cover file to be provided by Gene Sherman

The Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors

This Guide has been written for hospitals, dental offices, chiropractic clinics, veterinary clinics and industrial X-ray film processing (i.e., nondestructive testing) facilities. It contains a set of recommended operating procedures designed to reduce the amount of silver in film processing solutions AND the overall volume of solution discharged to the drain.

If your municipality ***has*** adopted the Code of Management Practice for Silver Dischargers, use this Guide to help you implement the requirements of the Code.

If your municipality ***has not*** adopted the Code of Management Practice for Silver Dischargers, use this Guide to help you establish an effective silver recovery or silver management program.

Limitations

The Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors ***does not*** supercede existing local regulations. Where the Code ***has not*** been adopted, relying exclusively on this Guide may cause diagnostic and industrial X-ray film processors to be out of compliance with local regulations. Therefore, before using this Guide, each diagnostic and industrial X-ray film processor should check with the local government agency to determine its regulatory requirements. For more information contact The Silver Council.

The Silver Council

The Silver Council is a national group focused on the environmentally sound management of silver derived from the processing of photographic images. The Silver Council is supported by the photographic chemical and equipment manufacturers and associations and represents more than 360,000 users. The purpose of the group is to encourage communications between the regulatory and regulated communities, to support scientific research, and to share current scientific, technical and economic information about silver so that the common goals of pollution prevention, recycling, water conservation, and compliance can be met.

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Acknowledgements

Many individuals representing the health care and industrial X-ray film processing industry have contributed to the Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors. This guide is the direct result of their participation in the committee process. We gratefully acknowledge all of these contributions.

The participants volunteered their time and expertise, thus ensuring this guide provides an approach written for diagnostic and industrial X-ray film processors. Our thanks to each of these people and their companies. Special thanks go to The Silver Council for funding this project.

CPAC, Inc.

Delta Medical Systems, Inc.

Envision Compliance Ltd.

Optima Health

Safety-Kleen Corp

The Silver Council

- Agfa Division, Bayer Corporation
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- Fuji Medical Systems U.S.A., Inc.
- Ilford Photo
- Imation Corporation
- Konica Corporation
- National Association of Photographic Manufacturers
- Photo Marketing Association International

White Mountain Imaging

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1.0 Introduction

Liquid effluent is a by-product of processing diagnostic and industrial X-ray films. After silver recovery, this effluent is generally discharged to the drain where it goes to the publicly owned treatment works (POTW) for treatment, and eventual release back to the environment.

Silver is the component of film that makes it possible to form an image. During processing the silver is removed from the film and goes into the fixer. While a small amount of silver may be carried over into the wash water, fixer is the only silver-rich solution produced in a diagnostic and industrial X-ray processing facility. Silver should be recovered from silver-rich solutions before they are discharged to the drain because:

- silver is a non-renewable resource,
- some cities/towns restrict the amount of silver that can be discharged, and
- silver has economic value.

A silver-rich solution is a solution that contains sufficient silver that cost-effective recovery can be done either on-site or off-site. For purposes of this guide, fixer is the only silver-rich solution produced from processing films.*

Effective silver recovery requires equipment that is appropriate to the size and activities of the diagnostic or industrial X-ray film processor. It also requires implementing a sound preventive maintenance program. Providing you with this silver recovery information is the primary focus of the Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors.

The principle element of the Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors is a set of recommended operating procedures designed to reduce the amount of silver in film processing solutions AND the overall volume of solution discharged to the drain.

The other element of the guide is ***voluntary*** pollution prevention. In addition to recovering silver efficiently, diagnostic and industrial X-ray film processors should be concerned with minimizing the amount of waste they create. Waste solutions are literally money down the drain. In cases where the solutions can't be discharged to the drain, such as when the processor discharges to a septic system, it costs money for off-site disposal. That's why it makes sense to minimize waste in the first place. The second half of the guide details several activities a diagnostic or industrial X-ray film processor can ***voluntarily*** undertake to reduce waste and save money.

The Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors is an industry-recommended guide. It is *NOT* a legal requirement. It was written by people just like yourselves

* The Code of Management Practice addresses silver from film processing solutions only.

— people who manage diagnostic or industrial X-ray film processing operations. The guide takes the guesswork out of determining the specific silver recovery equipment configurations and preventive maintenance activities you need. Terms used throughout this guide are defined in the Glossary of Terms (Appendix A).

1.1 Regulating Silver

Regulatory agencies can control the discharge of silver to the drain in two ways:

1. by using *concentration-based* limits and regulating the concentration or total amount of silver allowed in wastewater, or

2. by using *performance-based* limits and requiring that suitable treatment be applied before the wastewater is discharged.

a. Concentration-based limits

The traditional means of restricting silver is through **concentration-based numerical limits** in the city sewer ordinance. For example, silver may be restricted to four parts per million (4 ppm).* This means that for every million parts of effluent† there can be ***no more*** than four parts of silver.

Concentration-based limits have been shown to be a poor way to regulate diagnostic and industrial X-ray film processors for several reasons:

1. Our industry conserves water through standby water savers and lower replenishment chemicals. As we use less water, the concentration of silver in the effluent increases. Concentration-based limits, therefore, actually penalize those who practice water conservation.

2. Municipal and state sewage treatment authorities ideally develop pretreatment limitations by comparing wastewater coming into the sewage treatment plant and the treated water leaving the plant. The discharge of treated wastewater must meet limits set by the state to avoid impacting the water quality of the receiving body of water. Local development of pretreatment limitations has resulted in widely varied and often unrealistic restrictions across the country.

3. The sampling point used to determine whether or not a limit is being met is determined by the local sewer authority. It may be the property line manhole or a point where all process wastewater is combined. This introduces additional variation from city to city.

4. Industry's ability to recover silver cost-effectively is dependent upon the equipment available in the marketplace. Restrictions in some jurisdictions are so stringent they can not be met with the best available technology that is economically achievable.

b. Performance-based limits

Performance-based limits are spelled out as a percentage of the silver that must be

* ppm is the same measurement as milligrams per liter (mg/L).

† Effluent means the liquid waste generated from the processing of film.

recovered from discharged solutions. These limits provide environmental protection while taking into consideration the amount of silver-rich solutions generated by diagnostic and industrial X-ray film processors, the efficiency of the best available technology (equipment), and the capabilities of the generating facility.

The Code of Management Practice places diagnostic and industrial X-ray film processors into one of four categories and provides specific silver recovery equipment recommendations for each category. The category may vary for each film processing machine in your facility. For example, in a large hospital, there may be a small machine that runs only five films per day. This machine would fall into the small category. In the same hospital, there may be a very busy machine that runs 150 films per day and would, therefore, fall into the medium category.

If the POTW were categorizing your facility, it might take into consideration all the process effluent produced per day in the *entire* facility. For our purposes that's not very helpful. It could easily result in requiring an extensive silver recovery system on *every* film processing machine — even one on which only a few films per day are processed. If you have this type of situation in your facility, you may need to negotiate with your POTW when it comes to categorizing your equipment.

The exception is in facilities where silver recovery operations are centralized. In these cases, where the fixer from many processors is collected and desilvered in a central location, the category is based on the total volume of fixer and processing effluent produced at the centralized treatment site.

What's the Concern With Silver?

We wear silver jewelry, eat off silverware and carry silver fillings in our teeth. Then why is the silver in film processing solutions regulated? The answer has to do with the different forms silver can take. The metallic silver that we use in eating utensils and jewelry is nontoxic. But some forms of silver can be very toxic to aquatic organisms. In fact, years ago, silver cation (Ag^{+}) was used as a biocide in wastewater treatment. Even today, silver nitrate is sometimes added to the eyes of new infants in order to kill bacteria.

Because the silver ion is highly reactive, it quickly and easily complexes with materials in the environment such as sulfides and chlorides, to yield compounds with little or no toxicity. This means that silver rarely occurs in ionic or noncomplexed forms. The silver found in used film processing fixer, for example, is in the form of silver thiosulfate, a nontoxic form.

While there is general agreement among regulators that it's the ionic form of silver that's most toxic, there's no accurate and repeatable analytical test method to measure the ionic species. Therefore, regulations are based on total silver, with no differentiation made between ionic and complexed forms of silver.

Silver discharge regulations impact all film processors from the small dental office to the large diagnostic imaging clinic to the industrial X-ray film processor. While individual dischargers may have little impact on the POTW, collectively, diagnostic and industrial X-ray film processors discharge a significant amount of silver.

