Environment

INFORMATION FROM KODAK

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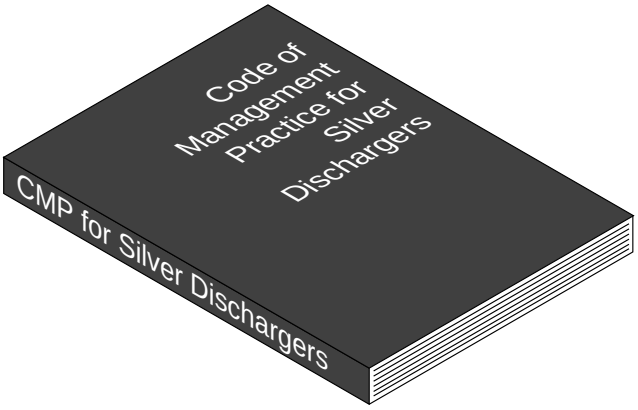
Using the Code of Management Practice to Manage Silver in Photographic Processing Facilities



A number of municipalities across the United States are adopting—or are considering adopting—a code for managing silver in the wastes that enter their sewage treatment plants.

The purpose of the code is to develop a consensus among the regulated and regulatory communities for controlling silver discharges in a cost-effective and environmentally sound manner.

The code includes recommendations on technology, equipment, and procedures for controlling silver discharges from photographic processing facilities.

Pollution prevention is another important part of the code. Recommendations include several activities for preventing pollution before it can occur—i.e., the use of processes, practices, materials, and energy in ways that avoid or minimize pollutants and waste.

If your business is located in a municipality that adopts the code, you need to know how it will affect you. This publication will help you to understand the Code of Management Practice and to see how it benefits both you and your treatment facility.

Kodak's health, safety, and environmental publications are available to help you manage your photographic processing operations in a safe, environmentally sound and cost-effective manner. This publication is part of a series of publications on silver management designed to help you optimize silver recovery. It will help you to understand and implement the Code of Management Practice in your business.

Kodak Environmental Services

Some of the terms in this publication may be unfamiliar to you. The glossary of terms on page 14 defines the environmental terms and some of the associations named in the following pages.

WHAT ARE THE BENEFITS?

By implementing the Code of Management Practice, you help your business by managing your photographic processes more efficiently; collecting a nonrenewable resource, silver; and obtaining a cash value for the recovered silver.

Your treatment plant benefits because it saves the large capital expense required to remove silver from huge volumes of water. Also, your municipality will not have to resort to implementing unnecessarily strict discharge limits for silver and expensive enforcement programs.

As a processor of photographic products, you may already be working with your publicly owned treatment works (POTW) and have an effective program of silver management in place. You may need to change or add some management procedures. Or you may need to begin a program of silver management.

Whatever level of assistance you need, this publication will help you by providing—

- practical guidelines for implementing the Code of Management Practice
- a better understanding of silver-recovery management and technology
- an overview of operation and maintenance of silver-recovery equipment
- an approach to evaluating your silver-management needs
- analytical recommendations and tools
- sources of information and assistance

WHAT IS A "PHOTOGRAPHIC PROCESSING FACILITY?"

Photographic processing facilities aren't just big photofinishers. Today more than 360,000 facilities in the United States process photographic films and papers that contain silver.

In many of these facilities, photography and photographic processing are not the principal businesses; they are essential functions in providing other services, such as health care and law enforcement. Small and medium-sized photographic processors represent about 90% of the total number of facilities. These include—

- hospitals
- offices of doctors, dentists, veterinarians, and chiropractors
- neighborhood medical clinics
- schools, colleges, and universities
- portrait studios
- minilabs
- industrial x-ray labs
- professional processing labs
- small microfilm facilities
- printers and service bureaus
- motion picture processors
- banks
- municipal, state, and federal, facilities

The majority of these facilities produce relatively low volumes of silver-rich solutions and process wash waters. More than 99% of them discharge their wastes to publicly owned treatment works.

All POTWs must establish discharge standards for their users. However, many don't have the resources to regulate, monitor, and assist large numbers of small facilities.

Most photographic processing facilities do practice some type of silver recovery, but many lack the knowledge to select, operate, and document the performance of their silver-recovery equipment.

WHO DEVELOPED THE CODE OF MANAGEMENT PRACTICE?

To help POTWs and processing facilities, Kodak has been working with the Silver Council, the Association of Metropolitan Sewerage Agencies (AMSA), and others to develop guidelines for silver recovery and controlling silver discharges.

The Silver Council—

- encourages communications between the regulators and the communities they regulate
- supports scientific research
- shares current scientific, technical, and economic information to help meet the common goals of pollution prevention, recycling, water conservation, and compliance

Kodak, through its participation in the Silver Council, has provided its resources in developing guidelines for controlling silver discharges from photographic processing facilities. In 1995, the Silver Council and AMSA issued the Code of Management Practice. (For more information on the Silver Council, go to www.silvercouncil.com.)

