Code of Management Practice for Silver Dischargers

Recommendations on Technology,
Equipment and Management Practices for
Controlling Silver Discharges from
Facilities that Process Photographic Materials

Association of Metropolitan Sewerage Agencies (AMSA) / The Silver Council

Code of Management Practice for Silver Dischargers

Directions for navigating through this document

Click on the Part you wish to view (e.g., Part 2 Definitions).

Once in the Part click on the Table of Contents item you wish to view.

To return to the Table of Contents in each Part, click any heading in bold type.

To return to this page, click on the Code of Management Practice for Silver Dischargers heading at the beginning of each Part.

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Recommendations on Technology, Equipment and Management Practices for Controlling Silver Discharges from Facilities that Process Photographic Materials

Association of Metropolitan Sewerage Agencies (AMSA) / The Silver Council

Code of Management Practice for Silver Dischargers

Part 1 Introduction
January 1996

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) describes the rationale for developing a Code of Management Practice, outlines the contents of the document, acknowledges the participants, and defines the responsibilities for maintenance and distribution of the document.

2 Overview

Pollution prevention is a critical component of any environmental program. This Code of Management Practice provides a cleaner, cheaper and smarter means of promoting environmental performance by enhancing the recovery of silver by processors of photographic materials, in firms of all types and sizes. It gives industry a framework for developing both cost-effective and sound environmental management systems, starting with pollution prevention.

The purpose of this Code of Management Practices is to provide information for developing a consensus among the regulated and regulatory communities for controlling silver discharges from photographic processing facilities in a cost-effective and environmentally-sound manner. Implementation of this Code of Management Practice as a consensus standard will result in many benefits including improved selection, operation, maintenance, and monitoring of silver recovery and management systems, especially among the small and medium-size facilities. This, in turn, will result in a net decrease in the amount of silver released to the environment and an increase in the amount of silver recycled and reused.

3 Organization

To make the Code of Management Practice easier to implement, maintain, and update, it is presented in parts. The publication date of each part indicates the version currently in print.

Part	Title	Publication Date
1	Introduction	01-97
2	Definitions	01-97
3	Photographic Processing	01-97
4	Silver Recovery and Management Technologies	01-97
5	Code of Management Practice—Recommendations	01-97
6	Considerations for Compliance with Specific Silver Pretreatment Limits	01-97
7	Considerations for Pollution Prevention Activities	01-97

This document supercedes the November, 1996 edition.

4 Acknowledgments

Many individuals representing regulatory agencies in conjunction with industry have contributed to developing this Code of Management Practice (CMP). It is a direct result of their participation in the committee process and we gratefully acknowledge all these contributions. The participants brought to the project, a broad variety of knowledge and experience in controlling silver discharges, making this CMP a well-conceived and common-sense approach to discharges to POTWs.

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A special thanks to Dr. Robert Cappel, representing the Silver Council, and Mr. Guy Aydlett and Ms. Margie Nellor representing AMSA for their initial efforts in formulating the concept document and early drafts of the Code of Management Practice.

5 Document Control

The National Association of Photographic Manufacturers (NAPM) has the assigned responsibility of maintaining and updating this document on behalf of AMSA, The Silver Council members and other participants.

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Code of Management Practice for Silver Dischargers

Part 2 Definitions
January 1997

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) defines the terms and acronyms used throughout the document.

2 Terms and Acronyms

AMSA: The Association of Metropolitan Sewerage Agencies represents the interests of the country's largest wastewater treatment agencies. AMSA maintains a key role in the development of environmental legislation and implementation of environmental rules, guidance and policy.

Batch Process: The collection of silver-rich solution into a tank or container which is processed through a silver recovery or management system.

CMP / Code of Management Practice: The site-specific plan implemented by the individual processing facility for the purpose of controlling and reducing discharges of silver to the POTW.

Continuous Process: The processing of silver-rich solution in a continuous flow from the processing machine through a silver recovery or management system.

CRC: A chemical recovery cartridge which recovers silver through a process known as metallic replacement.

Distillate: The liquid recovered by condensation during the process of distilling or concentrating used processing solutions and wash waters.

DOT: U.S. Department of Transportation

Effluent: Used or exhausted chemical overflow.

Electrolytic Silver Recovery: A method of recovering silver in which a direct current is applied across two electrodes immersed in a silver-rich solution.

Good Housekeeping: Maintenance of a neat, orderly and clean working environment.

GPD: Gallons per day

Large Photographic Processing Facility: A facility which produces on average more than 20 GPD of silver-rich solution and discharges less than 25,000 GPD of process wastewater.

Low-Silver Solution: A solution containing insufficient silver for cost effective silver recovery. Low-silver solutions include used developers, bleaches, stop baths, pre-bleaches, stabilizers following washes, and wash waters.

Medium Photographic Processing Facility: A facility which produces on average less than 20 GPD of silver-rich solution and discharges less than 10,000 GPD of process wastewater.

Metallic Replacement: A method of recovering silver from silver-rich solutions by an oxidation-reduction reaction with elemental iron and silver thiosulfate to produce ferrous iron and metallic silver. The device used is commonly called a chemical recovery cartridge (CRC).

Minilab: An establishment having a combined color printer and processor capable of offering one-hour on-site photographic film processing and printing services to the general public.

Milligrams Per Liter (Mg/L): Amount of a substance in relationship to the whole. Mg/L is the same measurement as parts per million (PPM).

Off-Site Silver Recovery and Management: Removal of silver-rich solutions from a facility by a licensed hauling service to a recovery facility.

On-Site Silver Recovery and Management: The management and treatment of silver-rich solutions on the premises at which the silver-rich solutions are generated.

Pollution Prevention: The use of processes, practices, materials, and energy that avoid or minimize the creation of processing and other wastes.

POTW: Publically Owned Treatment Works. A wastewater treatment plant owned by the public (municipality or service authority).

Preventive Maintenance: A routine set of procedures performed on equipment and processes to reduce the risk of a malfunction.

Pretreat: To change the characteristic of a waste by treatment before it is discharged to a POTW.

Significant Industrial User (SIU): Any industrial user that: discharges an average of 25,000 GPD or more of process wastewater to a POTW, contributes a process waste stream which makes up 5% or more of the average dry weather hydraulic or organic capacity of the POTW, is designated as such by the Control Authority on the basis that the industrial user has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard, or is subject to Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, subsection N.

Silver Council: A national group of trade associations, technical societies, municipalities, and government agencies whose members represent more than 360,000 facilities that process photographic materials.

Silver Recovery: The process of removing silver from silver-rich solutions such as fixers, bleach fixes, washless stabilizers, and low flow washes.

Silver-Rich Solution: A solution containing sufficient silver that cost-effective recovery could be done either onsite or offsite.

Silver Test Paper: A test paper coated with an analytical reagent which reacts by changing color in relationship to the amount of silver in solution. A reference color code allows users to determine the approximate amounts of silver in solution.

Small Photographic Processing Facility: A facility that produces on average less than 2 GPD of silver-rich solution and discharges less than 1,000 GPD of process wastewater.

Source Reduction: A decrease in the generation of both the volume and toxicity of liquid waste.

Spill: Discharge of liquid waste into the sewer that is not in the ordinary course of events.

Squeegee: Physical device (e.g., rollers, blades, etc.) used on processors to remove residual surface liquids before the film or paper travels from one processor tank to the next.

Sewer: An underground conduit for carrying off sewage to a POTW.

Code of Management Practice for Silver Dischargers

Part 3 Photographic Processing
January 1997

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) provides a rationale for examining photographic chemical discharges to the POTW, reviews the photographic industry sector and discusses the photographic process.

2 Overview

Silver discharges from photographic processing facilities to Publicly Owned Treatment Works (POTWs) have become of general interest to many municipal, state and federal agencies. POTWs must oversee and require the removal of silver, as well as other chemicals, to maintain compliance with their permit discharge limitations. While significant silver loading can come from domestic as well as industrial sources, the large number of facilities processing photographic films and papers make them of special concern to regulatory agencies.
A survey of the Water Environment Federation (WEF) membership identified photographic processing discharges to municipal sewerage systems as being of general concern. (Water Environment Federation,1994)

The Association of Metropolitan Sewerage Agencies (AMSA), the Association of State & Interstate Water Pollution Control Administrators (ASIWPCA), the Water Environment Federation (WEF), the U.S. Environmental Protection Agency (EPA), and several state and municipal agencies have expressed interest in developing guidance documents to assist POTWs in controlling discharges from small industrial and commercial sources. The Silver Council has offered its resources in developing guidance documents for controlling silver discharges from photographic processing facilities.

The Silver Council is a national group of trade associations, technical societies, municipalities, and government agencies whose members are vitally affected by the regulation of silver. The Silver Council's purpose is to encourage communications between the regulatory and regulated communities, to support scientific research, and to share current scientific, technical and economic information to achieve the common goals of pollution prevention, recycling, water conservation, and compliance. The Silver Council members supporting this Code of Management Practice are listed in Appendix A. Included in this listing are many of the major manufacturers and suppliers of photographic products and silver recovery equipment, as well as many of the major trade associations whose members process these photographic products.

In an initial study of the economic impact resulting from silver pretreatment standards for EPA, the Silver Council identified more than 500,000 facilities throughout the U.S. that process photographic films and papers containing silver (Dufficy, Cappel & Summers, 1993, pp. 52-56). More recent estimates suggest there are approximately 360,000 facilities. The majority of these facilities are small both in size, that is having fewer than 10 employees, and in volume of discharged wastewater, typically fewer than 1,000 gallons per day (GPD). An EPA study of the photographic processing industry, published in 1981, indicated that more than 99 percent of these facilities discharged to POTWs (U.S. Environmental Protection Agency, 1981). This continues to reflect accurately the current status of photographic processing discharges. Today, many POTWs do not have adequate resources to regulate and monitor the large numbers of small facilities, nor to assist them with improving the efficiencies of their silver recovery systems. The Silver Council, however, through its member organizations, does have resources to assist in improving silver recovery efficiencies.

AMSA agreed to work with the Silver Council to identify opportunities for reducing silver discharges from photographic processing facilities. Of particular interest is reducing silver discharges from the large number of small photographic processing facilities.

The primary areas of opportunity identified by AMSA and the Silver Council to assist facilities in reducing silver discharges from photographic processing operations include:

- Providing a better understanding of the technologies and the capabilities of on-site and off-site silver recovery equipment.

- Developing written, standardized procedures for operation and maintenance of the processing and silver recovery equipment, and collection and storage of the solutions for recovery.

- Providing better analytical tools for measuring silver concentration.
- Assisting with training programs for operators and maintenance personnel.
- Improving recordkeeping of silver recovery operations.
- Providing inspection and spill-control plans for silver-rich solutions.
- Recommending processor modifications to minimize silver-rich solution overflows.
- Recommending process modifications to optimize silver recovery.
- Translating the training materials and procedures into languages other than English.

Available technologies, equipment recommendations and cost-effective management practices are discussed in Part 4 of the CMP.

Typical costs and revenues for the silver recovery operations recommended by this CMP are presented in two appendices:

- Appendix B.1 for processing solutions containing 2,000 mg/l of silver
- Appendix B.2 for processing solutions containing 5,000 mg/l of silver.

This CMP could be implemented by any POTW that is in compliance with the silver discharge limits in its National Pollutant Discharge Elimination System (NPDES) permit, or implemented as an initial stage of a pretreatment program or a pollution prevention program. Future versions of this CMP will be expanded to include compliance manuals containing specific information, operating and maintenance procedures, training, recordkeeping, spill containment and clean up, trouble shooting, and other management practices for each photographic processing sector. The CMP will be implemented through the joint efforts of the Silver Council members and the regulatory agencies.

AMSA and the Silver Council also recognize that many POTWs currently have pretreatment programs with silver limits such that the CMP recommendations in Parts 4 & 5 could not provide compliance for their silver dischargers. These pretreatment limits may have been derived from state water quality standards and NPDES limits, or from previous pretreatment programs that are no longer valid. Part 6 discusses the types of technology, equipment and estimated costs necessary to meet some specific pretreatment discharge limits. This information is provided to assist POTWs in complying with their permits while improving the silver recovery techniques used by facilities processing photographic materials. This can prevent silver discharge limits which may result in substantial cost to both imaging and health care facilities without providing additional environmental benefits.

3 The Photographic Industry

Photographic films and papers are used to diagnose medical problems, identify structural defects, document, record, and transfer information, and to preserve memories. While the manufacture of these materials occurs at only a few sites around the world, the processing of these materials occurs at numerous facilities.

During processing of photographic films or paper, a silver-rich solution is generated. A silver-rich solution is defined as a solution containing sufficient silver that cost-effective recovery could be done either onsite or offsite. These solutions include used fix and bleach-fix solutions, low replenished (low-flow) washes following a fix or bleach-fix solution, and stabilizers for the washless minilab film and paper processes. Low-silver solutions include used developers, bleaches, stop baths, pre-bleaches, stabilizers following washes, and wash waters. Typical silver-rich and low-silver volumes for various processors are listed in Appendix C.

Small-size and medium-size photographic processors represent about 90 percent of the total number of photographic processing facilities. These include: small hospitals, doctors, dentists, veterinarians and chiropractors offices, neighborhood clinics, schools, portrait studios, minilabs, custom lab, professional processing labs, small microfilm facilities, printers, motion picture processors, and a large number of municipal, state, and federal facilities where some in-house photographic processing is done.

Medium-size facilities typically discharge 1,000 to 10,000 GPD of process wastewater and produce on average 2 to 20 GPD of silver-rich processing solutions. Small-size facilities typically discharge less than 1,000 GPD of process wastewater and produce on average less than 2 GPD of silver-rich solutions. The majority of these facilities typically practice some type of silver recovery. However, many of these facilities lack the necessary knowledge to properly select, operate and document the performance of silver recovery equipment. By providing an industry standard which addresses these issues, the CMP aims to optimize the efficiency of silver recovery operations.

