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ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Bourbon Whiskey

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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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 produces bourbon whiskey. Grains are ground, cooked, and fermented using yeast. The resulting fermented product is sent to a beer still for alcohol recovery. Overhead vapors go to a doubler from which they flash yielding a new whiskey. The new whiskey obtained is stored in charred wooden barrels for several years and, after maturation, is shipped offsite for bottling. The team's report, detailing findings and recommendations, indicated that carbon dioxide and ethanol are vented to the atmosphere in large quantities and that significant cost savings could be realized through carbon dioxide and ethanol recovery.

This Research Brief was developed by the principal investigators and EPA's National Risk Management Research 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 National Risk Management Research 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 pollution prevention opportunity 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 pollution prevention.

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 pollution prevention opportunity 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

Manufacturing Process

Whiskey Production

The production of whiskey is described in this section. A process flow diagram that depicts the process appears at the end of this section.

Corn, rye, and malt grains received via railcars and trucks are bottom-unloaded through a grate onto a screw conveyor. The grains are carried to a vibrating screen where large foreign material is removed, then transferred by bucket elevators to storage silos.

As needed, the grain is transported by screw conveyor to mills for grinding. The ground grain (also called meal) is then sent via bucket elevator to the meal room where each type of grain is stored in a separate bin. A small amount of malt meal is added to bins of corn meal and rye meal to keep them from hardening. The meal is then gravity fed to the scale room.

From the scale room, rye and malt are sent to separate slurry tanks prior to being added to the cooker. Corn meal is conveyed to one of three mash cookers to which water and spent stillage from fermentation are added. Steam is added to the cooker directly in order to cook the corn at high pressure and temperature. After the corn has been cooked, the vessel temperature is lowered by releasing the tank pressure. The rye slurry from the slurry tank is added to the cooking vessel where the resulting mixture is cooked at lower pressure and temperature then used for the initial corn cooking. Next, the malt slurry is added to the mixture (called the mash) in the vessel. The cooking process releases the starches from the grain and the malt provides the enzyme that converts the starch to sugar.

In a separate operation, yeast is prepared for the fermentation process. An inoculum and a mixture of rye and malt meals are combined in one of several yeast tubs. Once the yeast is ready, it is mixed with the mash and cooled. The mixture is fed to a fermentor where the yeast metabolizes the sugars to produce alcohol.

The fermented product, beer that is approximately 9% alcohol by volume, is sent to the beer well for storage. From the beer well the product is pumped to the beer still for alcohol recovery. The overhead vapors from the still go to a thumper (also called a doubler) where they flash into the high wine condenser, yielding a 145-proof new whiskey. The still bottoms or "slop" are sent to the dryhouse for further processing into distillers' dried grains for use as animal feed.

The new whiskey is sent to one of several storage tanks where it is reduced in proof using demineralized water. Charred white oak barrels are then filled with product. The filled barrels are sent to a temperature- and humidity-controlled warehouse where the product matures for several years.

Following the maturation process, the barrels are conveyed to vacuum pumps which transfer the whiskey into storage tanks. The whiskey is loaded into trucks and taken to an offsite bottling facility.

A process flow diagram for whiskey production is shown in Figure 1.

Dried Grains Production

The processing of the still bottoms begins with the initial separation of "thin slop" from "thick slop" by passing the mixture over a screen. A portion of the thin slop is sent to the mash cookers. The remaining thin slop is sent to a small holding tank. The thick slop is passed through a paddle screen and a press for further recovery of thin slop. Remaining thick slop is conveyed to a drier and then a storage tank. From the holding tank the thin slop is sent through a four-stage multi-effect evaporator and two finishing evaporators. The syrup is sent to a dehydrator and then to storage. Dried grain from the thin and thick slop is mixed and sold as animal feed.

A process flow diagram for production of distillers' dried grains is shown in Figure 2.

Existing Waste Management Practices

This plant already has implemented the following techniques to manage and minimize its wastes:

- A product, distillers' dried grains for animal feed, is made from the distillation residue.
- Spillage of grain during unloading has been reduced by funneling the grain into the delivery grate.
- Leakage of grain from the grain handling system has been reduced through the use of relatively new and tight equipment and through frequent routine maintenance.