Implementing the code recommendations will provide many benefits to municipalities and all types and sizes of photographic processing facilities:

- improved selection, operation, maintenance, and monitoring of silver-recovery and management systems
- an increase in the amount of silver recycled and reused
- a reduction in the amount of silver discharged to sewage-treatment plants and the environment
- reduced regulatory burdens and costs for municipalities, health-care facilities, and small businesses
- pollution prevention

The Code of Management Practice provides an easy-to-implement means of promoting environmental performance by enhancing silver recovery. It gives industry a framework for developing cost-effective and sound environmental management systems.

HOW DOES THE CODE APPLY TO YOUR MUNICIPALITY AND YOU?

The fundamental purpose of local sewer codes is to prevent adverse effects on the POTW, on the environment, and on public health. Local discharge codes are specific to each POTW.

POTWs generate local limits in many ways. For example, a POTW can regulate silver by—

- deriving limits based on its discharge permit limits or State Water Quality Standards
- adopting limits developed by another POTW of similar design in the same state
- basing its limits on literature findings

If your POTW chooses to adopt the Code of Management Practice, it can apply the code in a number of ways:

- It can adopt the code exactly as it is and require your business to follow code recommendations for silver recovery and management.
- It can adopt the code but modify specific requirements in it.
- If your POTW already has specific effluent limitations on silver concentrations, it can test the code to see if implementing it will achieve compliance with the existing limits.

Your POTW will communicate its specific requirements to you. (They may not be exactly the same as the recommendations in this publication.)

The following pages will lead you through a series of questions to help you understand and implement the Code of Management Practice.

WHAT CATEGORY OF PHOTOGRAPHIC PROCESSING FACILITY DESCRIBES YOUR BUSINESS?

The Code of Management Practice classifies processing facilities into four groups:

- Small
- Medium
- Large
- Significant Industrial User (SIU)

Small photographic processing facilities produce on average **less than 2 gallons per day** of silver-rich solutions and discharge **less than 1,000 gallons per day** of process wastewater. Silver-rich solutions contain enough silver to make cost-effective silver recovery possible either on site or off site. They include used fixers and bleach-fixes, low-flow washes that follow fixers or bleach-fixes, and stabilizers from washless minilab film and paper processes.

Medium-sized photographic processing facilities produce on average **less than 20 gallons per day** of silver-rich solutions and discharge **less than 10,000 gallons per day** of process wastewater.

Large photographic processing facilities produce on average **20 or more gallons per day** of silver-rich solutions and discharge **10,000 or more gallons per day** of process wastewater.

Significant Industrial Users (SIUs) are industrial facilities that fit one or more of the descriptions below:

- Discharges an average of 25,000 or more gallons per day of process wastewater to a POTW
- Produces a process waste stream that makes up 5 percent or more of the average dry-weather hydraulic or organic capacity of the POTW
- Is designated as an SIU because it can adversely affect the POTW's operation or violate a pretreatment standard
- Is subject to Categorical Pretreatment Standards by federal regulations

The POTW can approach the regulation of discharges of silver-rich solutions to the sewer in different ways. It has the option to establish silver-discharge limits based on mass loadings or flow-based concentration limits. As an alternative, the POTW may designate a photographic processing area within the SIU as a small, medium, or large facility. The corresponding on-site silver-recovery and management recommendations would then apply only to the discharges from that specific photographic processing area.

What Volume of Photographic Processing Solutions Do You Generate?

If you don't know or aren't sure what volumes of silver-rich solutions or process wastewater you produce on average, here are methods you can use to calculate them:

Calculating Volumes of Silver-Rich Solutions in Washless Processes—A simple method for calculating volumes of silver-rich solutions in washless minilabs is through replenishment rates and quantities of films and paper processed.

Example 1:
A washless minilab processes fifty 24-exposure rolls of color negative film per day. Process C-41 replenishment is—

Fixer:	3 mL / roll
Stabilizer:	40 mL / roll
Total:	75 mL / roll

Assuming paper usage at 5 square feet per roll of film, Process RA-4 replenishment is—

Fixer:	10 mL / ft ^{2}
Stabilizer:	23 mL / ft ^{2}
Total:	33 mL / ft ^{2}

Volume of silver-rich solutions:

75 mL / roll + (33 mL / ft ^{2}) (5 ft ^{2} roll) = 240 mL / roll

240 mL / roll x 50 rolls / day = 12,000 mL / day

(12,000 mL / day)(0.00027 gal / mL) = 3.24 gal / day

This is a medium-sized facility.

Calculating Volumes of Silver-Rich Solutions and Process Wastewater in Conventional Processes—In addition to calculating volumes of silver-rich solutions from replenishment rates, use wash water flow rates to determine the volume of process wastewaters.