Large photographic processors, representing about 9 percent of all photographic processing facilities, typically discharge 10,000 to 25,000 GPD of process wastewater and produce on average more than 20 GPD of silver-rich processing solution. Because of silver's value as a precious metal, large photographic processing facilities have focused substantial efforts on their silver recovery operations for many years. Using a combination of electrolytic and metallic replacement technologies, these facilities typically recover over 99 percent of the silver from their silver-rich processing solutions.

Significant Industrial Users (SIU) are facilities using more than 25,000 GPD of process wastewater and having the ability to adversely impact the POTW operations or causing pass-through of a regulated chemical. SIUs represent about 1 percent of the total number of facilities that process photographic materials.

Photographic processing facilities that could be SIUs include the major motion picture film processors, and a few very large hospitals, X-ray diagnostic clinics, printers, and photofinishers.

4 The Photographic Process

Silver-based photographic materials consist of solid crystals of silver chloride or silver bromide suspended in gelatin and coated on a film or paper support. The processing of photographic films and papers consists of three basic steps: development of the image, removal of some or all of the silver, and stabilizing the image by rinsing residual thiosulfate and silver-thiosulfate complexes out of the emulsion layers with water. In the case of washless processing, a stabilizer solution replaces the water.

Black-and-white photographic materials include X-ray films, graphic arts films and papers, and microfilms, as well as black-and-white motion picture films and professional films and papers. After processing, the image in these materials is metallic silver. In the non-image areas, the remaining solid silver chloride or silver bromide crystals are removed as a soluble silver-thiosulfate complex in a solution called a fix. In black-and-white products about 40 percent of the silver will remain in the film or paper as the metallic silver image.

Color photographic materials include the majority of amateur and professional films and papers and motion picture films, as well as some graphic arts products. During development, metallic silver is formed in the image areas along with a dye. This metallic silver is then converted to crystals of silver bromide or silver chloride by a solution called a bleach. After the bleach step, the silver chloride or bromide is removed as a soluble thiosulfate complex in a fix solution. In some paper processes, the bleach and fix baths are combined into a single solution called a bleach-fix. In color products, virtually no silver remains on the film or paper after processing.

In processing both black and white and color photographic materials, the exact process will vary depending on market demand, imaging media and application.

Even a relatively minor change can have a major impact on the process that may not be desirable. For example, improving silver recovery efficiency without considering the process as a whole can result in undesirable product quality. Water conservation and meeting unreasonable concentrations-based limits could have similar results.

5 References

Water Environment Federation. (1994) Controlling silver discharges in waste-water. Alexandria, VA: Author.

Dufficy, T., Cappel, R., & Summers, S. (1993). Silver discharge regulations questioned Water Environment & Technology, 5 (4), 52-56.

U.S. Environmental Protection Agency. (April, 1981). Guidance document for the control of water pollution in the photographic processing industry (EPA 440-1-81/082-9). Washington, DC: Effluent Guidelines Division WH-552.

Appendix A

Silver Council Members Supporting The Code Of Management Practice

American Hospital Association

American Society for Photogrammetry and Remote Sensing

Association of Cinema and Video Laboratories

Association of Professional Color Laboratories

Association for Information & Image Management

City of Albuquerque

Florida Environmental Advisory Council

Georgia Environmental Silver Users

Graphic Arts Association

Graphic Arts Technical Foundation

Independent X-Ray Dealers Association

International Minilab Association

International Precious Metals Institute

Manufacturing Jewelers and Silversmiths of America, Inc.

National Association of Photo Equipment Technicians

National Association of Photographic Manufacturers, Inc.

New Mexico Silver Users Association

Photo Marketing Association International

Photographic Manufacturers and Distributors Association

Printing Industries of America

Professional Photographers of America

Professional School Photographers of America

Rhode Island Environmental Advisory Council

Silver Institute

Silver Users Association

Society of Photo Finishing Engineers

Society of Photographic Counselors

Texas Environmental Advisory Council

The Society for Imaging Science and Technology

Appendix B.1

Costs and Revenues for Silver Recovery Operations at a 2,000 mg/L Level

	Volume Silver-Rich Solutions, GPD[1]				
	1	5	10	25	100
Silver/day (troy oz.)	0.25	1.2	2.4	6.1	24
Silver/year (troy oz.)[2]	75	360	720	1,830	7,300
Equipment Capital ($)	130	2,500	5,000	9,000	18,000
Equipment Cost/year ($)[3]	25	500	1,000	1,800	3,600
Operating Cost/year ($)	175	450	900	1,800	3,600
Refining Cost/year ($)[4]	150	250	500	800	3,100
Annual Cost ($)	350	1,200	2,400	4,400	10,300
Annual Revenue ($)[5]	360	1,800	3,650	9,100	36,500
Net Return ($)	10	640	1,300	4,800	26,000

[1] Volume of silver-rich solution (fix, bleach-fix, washless stabilizer and low-flow wash).

[2] Amount of silver assuming 2,000 mg/l (31.1 troy oz./kg) with operations 6 days/week and 50 weeks/year.

[3] Capital equipment costs amortized over 5 years. System uses CRCs for volumes under 5 GPD and electrolytic plus CRCs for higher volumes.

[4] Assumes a smelting and refining charge of $0.50/troy oz. with volumes less than 1,000 troy oz. and $0.25/troy oz. with volumes greater than 1,000 troy oz. for electrolytic flake. Smelting and refining charges for CRCs are calculated at $2.00/troy oz. less than 1,000 troy oz. and at $1.00/troy oz. at volumes greater than 1,000 troy oz.

[5] Assumes a selling price of $5.00/troy oz.

Appendix B.2

Costs and Revenues for Silver Recovery Operations at a 5,000 mg/L Level

	Volume Silver-Rich Solutions, GPD[1]				
	1	5	10	25	100
Silver/day (troy oz.)	0.6	3	6	15	60
Silver/year (troy oz.)[2]	180	900	1,800	4,500	18,000
Equipment Capital ($)	250	3,000	6,000	10,000	20,000
Equipment Cost/year ($)[3]	50	600	1,200	2,000	4,000
Operating Cost/year ($)	200	500	1,000	2,000	4,000
Refining Cost/year ($)[4]	360	590	760	1,900	5,800
Annual Cost ($)	610	1,700	3,000	5,900	14,000
Annual Revenue ($)[5]	900	4,500	9,000	22,00	90,000
Net Return ($)	290	2,800	6,000	17,000	76,000

1 Volume of silver-rich solution (fix, bleach-fix, washless stabilizer, and low-flow wash).

2 Amount of silver assuming 5000 mg/l (31.1 troy oz.) with operations 6 days/week and 50 weeks/year.

3 Capital equipment costs amortized over 5 years. System uses CRCs for volumes under 5 GPD and electrolytic plus CRCs for higher volumes.

4 Assumes a smelting and refining charge of $0.50/troy oz. with volumes less than 1000 troy oz. and $0.25/troy oz. with volumes greater than 1000 troy oz. for electrolytic flake. Smelting and refining charges for CRCs are calculated at $2.00/troy oz. less than 1000 troy oz. and at $1.00/troy oz. at volumes greater than 1000 troy oz.

5 Assumes a selling price of $5.00/troy oz.

Estimated Process Volumes in Gallons Per Day (GPD)

Facility Type (Size)	Silver-Rich Solution	Low-Silver Solution
Dental Office—Small*	0.1	5
Dental Office—Medium*	0.2	10
Dental Office—Large*	0.4	20
Hospital—Small	20	2,600
Hospital—Medium	40	5,200
Hospital—Large	80	10,400
Medical Professional—Small	0.2	100
Medical Professional—Medium	1	500
Medical Professional—Large	5	1,000
Microfilm—Small	0.1	15
Microfilm—Medium	0.3	75
Microfilm—Large	50	3,750
Printer/Graphic Art—Small	1	225
Printer/Graphic Art—Medium	2	450
Printer/Graphic Art—Large	20	4,500
Minilab:—Washless—All sizes	2.3	21
Minilab:—Washwater—All sizes	1	100
Photofinisher/Professional—Small	10	1,325
Photofinisher/Professional—Medium	100	13,250
Photofinisher/Professional—Large	265	33,000
Motion Picture—Small	25	1,000
Motion Picture—Medium	50	2,000
Motion Picture—Large	2,000	80,000
Police Dept.—Small	0.2	25
Police Dept.—Medium	0.4	50
Police Dept.—Large	2	250
School—Small	1	125
School—Medium	5	650
School—Large	10	1,250

* This volume does not include wastewater containing silver from dental chairs.

Code of Management Practice for Silver Dischargers

Part 4 Silver Recovery and Management Technologies January 1997

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) describes a number of silver recovery and silver management technologies. Recovery options include electrolysis, metallic replacement (CRC) and precipitation. Management options include evaporation/distillation, ion exchange, and reverse osmosis.

2 Overview

Several technologies are available to control silver in photographic effluent. The two most common technologies generally available to the photographic processor for recovering silver from silver-rich photographic processing solutions are electrolysis and metallic replacement (CRC). Precipitation, is a third, less common technology, that is also available for silver recovery. These three technologies have been in use in the industry for many years and are the subject of considerable research to improved recovery efficiencies, ease of use and economics.

Evaporation/distillation, ion exchange, and reverse osmosis have been used as silver management technologies in some photographic processing facilities. These technologies provide a means of concentrating the solutions containing silver which can provide more efficient recovery or refining, or reduce the volume of solution to be transported if off-site recovery is utilized. These technologies are used in situations where the primary focus is on discharge requirements and where capital and operating costs are a secondary concern. These technologies are generally supplemental to more basic silver recovery options.

Technologies used in metal finishing, such as electrowinning, cannot be used for photographic processing solutions or wash waters. The heat required by electrowinning will cause decomposition of some of the processing chemicals resulting in fouled equipment and noxious and hazardous odors. Thus, it is never appropriate to apply the categorical Best Available Technology (BAT) discharge limits of 0.24 or 0.43 mg/L for metal finishers to photographic processors. Photographic processors are not categorical dischargers and cannot use these BAT technologies and equipment.

3 Silver Recovery Technologies

3.1 Electrolysis

Electrolysis, or electrolytic recovery, is an efficient and cost-effective silver recovery technology. The equipment is continuously reused and few additional chemicals are required to perform the recovery operation. In electrolytic silver recovery, electric current reduces the silver-thiosulfate complex and plates almost pure silver metal onto the negatively-charged electrode. This electrode is called the cathode and is made of a piece of stainless steel or other material. There are two basic types of electrolytic equipment: one in which the cathode rotates in the solution, and the other in which the solution flows around a stationary cathode. Either type of equipment is capable of recovering more than 90 percent of the silver from the silver-rich solutions.

The use of in-line electrolytic silver recovery and closed-loop fix solutions can significantly reduce the amount of silver carried over into the final wash water and discharged to the POTW. Where the use of such closed-loop fixers and in-line silver recovery is possible, mixing and chemical usage can be reduced by up to 50 percent, further increasing the cost effectiveness of this technology. This approach may not be feasible in all circumstances and is dependent upon the imaging media and application.

Fix solutions from black and white processes are easy to desilver electrolytically and require little, if any pH adjustment. Recovery efficiencies of more than 90 percent can be achieved.

Bleach-fix and fix solutions from color processes that contain iron-complex oxidizing agents are not as easy to desilver electrolytically. Higher current densities and longer times are required, with occasional pH adjustments. The optimum pH range for silver-rich solutions containing iron is 7.8 - 8.5. Under acidic pH conditions ($pH < 7.0$), the iron-EDTA complex used in bleaches and bleach-fixes will oxidize the silver plated on the electrode and move it back into solution. As the pH becomes more basic ($pH > 7.5$), the oxidizing power of this iron-EDTA complex is reduced and the plating of silver onto the electrode becomes more efficient. With proper equipment and pH adjustments, silver recovery efficiencies approaching 90 percent can be achieved from these solutions.

Attempts to achieve higher efficiencies than those recommended by the manufacturer can actually lead to lower silver recovery rates. By over extending the electrolysis time or significantly raising the current density, sulfiding will occur. This problem results in coating the cathode with a black sulfide precipitate rendering it unsuitable for continued silver recovery.

3.2 Metallic Replacement

Metallic replacement is a process where elemental iron undergoes an oxidation-reduction reaction with silver thiosulfate to produce ferrous ions and metallic silver. The exchange reaction is very rapid, but is dependent on the contact of the silver-thiosulfate complex with the iron surface. Flow rate, iron surface area, contact time, and the solution pH are the major variables influencing the recovery efficiencies.

To ensure good and controlled contact, metallic replacement is accomplished by metering the silver-rich solutions through a container of steel wool, iron particles or an iron-impregnated resin.

These containers are generally referred to as metallic replacement cartridges (MRCs), chemical recovery cartridges (CRCs) or silver recovery cartridges (SRCs). In this document metallic replacement cartridges will be termed CRCs.

As the recovery cartridge is used, the active surface area is reduced and small channels will begin to develop in the iron substrate. The efficiency of recovery will gradually diminish until breakthrough occurs at which time the cartridge is replaced with a new one.

A properly designed and maintained CRC is capable of recovering more than 95 percent of the silver from silver-rich solutions when used in accordance with manufacturer-specified flow rates. Two CRCs connected in series, with a valve in between to allow testing, will prevent the discharge of silver-rich solutions to the drain. A properly designed and maintained two-cartridge system with manufacturer-specified flow rates is capable of recovering more than 99 percent of the silver from silver-rich solutions.

3.3 Precipitation

Silver can be precipitated using a wide variety of compounds (precipitants) that form insoluble complexes when added to silver-rich waste streams. Older precipitants such as sulfide, borohydride and amineboranes are somewhat difficult and potentially hazardous to use. Consequently, these precipitants are not generally recommended for use at facilities processing photographic materials unless personnel are available with adequate chemical training in the use and handling of these chemicals. These older precipitants, however, are gradually being replaced with more reliable and less hazardous organic precipitants and equipment combinations, making this technology much more favorable.

