (from fermentation) Ethanol (from fermentation)	20,160,000 161,700	79 79	223,600[1]	930,000	4.2[2]
Install a refrigerated water-cooled condenser on the vent discharges from the distillation process in order to recover ethanol. Use the recovered ethanol onsite as a supplemental fuel.	Ethanol (from distillation)	228,100	100	19,800	39,000	2.0[2]
Recover ethanol emissions from the barrel warehouse using activated carbon adsorption. Redistill the recovered ethanol and sell the product obtained.	Ethanol (from warehousing)	2,900,000	90	495,380	2,050,000	4.1[2]
Replace the loading apparatus currently used for loading the distiller dried grains with a telescoping loading nozzle in order to reduce grain losses.	Distiller dried grain losses	2,000,000	100	17,000	45,000	2.7

[1] *Exact savings may vary from this estimate depending on the exact price obtained for the CO_2.*
[2] *A much shorter payback will be realized should a carbon emissions tax and/or a VOC emissions tax or permit for ethanol be required in the future.*

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