Example 2:
A graphic arts facility processes four sheets of 20 x 24-inch film per day (480 square inches per sheet). The fixer replenishment rate is 0.35 mL per square inch.

To calculate the volume of silver-rich solutions:

1. Determine the fixer replenishment rate (0.35 mL / in. ^{2} in this example)
2. Multiply the replenishment rate by the total area of films processed per day

   (4 films / day)(480 in. ^{2} / sheet) = 1920 in. ^{2} / day

   (1920 in. ^{2})(0.35 mL / in. ^{2}) = 672 mL / day

   (672 mL / day)(0.00027 gal / mL) = 0.18 gal / day of silver-rich solutions

Tip: If your processor work load varies, perform this procedure each day for a week to calculate an average.

To calculate the volume of process wastewater:

1. Determine the wash water flow rate for the processor. The volume of wash water will vary with the type of film processor. See the processor manual for equipment specifications, or contact the manufacturer. An average processor uses 1.24 gallons of wash water per minute when film is being processed. Typically, the processor will not consume wash water when it is in standby mode.
2. To determine the total volume of wash water, multiply the flow rate by the time the water is running during processing.

   In this example, the flow rate is 1.24 gal / min. The water runs only when film is being processed. The total processing time for each sheet of film is 2.5 minutes.

   (4 sheets / day)(124 gal / min) (2.5 min) = 12.4 gallons / day of wash water

This is a small photographic processing facility.

Example 3:
A hospital discharges 50,000 gallons per day of wastewater generated from numerous health-care related activites. The POTW considers the hospital to be a significant industrial user.

The hospital operates an x-ray film processing area in the building. The POTW elects to treat the x-ray processing area as a separate photographic processing facility.

To determine the volume of silver-rich solutions:

1. Note the fixer replenishment rate from the x-ray processor setting (usually between 70 mL and 120 mL).
2. Multiply this value by the number of films processed per day (11 x 17 equivalent area of film). This provides an estimate of the silver-rich solution volume generated each day.

The processor work load is 50 films per 8-hour day. The replenishment rate is set at 85 mL. The work load is constant.

(50 films / day)(85 mL / film) = 4250 mL / day

(4250 mL / day)(0.00027 gal / mL) = 1.15 gal / day of silver-rich solutions

Determining the Code Category for Your Facility

- Calculate your average volume of silver-rich solution produced per day.
- Calculate the average volume of process wastewater used per day.
- Find your category below.

Facility Category	Volume of Silver-Rich Solution (gallons per day)	Volume of Process Wastewater (wash waters gallons per day)
Small	Less than 2	Less than 1000
Medium	Less than 20	Less than 10,000
Large	20 or more	10,000 or more
Significant Industrial User (SIU)	• POTW may establish a silver-discharge limit based on mass loading or flow-based concentration limits. • POTW may designate a facility within an SIU as small, medium, or large.	

Tip: If your processor work load varies, perform this procedure each day for at least a week to calculate an average.

To calculate the volume of process wastewater:

1. Determine the wash water flow rate for the processor. The volume of wash water will vary with the x-ray film processor in use. See the manufacturer's equipment specifications, or contact the manufacturer to find out the wash water flow rate.
2. Multiply the flow rate by the time that water is entering the system to determine the total volume of wash water. (Flow may be constant or intermittent, depending on the type of processor. Contact the manufacturer if you need help in determining how your processor operates.)

The wash water flow rate is 1.5 gallons per minute. The time the wash water is turned on is 8 hours.

(1.5 gal / min)(60 min / hr)(8 hrs) = 720 gal / day

This is a small photographic processing facility.

Example 4:
A small dental office processes intraoral film manually in a 1-gallon tank. The volume of silver-rich solutions equals the volume of fixer that is replenished every three to four weeks, or 1 gallon. The volume of wash water used in the process equals 8 volume changes per hour, or 8 gallons per hour. The wash water is on for 3 hours per day. Therefore the total volume of process wastewater equals 24 gallons per day.

This is a small photographic processing facility.

Typical Categories for Photographic Processing Facilities

Type of Facility	Category
Dental Office*	Small
Hospital	Small to Large
Medical Professional	Small to Medium
Microfilm Lab	Small to Medium
Printer/Graphic Arts	Small to Large
Minilab, Washless	Small to Medium
Minilab, with Wash	Small to Medium
Professional Lab	Medium to Large
Motion-Picture Lab	Large
Police Department	Small to Medium
School	Small to Medium

* Does not include volumes from dental chairs.

ARE YOU CURRENTLY RECOVERING SILVER FROM SILVER-RICH SOLUTIONS? HOW?

Several technologies are available to control silver in photographic effluent.

On-Site Silver Recovery

The two methods most commonly used by photographic processors to recover silver from silver-rich solutions are metallic replacement and electrolytic recovery.