The silver-precipitation process is accomplished by metering silver-rich solutions or wash water into a reaction vessel. A prescribed amount of precipitant is added according to the manufacturer's direction. The resulting insoluble silver complex is allowed to settle or be filtered out as a sludge. The desilvered supernatant can then be discharged, while the sludge containing silver is collected and sent to a silver refiner. A properly designed and maintained system is capable of recovering 99.9 percent or more of the silver from silver-rich solutions.

4 Silver Management Technologies

4.1 Evaporation /Distillation

Evaporation/distillation represents a method to concentrate the silver-rich processing solutions. Silver-rich processing solutions can be concentrated to between 8 percent and 30 percent of their original volume. In general, the residue that remains is still a liquid sludge, although some companies offer a distillation device for small volumes that produces a solid. The distillate will contain small amounts of ammonia and some organics, making it unusable for mixing fresh developer solutions. Distillate can be used to make new secondary replenishers such as bleach, fixer and stabilizers.

4.2 Ion Exchange

Ion exchange technology can be used to recover silver from dilute processing solutions and wash waters. Two types of ion exchange technology exist.

Conventional ion exchange relies on attracting the negatively-charged silver thiosulfate complex to positively-charged sites on an ion exchange resin. When the positively-charged sites are filled, breakthrough occurs. The resin is either regenerated by removing the silver-thiosulfate complex with a concentrated negatively-charged ion solution, or replaced.

In situ ion exchange relies on converting the silver thiosulfate complex to a silver sulfide precipitate in or on the resin beads. These resin beads are typically sent to a silver refiner or reclaimer where the beads are smelted to recover the silver.

Ion exchange cannot be used for recovering silver directly from silver-rich fix and bleach-fix solutions. These concentrated thiosulfate solutions will strip silver from the resin, and can actually result in more silver being discharged from the resin column than is present in the feed solution. Thus, ion exchange lends itself only to the recovery of silver from wash waters and dilute processing solutions. Typically, more than 90 percent of the silver from wash waters can be removed.

In certain circumstances, where image permanence is not critical (such as pre-press facilities), equipment that utilizes ion exchange technology is an effective and economic means of managing silver in the wash water and reducing the volume of process water required. It is most effective when used in conjunction with an in-line silver recovery unit for the preceding fixer solution. The spent cartridges may be sent to a refiner for the recovery of silver.

However, in other photographic processing operations such as photofinishing, the cost, space and technical requirements of a properly-sized system may preclude its use. Other considerations include the environmental impact of back-flush systems versus the small amount of silver recovered. Acidification of silver-rich solutions for in situ precipitation can release sulfur dioxide presenting a potentially dangerous health hazard. The acidic solution produced must also be neutralized before disposal to the POTW.

Ion exchange is not recommended as a primary silver recovery operation for silver-rich solutions. It could, however, be a valuable technology for removing silver thiosulfate and thiosulfate ions from wash waters in circumstances where reuse of wash water is important from a conservation perspective.

4.3 Reverse Osmosis

Reverse osmosis (RO) is a type of membrane filtration technology. In RO the waste water stream flows under pressure over the surface of a selectively-permeable membrane. Under pressure, water molecules pass through the membrane and the other constituents, including silver, are left behind. The extent of the separation is determined by the pore size, dynamic pressure and surface chemistry of the membrane. The result is two streams. One is a permeate of relatively clean water. The other is a concentrated waste stream containing silver, which can be sent to a silver refiner (U.S. Environmental Protection Agency, 1991).

RO has been successfully used to remove up to 90 percent of the silver from process wash waters and very dilute photoprocessing solutions. Recent developments in this technology have allowed its use for in-line recovery and reuse of silver-rich solutions in limited circumstances. This technology is not, however, appropriate for removing silver from most spent silver-rich solutions in photographic processing operations. The high chemical content of these solutions tends to quickly clog the membranes. The maintenance requirements and application limitations of this technology can be significant and may discourage its use in photographic processing facilities.

The following chart outlines some of the major advantages and limitations for each of the silver recovery and management systems listed in Part 4.

Comparison of Silver Recovery and Management Systems

System	Advantages	Limitations
Chemical Recovery Cartridges (CRCs)	Can be used for all silver-rich solutions Little maintenance Low capital costs Can achieve 99% when 2 CRCs used in series	Requires metered flow for consistency Must be replaced on schedule Tendency to channel causes silver concentration fluctuations High smelting & refining costs Cannot determine amount of silver recovered until refined. pH dependent Cannot reuse treated solutions in photo process
Electrolytic (terminal)	High silver quality flake Low refining costs Can determine silver recovered Capital costs moderate Can achieve 90% recovery	Cannot achieve 5 mg/l with electrolytic alone. Can sulfide if not properly maintained pH dependent Not suitable for low-silver solutions
Electrolytic (in-line)	High silver quality flake Can reduce silver concentration in wash waters Allows fixer replenishment rate reductions Reduces chemical usage & mixing labor	Used for fixers only Can sulfide and damage fixer if not properly maintained Not suitable for low-silver solutions
Precipitation	Can achieve consistent recovery over 99% Little operator maintenance Moderate capital costs	Smelting cost higher than electrolytic Requires ongoing additives Operation costs vary from moderate to high
Evaporation/ Distillation	Reduces wastes up to 90% Virtually zero overflow of silver	Moderate to high capital costs Sludges are messy to handle
Ion Exchange	Efficient way of recovering silver from dilute photoprocessing solutions and wash waters Recovery efficiency 98-99.5% range.	Capital costs vary significantly Biological growth problems May require the use of hazardous chemicals Works best on dilute solutions such as washwater
Reverse Osmosis	Efficient way of recovering silver from dilute photoprocessing solutions and wash waters No water treatment chemicals required Reduces effluent volume significantly	Capital costs vary significantly Size of equipment needed to obtain sufficient flow Frequent maintenance of membrane and pumps Works best on dilute solutions such as washwater Large installations can be noisy

5 References

U.S. Environmental Protection Agency. (October 1991). Guides to pollution prevention: the photoprocessing industry (EPA/625/7-91/012). Washington, DC: Office of Research and Development.

Additional Sources of Information

Eastman Kodak Company. (1990) Disposal and treatment of photographic effluent. In support of clean water. Publication J-55.

Fuji Photo Film U.S.A., Inc. (1993) Chemical Waste Management: A silver recovery/waste disposal guide for the imaging industry. Publication Ref No. FEDS-7.

Code of Management Practice for Silver Dischargers

Part 5 Code of Management Practice—Recommendations January 1997

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) describes the recommendations for on-site and off-site recovery and management of silver-rich solutions. It defines facility size as a criteria for silver recovery and management options for a POTW that is in compliance with silver discharge limits in its National Pollutant Discharge Elimination System (NPDES) permit.

2 Local Limits Development and Implementation

Under the National Pretreatment Program, local limits are POTW-specific discharge standards that are based on site-specific information and are typically applied to both categorical and non-categorical industrial users of POTWs. The purpose of local limits is to prevent pass through and interference, protect sludge quality and ensure nontoxic effluent. This protects POTW operations, ensures worker health and safety and allows for chosen sewage sludge use and disposal practices in addition to protecting the receiving water quality. More specifically, POTWs develop local limits to prohibit specific discharges regardless of whether any of its industrial dischargers are subject to categorical pretreatment standards. EPA's July 24, 1990 revisions to the General Pretreatment Regulations (55 FR 30082) require each POTW with an approved pretreatment program to submit with its NPDES permit application a formal evaluation of the need to revise local limits.

There are many ways in which a POTW may generate its local limits. For example, it may choose to adopt limits developed by another POTW of similar design; it may use modified drinking water standards; it may adopt categorical standards, such as metal finishing limits; or, it may adopt limits based on literature findings. None of these methods specifically addresses the fundamental purpose of local limits previously defined, which is to prevent adverse effects on the POTW, the environment, and on public health. To address these concerns, which are highly site specific, the POTW must conduct a comprehensive evaluation of its operational and environmental characteristics and develop protective local limits based on this evaluation.

3 On-Site Silver Recovery and Management

In developing on-site recovery requirements, it is necessary to separate photographic processing facilities by size into four categories. These would include small photographic processors, medium-size photographic processors, large photographic processors, and Significant Industrial Users (SIUs).

Small photographic processing facilities produce on average less than 2 GPD of silver-rich solution **and** discharge less than 1,000 GPD of process wastewater. These facilities could be required to have a simplified permit from the POTW or Control Authority requiring the proper use, operation and maintenance of a silver recovery system capable of removing at least 90 percent of the silver from their silver-rich processing solutions before discharge to the sewer.

Medium-size photographic processing facilities produce on average less than 20 GPD of silver-rich solution **and** discharge less than 10,000 GPD of process wastewater. These facilities could be required to have a simplified permit from the POTW or Control Authority requiring the proper use, operation and maintenance of a silver recovery system capable of removing at least 95 percent of the silver from their silver-rich processing solutions before discharge to the sewer.

Large photographic processing facilities produce on average 20 GPD or more of silver-rich solutions **and** discharge less than 25,000 GPD of process wastewater. These facilities could be required to have a simplified permit from the POTW or

Control Authority requiring the proper use, operation and maintenance of a silver recovery system. This system must be capable of removing at least 99 percent of the silver from their silver-rich processing solutions before discharge to the sewer and to have processors modified where possible, to reduce the concentrations of silver in their process wash waters. In-line silver recovery should be installed on processing machines that allow this modification.

Significant Industrial Users (SIUs) are defined by regulation as any industrial user that: discharges an average of 25,000 GPD or more of process wastewater to a POTW, contributes a process waste stream which makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW, is designated as such by the Control Authority on the basis that the industrial user has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard, or is subject to Categorical Pretreatment Standards under 40 CFR 403.6 and 40 CFR Chapter I, subsection N.

An SIU may be a small, medium or large photoprocessing facility depending on average daily quantity of silver-rich solution and wash water produced by the photographic process. SIUs would have to continue to be regulated by an SIU permit.

This CMP recommends the silver-discharge limitations be allocated by the POTW or Control Authority based on either:

- Loading or
- The requirements for silver recovery for small, medium and large photographic processing facilities be used based on the daily volume of silver-rich solution and wash water produced by the photographic process.

Of particular interest would be a facility such as a large hospital which would be an SIU and where photographic processing could be done in many (10-30) different locations. In these circumstances it may not be possible to transfer the silver-rich solutions to one centralized location for silver recovery or management. The CMP recommends permit requirements for silver discharges be based on individual photographic-processing area flows. For example, an isolated X-ray processor in a low-use area which produces on average less than 2 GPD of silver-rich solutions and uses less than 1,000 GPD of process wash water, would have the same requirements as a small-size photographic processing facility. This processing facility would be required to operate and maintain a silver recovery or management system capable of removing at least 90 percent of the silver-rich solutions before discharge to the sewer.

A high-volume X-ray diagnostic area, which may include several processors and produce on average more than 20 GPD of silver-rich solution and discharge more than 10,000 GPD of process wastewater, would have the same requirements as a large photographic processing facility. This area would be required to operate and maintain a silver recovery or management system capable of removing at least 99 percent of the silver-rich solutions before discharge to the sewer.

Staff at each photographic processing facility would be responsible for monitoring the silver removal efficiencies. The type of monitoring and required documentation would be specified by the POTW or Control Authority.

3.1 Recommendations for On-Site Silver Recovery and Management at Small -Size Photographic Processing Facilities

Small photographic processing facilities that produce on average less than 2 GPD of silver-rich processing solution and discharge less than 1,000 GPD of process wastewater must use one of the following equipment options capable of recovering or managing at least 90 percent of the silver. The options are listed in order of increasing cost:

- One or two CRCs with manufacturer-specified flow control *
- One electrolytic unit **
- One precipitation unit
- One evaporation or distillation unit
- Alternative technology providing at least 90 percent recovery or management

*Very small photographic processing facilities that generate less than 0.5 GPD of silver-rich processing solution, require only one recovery cartridge. A second recovery cartridge used in these circumstances would oxidize and channel by the time the first cartridge was exhausted, resulting in higher waste and added costs with no additional silver recovery. For all other processing facilities it is strongly recommended to use two CRCs in series to reduce the potential of silver breakthrough.

** It is strongly recommended that an additional CRC be used after electrolytic recovery to ensure consistent recovery.

3.1.1 Operating Procedures

The following procedures should be used in small photographic processing facilities:

- Processing and holding tanks for silver-rich solutions and the silver recovery or management system must be maintained in a manner that protects the material from accidental release to the POTW.

- The facility must have a spill plan to ensure spills of silver-rich solutions are not accidentally released to the POTW. (see Part 7.4.5 for more spill information)

Analytical and recordkeeping requirements for facilities using a batch operation for silver recovery:

- The silver concentration must be checked weekly after the recovery or management system to ensure proper system operation.
- The test can be performed with silver test papers, an analytical test kit or a lab analysis. This test will identify problems or failures with the recovery/management system.
- Test results must be recorded in a silver recovery log.

Analytical and recordkeeping requirements for facilities using a continuous operation for silver recovery and management.

- The silver concentrations in effluent must be checked weekly.
- The test can be performed using silver test papers, an analytical test kit or a lab analysis. This test will identify problems or failures with the recovery system.
- Test results must be recorded in a silver recovery log.

3.1.2 Verification

For the purpose of verifying at least 90 percent recovery, all facilities must have a silver analysis done on the influent and effluent to the recovery system at least every 12 months by an analytical laboratory acceptable to the POTW. The facility must retain the analytical records for a period of time acceptable to the POTW.

3.2 Recommendations for On-Site Silver Recovery and Management at Medium-Size Photographic Processing Facilities

For medium-size photographic processing facilities that produce on average less than 20 GPD of silver-rich processing solution and discharge less than 10,000 GPD of process wastewater, one of the following equipment options capable of recovering or managing at least 95 percent of the silver must be used. The options are listed in order of increasing cost:

- Two or more CRCs with manufacturer-specified flow control
- One electrolytic unit plus one CRC with manufacturer-specified flow control
- One precipitation unit
- One electrolytic unit plus one precipitation unit
- One evaporation or distillation unit
- Alternative technology providing at least 95 percent recovery or management

3.2.1 Operating Procedures

The following procedures should be used in medium-size photographic processing facilities:

- Processing and holding tanks for silver-rich solutions and the silver recovery or management system must be maintained in a manner that protects the material from accidental release to the POTW.