The four categories of film processors identified in the Code of Practice, are as follows:

90%

- A **small** diagnostic or industrial X-ray film processor is one that produces *less than* two gallons per day of silver-rich solutions and *no more than* 1,000 gallons per day of total process effluent. Small processors should recover silver to at least 90 percent efficiency.

95%

- A **medium** diagnostic or industrial X-ray film processor is one that produces *less than* 20 gallons per day of silver-rich solutions and *no more than* 10,000 gallons per day of total process effluent. Medium processors should recover silver to at least 95 percent efficiency.

99%

- A **large** diagnostic or industrial X-ray film processor is one that produces *more than* 20 gallons per day of silver-rich solutions and *no more than* 25,000 gallons per day of total process effluent. Large processors should recover silver to at least 99 percent efficiency.

- A **significant industrial user** (SIU) is a processor that discharges more than 25,000 gallons per day of total process effluent.* SIUs have no set percentage recovery efficiency as each SIU is individually permitted.

Through the use of this guide, diagnostic and industrial X-ray film processors, together with the local agency can cooperatively manage silver discharges to sewer. This guide offers a uniform set of recommendations for controlling photoprocessing waste and moves away from existing restrictions that are difficult to achieve given today's technology and our efforts to conserve water.

Performance-based limits are realistic, given the technology currently available to diagnostic and industrial X-ray film processors. Performance-based limits that are uniform across the country will allow film processors to self-regulate.

Performance-based limits are the best way to ensure industrial waste is properly managed while providing economic incentives to diagnostic and industrial X-ray film processors.

1.2 Implementing the Code

Who is responsible for ensuring this silver management program is implemented? In a medium or large operation, the responsible person is most likely the film processing manager. While the technical services department, a quality assurance (QA) technician or even a radiology technologist (RT) may be assigned the job of putting certain aspects of the Code in place, the final responsibility rests with management. ***That responsibility cannot be delegated.*** Even if an outside contractor services the processors and silver recovery systems, the responsibility stays with the diagnostic or industrial X-ray film processing manager.

In a small facility such as a dental or veterinary office, the doctor is most likely the responsible person. While a hygienist or assistant may undertake some of the duties of silver management and pollution prevention, the final responsibility lies with the person in charge.

* The EPA defines a significant industrial user as a facility that discharges an average of 25,000 gallons per day or more of *process wastewater* to the publicly owned treatment works (POTW) (excluding sanitary, noncontact cooling and boiler blowdown wastewater). Individual municipalities are free to use a more stringent definition. (40 CFR 403.3 (t)(ii))

2.0 Determining the Category

The first step is to determine which of the four categories best describes each of your film processors: small, medium, large or significant industrial user (SIU). Remember: If you have centralized silver recovery, you should consider the number of films processed *throughout the entire facility* rather than by individual machine.

To determine your size you can monitor the volume of both fixer and total process effluent produced daily for each film processor. Then use the definitions on page 4 to find out which category best describes your situation: small, medium or large.

Since it may be easier for you to simply track the amount of film used, we've provided the chart below that translates the volume of chemicals used into the number of films processed. To use this simple chart, follow these steps:

1. Find the box in the left-hand column of the chart that best describes the type of film you process — dental, general purpose, mammography or industrial X-ray.

Size Category Based on Type and Quantity of Film Processed Daily*

Type of Film Processed	Small	Medium	Large
Dental	1 - 750	751 - 7,500	N/A
General Purpose	1 - 100	101 - 900	901 - 24,000
Mammography	1 - 250	251 - 2,500	2,501 - 24,000
Industrial X-ray	1 - 50	51 - 400	401 - 6,000

* These numbers are based on the assumptions shown in Appendix H.

2. For a specific film processor, estimate the number of films processed *per da*y.

3. Move across the row to the square containing the number of films processed per day as estimated above.

4. Look at the heading in that column to identify the size category for that processing machine.

5. Now, categorize each of the remaining film processors if you have more than one.

For example, a machine processing 60 dental radiographs per day would be in the *small* category. On the other hand, a machine processing 60 industrial X-ray films per day would be considered *medium*. Note: If a machine falls at a break point between categories (e.g., 100 general purpose films), talk with your supplier to make sure that you select the correct category.

Now that you've identified the category of each of your processors, let's move on.

- For small processors, turn to Section 3.0 on page 6.

- For medium processors, turn to Section 4.0 on page 9.

- For large processors, turn to Section 5.0 on page 14.

- SIUs are beyond the scope of this guide. If you fall into this category, you should consult your POTW.

3.0 Small Processors

A small diagnostic or industrial X-ray film processor is one that produces less than 2 gallons per day of silver-rich solutions and no more than 1,000 gallons per day of total process effluent. Small processors should recover silver to at least 90 percent efficiency.

Remember: The category size of *small* is based on an individual machine *not* the whole facility. This is done to ensure the silver recovery equipment and testing recommendations are appropriate for the size and utilization of the processing equipment.

Small diagnostic and industrial X-ray film processors have three practical options for achieving a 90 percent removal. These can be configured in several ways, discussed below.

3.1 Options

The following options are recommended for recovering at least 90 percent of the silver from silver-rich solutions:

1. one or two metallic replacement cartridges (MRCs)* with manufacturer-specified flow control,† or
2. off-site management, or
3. alternative technology providing at least 90 percent silver recovery.**

3.2 Equipment Configurations

In this section for small diagnostic and industrial X-ray film processors, we'll review typical silver recovery equipment configurations for each of the compliance options. Detailed information is available in the appendices.

We'll also describe the testing methods and procedures to use with the equipment to verify that it is recovering at least 90 percent of the silver.

Finally, we'll show you samples of simple silver recovery logs to use for recording the results of the testing.

For detailed information about a specific silver recovery option, how it works, and preventive maintenance recommendations, refer to:

Appendix C Metallic Replacement Cartridges
Appendix D Off-Site Management

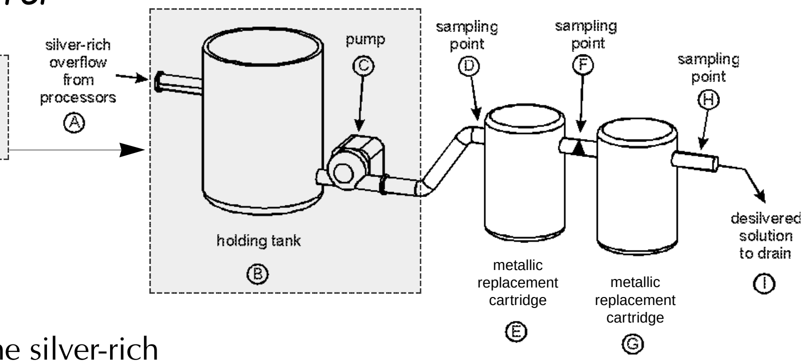
* Facilities that generate less than 0.5 gallons per day of silver-rich solutions need only one MRC. Due to the low volume, a second MRC would oxidize and channel by the time the first MRC was exhausted resulting in no additional silver recovery.

† Flow control may be gravity feed or a metering pump, depending upon the design capabilities of the cartridge and the processing workload. Work with your supplier to determine the flow control appropriate for your system.

** This option allows for improvements to existing technology and for new technology, developed after this guide was written. It also allows for less commonly used technology that is available and can meet the percent recovery requirements.

1. One or two metallic replacement cartridges (MRCs) with manufacturer-specified flow control

Optional — for low volumes the overflow may feed directly from the film processor to the MRC via gravity.



How it works

In this configuration, the silver-rich overflow from the processor (A) is directed to a holding tank (B). Next, it is fed via gravity or a metering pump (C) at a fixed rate through the metallic replacement cartridges (MRCs) set up in series (E and G). In this diagram two MRCs are shown. Once the solution exits the last cartridge in series (H) at least 90 percent of the silver has been recovered and the solution can be discharged to the drain (I) with permission.

Testing methods

There are two types of testing methods you should use:

- **once each week**, use silver-estimating test papers or another method of approximating silver concentration to check whether the system is working (if the paper shows any change in color, the system is not working*), and

- **once every year**, use highly accurate analytical laboratory testing such as atomic absorption (AA) or inductively coupled plasma spectroscopy (ICP). Use an outside service for analytical testing.

Testing procedures

1. To indicate whether the system is working, check the solution ***weekly*** at two locations using a method of approximating the silver concentration:
   - after the first MRC at (F)
   - after the last MRC at (H)

2. To verify the percent efficiency of the system, use an analytical laboratory to test the solution ***once every year,*** from two locations:
   - before the first MRC at (B) or (D)
   - after the last MRC at (H)

See Appendix F for more information about testing for silver.