Metallic replacement is a process in which iron reacts with the silver thiosulfate in the solution to produce ferrous ions and metallic silver. For good and controlled contact, the silver-rich solutions are metered through a container of steel wool, iron particles, or iron-impregnated resin. The containers are called metallic replacement cartridges (MRCs), chemical recovery cartridges (CRCs), or silver-recovery cartridges (SRCs). Use of the cartridges gradually reduces the active iron surface, and small channels will begin to develop in the iron. Then recovery efficiency will taper off until the cartridge is replaced with a new one. Off-site facilities recover the silver from the spent cartridges.

A properly designed and maintained MRC can recover more than 90 percent of the silver from silver-rich solutions. Two MRCs connected in series, with a valve between them to allow testing, can prevent the discharge of untreated silver-rich solutions to the drain.

A properly designed and maintained two-cartridge system used with the flow rates specified by the manufacturer can recover more than 95 percent of the silver from silver-rich solutions.

SILVER-RECOVERY TECHNOLOGY	Metallic Replacement	Terminal Electrolysis	In-Line Recirculation Electrolysis	Precipitation
Typical Initial Concentration	Variable	2000 to 8000 mg/L	500 to 7000 mg/L	> 250 mg/L
Typical Final Concentration	< 100 to 400 mg/L	< 200 to 800 mg/L	Adjustable—usually 250 to 1000 mg/L	0.3 to 1.5 mg/L
Treatable Solutions	Most silver-rich solutions	Most silver-rich solutions	Fixers in certain processes	Most silver-rich solutions
Advantages	Can be relatively inexpensive	Can produce > 90% pure silver	Minimizes silver carry-over to following wash; reduces replenishment rates	Consistently low silver concentrations
Disadvantages	Difficult to know when to replace; discharges iron, limited by some sewer codes	Usually requires secondary recovery	May require electronics adjustment; requires terminal treatment system	Not currently available for all processes
Application	All facilities	All facilities except very small labs	All facilities except small labs	Large facilities and minilabs
Operating Cost	High	Low	Low	Medium

Electrolytic silver recovery is efficient and cost-effective. The equipment is reusable, and the process requires no chemicals. An electric current reduces the silver thiosulfate complex in the solution and plates almost pure silver metal onto the negatively charged electrode (cathode).

In-line electrolytic silver recovery can significantly reduce the amount of silver carried over into final wash waters. These "closed-loop" in-line desilvering units can reduce chemical usage by up to 50 percent, which further increases cost-effectiveness.

Precipitation is a technology in which the silver-rich solution or wash water is metered into a reaction vessel and combined with a precipitant. An insoluble silver complex then settles or is filtered out as a sludge, which is collected and sent to a silver refiner.

These three technologies have been in use in the industry for many years.

For more detailed information on silver-recovery methods, equipment, and technology, see KODAK Publication No. J-212. (See More Information for sources of publications.)

Off-Site Silver Recovery

Companies that provide hauling and centralized silver recovery are located in many cities in the U.S. The cost of having silver-rich solutions hauled away for recovery typically ranges from $2.00 to $6.00 per gallon. For some facilities that produce small volumes of silver-rich solutions, off-site recovery can be a cost-effective and efficient way to reduce silver discharges. For facilities that produce larger volumes, the cost of off-site treatment may be too great. Other considerations for off-site recovery involve collection, safe storage, and handling of silver-rich solutions, as well as compliance with applicable hazardous-waste regulations.

Code Recommendations for Silver-Recovery Equipment

Note: Options are listed in order of increasing cost.

Facility Category	Metallic Replacement	Electrolytic Recovery	Precipitation	Minimum Recovery
Small	1 or 2 MRCs with flow control*	1 unit†	1 unit	90%
Medium	1 or 2 MRCs with flow control	1 unit followed by 1 MRC with flow control **or** 1 unit plus 1 precipitation unit	1 unit	95%
Large	See Electrolytic Recovery	1 unit followed by 2 or more MRCs with flow control **or** 1 unit plus 1 precipitation unit	See Electrolytic Recovery	99%
Significant Industrial User (SIU)	Requirements can vary widely and may be based on mass loading of silver or flow-based concentration limits rather than uniform concentration limits. Code recommendations will vary from facility to facility.			

* Very small processing facilities that generate less than 0.5 gal/day of silver-rich solution need just one MRC with flow control.

† May need to be followed by an MRC to ensure consistent recovery.

Code recommendations for off-site recovery and management include the following:

- Notify the POTW that you are using off-site recovery and disposal services. You may need to specify which silver-bearing solutions will be managed off site and list the hauling service and the recovery facility.
- Store silver-rich spent solutions in Department of Transportation (DOT)-approved containers in a manner that protects them from accidental release to the POTW. This could include secondary containment, storage areas without floor drains, or standpipes in existing floor drains.
- Comply with applicable hazardous-waste (RCRA) and DOT regulations.
- Keep records of the volumes and types of solutions transferred off site, and retain all records for three years. Make these records available for inspection if requested by the POTW.

