



ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Pharmaceuticals

Harry W. Edwards*, Michael F. Kostrzewa*,
and Gwen P. Looby**

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. In an effort to assist these manufacturers 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Colorado State University performed an assessment at a plant that manufactures intermediates for pharmaceuticals and other chemicals. Raw materials and preprocessed materials undergo verification and blending and mixing. The resulting advanced pharmaceutical intermediates are then shipped to another plant for final processing. The team's report, detailing findings and recommendations, indicated that the waste streams generated in the greatest quantities are waste solvents that are reused onsite, incinerated as fuel in an onsite boiler, or shipped offsite for disposal. The greatest cost savings could be achieved by reusing additional amounts of methylene chloride in the plant.

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.

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 Colorado State University's (Fort Collins) 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.

* Colorado State University, Department of Mechanical Engineering

** University City Science Center, Philadelphia, PA

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

This plant manufactures intermediates for pharmaceuticals and other miscellaneous chemicals. Over six million pounds of product are produced annually during 8,640 hr/yr of operation.

Manufacturing Process

Production is performed by the plant in batches. The required raw materials and pre-processed materials are received from a sister plant. The production of the pharmaceuticals requires several reaction and purifying steps that are combined to make up a single batch. Batches isolate either intermediate or final products. Several intermediates may be required to get to the final product stage.

An abbreviated process flow diagram for the manufacture of pharmaceuticals is shown in Figure 1.

Existing Waste Management Practices

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

- The Responsible Care program of the Chemical Manufacturer's Association is used as the plant's waste minimization vehicle. The program emphasizes pollution prevention at the source rather than end-of-pipe solutions.
- An average of 95% of solvents are reused by the plant.
- Some of the spent solvents are incinerated onsite to produce required steam, thereby reducing purchased fuel consumption.
- Off-specification batch materials are reused.
- Enclosed centrifuges are used for dedicated processes to reduce air emissions of volatile organic compounds from solvents.
- A policy has been implemented for the chemists to avoid new production processes that require metallic compounds or chlorinated solvents.
- A site reduction plan for air emissions that includes a mass spectrometer used to monitor air emissions throughout the plant has been implemented.

- Since the initial site visit by the WMAC assessment team, some of the production steps for one of the products have been revised thereby reducing the generation rate of waste acetone dramatically.

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 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 simple 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, results from the reduction in raw material and 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 that pollution prevention opportunity alone and do not reflect duplication of savings that may result when the opportunities are implemented in a package.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, several other measures were considered. These measures were not analyzed completely because of insufficient data, minimal savings, implementation difficulty, or a projected lengthy payback. Since 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.

- Reuse the water from the onsite wastewater treatment plant as make-up water for the cooling tower.
- Install suitable storage tanks, piping, and a pump to permit onsite reuse of waste hexane.
- Install a sludge dryer to remove water from the wastewater treatment sludge.
- Extend the life of the solvents used for tank cleaning by implementing staged cleaning.
- Install a small solvent recovery unit to distill small volumes of waste solvent for reuse onsite.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-819557 by the University City Science Center under the sponsorship of the U. S. Environmental Protection Agency. The EPA Project Officer was **Emma Lou George**.