Testing records

- Record all test results in a silver recovery log. See the examples below. Check with the publicly owned treatment works (POTW) to find out how long to keep records on file.

Silver Recovery Log		
Date	Weekly Effluent Check*	
	MRC #1	MRC #2
7/1/96	P	P
7/8/96	P	P
7/15/96	F	P

* Pass (P) = no color, Fail (F) = color

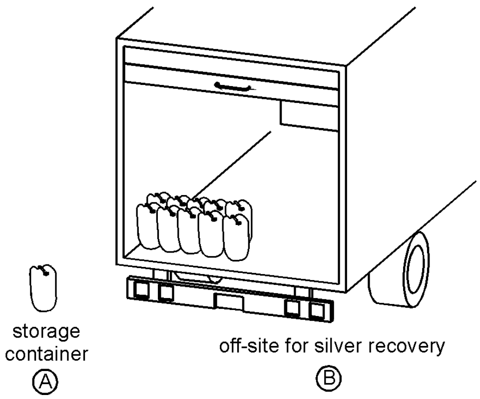
When the weekly check indicates cartridge failure, refer to the equipment manual for the manufacturer's recommendations.

Silver Recovery Log (ppm)			
Date	Annual Test		% Recovery
	Influent	Effluent	
7/1/96	2,500	150	94%*
7/1/97			
7/1/98			

* To obtain the percent recovery, use the following formula:
100 - (effluent x 100 ÷ influent).

* This may vary for systems in which the MRCs are rotated rather than both replaced at the same time.

2 . Off-site management



How it works

In this configuration, the silver-rich solution overflow from the processor is stored in a container (A) until it is picked-up by a licensed hauler for off-site silver recovery, treatment and/or disposal (B).

Testing requirements

There are no Code of Management Practice testing requirements for verifying silver recovery efficiencies. State waste agencies, however, may require testing in order to characterize the waste.

Additional requirements

Diagnostic and industrial X-ray film processors using off-site management must meet the following requirements:

- Store the silver-rich solutions in containers that are compatible with film processing solutions.
- If it's required in your jurisdiction, provide secondary containment for storage tanks.
- Comply with all applicable hazardous waste and DOT regulations.
- Keep records of volumes and types of solutions transferred off-site. See the example log below.

Off-Site Chemical Log

Date	Amount (gallons)	Type of Solution	Manifest Number
9/9/96	44	silver - rich photo	MI 3084201
10/7/96	44	silver - rich photo	MI 3084202
11/4/96	55	silver - rich photo	MI 3084203
12/2/96	48	silver - rich photo	MI 3084204
1/6/97	55	silver - rich photo	MI 3084205

- Maintain logs, hazardous waste manifests and other records for at least three years. Make the records available for inspection by the sewage treatment authorities.
- Verify the contractor is properly licensed to transport your waste and is handling it correctly.

4.0 Medium Processors

A medium diagnostic or industrial X-ray film processor is one that produces less than 20 gallons per day of silver-rich solutions and no more than 10,000 gallons per day of total process effluent. Medium processors should recover silver to at least 95 percent efficiency.

Remember: The category size of *medium* is based on an individual machine *not* the whole facility. This is done to ensure the silver recovery equipment and testing recommendations are appropriate for the size and utilization of the processing equipment.

Medium diagnostic and industrial X-ray film processors have five practical options for achieving a 95 percent removal. These can be configured in several ways, discussed below.

4.1 Options

The following options are recommended for recovering at least 95 percent of the silver from silver-rich solutions:

1. terminal electrolytic unit followed by a metallic replacement cartridge (MRC) with manufacturer-specified flow control*, or
2. in-line electrolytic unit with a metallic replacement cartridge (MRC) with manufacturer-specified flow control*, or
3. two or more MRCs with manufacturer-specified flow control, or
4. off-site management, or
5. alternative technology providing at least 95 percent silver recovery.**

* Flow control may be gravity feed or a metering pump, depending upon the design capabilities of the cartridge and the processing workload. Work with your supplier to determine the flow control appropriate for your system.

4.2 Equipment Configurations

In this section for medium diagnostic and industrial X-ray film processors, we'll review typical silver recovery equipment configurations for each of the compliance options. Detailed information is available in the appendices.

We'll also describe the testing methods and procedures to use with the equipment to verify that it is recovering at least 95 percent of the silver.

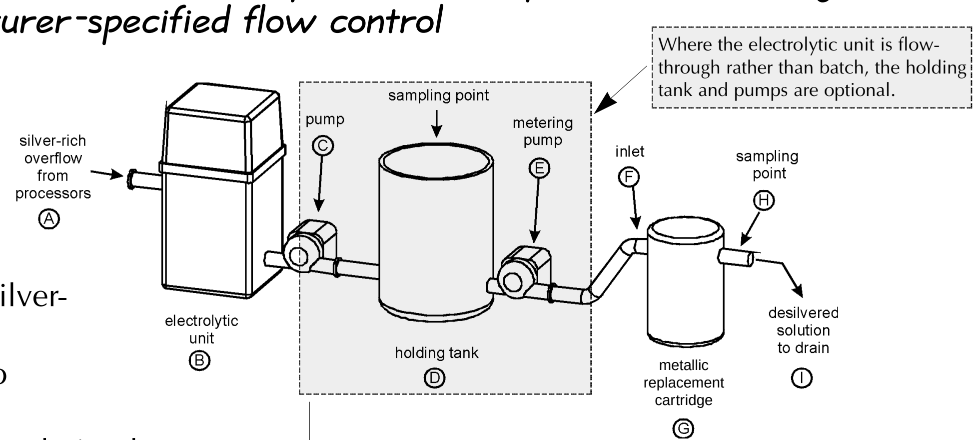
Finally, we'll show you samples of simple silver recovery logs to use for recording the results of the testing.

For detailed information about a specific silver recovery option, how it works, and preventive maintenance recommendations, refer to:

Appendix B Electrolytic Silver Recovery
Appendix C Metallic Replacement Cartridges
Appendix D Off-Site Management

** This option allows for improvements to existing technology and for new technology, developed after this guide was written. It also allows for less commonly used technology that is available and can meet the percent recovery requirements.

1. Terminal electrolytic unit followed by a metallic replacement cartridge (MRC) with manufacturer-specified flow control



How it works

In this configuration, the silver-rich overflow from the processor (A) is directed to the electrolytic unit (B). When sufficient silver-rich solution has accumulated, the electrolytic unit begins to desilver the solution. When the batch is completed, the partially desilvered solution is pumped out (C) of the electrolytic unit into the holding tank (D). From here, it is metered (E) at a fixed rate through the metallic replacement cartridge (G). Once the solution exits the cartridge (H) at least 95 percent of the silver has been recovered and the solution can be discharged to the drain (I), with permission.

Testing methods

There are two types of testing methods you should use:

- **once each week**, use silver-estimating test papers or another method of approximating silver concentration to check whether the system is working (if the paper shows any change in color, the system is not working), and

- **once every six months**, use highly accurate analytical laboratory testing such as atomic absorption (AA) or inductively coupled plasma spectroscopy (ICP). Use an outside service for analytical testing.

Testing procedures

1. To indicate whether the system is working, check the solution ***weekly*** at two locations using a method of approximating the silver concentration:
   - after the electrolytic unit at (D)
   - after the MRC at (H)

2. To verify the percent efficiency of the system, use an analytical laboratory to test the solution ***once every six months***, from two locations:
   - before the electrolytic unit at (A)
   - after the MRC at (H)

See Appendix F for more information about testing for silver.

Testing records

- Record all test results in a silver recovery log. See the examples below. Check with the POTW to find out how long to keep records on file.

Silver Recovery Log		
Date	Weekly Effluent Check*	
	Electrolytic	MRC
7/1/96	P	P
7/8/96	P	P
7/15/96	P	F

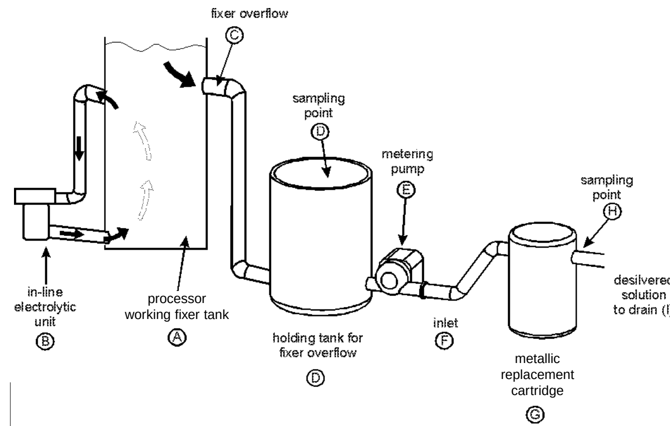
* Pass (P) = no color, Fail (F) = color

When the weekly check indicates cartridge failure, refer to the equipment manual for the manufacturer's recommendations.