- The facility must have a spill plan to ensure spills of silver-rich solutions are not accidentally released to the POTW. (See Part 7.4.5 for more spill information.)

Analytical and recordkeeping requirements for facilities using batch operations for silver recovery:

- The primary unit must be checked weekly after the batch with silver test papers, an analytical test kit, or a lab analysis to ensure proper operation.

- The effluent from the secondary unit must also be checked with silver test papers, an analytical test kit, or a lab analysis before discharge to the sewer. This will identify any problems or failures with the recovery or management system.

- Test results must be recorded in a silver recovery log.

For facilities using continuous operations for silver recovery:

- The silver concentration in the effluent of the primary unit must be tested weekly with silver test papers, an analytical test kit, or a lab analysis to ensure it is operating properly.
- The effluent from the secondary unit must also be tested weekly with silver test papers, an analytical test kit, or a lab analysis before discharge to the sewer.
- Test results must be recorded in a silver recovery log.

3.2.2 Verification

When using an in-line electrolytic unit, the silver concentration in the processing tank must be tested weekly to ensure proper operation of the unit. The test can be performed with silver test papers, an analytical test kit or a lab analysis. This information must be recorded in a silver recovery log.

All facilities must have a silver analysis done on the influent and effluent of the recovery system at least every six months by an analytical laboratory acceptable to the POTW. The facility must retain the analytical records for a period of time acceptable to the POTW.

3.3 Recommendations for On-Site Silver Recovery and Management at Large Photographic Processing Facilities

For large photographic processing facilities that produce on average 20 GPD or more of silver-rich processing solution and discharge less than 25,000 GPD of process wastewater, one of the following equipment options capable of recovering or managing at least 99 percent of the silver must be used. The options are listed in order of increasing cost:

- Electrolytic unit plus two or more CRCs with manufacturer-specified flow control
- Electrolytic unit plus a precipitation unit
- Evaporation or distillation unit
- Alternative technology providing at least 99 percent recovery or management

3.3.1 Operating Procedures

The following procedures should be used in large photographic processing facilities:

- Processing and holding tanks for silver-rich solutions and the silver recovery or management system must be maintained in a manner that protects the material from accidental release to the POTW.
- The facility must have a spill plan to ensure spills of silver-rich solutions are not accidentally released to the POTW. (See Part 7.4.5 for more spill information.)
- In-line electrolytic desilvering units should be used in processes where possible.
- Squeegees or air knives and low-flow washes should be used on processors where possible.
- Conservation of wash water should be encouraged where possible.

Analytical and record keeping requirements are as follows:

- All facilities must have access to analytical testing capability to provide quick evaluations of the silver recovery or management units to ensure the units are operating properly. The test results must be recorded in a silver recovery log.
- The silver recovery or management system must be tested at least weekly to ensure proper operation.
- The test results must be recorded in a silver recovery log.

3.3.2 Verification

All facilities must have a silver analysis done on the influent and effluent of the recovery system at least every three months by an analytical laboratory acceptable to the POTW. The facility must retain the analytical records for a period of time acceptable to the POTW.

3.4 Recommendations for On-Site Silver Recovery and Management at Significant Industrial Users

Facilities that discharge more than 25,000 GPD of process wastewater would be classified as SIUs by the POTW, and would be regulated by full permit.

For these facilities, the POTW could consider establishing silver discharge limits based on mass loading or flow-based concentration limits, rather than uniform concentration-based limits, as is the general practice today. The application of mass discharge limits in lieu of concentration limits would encourage water conservation in these facilities. To use this approach, a POTW may have to revise its local limits in accordance with its National Pollutant Discharge Elimination System (NPDES) requirements. Some POTWs have developed local limits based on the size of a facility as measured by the volume of discharge, such that smaller facilities have higher concentration limits while larger facilities have lower concentration limits. Another approach would be to base the silver requirements on the actual photographic processing flows for silver-rich solution and wash water. For example, a small processing area in an SIU that used less than 1,000 GPD of process wash water and produced less than 2 GPD of silver-rich solution would have the same requirements as a small photographic processing facility. A large processing area that used more than 10,000 GPD of process wash water and produced more than 20 GPD of silver-rich solution would have the same requirements as a large photographic processing facility.

4 Off-Site Silver Recovery and Management

Companies providing acceptable hauling and centralized silver recovery exist in many cities throughout the United States. While the technologies and equipment used in these central facilities are typical of what would be used onsite in a small-to-medium-size photographic processor, the larger volumes and more experienced personnel in an off-site facility can often provide greater recovery efficiencies.

The cost of having silver-rich solutions hauled offsite for recovery at a centralized facility typically ranges from $2.00 to $6.00 per gallon. For some photographic processing facilities generating small quantities of silver-rich solutions per week, off-site recovery can be a cost-effective and efficient way to reduce their silver discharges. This type of off-site program has been offered since 1991 in Palo Alto, California. It has been very successful for both the small photographic processors and the POTW in providing a cost-effective way to reduce silver discharges to the POTW. When larger volumes are involved, the cost of off-site treatment may be prohibitive.

Considerations should be given to the environmental impact of hauling the silver-rich solutions for off-site recovery which include transportation, treatment and final disposal. Other considerations may involve the safe storage and handling of silver-rich solutions, and compliance with applicable hazardous waste regulations. This option should be available where acceptable recovery facilities and haulers are present.

Off-site silver recovery and management may impact the implementation of pollution prevention programs and processor modifications to provide in-line fixer desilvering and low-flow washes. The use of closed-loop fixers can reduce mixing time and chemical use by 50 percent. In-line silver recovery can reduce the amount of silver carried over into the process final wash waters and discharged to the POTW. When the quantities of silver-rich solutions to be hauled offsite result in substantial economic hardships or transportation pollution, on-site treatment should be encouraged.

Photographic processing facilities that choose to send silver-rich solutions offsite for recovery and disposal could be required to notify the POTW that they are using off-site recovery. These facilities may have to meet the requirements outlined in part 5.4.1 Recommendations for Off-Site Silver Recovery and Management for All Facilities. These requirements could include, but would not be limited to: use of an acceptable hauler and recovery facility, records of the volumes and type of solutions transferred offsite, and a prohibition to discharge silver-rich photographic processing solutions to the sanitary sewer.

4.1 Recommendations for Off-Site Silver Recovery and Management for All Facilities

Facilities utilizing solution hauling and treatment services would be asked to meet the following requirements:

- The photographic processor should submit notification to the POTW that off-site recovery and disposal services will be used. The notification may require the facility to specify which silver-bearing solutions will be managed offsite and should list the hauling service and the recovery facility.

- The photographic processor will store the silver-rich spent solutions in Department of Transportation (DOT) approved containers in a manner that protects the material from accidental release to the POTW. This protection could include secondary containment, storage areas without floor drains or stand pipes in existing floor drains.

- The photographic processor will comply with applicable hazardous waste and DOT regulations.

- The photographic processor will maintain records for a period of three years of the volumes and type of spent solutions transferred offsite. The photographic processor will make these records available for inspection when requested by the POTW.

5 Additional Recommendations for Both On-Site and Off-Site Silver Recovery and Management

Many facilities currently implement successful measures to reduce and control environmental releases of photographic chemicals. These measures have been successfully implemented both formally, as part of a written management plan and informally, as part of unwritten standard operating procedures. To ensure the continuing and greater success of these programs, this CMP recommends including several basic components: a chemical inventory including silver-rich solutions, a floorplan, and spill containment and response plan. Additional elements in a user CMP would include a CMP committee, a policy statement, a release identification and assessment, good housekeeping, preventive maintenance, inspections, security, employee training, and recordkeeping.

Pollution Prevention considerations are discussed in Part 7 of the Code of Management Practice.

Code of Management Practice for Silver Discharges

Part 6 Considerations for Compliance with Specific Silver Pretreatment Limits
January 1997

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) outlines the considerations for technologies and equipment and the economic realities of complying with specific silver pretreatment limits for silver discharges. It recommends a sampling location and discusses typical silver concentrations after processing and silver recovery.

2 Overview

It is important to realize that all facilities processing photographic material are different with respect to the amount of silver in their silver-rich solutions and wash waters. This is the result of the great number of photographic processes necessary to accommodate the variations in market demand, imaging media and application (see Appendices A.1 to A.4).

When attempting to conserve water or control silver recovery based on very low concentration instead of mass loading, a systems approach must be used. This approach integrates the process, equipment configuration, application, and market demands with the technical and financial resources of the facility. When concentration-based limits are set below 5 mg/L, the type of process, the processing equipment and volume of wash water become more critical. It is important to note what may seem like a relatively-minor change in the process and processing equipment can result in profound changes within the process that may or may not be desirable. Such changes can affect the ability to recover silver. Silver recovery and management options can have effects on the photographic processing system. Some of the major variables that should be considered in a systems approach to silver management are listed in Appendix B.

An on-site evaluation is the best way to determine accurately the effects of specific discharge limits for any given photographic processing facility.

3 Local Limits Development and Implementation

Under the National Pretreatment Program, local limits are POTW-specific discharge standards based on site-specific information and are typically applied to both categorical and non-categorical industrial users of POTWs. The purpose of local limits is to prevent pass through and interference, protect sludge quality and ensure non-toxic effluent. This protects POTW operations, ensures worker health and safety and allows for chosen sewage sludge use and disposal practices in addition to protecting the receiving water quality. More specifically, local limits are developed at a particular POTW to implement the prohibited discharge, regardless of whether any of its industrial dischargers are subject to categorical pretreatment standards. EPA's July 24, 1990 revisions to the General Pretreatment Regulations (55 FR 30082) require each POTW with an approved pretreatment program to submit with its NPDES permit application a formal evaluation of the need to revise local limits.

There are many ways in which a POTW may generate its local limits. For example, it may choose to adopt limits developed by another POTW of similar design; it may use modified drinking water standards; it may adopt categorical standards, such as metal finishing limits; or, it may adopt limits based on literature findings. None of these methods, however, specifically addresses the fundamental purpose of local limits defined previously, which prevent adverse effects on the POTW, the environment, and on public health. To address these concerns, which are highly site specific, the POTW must conduct a comprehensive evaluation of its operational and environmental characteristics and develop protective local limits based on this evaluation.

4 Compliance Sampling Location

Most pretreatment programs establish silver discharge limits at the facility outfall. This sampling location is the correct place for compliance when uniform concentration limits are applied. Photographic processors are not subject to categorical pretreatment standards, so there are no requirements to measure for compliance at the end-of-process (as is the case for metal finishers).

Normal dilution from domestic and other process waste streams at a facility outfall will vary greatly between the same types of photographic processing facilities in different locations. For example, an X-ray, graphic arts, microfilm, professional, or amateur photographic processing facility located in a large building or mall will have much greater dilution from other waste waters at the building or mall outfall than a stand-alone facility. Although these differences may result in similar types of photographic processing facilities having a wide variation in their silver discharge concentrations at the facility outfall, these facilities should be able to achieve equivalent silver recovery efficiencies from silver-rich solutions with silver recovery systems. The application of mass-based limits or flow-based concentration limits would aid in making compliance with discharge limits more equal among facilities.

Additionally, the same types of photographic processing facilities will have different types of processing equipment, process and processor modifications, and product mix, all of which will result in different silver concentrations in their discharged waste waters, even though they may all be achieving the same silver recovery efficiency. Some of the parameters affecting the concentration of silver in wash water are listed in Appendix B.

The location where the discharge limits apply and where compliance sampling must be done is extremely important to each facility processing photographic materials. The location of each will directly determine the efficiency and cost associated with compliance.

5 Silver Reference Point

Because of the large differences in domestic and other process flows, the silver pretreatment limits identified in this part are considered to be achieved at the end of the total photographic process flow. This includes all process solution flows after silver recovery of the silver-rich solutions and all wash waters from all processes and processors.

6 Silver Concentrations

Before silver recovery, the combined silver-rich solutions will contain between 2,000 and 8,000 mg/L of silver.

This concentration will vary even within the same facility. If the silver recovery system removes 90 percent of the silver, the solution exiting the silver recovery unit will contain between 200 and 800 mg/L of silver. If the system removes 95 percent of the silver, the solution exiting the recovery system will contain between 100 and 400 mg/L of silver. If the system removes 99 percent of the silver, the solution exiting the system will contain between 20 and 80 mg/L. If the system removes 99.9 percent of the silver, the exiting solution will contain between 2 and 8 mg/L of silver.

When this solution is recombined with the low-silver processing solutions, the silver concentrations will be reduced approximately by a factor of 2. Thus, the silver concentrations will be between 100 and 400 mg/L for a system giving 90 percent recovery, between 50 and 200 mg/L for a system giving 95 percent recovery, between 10 and 40 mg/L for a system giving 99 percent recovery, and between 1 and 4 mg/L for a system giving 99.9 percent recovery. This represents the best achievable limits for washless processing systems.

After recombination with wash waters, the silver concentrations will be reduced approximately by a factor of 10. The silver concentrations at the end of process will be between 10 and 40 mg/L for a system giving 90 percent recovery, between 5 and 20 mg/L for a system giving 95 percent recovery, between 1 and 4 mg/L for a system giving 99 percent recovery. Lower results could be obtained if the wash waters contained no silver. However, wash waters will contain between 0.1 and 4 mg/L of silver. This concentration will also vary between different types of facilities, and will vary daily within a facility. It is dependent on the amount of silver in the silver-rich solutions and the amount of these solutions carried into the wash waters during processing. The amount of solution carried into the wash waters during processing will depend on the type of process and processing machine, the type, volume and size of the film or paper processed, and on the number, configuration and replenishment rates of the wash tanks. Because of the silver concentration in the wash waters, the amount of silver in the solutions at the end of process will range between 0.1 and 4 mg/L, even with a recovery system giving 99.9 percent recovery.