Pollution Prevention 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 pollution prevention that the WMAC team recommended for the plant. The 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 opportunity, in most cases, result from the reduction in raw materials 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 em-

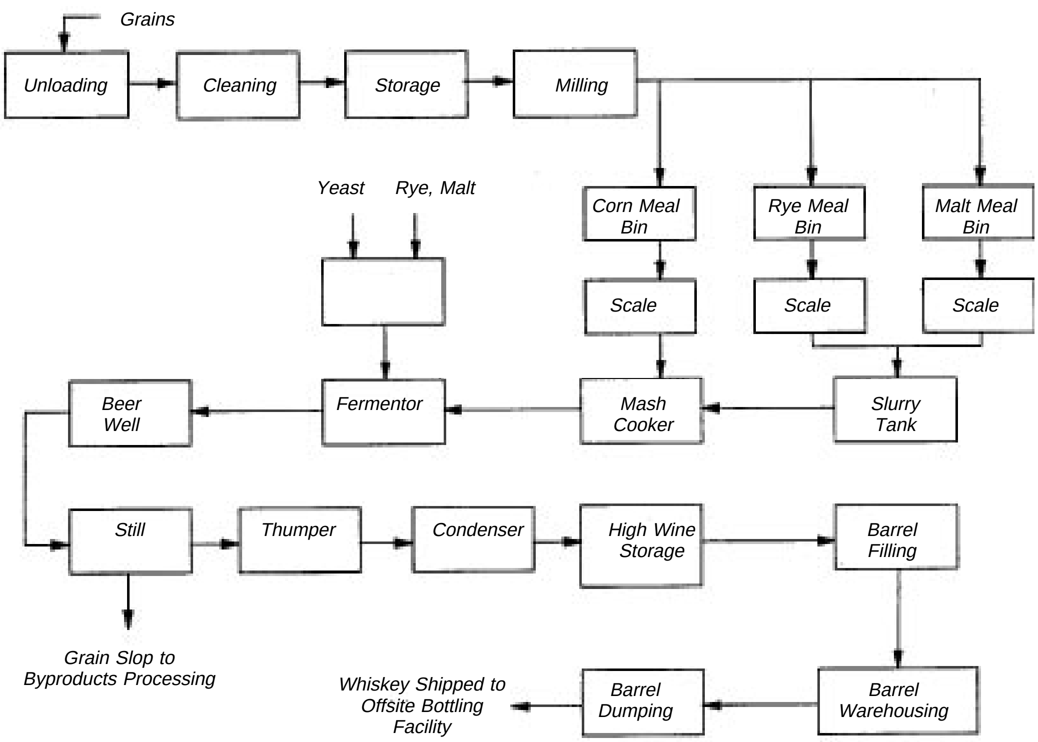

Figure 1. *Abbreviated process flow diagram for whiskey manufacturer.*

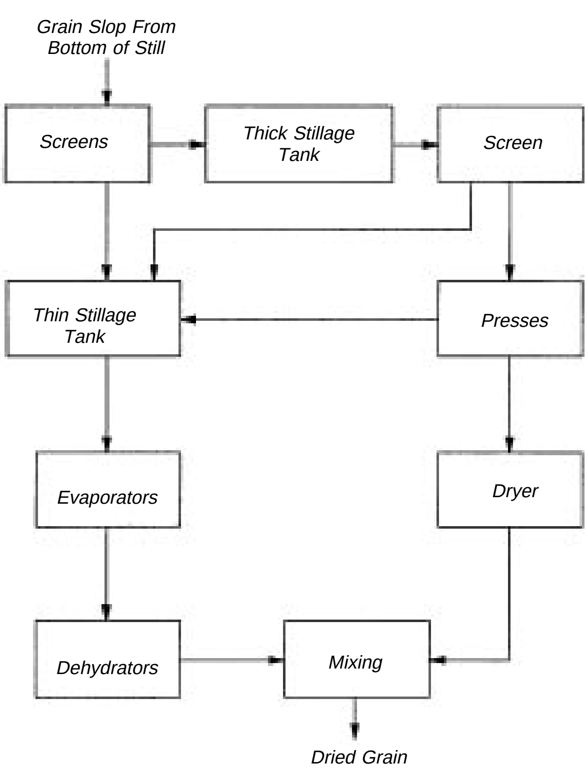

Figure 2. *Abbreviated process flow diagram for dried grain production.*

ployee health. It also should be noted that the savings given for each pollution prevention 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 analyzed completely because of insufficient data, minimal savings, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to pollution prevention may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Install a system to reduce the concentrations of BOD_5 and suspended solids in the wastewater currently sent to the POTW.
- Use an enclosed filter on the off-gas of the granary cyclone; direct the collected dust to the corn meal storage bin.
- Use high-pressure water spraying to clean cookers in order to reduce the quantity of water required for cleaning.
- Reuse the evaporator scrubber effluent for cleaning of the vent from the steam tube dryers.
- Recover ethanol emissions from the storage tanks in various stages of the manufacturing process.