HOW CAN YOU MEASURE SILVER CONCENTRATIONS IN SILVER-RICH SOLUTIONS AND EFFLUENT FROM YOUR FACILITY?

All facilities processing photographic materials will have different amounts of silver in their silver-rich solutions and wash waters. This is because of the variety of photographic processes needed to accommodate market demand, imaging media, and applications.

Particular process conditions will also vary with market demand, the mix of products processed, and the applications in which customers use the products.

Even the same types of photographic processing facilities will have different types of processing equipment, process and processor modifications, and product mixes, all of which will result in different silver concentrations in their discharged wastewaters.

SILVER CONCENTRATIONS

Before silver recovery, combined silver-rich solutions will contain between 2000 and 8000 mg/L of silver. The concentration will vary from day to day even within the same facility.

If the silver-recovery system removes 90% of the silver, the solution leaving the silver-recovery unit will contain between 200 and 800 mg/L of silver. (See the table above for additional examples of silver concentrations at different levels of recovery efficiency.)

Typical Silver Concentrations in Recovery Process

Starting Concentration in Silver-Rich Solution (mg/L)	Percent Recovery	Concentration in Silver-Rich Solution After Recovery (mg/L)*	Concentration After Combination with Low-Silver Solutions (mg/L)	Concentration After Combination with Wash Water (mg/L)
2000 to 8000	90	200 to 800	100 to 400	10 to 40
	95	100 to 400	50 to 200	5 to 20
	99	20 to 80	10 to 40	1 to 4
	99.9	2 to 8	1 to 4	0.1 to 4

* Silver concentration immediately after pre-treatment.

After recovery, the solution leaving the silver-recovery unit is normally recombined with the low-silver processing solutions. With a *washless* processing system, the concentrations at this point are the best achievable levels.

If the process solutions are recombined with process wash waters, the silver concentrations will be reduced further—by approximately a factor of 10. Wash waters typically contain between 0.1 and 4 mg/L of silver.

In systems that are conserving or reusing wash water, silver concentrations in the wash water and in the total process wastewater after silver recovery may be higher.

MEASUREMENT METHOD

You will most frequently use on-site techniques to monitor the efficiency of your silver-recovery system. The two most common techniques are quite inexpensive and easy to perform, and are ideal for frequent process-control checks.

Qualitative Test Strips—The most common type of qualitative test strips are KODAK Silver Estimating Test Papers. These yellow paper strips change to shades of brown in the presence of silver. You compare the strips with a color-comparison chart included with the strips to estimate the silver concentration. You can use these test strips to monitor the efficiency of recovery cartridges and electrolytic recovery systems.

Soaking the strips for longer periods in the test sample can give an indication of the silver present at concentrations lower than 1 gram per litre. However, this technique is qualitative and isn't reliable in measuring low levels of silver in solutions.

Colorimetry—This technique involves adding a chemical to a sample that contains silver. The silver reacts with the chemical to produce a specific color. The colorimeter measures the color intensity of the treated sample by comparing it with a reference sample. The difference in color corresponds to the silver concentration in the solution.

The Colorimetric method can detect silver levels as low as 30 mg/L in most processing solutions with an accuracy that is within 10 percent of analytical laboratory techniques. Solutions that contain high levels of iron, such as bleach-fixes, have a higher silver-detection limit of 60 mg/L. The equipment is portable, quite inexpensive, and easy to operate. The analysis takes less than 3 minutes.

Code Recommendations for On-Site Silver Monitoring

Facility Category	Batch Operations	Continuous Operations	On-Site Monitoring* Method	Verification by Analytical Lab
Small	Check each batch before and after recovery	Check solution entering and leaving recovery system weekly.	Test strips, colorimetric test kit, or analytical lab	At least every 6 months
Medium	Check operation of primary unit after each batch; check effluent from secondary unit before discharge	• Check solution entering and leaving primary unit weekly • Check effluent from secondary unit weekly before discharge • With in-line electrolytic systems, check processor tank solution weekly.	Test strips, colorimetric test kit, or analytical lab	At least every 3 months
Large	Check operation of primary unit after each batch; check effluent from secondary unit before discharge.	• With in-line electrolytic systems, check processor tank solution at least weekly. • Check solution entering and leaving primary unit at least weekly • Check effluent from secondary unit at least weekly before discharge	Test strips, colorimetric test kit or analytical lab for routine monitoring; analytical lab for verification	At least every 3 months
Significant Industrial User (SIU)	SIUs may follow same recommendations as small, medium, or large facilities depending on designation assigned by POTW.			

* Record results in a silver-recovery log.

OFF-SITE TESTING

Samples that require precise analysis for silver, such as tests required for regulatory compliance, are normally sent off site to an analytical laboratory. Testing for regulatory compliance requires sophisticated equipment, trained personnel, and adherence to EPA procedures. The lab may also need to be certified to perform these analyses.