Silver Recovery Log (ppm)			
Date	Six Month Test		%
	Influent	Effluent	Recovery
7/4/96	2,500	75	97%*
1/4/97	2,530	50.6	98%*
7/4/97			

* To obtain the percent recovery, use the following formula: 100 - (effluent x 100 ÷ influent).

2. In-line electrolytic unit with a metallic replacement cartridge (MRC) with manufacturer-specified flow control



How it works

In this configuration, the silver-rich overflow from the processor fixer tank (A) is continuously recirculated through the in-line electrolytic silver recovery unit (B) and back into the fixer tank (A). Fixer overflow (C) is fed into the holding tank (D). From here, it is metered (E) at a fixed rate through the metallic replacement cartridge (G). Once the solution exits the cartridge (H) at least 95 percent of the silver has been recovered and the solution can be discharged to the drain (I), with permission.

Testing methods

There are two types of testing methods you should use:

- **once each week**, use silver-estimating test papers or another method of approximating silver concentration to check whether the system is working (if the paper shows any change in color, the system is not working), and

- **once every six months**, use highly accurate analytical laboratory testing such as atomic absorption (AA) or inductively coupled plasma spectroscopy (ICP). Use an outside service for analytical testing.

Testing procedures

1. To indicate whether the system is working, check the solution ***weekly*** at two locations using a method of approximating the silver concentration:
   - after the electrolytic unit at (D)
   - after the MRC at (H)

2. To verify the percent efficiency of the system, use an analytical laboratory to test the solution ***once every six months,*** from one location:
   - after the MRC at (H)

Note: Where an in-line unit is installed, it maintains the fixer working tank silver concentration below 1000 ppm. Since it's not possible to obtain a pre silver recovery sample, we will assume that if the in-line unit weren't there, the silver concentration in the tank would be approximately 2500 ppm.

See Appendix F for more information about testing for silver.

Testing records

- Record all test results in a silver recovery log. See the examples below. Check with the POTW to find out how long to keep records on file.

Silver Recovery Log		
Date	Weekly Effluent Check*	
	Electrolytic	MRC
7/1/96	P	P
7/8/96	P	P
7/15/96	P	F

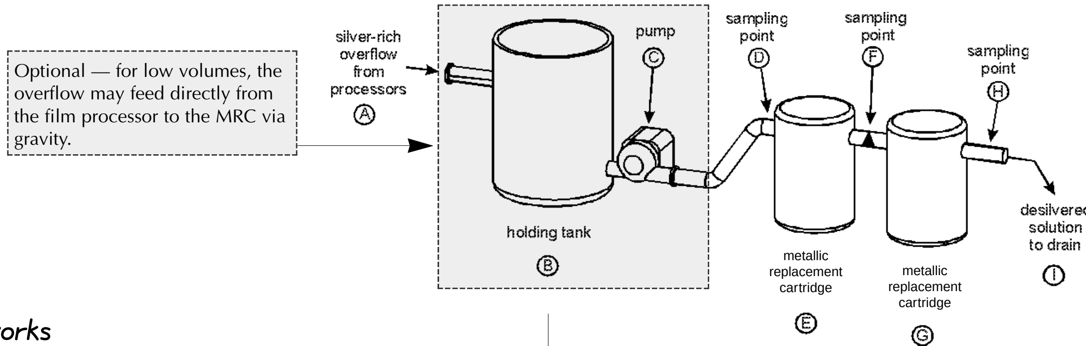
* Pass (P) = no color, Fail (F) = color

When the weekly check indicates cartridge failure, refer to the equipment manual for the manufacturer's recommendations.

Silver Recovery Log (ppm)			
Date	Six Month Test		% Recovery
	Influent	Effluent	
7/4/96	2,500	75	97%*
1/4/97	2,500	50.6	98%*
7/4/97			

* To obtain the percent recovery, use the following formula:
100 - (effluent x 100 ÷ influent).

3. Two or more metallic replacement cartridges (MRCs) with manufacturer-specified flow control



How it works

In this configuration, the silver-rich overflow from the processor (A) is directed to the holding tank (B). Next, it is metered (C) at a fixed rate through the metallic replacement cartridges (MRCs) set up in series (E and G). Once the solution exits the last cartridge in series (H) at least 95 percent of the silver has been recovered and the solution can be discharged to the drain (I), with permission.

Testing methods

There are two types of testing methods you should use:

- **once each week**, use silver-estimating test papers or another method of approximating silver concentration to check whether the system is working (if the paper shows any change in color, the system is not working*), and

- **once every six months**, use highly accurate analytical laboratory testing such as atomic absorption (AA) or inductively coupled plasma spectroscopy (ICP). Use an outside service for analytical testing.

Testing procedures

1. To indicate whether the system is working, check the solution ***weekly*** at two locations using a method of approximating the silver concentration:
   - after the first MRC at (F)
   - after the second MRC at (H)

2. To verify the percent efficiency of the system, use an analytical laboratory to test the solution ***once every six months***, from two locations:
   - before the first MRC at (B)
   - after the second MRC at (H)

See Appendix F for more information about testing for silver.

Testing records

- Record all test results in a silver recovery log. See the example below. Check with the POTW to find out how long to keep records on file.

Silver Recovery Log		
Date	Weekly Effluent Check*	
	MRC #1	MRC #2
7/1/96	P	P
7/8/96	P	P
7/15/96	F	P

* Pass (P) = no color, Fail (F) = color

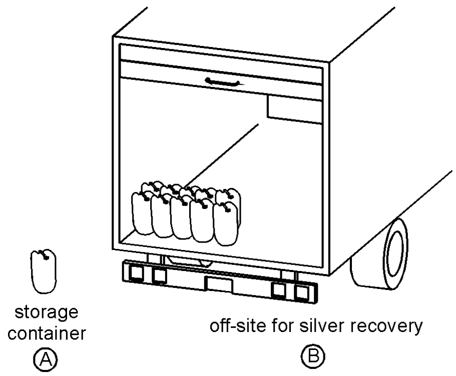
When the weekly check indicates cartridge failure, refer to the equipment manual for the manufacturer's recommendations.

Silver Recovery Log (ppm)			
Date	Six Month Test		%
	Influent	Effluent	Recovery
7/4/96	2,500	75	97%*
1/4/97	2,530	50.6	98%*
7/4/97			

* To obtain the percent recovery, use the following formula: 100 - (effluent x 100 ÷ influent).

* This may vary for systems in which the MRCs are rotated rather than both replaced at the same time.

4. Off-site management



How it works
In this configuration, the silver-rich solution overflow from the processor is stored in a container (A) until it is picked-up by a licensed hauler for off-site silver recovery, treatment and/or disposal (B).

Testing requirements
There are no Code of Management Practice testing requirements for verifying silver recovery efficiencies. State waste agencies, however, may require testing in order to characterize the waste.

Additional requirements
Diagnostic and industrial X-ray film processors using off-site management must meet the following requirements:

- Store the silver-rich solutions in containers that are compatible with diagnostic and industrial X-ray film processing solutions.
- If it's required in your jurisdiction, provide secondary containment for storage tanks.
- Comply with all applicable hazardous waste and DOT regulations.
- Keep records of volumes and types of solutions transferred off-site. See the example log below.

Off-Site Chemical Log			
Date	Amount (gallons)	Type of Solution	Manifest Number
9/9/96	44	silver - rich photo	MI 3084201
10/7/96	44	silver - rich photo	MI 3084202
11/4/96	55	silver - rich photo	MI 3084203
12/2/96	48	silver - rich photo	MI 3084204
1/6/97	55	silver - rich photo	MI 3084205

- Maintain logs, hazardous waste manifests and other records for at least three years. Make the records available for inspection by the sewage treatment authorities.
- Verify that the contactor is properly licensed to transport your waste and is handling it correctly.

5.0 Large Processors

A large diagnostic or industrial X-ray film processor is one that produces more than 20 gallons per day of silver-rich solutions and less than 25,000 gallons per day of total process effluent. Large processors should recover silver to at least 99 percent efficiency.

Remember: The category size of *large* is based on an individual machine *not* the whole facility. This is done to make sure the silver recovery equipment and testing recommendations are appropriate for the size and utilization of the processing equipment.