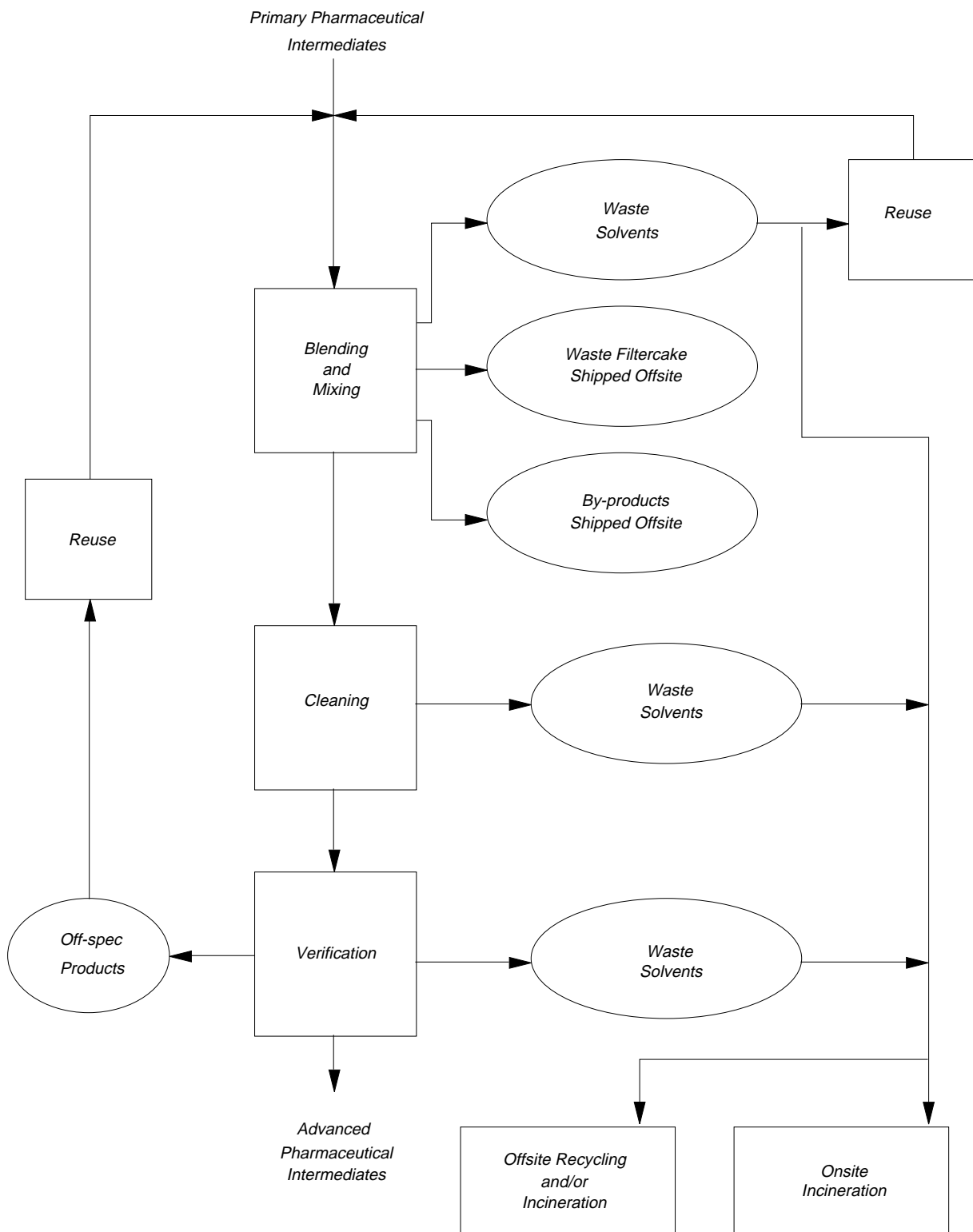


Figure 1. Abbreviated process flow diagram for pharmaceutical manufacture.

Table 1. Summary of Current Waste Generation

Waste Stream Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost
Waste solvents (acetone, toluene, methanol, THF, hexane, ethyl acetate, isopropyl acetate, DMF, methylene chloride, acetic acid, heptane, ethyl ether, dimethoxy methane)	Verification, blending and mixing, and clean-up	Reused onsite in subsequent formulations	63,442,000	\$ 0 ¹
Waste solvents (acetone, toluene, methanol, THF, hexane, ethyl acetate, isopropyl acetate, DMF, acetic acid, heptane, ethyl ether, dimethoxy methane)	Verification, blending and mixing, and clean-up	Incinerated as fuel in onsite boiler	2,359,000	0 ¹
4 Waste solvents (acetone, toluene, methanol, THF, hexane, ethyl acetate, isopropyl acetate, DMF, methylene chloride, acetic acid, heptane, ethyl ether, dimethoxy methane)	Verification, blending and mixing, and clean-up	Shipped offsite to disposal facility for recycling and/or incineration	2,333,500	329,040 ²
Waste process sludge	Byproduct of production	Shipped offsite for stabilization and burial	412,000	133,000 ²
Filter cake/solid wastes	Blending and mixing of product	Shipped offsite to disposal facility for recycling and/or incineration	26,700	85,200 ²
Wastewater	Various plant areas	Treated in onsite wastewater treatment plant and sewer	395,000,000	81,100 ³
Wastewater treatment sludge	Onsite wastewater treatment plant	Shipped offsite for burial	240,000	90,800 ²

¹ No cost reported by plant

² Waste disposal costs

³ Waste disposal cost and value of lost raw material

Table 2. Summary of Recommended Waste Minimization Opportunities

Minimization Opportunity	Waste Stream Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yrs)
		Quantity (lb/yr)	Per Cent			
Reuse the waste methylene chloride from the last stage of each campaign for a particular product in subsequent campaigns.	Waste solvent shipped offsite (methylene chloride)	141,000	6	\$70,200	\$80,000	1.1
Reuse a portion of the waste methanol generated as make-up in the low-temperature cooling system.	Waste solvent shipped offsite (methanol)	153,410	7	46,900	40,000	0.9
	Waste solvent incinerated onsite (methanol)	222,590	9			
Reuse the methanol used in the verification process in the production and cleaning processes.	Waste solvent shipped offsite (methanol)	27,380	1	8,370	24,000	2.9
	Waste solvent incinerated onsite (methanol)	39,720	2			

United States
Environmental Protection Agency
National Risk Management Research Laboratory (G-72)
Cincinnati, OH 45268

Official Business
Penalty for Private Use
\$300

EPA/600/S-95/030

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35