If wash water conservation or reuse is being used, there will be higher silver concentrations in the wash water and in the total process discharge after silver recovery. Thus, a facility with a silver recovery and management system recovering 99.9 percent of the silver from the silver-rich solutions and reducing their wash water usage by 50 percent will have a silver concentration in the solutions at the end of process that will range between 0.2 and 8 mg/L.

These values are consistent with EPA studies of the photographic processing industry. In 1980, the EPA studied 1,100 photographic processors over a 2-year period. The 24-hour total facility composite silver concentration averaged 1.1 mg/L and the daily maximum was as high as 3.7 mg/L. Locations studied used a combination of electrolytic and metallic replacement units. They achieved over 99 percent recovery from their silver-rich solutions.

This chart summarizes the silver concentration at typical recovery efficiencies for the following: end of process, in combination with low silver solutions, and in combination with process wash waters.

Silver Concentrations After Silver Recovery (mg/L)			
Percent Recovery	Ag in Silver-Rich After Recovery[1]	When combined with Low-Silver[2]	When Combined with Wash Water[3]
90%	200 - 800	100 - 400	10 - 40
95%	100 - 400	50 - 200	5 - 20
99%	20 - 80	10 - 40	1 - 4
99.9%	2 - 8	1 - 4	0.1 - 4

1 Silver concentration immediately after pretreatment.

2 Silver concentrations when treated silver-rich solutions are combined with low-silver solutions.

3 Silver concentrations when treated silver-rich solutions are combined with low-silver solutions and process wash waters.

7 Silver Pretreatment Limits in the Range of 2.5 to 5.0 mg/L

Silver pretreatment limits in the range of 2.5 to 5.0 mg/L as measured at the end-of-process can be consistently achieved by most photographic processors by using any of the technologies that give greater than 99 percent recovery. They are outlined in Part 5 of this Code of Management Practice for Silver Dischargers. The costs to meet these limits are summarized in Appendix A.1.

It is recommended that the POTW personnel contact the resources at AMSA and the Silver Council for assistance with those facilities that cannot consistently meet these limits. Appendices C.1 and C.2 contains a list of contacts.

The following chart provides general recommendations by facility type to meet silver discharge limits of 2.5 to 5.0 mg/L.

General Recommendations to meet 2.5 to 5.0 mg/l Ag by Facility Type		
Facility	**Process Description**	**Typical Recovery**
Dental	B&W X-ray process generally treated as a batch process. Solutions are replaced periodically rather than replenished.	Chemical Recovery Cartridges (CRC) or solution is hauled off site.
Hospitals	B&W X-ray process. May be continuously replenished or treated as a batch process. Number of processors vary greatly from small clinics with 1 processor to large hospitals with over 25 processors.	CRCs, terminal electrolytic and in-line electrolytic are used where possible. Silver recovery generally not centralized but done at each processing center. Wash water volume too large to be economically hauled.
Medical Professional	Includes physicians, osteopaths, chiropractors, veterinarians. B&W X-ray process. Similar to dental offices. If large, then similar to hospitals	Chemical Recovery Cartridges (CRC) or solution is hauled off site. May use more wash water than dental office.
Microfilm	B&W positive process. Significant water usage	Terminal CRCs or equivalent. Water volumes to great to be hauled.
Printer/Graphic Arts	Primarily pre-press B&W litho process. Some large facilities may have color film and print processes.	CRCs, terminal electrolytic and in-line electrolytic are used where possible. Could use wash water recycling, ion exchange or RO. Water volumes too great to be hauled off site.
Minilabs	Color negative/paper processes, some reversal, some B&W. Relatively small film volumes per day. Trend is toward less water usage.	CRCs, terminal electrolytic and precipitation. May use evaporation, distillation or RO. Small washless labs may haul. Not practical to haul for those labs using wash water.
Photofinishers Commercial Labs	Color negative/paper processes, Reversal, B&W. Large film volumes per day. Typically use large amounts of process water.	CRCs, terminal & inline electrolytic and precipitation. May use wash recirculation, ion exchange and RO. Wash water volumes too great to be hauled off site.
Police Departments Schools, Government Industrial	Color negative/paper processes. May use reversal and B&W.	CRCs ,electrolytic and precipitation typically used. Wash water volumes too large to be hauled off site.

8 Silver Pretreatment Limits in the Range of 1.0 to 2.5 mg/L

To consistently achieve silver discharge concentrations below 2.5 mg/L at the end of process, facilities must either modify or replace existing machines (if possible) to limit the amount of silver being carried into the wash waters or treat the wash waters to remove the silver. In addition, both of these options are expensive. Because of the additional energy and chemical requirements, the treatment of wash water simply to remove the silver, may result in more environmental pollution than the silver it removes.

In order to meet these limits, photographic processing facilities would have to have the systems recommended to meet 2.5 to 5.0 mg/L. In addition, most facilities will either have to control the amount of silver being carried into their wash waters or treat their wash waters to remove some of the silver. Treatment of wash water to remove the silver could result in increased pollution compared to the small amounts of silver it removes. However, low silver discharge limits in the POTW's NPDES permit may require this type of recovery. The costs to meet these limits are summarized in Appendix A.2.

If your pretreatment program requires silver limits in the range of 1.0 to 2.5 mg/L, you may wish to contact the resources from AMSA and the Silver Council provided in Appendices C.1 and C.2.

9 Silver Pretreatment Limits in the Range of 0.1 to 1.0 mg/L

In order to meet these limits at the end of process, many of the photographic processors will have to have their silver-rich solutions hauled off-site for treatment and disposal. In addition, facilities will have to take extraordinary steps to extensively modify their processing machines to keep silver from being carried over into the wash waters or treat their wash waters with an ion exchange unit. These modification costs will have a significant impact on many processing facilities, and some operations may have to shut down. The costs for meeting these limits are summarized in Appendix A.3.

If your pretreatment program requires silver limits in the range of 0.1 to 1.0 mg/L, you may wish to contact the resources from AMSA and the Silver Council provided in Appendices C.1 and C.2.

10 Silver Pretreatment Limits Less Than 0.1 mg/L

It will not be possible for most facilities to recover silver on-site and meet these limits. All process solution overflows and wash waters will have to be collected and hauled off-site for treatment and disposal. Evaporators and distillation units are available which can reduce the volumes by approximately 90 percent thus reducing the cost of hauling. These costs will have a severe impact on your community with many of the photographic processors closing and increased costs for health care. In addition, the energy requirements for evaporation and the transportation emissions from hauling may more than offset any environmental benefits gained from silver reductions. The costs for compliance with these limits is summarized in Appendix A.4.

If your pretreatment program requires silver limits less than 0.1 mg/L, you may wish to contact the resources from AMSA and the Silver Council provided in Appendices C.1 and C.2.

Appendix A.1

Estimated Costs to Meet Silver Limits in the Range of 2.5 to 5.0 mg/L

Facility Type (Size)	**Initial Equipment ($)**	**Annual Operation Labor $**
Dental Office—All sizes	150	90
Hospital—Small	4,500	1,600
Hospital—Medium	7,500	2,650
Hospital—Large	15,000	5,300
Medical Professional—Small	150	140
Medical Professional—Medium	1,000	240
Medical Professional—Large	1,500	525
Microfilm—Small	150	140
Microfilm—Medium	150	240
Microfilm—Large	5,000	1,000
Printer/Graphic Art—Small	1,000	180
Printer/Graphic Art—Medium	1,200	280
Printer/Graphic Art—Large	3,500	1,000
Minilab—Washless—All sizes	3,500	1,000
Minilab—Washwater—All sizes	1,000	525
Photofinisher/Professional—Small	3,500	1,000
Photofinisher/Professional—Medium	7,500	2,250
Photofinisher/Professional—Large	20,000	4,500
Motion Picture—Small	5,000	1,250
Motion Picture—Medium	7,500	2,250
Motion Picture—Large	75,000	15,000
Police Dept.—Small/medium	150	90
Police Dept.—Large	1,000	180
School—Small	1,000	180
School—Medium	1,500	480
School—Large	3,500	1,000

Appendix A.2

Estimated Costs to Meet Silver Limits in the Range of 1.0 to 2.5 mg/L

Facility Type (Size)	**Initial Equipment ($)**	**Annual Operation Labor $**
Dental Office—All sizes*	100	500
Hospital—Small	6,000	2,900
Hospital—Medium	10,000	3,600
Hospital—Large	20,000	10,900
Medical Professional—Small	650	850
Medical Professional—Medium	1,500	900
Medical Professional—Large	2,500	1,400
Microfilm—Small	650	850
Microfilm—Medium	650	950
Microfilm—Large	6,000	2,500
Printer/Graphic Art—Small	1,500	950
Printer/Graphic Art—Medium	1,700	1,050
Printer/Graphic Art—Large	4,500	2,500
Minilab—Washless—All sizes*	100	2,700
Minilab—Washwater—All sizes	1,500	750
Photofinisher/Professional—Small	4,000	2,000
Photofinisher/Professional—Medium	8,500	3,750
Photofinisher/Professional—Large	22,000	7,500
Motion Picture—Small	5,500	1,850
Motion Picture—Medium	8,000	3,100
Motion Picture—Large	81,000	21,500
Police Dept.—Small/medium	650	800
Police Dept.—Large	1,500	900
School—Small	1,500	900
School—Medium	2,000	1,200
School—Large	4,500	2,500

* These facilities must haul their wastewater. They cannot treat to meet these limits.

Appendix A.3

Estimated Costs to Meet Silver Limits in the Range of 0.1 to 1.0 mg/L

Facility Type (Size)	Initial Equipment ($)	Annual Operation Labor $
Dental Office—All sizes*	100	500
Hospital—Small	42,000	11,500
Hospital—Medium	60,000	18,000
Hospital—Large	100,000	30,000
Medical Professional—Small	12,000	2,500
Medical Professional—Medium	12,000	3,000
Medical Professional—Large	12,000	6,000
Microfilm—Small	12,000	2,500
Microfilm—Medium	12,000	3,000
Microfilm—Large	52,000	13,000
Printer/Graphic Art—Small	12,000	3,000
Printer/Graphic Art—Medium	12,000	4,000
Printer/Graphic Art—Large	42,000	11,000
Minilab—Washless—All sizes*	100	2,700
Minilab—Washwater—All sizes	12,000	3,000
Photofinisher/Professional—Small	15,000	10,000
Photofinisher/Professional—Medium	90,000	25,000
Photofinisher/Professional—Large	150,000	50,000
Motion Picture—Small	42,000	11,000
Motion Picture—Medium	55,000	14,000
Motion Picture—Large	325,000	200,000
Police Dept.—Small/medium	12,000	2,500
Police Dept.—Large	12,000	4,000
School—Small	12,000	3,000
School—Medium	12,000	6,000
School—Large	12,000	10,000

* These facilities must haul their wastewater. They cannot treat to meet these limits.

Appendix A.4

Estimated Costs to Meet Silver Limits of Less than 0.1 mg/L

Facility Type (Size)	Initial Equipment ($)	Annual Operation Labor $
Dental Office—All sizes*	100	500
Hospital—Small	225,000	75,000
Hospital—Medium	330,000	135,000
Hospital—Large	425,000	245,000
Medical Professional—Small	45,000	11,000
Medical Professional—Medium	75,000	28,000
Medical Professional—Large	100,000	37,000
Microfilm—Small	15,000	6,000
Microfilm—Medium	45,000	12,000
Microfilm—Large	225,000	75,000
Printer/Graphic Art—Small	55,000	16,000
Printer/Graphic Art—Medium	75,000	26,000
Printer/Graphic Art—Large	225,000	83,000
Minilab—Washless—All sizes*	100	2,700
Minilab—Washwater—All sizes	25,000	8,000
Photofinisher/Professional—Small	10,000	45,000
Photofinisher/Professional—Medium	500,000	220,000
Photofinisher/Professional—Large	1,200,000	520,000
Motion Picture—Small	100,000	37,000
Motion Picture—Medium	130,000	67,000
Motion Picture—Large	2,500,000	1,200,000
Police Dept.—Small/medium	30,000	7,000
Police Dept.—Large	45,000	16,000
School—Small	55,000	17,000
School—Medium	75,000	28,000
School—Large	125,000	67,000

* These facilities must haul their wastewater. They cannot treat to meet these limits.

Appendix B

Parameters Affecting Silver Concentration in Wash Water	
Number and Configuration of Wash Tanks	
Number of Tanks	Generally the more tanks the lower the silver concentration.
Counter-Current Flow	Concentrates the silver in the tank adjacent to the silver-rich solutions
Low-Flow Washes	Reduces the amount of silver in the wash water.
In Line Water System	Recirculation reduces the amount of water used and increases the silver concentration in process wash water
Type of Processor	
Leader Belt	Silver-rich solutions can transport on the belt to wash waters.
Roller Transport	Most common processor type. Rollers can squeeze photographic media before transport to the wash water reducing carry-over.
Rack and Tank	Older technology does not allow for physical squeegee thus carry-over of silver-rich solutions into wash water is high.
Squeegees	
Squeeze Roller	Photographic media passes between two soft rollers in close proximity. Effectively removes surface chemicals on both sides of the photographic media.
Single Blade	Physical pressure of blade removes surface liquid.
Delta Blade	Similar to single blade but can be rotated to increase efficiency life.
Air Knife	Uses a concentrated force of air to remove chemicals from surface.
Imaging Media & Type	
Type of Media	X-ray film has more silver per square unit than graphic arts film. In turn graphic arts film has more silver per square unit than consumer color film. Generally, the more silver in the product, the more silver in the process wash water.
Exposure Percentage	In negative B&W media, the more exposure, the less silver in the process wash water. In positive B&W media, the more exposure, the more silver in process wash water.
Surface	A matte or rippled media surface will retain more chemicals which can be transferred to wash water than a glossy or smooth surfaced media.
Quantity and Size	If product size is not matched to processor sensors over or under replenishment can occur causing fluctuations of silver-rich carry-over to wash water. Mismatched product to equipment can also cause an increase in wash water usage.
Silver Recovery	
Terminal	Has no effect on silver concentration in process wash water.
In-Line	Can reduce silver concentration in process wash water by lowering concentration in preceding fix tank.
Chemistry	
Low Replenishment	Generally causes higher silver concentrations in process wash water.
Over Replenishment	Generally causes lower silver concentrations in process wash water.
Regeneration	Marginally increases silver concentration in process wash water.