KODAK Analytical Services provides customers with compliance testing by EPA-approved methods. Its laboratory certification for compliance testing is accepted in most states.

For more information on Kodak Analytical Services, call 1-800-283-4173. For more information on silver analysis, see KODAK Publication No. J-211, *Measuring Silver in Photographic Processing Facilities*.

HOW DOES THE CODE PROMOTE POLLUTION PREVENTION?

Using resources wisely and controlling waste makes good business sense and reduces industry's impact on the environment. Pollution prevention means using processes, practices, materials, and energy in ways that avoid or minimize pollution and waste. It shifts the focus from "end-of-pipe" control (dealing with pollution after it already exists) to "front-of-process" management that minimizes the volume or hazard of the waste generated.

The photographic industry is continuously making product improvements to prevent pollution by developing:

- reformulated chemicals that require much less replenishment
- chemicals that are more easily regenerated for reuse
- films and papers that contain less silver
- washless processes that dramatically reduce water usage
- more reliable processing and printing equipment that reduces waste

Pollution prevention also includes standard operating procedures that promote wise use of resources and generate less waste.

Each facility needs to decide which procedures to adopt. Many facilities are already implementing successful systems for reducing and controlling releases of photographic chemicals. Their methods may be part of a formal written pollution-prevention plan, or they may be part of standard operating procedures. To ensure the success of these methods, the Code of Management Practice offers the following suggestions for you to consider as components of a pollution-prevention plan.

EMPLOYEE INVOLVEMENT

An ongoing pollution-prevention program requires the support and commitment of management and staff. Management can visibly and effectively demonstrate support through—

- a clear, concise, and positive policy statement. Solicit employee ideas and participation in preparing the statement, and distribute it throughout the facility.
- dedication of personnel to implement pollution prevention activities
- training in pollution prevention

CHEMICAL MANAGEMENT

Sound chemical management can reduce chemical costs and waste. Key elements include—

Process Control—Routinely monitor all the variables that produce a consistent, high-quality product, i.e., replenishment rates, temperature, control strips / charts, mixing procedures, and preventive maintenance. Maintain records of preventive maintenance and control charts. Through careful process control, you can normally avoid out-of-control situations that require dumping of solutions and reprinting of photographic materials.

Chemical Inventory—Develop and maintain a chemical inventory that identifies all chemical products—including silver-rich solutions—that are generated and stored in your facility. Include the name of the solution, its location in the facility, and the volume typically on hand. The inventory will help you to keep an appropriate supply on hand and to use stock in the order in which you receive it (minimizing the risk of outdated chemicals).

Storage and Containment—Reduce the risk of chemical leaks and ruptures that cause waste and interrupt work schedules. Stack unopened boxes neatly and safely, and inspect for leaks. Provide containment for recovery cartridges, mixing containers, and tanks.

Good Housekeeping—Establish a storage area for every material and piece of equipment. Require every employee to return all materials and equipment to the designated area. Regularly inspect for leaks and spills. Establish a clean-up procedure and take steps to prevent recurrence.

Spill Containment and Response—Facilities of all sizes must maintain all processing tanks and holding tanks for storing silver-rich solutions in a way that prevents accidental release to the POTW.

They should also establish and maintain a spill plan to prevent accidental release to the POTW of volumes of liquid that would upset POTW operations.

A "spill" is an *unplanned* discharge of liquid waste of that volume into the sewer. Effluents discharged through normal operations are *not* considered to be spills. These include—

- replenisher overflows generated by processing
- solution replacement recommended by the chemical manufacturer
- solution generated during tank and rack cleaning
- rinse water from chemical containers

Effluents discharged in other situations *may be considered to be spills.* These include—

- a dropped container of a chemical
- leaks
- overfilling a tank
- a rupture of a replenisher tank

Spills that typically concern a POTW could include spills of concentrates used to prepare working-strength replenishers and spills or releases of silver-rich solutions before silver recovery.

In general, spills of working-strength processing solutions are not emergency situations, because they consist mainly of water and have a relatively neutral pH. However, some chemical concentrates may be very acidic (ph < 2) or basic (ph> 13). Some chemicals used for pH adjust-ment 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.

Each POTW must decide when it will require photographic processors to provide notification of spills of concentrates or silver-rich solutions. Check with your POTW to find out its specific reporting requirements.

To develop a spill-response plan, you can follow these guidelines:

- Develop and maintain a floor plan to identify all areas where a spill or non-compliant discharge could occur.
- Determine the supplies and equipment required to clean up a spill and where you will store them.
- Develop procedures for using the supplies and equipment.
- Train designated employees in spill-response procedures. Post the procedures in appropriate areas.
- Maintain a log of spills to identify trends and help eliminate the causes.