- Reduce dust losses that occur during the loading of distillers' dried grains into trucks.

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**.

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 waste	*Vibratory screens and cleaning of conveyors*	*Given to employees for use as animal feed*	*6,350*	*0*
Grain and water	*Water scrubber for cyclone*	*Sewered*	*33,259,000*	*4,680*[2]
Grain	*Granary operations*	*Dust reduced using water scrubber*	*Included in above*	*369,000 (lost material value)*
Water and caustic	*Cleaning of mashers, fermentors, beer well, and mash lines*	*Sewered*	*25,146,500*	*3,390*[2]
Wastewater	*Rinsing of cooker and cleaning of sight glasses on cookers*	*Sewered*	*8,300*	*negligible*
Carbon dioxide	*Fermentors*	*Vented to atmosphere*	*106,240,000*	*0*
Ethanol	*Fermentors*	*Vented to atmosphere*	*637,400*	*136,000*
Water and caustic	*Cleaning of stills*	*Sewered*	*5,196,000*	*680*[2]
Ethanol	*Condensers*	*Vented to atmosphere*	*630,530*	*134,400*
Water, acid, and caustic	*Regeneration of cation and anion exchangers*	*Used for neutralization; sewered*	*3,572,940*	*1,240*[2]
Ethanol	*Filling of storage tanks*	*Vented to atmosphere*	*4,960*	*1,060*
Ethanol	*Barrel breathing during maturing process*	*Vented to atmosphere*	*2,545,000*	*1,027,000*
Ethanol	*Transfer of product for bottling*	*Vented to atmosphere*	*8,320*	*3,360*
Dried grains and water	*Cleaning of equipment used for byproduct processing*	*Sewered*	*37,413,000*	*5,080*[2]
Water and soluble grain	*Evaporator condensate from byproduct processing*	*Sewered*	*666,782,800*	*90,630*[2]
Other wastewater	*Various processes*	*Sewered*	*143,161,500*	*12,915*[2]
Coal ashes	*Burning of coal for steam generation*	*Shipped to landfill*	*32,000,000*	*98,700*
Spent oils	*Changing of lubricating oils*	*Recycled offsite*	*2,300*	*1,500*

[1] *Includes waste treatment, disposal, and handling costs and lost materials values.*
[2] *Estimated cost of individual waste stream. Additional surcharges of $113,410/yr are incurred for BOD and suspended solids.*

Table 2. Summary of Recommended Pollution Prevention Opportunities

Pollution Prevention Opportunity	Waste Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yr)
		Quantity (lb/yr)	Percent			
Install a packaged CO_2 recovery plant to recover CO_2 and ethanol vented from the fermentors. Sell the recovered liquified CO_2 to a CO_2 distributor. Recovered water/ethanol can be sent to the beer well to be further processed.	Carbon dioxide from fermentors Ethanol from fermentors	106,240,000 573,700	100 90	$1,248,200[1,2]	$2,600,00	2.1
Recover ethanol vent losses from the still condensers using a refrigerated water-cooled condenser. Use the recovered ethanol as a supplemental fuel in the boilers.	Ethanol from condensers	567,500	90	7,360[1,3]	16,600	2.3
Replace the currently used ion exchange system with a reverse osmosis unit that is available on-site for demineralizing water.	Water, acid, and caustic	3,572,940	100	2,740[1,4]	160	0.1
Recover ethanol from the ware-house exhaust air using carbon adsorption and steam stripping and distillation. Return the re-covered ethanol to the beer well.	Ethanol from barrel breathing	2,375,191	93	864,210[1,3]	831,000	1.0
Ship coal ash to a nearby cement kiln that can use the ash as a raw material instead of shipping it to a landfill.	Coal ash	32,000,000	100	68,300	0	0

1 Total annual savings have been reduced by the operating cost required for implementation.
2 If a tax is imposed on CO_2 emissions in the future, the savings from this WMO would be even higher.
3 If a tax is imposed on VOC emissions in the future, the savings from this WMO would be even higher.
4 It is possible that this plant will be reclassified as a hazardous waste generator in the future because of new regulations concerning the pH of regenerant material. In that case, savings from this WMO would be even higher.

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