Appendix C.1

Resources Available from the Silver Council

Name: Academy Corporation
Contact: David Nycz / Gary Sims
Address: 6905 Washington NE, Albuquerque, NM 87109
Phone (business hours): 800-545-6685 or 505-345-1805
Phone (after hours/weekends): none
Fax: 505-344-4638

Name: Agfa Division, Bayer Corporation
Contact: Environmental & Safety Department
Address:100 Challenger Rd., Ridgefield Park, NJ 07660
Phone (business hours): 201-440-2500
Phone (after hours/weekends): none
Fax: 201-440-4376

Name: Anitec
Contact: Daniel Sinto
Address: PO Box 4444, Binghamton, NY 13902-4444
Phone (business hours): 607-774-3116
Phone (after hours/weekends): none
Fax: 607-774-3313

Name: Association of Cinema and Video Laboratories
Contact: Frank Ricotta
Address: 4050 Lankershim Blvd., N. Hollywood, CA 91608
Phone (business hours): 818-505-5130
Phone (after hours/weekends): none
Fax: 818-761-4835

Name: Byers Industries
Contact: Lauren Larsen
Address: 6800 NE 59th Place, Portland, OR 97218
Phone (business hours): 503-281-0069
Phone (after hours/weekends): none
Fax: 503-281-1669

Name: CPAC Equipment Division
Contact: Ernest Thompson
Address: 2364 Leicester Rd.,Leicester, NY 14481
Phone (business hours): 716-382-3223
Phone (after hours/weekends): none
Fax: 716-382-3031

Name: City of Albuquerque Public Works Department
Contact: Bob Hogrefe, Industrial Pretreatment Coordinator
Address: 4201 2nd St. SW, Albuquerque, NM 87105
Phone (business hours): 505-873-7030
Phone (after hours/weekends): none
Fax: 505-873-7087

Name: Dupont Printing & Publishing
Contact: DuCare Customer Service
Address: 69 Seneca Avenue, Rochester, NY 14621
Phone (business hours): 800-210-8232
Phone (after hours/weekends): 800-210-8232
Fax: 716-339-4249

Name: Envision Compliance Ltd.
Contact: George Ayers
Address: 1495 Bonhill Rd., #3, Mississauga, ON L5T 1M2
Phone (business hours): 905-670-8889
Phone (after hours/weekends): 905-670-8889 (voicemail)
Fax: 905-670-0180

Name: Eastman Kodak Company
Contact: Kodak Environmental Services
Address: 1100 Ridgeway Ave Rochester, NY 14652-6255
Phone (business hours): 716-477-3194
Phone (after hours/weekends): none
Fax: 716-722-3173

Name: Fuji Hunt Photographic Chemicals, Inc.
Contact: Environmental Health & Safety
Address: P.O. Box 988, Paramus, NJ 07653-0988
Phone (business hours): 201-967-9603
Phone (after hours/weekends): none
Fax: 201-967-9299

Name: Fuji Medical Systems U.S.A., Inc.
Contact: Environmental Health & Safety
Address: PO Box 120035, Stamford, CT 06912-0035
Phone (business hours): 201-967-9603 (CMP issues)
Phone (after hours/weekends): none
Fax: 203-353-0926

Name: Fuji Photo Film U.S.A., Inc.
Contact: Operations Planning & Risk Management
Address: 555 Taxter Rd., Elmsford, NY 10523
Phone (business hours): 800-473-3854
Phone (after hours/weekends): none
Fax: 914-789-8504

Name: Graphic Arts Association
Contact: Walter Zerweck, President
Address: 1900 Cherry Street, Philadelphia, PA 19103
Phone (business hours): 215-299-3300
Phone (after hours/weekends): none
Fax: 215-299-3329

Name: Graphic Arts Technical Foundation
Contact: Gary Jones, Manager, Environmental Information
Address: 4615 Forbes Avenue, Pittsburgh, PA 15213-3796
Phone (business hours): 412-621-6941
Phone (after hours/weekends): none
Fax: 412-621-3049

Name: Ilford Photo
Contact: Joanne Kirwin, Technical Services
Address: W 70 Century Rd., Paramus, NJ 07653
Phone (business hours): 201-265-6000
Phone (after hours/weekends): 800-535-9205 MB 2599
Fax: 201-599-4348

Resources Available from the Silver Council

Name: Imation Corp
Contact: Loren Forsmark
Address: 3M Center, 235-3C-23, St. Paul MN 55144
Phone (business hours): 612-704-3755
Phone (after hours/weekends): none
Fax: 612-736-7616

Name: International Minilab Association
Contact: Jim Ryder
Address: 2627 Grimsley St., Greensboro, NC 27403
Phone (business hours): 910-854-8188
Phone (after hours/weekends): none
Fax: 910-854-8566

Name: International Precious Metals Institute
Contact: Walter D. Ramsay
Address: 4501 Arlington Blvd., #324, Arlington, VA 22203
Phone (business hours): 703-525-1780
Phone (after hours/weekends): none
Fax: 703-525-1780

Name: Konica Corporation - Konica EP Center
Contact: David Pasquini, PH.D, CIH, CSP
Address: 6900 Konica Drive, Whitsett, NC 27737
Phone (business hours): 910-449-8000 ext 201
Phone (after hours/weekends:) 910-449-8000 ext 201
Fax: 910-449-7554

Name: LED Italia SRL
Contact: Longo Vincenzo
Address: Via Nvova Di Corva 86, Pordemone, Italy
Phone (business hours): 011-39-571055
Phone (after hours/weekends): none
Fax: 011-39-571459

Name: National Association of Photographic Manufacturers
Contact: Thomas Dufficy
Address: 550 Mamaroneck Ave #307, Harrison NY 10528
Phone (business hours): 914-698-7603
Phone (after hours/weekends): none
Fax: 914-698-7609

Name: New Mexico Silver Users Association
Contact: Ron Taylor, President
Address: P.O. Box 25801, Albuquerque, NM 87125-0801
Phone (business hours): 505-294-5051
Phone (after hours/weekends): none
Fax: 505-296-2672

Name: Photo Marketing Association International
Contact: Environmental Activities Department
Address: 3000 Picture Place, Jackson, MI 49201
Phone (business hours): 517-788-8100
Phone (after hours/weekends): none
Fax: 517-788-8371

Name: Picker International - Health Care Products
Contact: Richard Rzepka
Address: 6700 Beta Drive, Mayfield, OH 44143
Phone (business hours): 216-473-6811
Phone (after hours/weekends): none
Fax: 216-473-6828

Name: Safety-Kleen Corp.
Contact: Imaging Services Group
Address: 1000 N. Randall Road, Elgin, IL 60123-7857
Phone (business hours): 1-800-755-5705
Phone (after hours/weekends): 708-468-2815 (voice mail)
Fax: 708-468-8505

Name: Silver Users Association, Inc.
Contact: Walter Frankland
Address: 1730 K. St N.W. # 304, Washington, DC 20006
Phone (business hours): 202-785-3050
Phone (after hours/weekends): 703-528-8451
Fax: 202-659-5760

Name: Texas Environmental Advisory Council
Contact: R. Kenneth Coppage
Address: 2710 Lakeview Lane, Carrollton, TX 75006
Phone (business hours): 972-418-5825
Phone (after hours/weekends): 972-418-5825
Fax: 972-416-6995

Appendix C.2

Resources Available from AMSA

For more information regarding the Association of Metropolitan Sewerage Agencies (AMSA), please contact:

Mr. Sam Hadeed
Director of Regulatory Affairs and Technical Services
AMSA
1000 Connecticut Avenue N.W., Suite 410
Washington, DC 20036
Tel: 202-833-AMSA

Specific questions regarding pretreatment issues can be directed to:
Mr. Guy Aydlett
Chair
AMSA Pretreatment & Hazardous Waste Committee
Tel: 757-460-7040

Ms. Margie Nellor
Vice-Chair
AMSA Pretreatment & Hazardous Waste Committee
Tel: 310-699-7411

Code of Management Practice for Silver Discharges

Part 7 Considerations for Pollution Prevention Activities January 1997

Table of Contents

1 Scope

This part of the Code of Management Practice (CMP) explains the term pollution prevention and identifies several pollution prevention activities that can be used by photo processors where the activities are appropriate.

For the purposes of this document, pollution prevention can be described as the use of processes, practices, materials, and energy in a manner that avoids or minimizes the creation of wastes. Pollution prevention fundamentally shifts the focus of environmental protection from end-of-pipe control, where wastes are managed after being generated, to front-of-process management where product and process design stress source reduction and good process control. It's far more cost-effective not to create waste than it is to try to manage it after it has been generated.

While every business must conform to the regulation and ordinances that govern it, pollution prevention options provide photoprocessors with tools to achieve compliance and further reduce waste generated by their facilities. Since there are so many different types of imaging operations, each with its own process, quality and financial considerations, determination of which pollution prevention activities make good business and environmental sense to implement must be made on a case-by-case basis. Because of the potential impact on quality and other key operating criteria, the activities discussed in this part of the CMP are considered voluntary and cannot be applied universally.

2 Overview

In the Pollution Prevention Act of 1990, the federal government gave an official name to this practice of reducing or eliminating waste at the source. It is called pollution prevention.

2.1 History

The photographic industry has a long history of source reduction and sound waste control practices as a means toward economic benefits and business viability. This industry has long recognized that these good business practices reduce the impact on the environment.

Pollution prevention (P2) in the photographic industry is an on-going activity. Examples of P2 accomplishments within the past 10 years include the following:

- manufacturers have redesigned film and paper to contain less silver while improving image quality, archival stability and handling,
- manufacturers have systematically reformulated photographic processing chemicals so that lower replenishment rates can be achieved (some processes have reduced replenishment rates by up to 80 percent over the past decade),
- washless processing, where possible, has resulted in dramatic reductions of up to 90 percent in water consumption,
- some chemicals have become easier to regenerate for reuse, and
- processing and printing equipment has been designed to produce less waste.

In addition to modifying production products and processes, pollution prevention also encompasses standard operating procedures that result in the wise use of resources and generate less waste. Several of these procedures are identified in the EPA's Guidance Manual for Developing Best Management Practices (BMP). Examples of these standard operating procedures include:

- good housekeeping,
- preventive maintenance,

- employee training,
- inspections,
- security, and
- recordkeeping and reporting.

2.2 Limitations

Pollution prevention activities voluntarily undertaken by the facility cannot be continued if they compromise the quality of the image or permanence of the product. Pollution prevention activities should not decrease the production capability of the processor.

A limiting factor of pollution prevention has historically been the use of concentration-based limits by POTWs in local sewer ordinances. The conservation and reuse of water are major issues that have been addressed by the photographic industry. As process water conservation is practiced, however, the concentration of some restricted components in the wastewater increases. By adopting performance-based limits, such as those recommended in Part 3 of this CMP, POTWs can encourage facilities that process photographic materials to reduce water consumption and by extension, reduce the hydraulic load to the treatment facility. Photo processors and local sewage treatment authorities are encouraged to work together to implement performance-based limits.

3 Involving employees

An on-going pollution prevention program in a facility requires the support and commitment of both management and staff. Management must demonstrate a belief in and support of the P2 program. Employees must understand, accept and participate in the formation and operation of the program.

3.1 Commitment from Management

Without commitment from management, a successful pollution prevention program can not exist. Management should demonstrate visible support through the development of a pollution prevention policy statement. Where an environmental policy already exists, the P2 policy can simply be incorporated. To create a P2 policy statement, a photo processor may consider the following steps:

- determine who will sign and issue the policy,
- solicit employee ideas and participation,
- keep the policy clear, concise, goal-oriented, and positive,
- distribute the policy throughout the organization,

- assign responsibilities and accountability, and
- ensure supervisors are fully aware of management's commitment, and expectations.

In addition, management should allocate the resources required to develop, implement and maintain a P2 program. These resources are not required to be extensive. Since most photo processors are small businesses and employee few people, extensive resources are simply not available. Facilities that allocate a proper level of resources should find a successful P2 program helps them to work smarter not harder.

3.2 P2 Team

The pollution prevention program and the formation of the P2 team should be a cooperative effort of management and staff. The P2 team is made up of interested staff within a facility who will develop and assist in managing the P2 program. Some considerations for selecting team members include the following:

- make the size of the P2 team appropriate to the size and complexity of the facility (a team of one person could be adequate for a small facility),
- choose people who are knowledgeable with the production processes and products,
- choose people who represent all areas of the facility and employees, and
- designate a lead team member.

3.3 Training

Training is routine in a photo processing facility. Examples of typical training include health, safety and environmental training, cross-training, and training for proper equipment operation. Training for pollution prevention can easily be incorporated into the existing training program.

P2 training should explain what pollution prevention is, why it is important and what each employee can do to ensure the success of the P2 program. For those employees who are responsible for specific P2 activities, their training should prepare them to carry out those duties (e.g., spill response and clean up, preventive maintenance, or process control).

As with other training, it is useful to maintain P2 records indicating who has been trained, when and on which topics. While records serve to provide proof that training has occurred, they also remind management when it is time for retraining. This helps management to ensure that its P2 efforts and the associated business efforts continue to grow.

4 Managing Chemicals

By instituting and applying certain management procedures, a photo processor can use the minimum amount of chemicals necessary to produce a quality product. Sound chemical management results in less chemical waste, reduced chemical costs, and reduced operational costs.

4.1 Process Control

A key chemical management strategy is process control. This involves routinely monitoring the variables that contribute to a consistent, high quality product—the first time through. Process control variables include:

- replenishment rates,
- process temperatures,
- control strips and control charts,
- chemical mix procedures, and
- preventive maintenance.