Large diagnostic and industrial X-ray film processors have several practical options for achieving a 99 percent removal. These can be configured in several ways, discussed below.

5.1 Options

The following options are recommended for recovering at least 99 percent of the silver from silver-rich solutions:

1. terminal electrolytic unit followed by two metallic replacement cartridges (MRC) with manufacturer-specified flow control, or

2. in-line electrolytic unit with two metallic replacement cartridges (MRC) with manufacturer-specified flow control, or

3. off-site management, or

4. alternative technology providing at least 99 percent silver recovery.*

5.2 Equipment Configurations

In this section for large diagnostic and industrial X-ray film processors, typical silver recovery equipment configurations for each of the compliance options. Detailed information is available in the appendices.

We'll also describe the testing methods and procedures to use with the equipment to verify that it is recovering at least 99 percent of the silver.

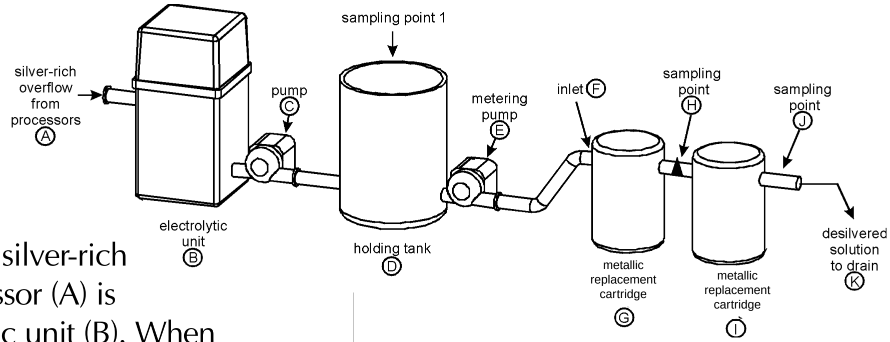
Finally, we'll show you samples of simple silver recovery logs to use for recording the results of the testing.

For detailed information about a specific silver recovery option, how it works, and preventive maintenance recommendations, refer to:

Appendix B Electrolytic Silver Recovery
Appendix C Metallic Replacement Cartridges
Appendix D Off-Site Management
Appendix E Ion Exchange

* This option allows for improvements to existing technology and for new technology, developed after this guide was written. It also allows for less commonly used technology that is available and can meet the percent recovery requirements.

1. Terminal electrolytic unit followed by two or more metallic replacement cartridges (MRC) with manufacturer-specified flow control



How it works

In this configuration, the silver-rich overflow from the processor (A) is directed to the electrolytic unit (B). When sufficient silver-rich solution has accumulated, the electrolytic unit begins to desilver the solution. When the batch is completed, the partially desilvered solution is pumped out of the electrolytic unit (C) into the holding tank (D). From here, it is metered (E) at a fixed rate through the MRCs (G and I). Once the solution exits the last MRC (J) at least 99 percent of the silver has been recovered and the solution can be discharged to the drain (K), with permission.

Testing methods

There are two types of testing methods you should use:

- **once each week**, use silver-estimating test papers or another method of approximating silver concentration to check whether the system is working (if the paper shows any change in color, the system is not working), and

- **once every three months**, use highly accurate analytical laboratory testing such as atomic absorption (AA) or inductively coupled plasma spectroscopy (ICP). Use an outside service for analytical testing.

Testing procedures

1. To indicate whether the system is working, check the solution ***weekly*** at two locations using a method of approximating the silver concentration:
   - after the electrolytic unit at (D)
   - after the first MRC at (H)
   - after the last MRC at (J)

2. To verify the percent efficiency of the system, use an analytical laboratory to test the solution ***once every three months***, from two locations:
   - before the electrolytic unit at (A)
   - after the last MRC at (J)

See Appendix F for more information about testing for silver

Testing records

- Record all test results in a silver recovery log. See the example below. Check with the POTW to find out how long to keep records on file.

Silver Recovery Log

Date	Weekly Effluent Check*		
	Electrolytic	MRC #1	MRC #2
7/1/96	P	P	P
7/8/96	P	P	P
7/15/96	P	F	P

* Pass (P) = no color, Fail (F) = color

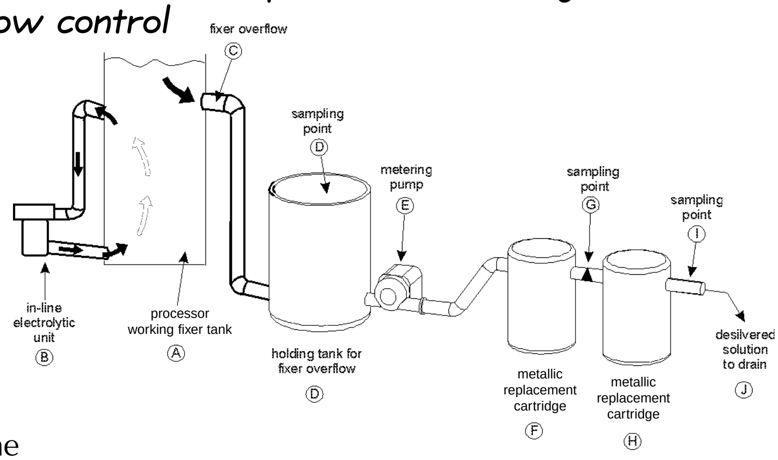
When the weekly check indicates cartridge failure, refer to the equipment manual for the manufacturer's recommendations.

Silver Recovery Log (ppm)

Date	Three Month Test		% Recovery
	Influent	Effluent	
7/4/96	2,500	5	99.8%*
10/4/96	2,420	2.4	99.9%*
1/4/97	2,531	2.5	99.9%*

* To obtain the percent recovery, use the following formula: 100 - (effluent x 100 ÷ influent).

2. In-line electrolytic unit with two metallic replacement cartridges (MRC) with manufacturer-specified flow control



How it works

In this configuration, the silver-rich overflow from the processor fixer tank (A) is continuously recirculated through the in-line electrolytic silver recovery unit (B) and back into the fixer tank (A). Fixer overflow (C) is fed into the holding tank (D). From here, it is metered (E) at a fixed rate through the metallic replacement cartridges (F and H). Once the solution exits the last cartridge (I) at least 99 percent of the silver has been recovered and the solution can be discharged to the drain (J), with permission.

Testing methods

There are two types of testing methods you should use:

- **once each week**, use silver-estimating test papers or another method of approximating silver concentration to check whether the system is working (if the paper shows any change in color, the system is not working), and

- **once every three months**, use highly accurate analytical laboratory testing such as atomic absorption (AA) or inductively coupled plasma spectroscopy (ICP). Use an outside service for analytical testing.

Testing procedures

1. To indicate whether the system is working, check the solution ***weekly*** at two locations using a method of approximating the silver concentration:
   - after the electrolytic unit at (D)
   - after the first MRC at (G)
   - after the second MRC at (I)
2. To verify the percent efficiency of the system, use an analytical laboratory to test the solution ***once every three months***, from one location:
   - after the last MRC at (I)

Note: Where an in-line unit is installed, it maintains the fixer working tank silver concentration below 1000 ppm. Since it's not possible to obtain a pre silver recovery sample, we will assume that if the in-line unit weren't there, the silver concentration in the tank would be approximately 2500 ppm.

See Appendix F for more information about testing for silver.

Testing records

- Record all test results in a silver recovery log. See the examples below. Check with the POTW to find out how long to keep records on file.

Silver Recovery Log

Date	Weekly Effluent Check*		
	Electrolytic	MRC #1	MRC #2
7/1/96	P	P	P
7/8/96	P	P	P
7/15/96	P	F	P

* Pass (P) = no color, Fail (F) = color

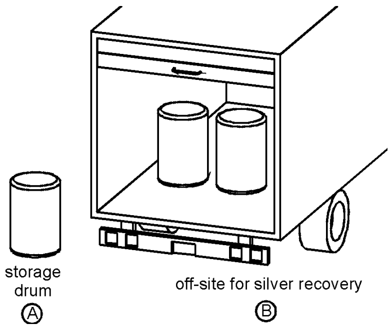
When the weekly check indicates cartridge failure, refer to the equipment manual for the manufacturer's recommendations.

Silver Recovery Log (ppm)

Date	Three Month Test		%
	Influent	Effluent	Recovery
7/4/96	2,500	5	99.8%*
10/4/96	2,500	2.4	99.9%*
1/4/97	2,500	2.5	99.9%*

* To obtain the percent recovery, use the following formula:
100 - (effluent x 100 ÷ influent).