Monitoring Chemical Use—Identifying discrepancies between the amount of chemicals you should have consumed and your actual usage will alert your facility to a problem. Calculate the number of films and feet of paper processed and multiply them by the replenishment rates. Determine the volumes of chemicals actually used by recording the volume in the replenisher tanks at the beginning of the month, adding the amount of chemicals mixed during the month, and subtracting the volume remaining in the replenisher tanks at the end of the month.

Security and Safety—Only employees who have received training in the safe handling of chemicals should have access to chemical storage and mixing areas. This may minimize spills or other problems that result in chemical waste or releases.

EQUIPMENT AND PROCESS MODIFICATIONS

In some situations, modifying equipment and processes can reduce chemical usage.

Equipment Modifications—Here are some examples of equipment modifications that can help prevent pollution:

- *Squeegees*—Air knives, wiper blades, and rollers reduce the amount of liquid carried over from one solution into the next during continuous film and paper processing. Effective squeegees can reduce chemical costs and water consumption.
- *Closed-loop silver recovery*—A properly sized closed-loop or in-line recovery unit can maintain the level of silver in the processor tank at about 500 mg / L. By reducing the concentration in the solution preceding the wash, you can reduce the amount of silver lost due to carry-over. The lower replenishment rate generally used with closed-loop systems also conserves chemicals. It's important to use a good-quality fixer with adequate preservative (sulfite) if you are using closed-loop silver recovery.
- *Countercurrent wash tanks*—Silver is carried out on film and paper into the final wash tanks. In counter-current plumbing, the replenisher enters the last tank of the series first, and the overflow cascades forward. This concentrates the silver in the first wash tank, making silver recovery easier, and reducing the volume of water required.
- *Low-flow wash*—A low-flow or replenished wash following the bleach-fix or fixer can further concentrate the silver in the wash water. The low-flow wash is considered to be a silver-rich solution, and is usually combined with other silver-rich solutions before silver recovery. (You must be able to configure your processor to take advantage of this option.)

Process Modifications—You may also be able to modify processes to reduce chemical usage. For example:

- *Low-replenishment chemicals*—Work with your supplier to select the most cost-effective options. (Some older equipment can't be modified to accommodate newer processes.)
- *Chemical regeneration and reuse*—Explore the option of regenerating and reusing chemicals if circumstances permit. Under some conditions, regeneration can reduce the volume of chemicals generated by a facility.
- *Wash water recycling*—Several options for water recycling exist, including reverse osmosis, ion exchange, and distillation.
- *Washless processes*—In some processes, a chemical rinse takes the place of wash water, eliminating the need to hard-plumb equipment. The chemical rinse requires much lower replenishment than the water wash.

SUMMARY OF RECOMMENDATIONS—CODE OF MANAGEMENT PRACTICE

Code Specification	Small Facility	Medium Facility	Large Facility	Significant Industrial User
Category Definition:				May fit any category **or** POTW may establish mass loading or flow-based concentration limits.
Average Volume of Silver-Rich Solution (gal/day) and	Less than 2 and	Less than 20 and	20 or more and	
Average Volume of Process Wastewater (wash water, gal/day)	Less than 1000	Less than 10,000	10,000 or more	
Minimum Recovery	90%	95%	99%	Photographic processing facilities within SIUs may follow same recommendations as small, medium, or large facility depending on category definition.
Recovery/Management Equipment Options	1 or 2 MRCs **or** 1 electrolytic unit **or** 1 precipitation unit **or** 1 evaporation/ distillation unit **or** 1 evaporation/ distillation unit **or** Alternative technology	2 or more MRCs **or** 1 electrolytic unit plus 1 MRC **or** 1 precipitation unit **or** 1 electrolytic unit plus 1 precipitation unit **or** 1 evaporation/ distillation unit **or** Alternative technology	1 electrolytic unit plus 2 or more MRCs **or** 1 electrolytic unit plus 1 precipitation unit **or** 1 evaporation/ distillation unit **or** Alternative technology	
Equipment and Process Modifications	—	—	Low-flow washes In-line silver recovery Squeegees or air knives	
Silver-Concentration Measurement Options:				
On-Site	Silver test papers, colorimetric test or laboratory analysis	Silver test papers, colorimetric test, or laboratory analysis	Laboratory analysis	
Off-Site	Analytical laboratory	Analytical laboratory	Analytical laboratory	
Recovery-System Monitoring Frequency:				
Batch Operations	Each batch	Primary unit after each batch; secondary unit batch before discharge	Primary unit after each batch secondary unit before discharge	
Continuous Operations	Weekly	Primary unit weekly; secondary unit before discharge In-line electrolytic unit weekly	At least weekly	
Verification Frequency	Every 6 months	Every 3 months	Every 3 months	
Pollution Prevention:				
Process Control	Monitor all process variables to avoid chemical dumping and waste.			
Chemical Inventory	Identify all chemicals (including silver-rich solutions) with name, potential hazard, location, volume. Identify all areas with potential for spill or accidental discharge, with drains, sewer connections.			
Monitoring Chemical Use	Calculate actual chemical usage against amount of product processed.			
Spill Containment and Response	Identify containment measures, personal protective equipment, and spill-response supplies. Inspect daily for leaks, spills.			
Recordkeeping:				
On-Site Testing, Inspections	Record silver concentrations, inspections for leaks and spills in log.			
Off-Site Testing	Maintain records for time acceptable to POTW.			
Off-Site Recovery/Management	Retain records of volumes and types of solutions for 3 years.			