To begin, the photo processor can obtain information from the chemical and equipment suppliers regarding optimum operating specifications. For example, photo processing chemical manufacturers can supply correct replenishment rates and processing temperatures. Equipment manufacturers can supply preventive maintenance procedures for processing equipment and densitometers.

Once the photo processor has identified each of the variables and the optimum control points, it is a matter of routinely monitoring the variables and making adjustments whenever necessary. Records, such as preventive-maintenance logs and control charts, should be maintained.

By systematically using process control tools, out-of-control situations requiring remixing chemicals and reprinting of film can usually be avoided. This results in waste minimization, greater productivity, and economic benefit.

4.2 Good Housekeeping

Good housekeeping is an essential element of a facility's overall pollution prevention effort. A well-maintained facility is less likely to have spills and leaks and is more likely to account for all the raw materials it uses. In a well-maintained facility, it is easier to find materials and equipment, and there are lower material losses due to waste and spills. Such an environment also provides greater health and safety for the employees. Operational losses should be lowered through improved efficiencies.

Good housekeeping is the same as good organization. There are three steps to making good housekeeping an everyday activity:

1. Establish an appropriate storage area for all materials and every piece of equipment.
2. Require every employee to place or return all materials and equipment to their designated area.
3. Establish a procedure and a schedule to inspect chemical receiving, storage, mixing and use areas for spills and leaks. Ensure they are cleaned up and the cause is eliminated.
4. Establish a procedure to ensure that equipment is cleaned and properly maintained.
5. Maintain a high level of employee awareness for good housekeeping.

4.3 Chemical Inventory

Each facility should develop and maintain a chemical inventory. An inventory allows the photo processor to determine the types, quantities and locations of chemicals in the facility. The inventory should identify all the chemical products, including silver-rich solutions which are generated and stored in the facility. It should also contain the process solution name, the type of potential hazard, the location within the facility, the amount used over a pre-determined period of time, and the quantity typically on hand.

Preparing a chemical inventory provides insight into several other activities which can improve chemical management:

- An appropriate supply of chemicals can be maintained. This minimizes the risk of stock depletion, which affects productivity and the ability to meet deadlines. It also minimizes the need to tie up money in overstock.

- Stock can be used in the order in which it was received. This minimizes the risk of using old or outdated chemicals. Proper disposal of these chemicals may be expensive.

- Chemical hazards can be identified and, if practical, less hazardous chemicals can be substituted.

- Incompatible chemicals can be identified so that they can be stored separately.

- A comparison can be made of chemicals mixed versus chemicals used to examine chemical wastage or over-replenishment. (See Section 4.6.)

4.4 Chemical Storage and Chemical Containment

Although it is a relatively rare occurrence, chemical containers can leak and rupture resulting in lost materials and lost productivity while employees interrupt work to clean up. These containers include unused chemicals still in their original packaging and mixed chemicals, both in processors and replenishment tanks. To reduce the risk of chemical leaks and ruptures, the following practices may be used:

- Stack unopened boxes and cartons of chemicals neatly and no higher than waist level.
- Be alert for any leaking containers. Do not accept them from the transport company. If they are noticed after delivery, overpack them or pour the contents into compatible non-leaking containers, set them aside and contact the chemical supplier.
- Provide containment for silver recovery cartridges, mixing vessels, chemical storage tanks, and other containers that may leak or rupture.
- Inspect chemical storage areas routinely so that any leaks or ruptures can be cleaned up and the cause eliminated.

4.5 Spill Response Planning

A spill is any liquid chemical release that is not in the ordinary course of events. In a facility that processes photographic material, effluent is generated through several operations that are considered to be a normal part of the photo processing operation, including the following:

- replenisher overflows generated by processing,
- solution replacement recommended by the chemical manufacturer,
- tank and rack cleaning,
- rinse water from chemical containers, and
- contaminated solution and exhausted or oxidized chemical replacement.

These events are not spills since they occur as a normal part of the photoprocessing operation.

Situations that are considered to be spills might include a dropped container of chemical, a hose leak, a tank overfill, or a replenisher tank rupture. These are considered to be spills because they were not planned activities and so they are not considered to be a normal process event.

For the typical photographic processor, most spills are likely to be small and incidental. Incidental spills are those of a size and nature where the person discovering the spill can clean it up without generating excessive vapors and without requiring additional help or resources. In extreme cases, however, a spill may be of a size or nature that emergency response may be necessary and clean up activities would be regulated by OSHA, and/or possibly the EPA. Each photo processing facility must evaluate its own potential for spills along with its response capabilities. Regardless of the size and type of spill, proper planning and procedures can help prevent spills and the pollution they cause.

Spill-response planning is the process of developing a plan of action before a spill occurs. If a spill occurs, the plan can be put into place quickly, thus minimizing the effects of the spill. As with all pollution prevention activities, the scope of the spill-response plan should reflect the size and complexity of the facility.

To develop a spill-response plan, the following guidelines may be used:

- Develop and maintain a floor plan to identify all areas within the facility where the potential for a spill to the sewer exists.
- Cover any floor drain or provide a means to temporarily cover the drain(s) in the chemical storage area so that a leak will not reach the drain.
- Determine and acquire the supplies and equipment required to clean-up a spill. Store them in an accessible location.
- Develop a set of procedures for using cleanup supplies and equipment.
- Train designated employees on spill response procedures including notification, when necessary.
- Post the procedures in appropriate areas throughout the facility.
- Maintain a log of spills in order to identify any trends so that the cause of spills can be eliminated.

Spills in a photographic processing facility that would typically be of concern to a POTW may involve concentrates from which working-strength replenisher solutions are made, or a silver-rich solution before silver recovery.

In general, working strength processing solutions do not pose emergency situations, since these consist mainly of water and are not strongly acidic or basic. Some of the chemical concentrates, however may be very acidic ($pH < 2$) or basic ($pH > 13$). In addition, some of the chemicals used for pH adjustment in silver recovery and cleaning operations could be very acidic or basic. Discharges to a POTW of materials with a pH of less than 5 are prohibited by Federal Regulation (40 CFR 403). Local limits may be more restrictive. Each facility should check with its local POTW to determine the applicable limits before discharging spills to a sewer.

Each POTW must decide when to involve its limited resources in spill notification from photographic processors. It is recommended that the POTW specify the minimum quantity required for spill notification of concentrate or silver-rich solutions. Each photographic processing facility should check with its local POTW to determine specific reporting requirements.

4.6 Chemical Usage Monitoring

In order to identify any discrepancies between the amount of chemicals that should have been used versus actual usage, the photo processor may choose to monitor chemical usage. Any significant difference between these two numbers will alert the photo processor to a problem.

To determine the quantity of chemicals that should have been used requires a calculation. Multiply the number of films and/or the amount of paper processed by the replenishment rates.

To determine the quantity of chemicals that were actually used, record the amount of chemicals in the replenishment tank at the beginning of the monitoring period. Then add the quantity of chemicals mixed during the monitoring period. Finally, subtract the quantity of chemicals in the replenishment tanks at the end of the monitoring period. The monitoring period may be as short as one week or as long as a month.

4.7 Security and Safety

Access to chemical mixing and storage areas should be limited to employees who have been trained in the safe use and handling of photographic chemicals. This practice helps to minimize spills or other upsets resulting in chemical waste or a release to the environment—be it intentional or non-intentional. Safety training will also provide information to help employees minimize any health risks associated with improperly handling processing chemicals.

In designing a security and safety system, the size and location of the facility will usually determine the complexity of the system.

A security and safety system, designed with the physical layout of the facility in mind, can help to keep chemical areas secure and accident free.

In a minilab or other small photo processing facilities, the security and safety system may be as simple as a counter-high gate to let customers know the photo lab is off-limits. For after-hours security, the facility may have a building alarm.
In a larger lab, the chemical storage and mix areas are generally segregated from the production areas. The entrance to the room may be posted so that only authorized and trained staff are allowed in. After-hours security may include a routine patrol of the facility by a security guard.

4.8 Preventive Maintenance

Preventive maintenance is one of the most important pollution options. By implementing a complete preventive-maintenance program the equipment will work at its optimum level, keeping waste at a minimum. Photo processors should use preventive-maintenance recommendations found in the equipment operating manuals and other information provided by manufacturers, suppliers and associations.

5 Modifying Equipment and Processes

In some situations, manufacturer recommended changes or modifications to equipment and processes can reduce chemical usage.

5.1 Modifications to Equipment

Depending upon the equipment, photo processors may be able to make changes to their processing equipment that result in pollution prevention. Examples of these modifications include:

- Squeegees - Squeegees, such as air knives, wiper blades and rollers, can be used to reduce the amount of liquid carried over from one solution tank to the next during continuous film and paper processing. The effective use of squeegees will result in reduced chemical costs, improved silver recovery and reduced water consumption.

- Closed-loop silver recovery - A closed loop or in-line silver recovery unit can be installed on the film processor to maintain the level of silver in the processing fix tank to approximately 500 mg/L. By reducing the concentration of silver in the solution immediately preceding the wash, the amount of silver lost due to carryover is reduced. A lower replenishment rate is generally used with closed-loop silver recovery resulting in reduced chemical costs. In addition, closed-loop silver recovery is an electrolytic method which provides the photo processor with a high grade of silver flake. A specially formulated fix with a higher concentration of sulfite is generally used with closed-loop silver recovery.

- Counter-current wash tanks - Silver is carried out on the film and paper into the final wash/rinse tanks. Counter-current plumbing is the practice of plumbing the series of wash/rinse tanks so that the water enters the last tank first and the overflow cascades forward. This results in concentrating the silver in the first wash/rinse tank making it easier to recover the silver from the solution, as well as reducing the amount of water required in the process.

- Low-flow wash - Silver in the wash water may be further concentrated using a low-flow or replenished wash immediately following the bleach-fix or fix but prior to the final wash. The low-flow wash is considered to be a silver-rich solution and is typically combined with other silver-rich solutions prior to silver recovery. Low-flow washes can only be used when the processing equipment can be practically reconfigured to accommodate this modification.

5.2 Modifications to Processes

Photo processors may also be able to make modifications to their processes resulting in reduced chemical usage. Examples of process modifications include:

- Low-replenishment chemicals - Photo processors should work with their suppliers to select the most cost effective chemical option. In some cases, older equipment cannot be modified to accommodate the use of newer processes.

- Regeneration and reuse of chemicals - Photo processors should explore the option of regenerating and reusing chemicals if circumstances allow. Under certain limited conditions, regeneration of chemicals can be used to reduce the volume of chemicals generated by the facility.

- Dry chemical packaging and automated mixing - Under some conditions dry chemical packaging and automated mixing can contribute to waste minimization through extended shelf life and fewer mixing errors.

- Water reuse and recycling - Several options, including reverse osmosis and ion exchange can help conserve water. In addition, wash water recycling can be explored.

- Washless processing - In some processes, the wash water has been replaced with a chemical rinse. This eliminates the need for equipment to be hard plumbed. In addition, the chemical rinse is replenished at a much lower rate than the previous wash water.

6 Other Waste Streams

There are numerous solid waste streams that may require some pollution prevention action by the facility. Typical non-chemical waste streams include composite materials such as single-use cameras and process filters; metal waste such as film canisters; paper materials such as corrugated and boxboard; plastic materials such as chemical containers and film spools; and wood materials such as pallets or skids. The chart outlines typical waste streams along with some management options.

Material	Detail	Re-use	Recycle	Dispose
Composite	Single-use cameras		x	
	Batteries	x		x
	Photographic bags	x		x
	Process filters	x		x
Metal	Film canisters	x	x	
	Cans		x	
Plastic	Chemical containers		x	
	Film spools		x	
	Film tails/leader (silver)		x	
	Paper cores (plastic)	x	x	
Paper	Paper cores (paper)	x	x	
	Photographic paper			x
	Fine paper		x	
	Box board		x	
	Newspaper		x	
Textiles/Fabric	Felt strips			x
Wood	Pallets, skids, crates	x	x	

7 Tracking Results

Once P2 activities have been put into place, they need to be evaluated to determine whether they are working as implemented, are cost effective, changes are needed to increase their usefulness and if there has been any impact upon quality. This evaluation is carried out routinely by the P2 team, who review operations, examine records and talk with staff.

The specific evaluation method is determined by the activity under review. For example, to determine whether chemicals were being stored properly, a physical inspection of the area would provide sufficient proof. To determine if process control was being practiced, the P2 team may review control charts and preventive maintenance logs. In the case of training, the P2 team may talk with those employees designated as spill response personnel in order to find out if they received the proper training.

The next step is to determine whether the pollution prevention activity is cost effective. For example, to evaluate whether it is cost effective to use low-replenishment chemicals, the photo processor could compare the costs before and after the system was implemented. The costs to be considered should include items such as chemical costs, labor costs associated with mixing, and any chemicals replaced due to low tank turnover.

When the results of an evaluation indicate the pollution prevention activity has an adverse impact on quality or profits or does not meet the original pollution prevention goals, the activity must be reassessed. Industry suppliers constantly improve the state-of-the-art with regard to product performance and pollution prevention. There may be new options available when the activity is re-evaluated that can provide the originally desired pollution prevention benefits.

It can be very useful to document this periodic review in writing so that the photo processor has a record of how well the pollution prevention program is working. Over the course of time, the record will make it easier to make decisions about continuing and altering P2 activities. Written records can also help to reduce the efforts required in future reviews.

8 References

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Photo Marketing Association International (November 1994). Environmental code of management practice for minilabs. Jackson, MI.

U.S. Environmental Protection Agency (October 1993). Guidance manual for developing best management practices (EPA 833-B-93-004). Washington, DC: Office of Water.

U.S. Environmental Protection Agency (October 1991). Guides to pollution prevention, the photoprocessing industry (EPA/625/7-91/012). Washington, DC: Office of Research and Development.

U.S. Environmental Protection Agency (August 1990). Guides to pollution prevention, the commercial printing industry (EPA/625/7-90/008). Washington, DC: Office of Research and Development.