3. Off-site management



How it works

In this configuration, the silver-rich solution overflow from the processor is stored in a drum (A) until it is picked-up by a licensed hauler for off-site silver recovery, treatment and/or disposal (B).

Testing requirements

There are no Code of Management Practice testing requirements for verifying silver recovery efficiencies. State waste agencies, however, may require testing in order to characterize the waste.

Additional requirements

Diagnostic and industrial X-ray film processors using off-site management must meet the following requirements:

- Store the silver-rich solutions in containers that are compatible with film processing solutions.
- If it's required in your jurisdiction, provide secondary containment for storage tanks.
- Comply with all applicable hazardous waste and DOT regulations.
- Keep records of volumes and types of solutions transferred off-site. See the example log below.

Off-Site Chemical Log			
Date	Amount (gallons)	Type of Solution	Manifest Number
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12/2/96	48	silver - rich photo	MI 3084204
1/6/97	55	silver - rich photo	MI 3084205

- Maintain logs, hazardous waste manifests and other records for at least three years. Make the records available for inspection by the sewage treatment authorities.
- Verify that the contractor is properly licensed to transport your waste and is handling it correctly.

6.0 Pollution Prevention

This section of the guide introduces several ***voluntary*** activities that can result in preventing pollution. We recommend that you read through it and adopt any ideas that are appropriate for your film processing operation. While many of these activities are better suited to larger operations, there are some that can also benefit even the smallest film processor.

Minimizing or reducing waste is a common practice among film processors. For example, automated processing chemical mixers are used to reduce waste caused by mixing errors. Outdated radiographs and other scrap films are sent to a recycler where the silver is recovered and the film base is recycled for use in manufacturing new film. Using good waste control practices has two benefits: it can lower the impact the operation has on the environment and it can save money through reduced materials and labor.

In today's language, waste control is called *pollution prevention*. Pollution prevention, or *P2*, is the name given to good management practices, as well as equipment and chemical modifications that result in reducing or eliminating waste. While P2 activities can be applied throughout a facility, in this guide we'll focus on the film processing area.

Most diagnostic and industrial X-ray film processors are already using some pollution prevention practices. In this section of the Code of Management Practice Guide for Diagnostic and Industrial X-Ray Film Processors we're going to give you a method to look at your diagnostic or industrial X-ray film processing operation, identify options for voluntary pollution prevention, put a P2 plan in place and follow-up on the success of that plan. The diagram on the next page shows the five steps of P2 planning:

1. **Create a team** of interested and capable staff and administrative employees to develop and oversee pollution prevention activities in your facility.

2. **Review your options** by examining your current practices in light of alternative or additional measures that can reduce or eliminate waste.

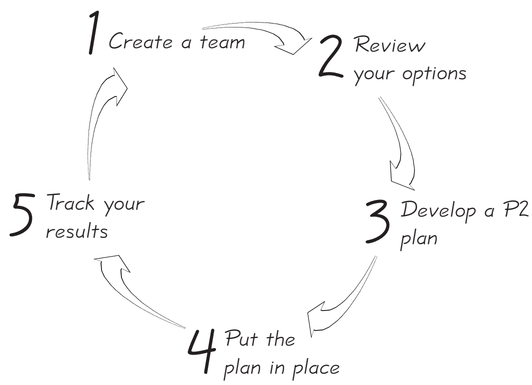
3. **Develop a P2 plan** by deciding which options you'll adopt, the time frame for adopting them, and who will be responsible for overseeing implementation and maintenance of the option.

4. **Put the plan in place** by providing the staff with pollution prevention training and resources.

5. **Track your results** by keeping records where they are helpful and by routinely auditing or inspecting your diagnostic or industrial X-ray film processing operation for pollution prevention opportunities.

Not every pollution prevention activity discussed in this section will make sense for you. For example, if the film processing volume is low, an in-line electrolytic system is probably not a good choice. This is just one example of why

Planning for Pollution Prevention



it's so important for you to conduct a thorough review of your operation and examine your options before you begin to develop a P2 plan.

In the following pages of this section, we provide you with specific P2 information and checklists to assess your performance.

6.1 Create a Team

Commitment from management and staff is an essential element of a successful pollution prevention plan.

Management supports the plan by 1) developing, implementing and maintaining a P2 policy, 2) forming a P2 team, and 3) allowing adequate time and resources for P2 activities.

Staff supports the plan by working with management to ensure pollution prevention is a priority in the diagnostic or industrial X-ray film processing area.

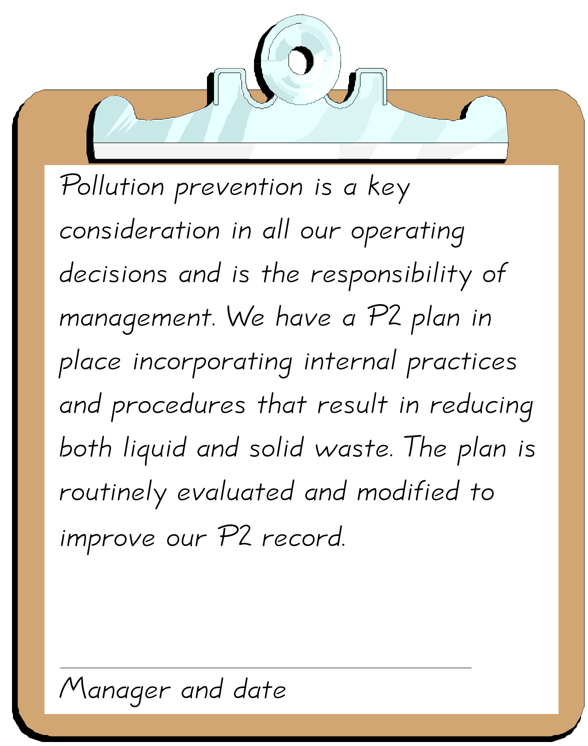
a. Management activities

There's no substitution for good leadership in pollution prevention. Management is responsible for setting the pollution prevention policy, establishing who will help with the plan and providing the necessary resources.

A pollution prevention policy

A pollution prevention policy is a simple and clear statement that waste reduction and elimination are goals of your facility. We've provided an example of a policy below. Make sure your policy is signed by a manager to show commitment and responsibility for P2 activities.

Once the policy is developed, post it for all employees, and perhaps even patients clients or customers to see. Remember — the success of P2 depends upon support from all the people in the film processing operation. You may decide to develop the policy with the help of the P2 team.



The P2 team

The pollution prevention team is the group of managers and staff people who develop, implement and evaluate all the activities that go into making up the P2 plan.

• *How many people should be on the team?* That depends upon the size of your operation. In a three or four person diagnostic or industrial X-ray film processing operation, it might be a team of one — the supervisor. In a large facility, it might be a team of five or six. You decide how many people you need.

• *Who makes the best team member?* The best team member is someone who's interested in pollution prevention, who wants to be on the team and who has a good understanding of film processing systems. In large facilities try to get representatives of different departments where film processing is done.

• *What about a team leader?* The P2 team needs a leader. Management can leave that decision up to the team or it can designate someone.

Time and resources for the P2 team

The P2 team needs time and resources to do its job properly. Time means time to meet, audit the facility, develop the P2 plan, put it into action, and periodically evaluate it. Resources mean training and technical information such as number of films processed and replenishment rates. Management should provide these as part of its commitment to P2.

b. Staff activities

Everyone has a part to play in pollution prevention. Some staff will be part of the P2 team. Their responsibilities will be to help develop the P2 plan and put it in place.

The rest of the staff will be trained to recognize pollution prevention opportunities and to work in such a way that doesn't create waste in the first place.

Checklist

This checklist reviews all the elements for putting together a P2 team. When you have the team in place, you should be able to answer "Yes" to all questions. "No" answers are potential pollution prevention opportunities. When you don't have adequate information to answer, check the "?" Then get the information you need to make an assessment.

Pollution Prevention Team			
	Yes	No	?
• Do you have a P2 policy?			
• Has it been signed and dated by a manager?			
• Is the policy posted where all staff can see it?			
• Have staff members been told about the P2 policy and its purpose?			
• Has the P2 team been formed?			
• Are the team members knowledgeable about film processing?			
• Has a team leader been chosen?			
• Does management provide the team with the time and resources needed for P2 planning and implementation?			

6.2 Review Your Options

Pollution prevention options for film processing solutions can be placed into one of three categories:

1) management practices,
2) equipment modifications, and
3) process modifications.