TRACKING RESULTS

After pollution-prevention activities are in place, you need to evaluate them to determine if they're working properly and are cost-effective, and whether or not you need to make modifications. The pollution-prevention team routinely evaluates procedures by reviewing operations, examining records, and talking with staff.

Evaluating Procedures—Evaluation methods will depend on the activity under review. For example, to evaluate chemical storage, a physical inspection of the area would provide enough information. To evaluate process control, the team may review control charts and preventive-maintenance logs.

Cost Effectiveness—The next step is determining whether or not the pollution-prevention activity is cost-effective. For example, does a comparison of the costs before and after justify the use of low-replenishment chemicals? (Costs include such things as chemical costs, employee time spent mixing, and any chemical dumps due to lowtank turnover.)

When an evaluation shows that the pollution-prevention activity increases costs, you must decide whether to alter the activity or eliminate it.

GLOSSARY OF TERMS

Some of the following terms used in this publication may be unfamiliar to you.

AMSA. The Association of Metropolitan Sewerage Agencies, representing the interests of the largest wastewater-treatment agencies in the U.S.

Batch Process. The collection of silver-rich solutions in a holding tank for processing through a silver-recovery or management system.

Continuous Process. The processing of silver-rich solutions in a continuous flow from the processing machine through a silver-recovery or manage-ment system.

Effluent. Used or exhausted chemical overflows and wash waters.

Electrolytic Silver Recovery. A method of recovering silver by applying a direct current across two electrodes in a silver-rich solution.

Large Photographic Processing Facility. A facility that produces on average 20 or more gallons per day of silver-rich solution and discharges 10,000 or more gallons per day of process wastewater.

Low-Silver Solution. A solution that does not contain enough silver for cost-effective silver recovery. Includes used developers, bleaches, stop baths, pre-bleaches, stabilizers following washes, and wash waters.

Medium-Sized Photographic Processing Facility. A facility that produces on average less than 20 gallons per day of silver-rich solution and discharges less than 10,000 gallons per day 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 metallic replacement cartridge (MRC).

Minilab. A business that offers one-hour on-site photographic film processing and printing.

MRC. A recovery cartridge that recovers silver through metallic replacement.

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

On-Site Silver Recovery and Management. Management and treatment of silver-rich solutions in the facility that generates the silver-rich solutions.

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

Pretreatment. Changing the character of a waste by treatment before discharging it to a POTW.

Process Wastewater. The total volume of effluent discharged from the photographic processing operation. This includes all used / exhausted chemicals and wash waters. To determine an "estimate" of the process wastewater discharged from the photographic processing operation, calculate the wash water flow rate.

Significant Industrial User (SIU). Any industrial user that discharges an average of 25,000 gallons or more per day of process wastewater to a POTW; contributes a process waste stream that makes up 5 percent or more of the average dry-weather hydraulic or organic capacity of a POTW; is designated as an SIU by the Control Authority on the basis that it has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard; or is subject to Categorical Pretreatment Standards.

Silver Council. A national group of trade associations, technical societies, municipalities, and government agencies whose members are affected by silver regulation.

Silver-Rich Solution. A solution that contains enough silver for cost-effective recovery either on site or off site. Includes fixers, bleach-fixes, washless stabilizers, and low-flow washes.

Silver Test Paper. A test paper coated with a chemical reagent that changes color according to the amount of silver in a solution.

Small Photographic Processing Facility. A facility that produces on average less than two gallons per day of silver-rich solution and discharges less than 1000 gallons per day of process wastewater.

MORE INFORMATION

If you have environmental or safety questions about Kodak products or services, contact Kodak Environmental Services at 1-716-477-3194, between 8 a.m. and 5 p.m. (Eastern time) or visit KES on-line at www.kodak.com/go/kes.

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The following publications are available from Kodak Customer Service or from dealers who sell Kodak products.

J-210	*Sources of Silver in Photographic Processing Facilities*
J-211	*Measuring Silver in Photographic Processing Facilities*
J-212	*The Technology of Silver Recovery for Photographic Processing Facilities*
J-213	*Refining Silver Recovered from Photographic Processing Facilities*
J-214	*The Regulation of Silver in Photographic Processing Facilities*
J-215	*Recovering Silver from Photographic Processing Facilities*
J-216	*The Fate and Effects of Silver in the Environment*

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