Pollution Prevention Resources - Manufacturers & Associations

Name: Agfa Division, Bayer Corporation
Contact: Environmental & Safety Department
Address:100 Challenger Rd., Ridgefield Park, NJ 07660
Phone (business hours): 201-440-2500
Phone (after hours/weekends): none
Fax: 201-440-4376

Name: Anitec
Contact: Daniel Sinto
Address: PO Box 4444, Binghamton, NY 13902-4444
Phone (business hours): 607-774-3116
Phone (after hours/weekends): none
Fax: 607-774-3313

Name: DuPont Printing & Publishing
Contact: DuCare Customer Service
Address: 69 Seneca Avenue, Rochester, NY 14621
Phone (business hours): 800-210-8232
Phone (after hours/weekends): 800-210-8232
Fax: 716-339-4249

Name: Eastman Kodak Company
Contact: Kodak Environmental Services
Address: 1100 Ridgeway Ave., Rochester, NY 14652-6255
Phone (business hours): 716-477-3194
Phone (after hours/weekends): none
Fax: 716-722-3173

Name: Fuji Hunt Photographic Chemicals, Inc.
Contact: Environmental Health & Safety Department
Address: P.O. Box 988, Paramus, NJ 07653-0988
Phone (business hours): 201-967-9603
Phone (after hours/weekends): none
Fax: 201-967-9299

Name: Fuji Medical Systems U.S.A., Inc.
Contact: Environmental Health & Safety Department
Address: PO Box 120035, Stamford, CT 06912-0035
Phone (business hours): 201-967-9603 (CMP issues)
Phone (after hours/weekends): none
Fax: 203-353-0926

Name: Fuji Photo Film U.S.A., Inc.
Contact: Environmental & Safety Affairs Department
Address: 555 Taxter Rd., Elmsford, NY 10523
Phone (business hours): 800-473-3854
Phone (after hours/weekends): none
Fax: 914-789-8504

Name: Graphic Arts Technical Foundation
Contact: Gary Jones, Manager, Environmental Information
Address: 4615 Forbes Avenue, Pittsburgh, PA 15213-3796
Phone (business hours): 412-621-6941
Phone (after hours/weekends): none
Fax: 412-621-3049

Name: Ilford Photo
Contact: Joanne Kirwin, Technical Services
Address: W 70 Century Rd., Paramus, NJ 07653
Phone (business hours): 201-265-6000
Phone (after hours/weekends): 800-535-9205 MB 2599
Fax: 201-599-4348

Name: International Minilab Association
Contact: Jim Ryder
Address: 2627 Grimsley St., Greensboro, NC 27403
Phone (business hours): 910-854-8188
Phone (after hours/weekends): none
Fax: 910-854-8566

Name: Konica Corporation
Contact: Environmental Protection Center
Address: 6900 Konica Drive, Whitsett, NC 27377
Phone (business hours): 910-449-8000 ext 201
Phone (after hours/weekends): none
Fax: 910-449-7554

Name: National Association of Photographic Manufacturers
Contact: Thomas Dufficy
Address: 550 Mamaroneck Ave, # 307, Harrison, NY 10528
Phone (business hours): 914-698-7603
Phone (after hours/weekends): none
Fax: 914-698-7609

Name: Photo Marketing Association International
Contact: Ron Willson, Director, Environmental Activities
Address: 3000 Picture Place, Jackson, MI 49201
Phone (business hours): 517-788-5980
Phone (after hours/weekends): none
Fax: 517-788-8371

Name: Printing Industries of America
Contact: Ben Cooper
Address: 100 Daingerfield Road, Alexandria, VA 22314
Phone (business hours): 703-519-8100
Phone (after hours/weekends): none
Fax: 703-548-3227

Appendix A.2

Pollution Prevention Resources - Federal Government

Name: U.S. EPA Regional Office
Region 1 (VT, NH, ME, MA, CT, RI)
Address: JFK Federal Building, One Congress Street
Boston, MA 02203
Phone (business hours): 617-565-3420

Name: U.S. EPA Regional Office
Region 2 (NY, NJ)
Address: 26 Federal Plaza
New York, NY10278
Phone (business hours): 212-637-3000

Name: U.S. EPA Regional Office
Region 3 (PA, DE, MD, WV, VA)
Address: 841 Chestnut Street
Philadelphia, PA 19107
Phone (business hours): 215-597-9800

Name: U.S. EPA Regional Office
Region 4 (KY, TN, NC, SC, GA, FL, AL, MS)
Address: 345 Courtland Street, NE
Atlanta, GA 30365
Phone (business hours): 404-347-4727

Name: U.S. EPA Regional Office
Region 5 (WI, MN, MI, IL, IN, OH)
Address: 77 West Jackson Boulevard
Chicago, IL 60604-3507
Phone (business hours): 312-353-2000

Name: U.S. EPA Regional Office
Region 6 (NM, OK, AR, LA, TX)
Address: 1445 Ross Avenue, 12th Floor, Suite 1200
Dallas, TX 75202-2733
Phone (business hours): 214-665-6444

Name: U.S. EPA Regional Office
Region 7 (NE, KS, MO, IA)
Address: 726 Minnesota Avenue
Kansas City, KS 66101
Phone (business hours): 913-551-7000

Name: U.S. EPA Regional Office
Region 8 (MT, ND, SD, WY, UT, CO)
Address: 999 18th Street, Suite 500
Denver, CO 80202-2405
Phone (business hours): 303-293-1603

Name: U.S. EPA Regional Office
Region 9 (CA, NV, AZ, HI)
Address: 75 Hawthorne Street
San Francisco, CA 94105
Phone (business hours): 415-744-1702

Name: U.S. EPA Regional Office
Region 10 (AK, WA, OR, ID)
Address: 1200 Sixth Avenue
Seattle, WA 98101
Phone (business hours): 206-553-4973

Appendix A.2

Pollution Prevention Resources - State Government

Name: Alabama Department of Environmental Management Special Projects
Address P.O. Box 301463
Montgomery, AL 36130-1463
Phone 205/260-2777 **Fax**: 205/260-2795

Name: Arizona Department of Environmental Quality
Address: 3033 N Central Ave
Phoenix, AZ 85012
Phone: 602/207-4247 **Fax**: 602/207-4346

Name: California State Department of Toxic Substances Control
Address: P.O. Box 806
Sacramento, CA 95812-0806
Phone: 916/322-3670 **Fax:** 916/327-4494

Name: Colorado Dept. of Public Health & Environment Pollution Prevention Unit
Address: 4300 Cherry Creek Drive South
Denver, CO 80222
Phone: 303/692-3003 **Fax:** 303/782-4969

Name: Connecticut Technical Assistance Program (ConnTAP)
Address: 50 Columbus Blvd. 4th floor
Hartford, CT 06106
Phone: 203/241-0777 **Fax:** 203/244-2017

Name: Delaware Department of Natural Resources and Environmental Conservation P2 Program
Address: P.O. Box 1401, 89 Kings Highway
Dover, DE 19903
Phone: 302/739-6242 **Fax**: 302/739-5060

Name: Florida Dept. of Environmental Resource Mgmt Pollution Prevention Program
Address: 33 SW Second Ave., Suite 800
Miami, FL 33130
Phone: 305/372-6804 **Fax:** 305/372-6729

Name: Georgia Department of Natural Resources Pollution Prevention Assistance Division
Address: 7 Martin Luther King, Jr. Drive, Suite 450
Atlanta, GA 30334
Phone: 404/651-5120 **Fax:** 404/651-5130

Name: Guam Environmental Protection Agency
IT & E Harmon Plaza Complex Unit D-107,
Address: 130 Rojas Street
Harmon, Guam 96911
Phone: 671/646-8863/5 **Fax:** 671/646-9402

Name: State of Hawaii Department of Health Environmental Management Division
Address: 919 Ala Moana Blvd.
Honolulu, HI 96814
Phone: 808/586-4226 **Fax:** 808/586-4370

Name: Idaho Division of Environmental Quality Prevention and Certification Bureau
Address: 1410 North Hilton
Boise, ID 83706
Phone: 208/334-5860 **Fax:** 208/334-0576

Name: Illinois Environmental Protection Agency Office of Pollution Prevention
Address: 2200 Churchill Road, P.O. Box 19276
Springfield, IL 62794-9276
Phone: 217/782-8700 **Fax**: 217/782-9142

Name: Indiana P2 & Safe Materials Institute
Address: 1291 Cumberland Ave. Suite C1
West Lafayette, IN 47906
Phone: 317/494-6450 **Fax:** 317/494-6422

Name: Indiana Dept. of Environmental Management Office of P2 and Technical Assistance
Address: 100 North Senate Avenue, P.O. Box 6015
Indianapolis, IN 46206-6015
Phone: 317/232-8172 **Fax:** 317/233-5627

Name: Iowa Department of Natural Resources Waste Reduction Assistance Program
Address: Wallace State Office Bldg.
Des Moines, IA 50319-0034
Phone: 515/281-8941 **Fax:** 515/281-8895

Name: Kansas Department of Health and Environment Office of Pollution Prevention
Address: Building 740, Forbes Field
Topeka, KS 66620
Phone: 913/296-6603 **Fax:** 913/296-6247

Appendix A.2

Pollution Prevention Resources - State Government

Name: Kentucky Partners
State Waste Reduction Center
Address: Rm 312 Ernst Hall, University of Louisville
Louisville, KY 40292
Phone: 502/852-7260 **Fax:** 502/852-0964

Name: Maine Department of Environmental Protection
Address: State House Station #17
Augusta, ME 04333
Phone: 207/287-2811 **Fax:** 207/287-7826

Name: Massachusetts Dept. of Environmental Protection
Address: 1 Winter Street
Boston MA 02108
Phone: 617/292-5870 **Fax**: 617/292-5778

Name: Massachusetts Dept. of Environment
Office of Technical Assistance
Address: 100 Cambridge Street
Boston, MA 02202
Phone: 617/272-3260 **Fax**: unknown

Name: Michigan Dept of Commerce & Natural Resources Environmental Services Division
Address: P.O. Box 30004
Lansing, MI 48909-7504
Phone: 517/335-1178 **Fax:** 517/335-4729

Name: Minnesota Pollution Control Agency
Environmental Assessment Office
Address: 520 Lafayette Road
St. Paul, MN 55155
Phone: 612/296-8643 **Fax:** 612/297-8324

Name: Mississippi Dept. of Environmental Quality
Waste Reduction/Waste Minimization Program
Address: PO Box 10385
Jackson, MS 39289-0385
Phone: 601/961-5171 **Fax**: 601/354-6612

Name: Missouri Department of Natural Resources
Technical Assistance Program P2 Unit
Address: P.O. Box 176
Jefferson City, MO 65102
Phone: 314/526-6627 **Fax:** 314/526-5808

Name: Montana Pollution Prevention Program
Address: Montana State University Extension Service
Taylor Hall, Bozeman, MT 59717
Phone: 406/994-3451 **Fax:** 406/994-5417

Name: New Jersey Department of Environmental Protection, Office of Pollution Prevention
Address: CN423; 401 East State Street
Trenton, NJ 08625
Phone: 609/777-0518 **Fax:** 609/777-1330

Name: New York State Dept. of Environmental Conservation, Pollution Prevention Unit
Address: 50 Wolf Rd
Albany, NY 12233-8010
Phone: 518/457-2480 **Fax:** 518/457-2570

Name: Nevada Small Business Development Center
Business Environmental Program
Address: MS-032 University of Nevada at Reno
Reno, NV 89557-0100
Phone: 702/784-1717 **Fax:** 702/784-4337

Name: North Carolina Department of Environment, Health, and Natural Resources
Address: Office of Waste Reduction P.O. Box 27687
Raleigh, NC 27611-7687
Phone: 919/571-4100 **Fax:** 919/571-4135

Name: North Dakota Department of Health
Environmental Health Section
Address: P.O. Box 5520
Bismark, ND 58502-5200
Phone: 701/221-5150 **Fax:** 701/221-5200

Name: Ohio Environmental Protection Agency
Pollution Prevention Section
Address: 1800 Watermark Dr.
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Phone: 614/644-3469 **Fax:** 614/644-2329

Name: Oklahoma Department of Environmental Quality
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Oklahoma City, OK 73117-1212
Phone: 405/271-1400 **Fax:** 405/271-1317

Appendix A.2

Pollution Prevention Resources - State Government

Name: Oregon Department of Environmental Quality
Waste Reduction Assistance Program
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Name: Pennsylvania Dept. of Environmental Resources
Source Reduction Program
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Harrisburg, PA 17105
Phone: 717/787-7382 **Fax**: 717/787-1904

Name: Rhode Island Dept. of Environmental Mgt
Office of Environmental Coordination P2 Section
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Providence, RI 02903
Phone: 401/277-3434 **Fax**: 401/277-2591

Name: South Carolina Dept. of Health & Env Control
Center for Waste Minimization
Address: 2600 Bull St
Columbia, SC 29201
Phone: 803/734-4761 **Fax**: 803/734-5199

Name: South Dakota Dept. of Environment & Natural
Resources, Joe Foss Building
Address: 523 E. Capitol Ave.
Pierre, SD 57501-3181
Phone: 605/773-4216 **Fax**: 605/773-4068

Name: Texas Natural Resource Conservation
Commission, Office of P2 and Recycling
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Name: Utah Department of Environmental Quality
Office of Planning and Public Affairs
Address: 168 N 1950 W, P.O. Box 144810
Salt Lake City, UT 84114-4810
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Name: Vermont Department of Environmental
Conservation, Pollution Prevention Division
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Waterbury, VT 05676
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Name: Virginia Department of Environmental Quality
Office of Pollution Prevention
Address: P.O. Box 10009
Richmond, VA 23240-0009
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Name: Washington Department of Ecology
Hazardous Waste and Toxics Reduction Program
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Olympia, WA 98504-7600
Phone: 206/407-6705 **Fax**: 206/407-6715

Name: West Virginia Division of Environmental
Protection, Pollution Prevention Services
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Beckley, WV 25801-8320
Phone: 304/256-6850 **Fax**: 304/256-6948

Name: Wisconsin Department of Natural Resources
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Name: Wyoming Department of Environmental Quality
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