We'll examine each of these. We'll also look at options for managing the solid waste produced in diagnostic and industrial X-ray film processing.

At this phase of the P2 process, we're only *looking* at the possible options. After each discussion, we've included a checklist for you to evaluate your practices and equipment. A "Yes" answer means you're already practicing that P2 activity. Anytime you answer "No" you've found a potential pollution prevention opportunity. Anytime you answer "?" it means you need more information to evaluate the option. When you finish, look back at the checklists and with the team, choose the best P2 options for your operation.

a. Management practices

Some of the simplest and least expensive management practices may produce the most effective pollution prevention results. Keep this in mind as we look at the following management practices.

Preventive maintenance

Preventive maintenance should be your first pollution prevention option. By implementing an effective preventive maintenance program, the film processing equipment will work at its optimum level, keeping waste at a minimum. Use the recommendations found in the equipment operating manuals as a starting point for your preventive maintenance program. Contact the equipment manufacturer for more information.

Process control

Process control is the routine monitoring of variables that affect the quality of your product. These variables include:

- replenishment rates,
- processing temperatures
- processing times, and
- chemical mix procedures.

They should be checked routinely to ensure that film image quality is good, image stability is maximized and waste is minimized. These variables should be monitored on a schedule tied to the preventive maintenance schedule.

The film processor should also routinely run control strips, chart the results of each strip (see the control chart on the next page) and take action based on the results.

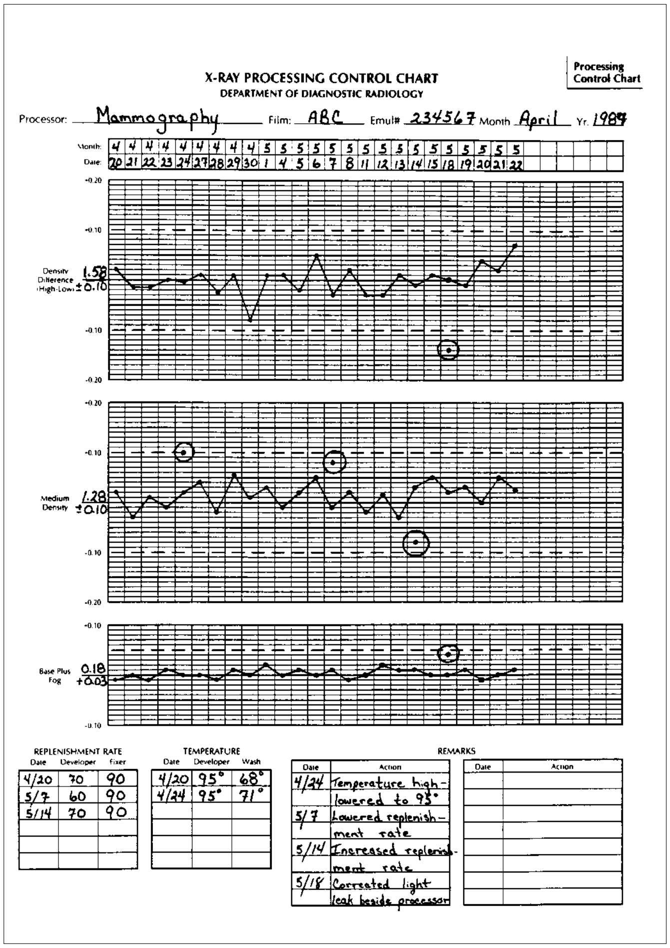
Inventory control

Managing the chemical inventory includes rotating the stock so that the oldest is used first and maintaining an appropriate supply of chemicals on-hand. This reduces the amount of money tied-up in overstock or having to dispose of old, unused chemicals.

Spill response planning

Any time a solution is unintentionally released it's a spill. The key word is ***unintentional***. When you produce a waste solution during processor cleaning and recharging, it's intentional. But if a container of film processing solution is dropped on the floor, ruptures and leaks, you have an unintentional spill.

Example process control chart



Most spills are minor splashes or leaks and can be cleaned up with a sponge or mop. Occasionally, however, a larger spill could occur requiring specialized clean-up materials and procedures.

The time to plan for a spill is long before it happens. A good spill response plan will help minimize the effects of the spill on the environment and ensure the diagnostic or industrial X-ray film processor returns to normal as quickly as possible. Some of the items to include in your spill response plan include:

- an inventory of all the chemicals used in the diagnostic or industrial imaging film processing operation,
- a floor plan showing the location of all chemicals in the film processing area, floor drains, exits, fire extinguishers and spill response supplies,
- a description of the containment used for silver recovery equipment, chemical mixers and storage tanks and any other containers that could leak or rupture,
- a list of spill response supplies and equipment such as mop, pail, sponge, co-polymer or other absorbent materials and personal protective equipment, and
- a set of tested procedures for responding to a spill. A sample spill response procedure, as shown below, is included in Appendix G.

Film Processor Inc.*

SPILL CONTINGENCY PLAN

Spill Response Personnel

Name	pager/phone
Name	pager/phone
Name	pager/phone

Environmental Emergency Phone **(999) 999-9999** 24 hours a day 7 days a week

EQUIPMENT REQUIRED

- **Gloves**
- **Apron**
- **Goggles**
- **Bucket**
- **Mop**
- **Sponge**
- **Absorbent Materials**

SPILL RESPONSE PROCEDURES

1. Put on gloves, goggles and an apron.
2. Contain the spill with a mop or absorbent materials available.
3. Check the appropriate material safety data sheet (MSDS) for special handling, ventilation, personal protection or other pertinent data.
4. Clean up the spill, as directed, using generous amounts of water.
5. Use the mop and sponge to clean the area thoroughly.
6. Package and label all contaminated absorbent materials for off-site disposal.
7. Notify the supervisor or manager that a spill has occurred.
8. (If required) Notify the appropriate government agency that a spill has occurred.

* This plan will not meet the requirements in all states, including California.

Good housekeeping

In a clean and orderly facility, there's better control over materials and equipment and less likelihood of spills. This results in less operational waste and prevents pollution.

Good housekeeping is one of those inexpensive and simple management practices that can significantly reduce waste, increase productivity and lower costs. You can't afford to neglect it. Here are three basic good housekeeping guidelines:

1. Designate an appropriate storage area for all materials and equipment.

2. Require every employee to 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, leaks, cleanliness and orderliness.

Safety and security

Keeping chemical areas safe and secure can minimize spills and other upsets.

- Make sure there is always someone trained in spill response procedures in the facility or who can be contacted to respond immediately.
- Restrict staff admittance to areas where chemicals are used and stored to those who have had hazard communication training.
- Make sure there's an MSDS on file for every chemical in the facility.
- Maintain a security system so that you know when someone is in the facility, both during and after working hours.

Checklist

This checklist reviews all the elements for evaluating management practices. "Yes" answers indicate that you're already using that pollution prevention measure. "No" answers are potential pollution prevention opportunities. When you don't have adequate information to answer, check the "?" Then get the information you need to make an assessment. Mark "N/A" (not applicable) when the item doesn't apply in your situation.

Management Practices				
Preventive Maintenance	Yes	No	?	N/A
• Is there a preventive maintenance program in place incorporating all the equipment manufacturer recommendations?				
Process Control	Yes	No	?	N/A
• Are solution replenishment rates routinely monitored?				
• Are processing tank temperatures routinely checked?				
• Are the appropriate staff trained in correct chemical mix procedures?				
• Are control strips run on processors at least once per day?				
• Are all control strips plotted on control charts?				
• When corrective action is taken, is it noted on the control chart?				
Inventory Control	Yes	No	?	N/A
• Is the oldest chemical stock always used first?				
• Are appropriate levels of stock maintained?				
Spill Response Planning	Yes	No	?	N/A
• Is there a spill response plan?				
• Is there an inventory of all chemicals in the film processing area?				
• Is there a floor plan detailing the location of chemicals, floor drains, exits, fire extinguishers and spill response supplies?				
• Is there containment around all permanent chemical containers?				
• Are the spill response supplies easily accessible?				
• Are spill response personnel properly trained?				

Management Practices (continued)				
Good housekeeping	Yes	No	?	N/A
• Are all materials and equipment kept in a specified location?				
• Are all chemical containers routinely checked for cracks or leaks?				
• Is all equipment wiped clean of chemical residue and dirt?				
• Are all floors free of chemical spills and residue?				
• Are aisles and walkways clear?				
• Does the film processing area look orderly and clean?				
• Are all employees held accountable for good housekeeping?				
Safety and Security	Yes	No	?	N/A
• Is there at least one staff member trained in spill response in the facility or available at all times?				
• Are areas where chemicals are used and stored restricted to staff trained in safe chemical handling (hazard communication)?				
• Where it's required, is there an MSDS for every chemical?				
• Is there a security system in place during both working and nonworking hours?				

b. Equipment modifications

A second category of pollution prevention options is equipment modifications. This refers to the changes made to film processors to reduce the amount of waste solution produced through processing. As we examine each of these options remember what we said earlier:
Not every one of these options is appropriate for your equipment. In some cases, equipment cannot be modified. Check with your equipment manufacturer.

Crossovers/squeegees

Crossovers/squeegees are an effective P2 option that improves silver recovery. As the film exits the fixer tank, it carries over a certain amount of silver-rich solution into the wash. Crossovers/squeegees reduce carryover, therefore keeping the silver in the fixer tank where the overflow can be sent to silver recovery instead of being lost in the wash tanks.* Care and routine maintenance can extend the life and effectiveness of crossovers/squeegees.

In-line silver recovery

Another way to reduce the silver carried over from the fixer tank into the wash tanks is to reduce the concentration of silver in the fixer. This can be done with in-line silver recovery (sometimes called recirculating or closed-loop silver recovery).

In-line silver recovery is an electrolytic unit through which the fixer in the processor tank is recirculated and constantly desilvered. By keeping the silver concentration in the fixer tank at a lower level, the amount of silver lost to the wash is significantly reduced.
There are other benefits of in-line silver recovery. Generally, it's possible to use a lower fixer replenishment rate which means lower chemical consumption. Additionally, the silver recovered is high grade silver flake.

If you use in-line silver recovery, check with your chemical supplier to determine if you need a specially formulated fixer.

Standby water saver

Today, most processors come equipped with an extremely efficient water saving device called standby water saver. This controls the wash water so it runs *only* when film is being processed. When the film clears the machine, the wash goes into standby position and doesn't begin again until the next film is processed. This equipment modification can save hundreds of gallons of water. If you have an older machine, check with your supplier to find out if it's possible to have it modified for a standby water saver.

* Crossovers/squeegees are also used between the developer and fixer tanks. This minimizes developer carryover that can contaminate the fixer.

Checklist

This checklist reviews all the elements for evaluating equipment modifications. "Yes" answers indicate that you're already using that pollution prevention measure. "No" answers are potential pollution prevention opportunities. When you don't have adequate information to answer, check the "?" Then get the information you need to make an assessment. Mark "N/A" (not applicable) when the item doesn't apply in your situation.

Equipment modifications				
Crossovers/Squeegees	Yes	No	?	N/A
• Are there crossovers/squeegees on processors capable of being equipped?				
• Are all crossovers/squeegees routinely checked, cleaned and replaced as necessary?				
• Are all crossovers/squeegees cleaned as part of the shut-down procedure?				
In-line Silver Recovery (if applicable)	Yes	No	?	N/A
• Is there an in-line electrolytic unit on all film fixer tanks?				
• Is the silver concentration in the tank monitored so that it doesn't get below 500 ppm or above 1000 ppm?				
• Is the fixer appropriate for in-line silver recovery?				
• Has the fixer replenishment rate been reduced?				
Standby Wash (if applicable)	Yes	No	?	N/A
• Are the processors equipped with standby wash?				

c. Process modifications

The third category of pollution prevention options is process modifications. Just as with equipment modifications, not all processors can be changed to accommodate every one of these process modifications.

Solution regeneration and reuse

Regenerating and reusing processing solutions may reduce the amount of chemicals to be desilvered or discharged to the drain. If the equipment can be modified and the film use is high enough, these pollution prevention options can significantly reduce waste. **Talk with your film and chemical suppliers to find out if this option is appropriate for your facility.**

Off-site chemical recycling may also be an option. In this case, the film processing facility collects the fixer overflow at the processor and periodically ships the collected solution to the recycler. From here, the fixer is desilvered and also regenerated for reuse. The regenerated fixer is then returned to the film processing facility to be used as fresh chemical for processing radiographs.

Water recirculation and recycling

Water is a valuable resource and should be conserved. Under certain conditions, wash water recirculators can be used to reduce the volume of water required for processing and reduce heat requirements for maintaining wash water temperatures. Another alternative is the standby wash discussed on page 27.

Because wash water has a direct affect on image stability, always consult with your manufacturer before making water conservation modifications to the processors.

Dry chemicals and automated mixing

Under some conditions, dry chemical packaging and automated mixing can contribute to waste minimization through extended shelf life and less packaging material.

Checklist

This checklist reviews all the elements for evaluating process modifications. "Yes" answers indicate that you're already using that pollution prevention measure. "No" answers are potential pollution prevention opportunities. When you don't have adequate information to answer, check the "?" Then get the information you need to make an assessment. Mark "N/A" (not applicable) when the item doesn't apply in your situation.

Process modifications				
Replenishment	Yes	No	?	N/A
• Have replenishment rates been measured or adjusted to manufacturer specifications?				
• Are there opportunities to lower fixer replenishment rates?				
Solution Reuse	Yes	No	?	N/A
• Is fixer regenerated where it's practical?				
• Is the portion of the silver-rich fixer that is not regenerated sent for silver recovery?				
• Are chemicals reused where it's practical? (e.g., developer or fixer recirculators)				
Water Reuse and Recycling	Yes	No	?	N/A
• Are wash water rates set at manufacturer recommendations?				
• Does the wash water run only during processing?				
• Is wash water conservation being used? (e.g., wash water recirculator or standby wash)				
Other Process Modifications	Yes	No	?	N/A
• Are dry chemicals used where it's practical?				
• Are automated mixers used where it's practical?				

d. Solid waste

There are pollution prevention opportunities for reducing the solid waste produced in diagnostic and industrial X-ray film processing. For example, film can be sent out for polyester plastic processing and silver refining. Local recyclers will accept cardboard from film boxes, the outer cardboard from chemical containers and they may also accept thoroughly rinsed plastic liners.

Many cities have recycling programs for most of the solid waste generated in your film processing area. Reusing and recycling reduces the amount of solid waste going to landfill and lowers your waste disposal fees.

Checklist

This checklist reviews all the elements for evaluating your solid waste management program. "Yes" answers indicate that you're already using that pollution prevention measure. "No" answers are potential pollution prevention opportunities. When you don't have adequate information to answer, check the "?" Then get the information you need to make an assessment. Mark "N/A" (not applicable) when the item doesn't apply in your situation.

Solid Waste				
Are the following solid wastes reused:	Yes	No	?	N/A
• Plastic film bags?				
• Cardboard film boxes?				
• Packing materials including pallets and plastic wrap?				
Are the following solid wastes recycled:	Yes	No	?	N/A
• Film?				
• Unwanted or excess exposed and processed film?				
• Lead sheets?				
• Plastic chemical bottles and box liners?				
• Plastic chemical box liners?				
• Corrugated cardboard?				
• Office paper?				
• Box board?				
• Packing materials including pallets and plastic wrap?				
list additional items here				

6.3 Develop a P2 Plan

Now that the P2 team has finished the audit or review, it's time for them to look at all the options and prioritize them as:

- **High priority** — needs immediate action
- **Medium priority** — needs action within 3 to 12 months
- **Low priority** — needs consideration within the next 1 to 2 years

Screening your options

Screen each option by asking the following questions and writing out your answers:

1. What is the potential for reducing waste and providing other environmental benefits?
2. What is it going to cost in time and materials?
3. How much money will it save in time and materials?
4. How difficult is it to implement?
5. Does it have an adverse affect on image quality?

Review the example below for screening the option of using in-line silver recovery on the film processor. A blank worksheet is included in Appendix G. Make copies as you need them and leave the original in this guide.

Worksheet for Screening Options

Date 10/2/96

Option: (example) Installing and maintaining an in-line silver recovery unit on the processor

1. **What is the potential for reducing waste and providing other environmental benefits?**
   Less silver will be lost to the wash tank and therefore the drain. In addition, we may be able to reduce replenishment rates.
2. **What is it going to cost in time and materials?**
   Cost of the electrolytic unit, labor for installation and periodic replacement, and labor for maintenance. (Note: estimate actual costs as closely as possible.)
3. **How much money will it save in time and materials?**
   The savings will come in the increased amount of silver recovered (Note: estimate actual savings as closely as possible) and lower fixer replenishment rates.
4. **How difficult is it to implement?**
   Not difficult. We can schedule the installment during the next preventive maintenance check on the machine. We need to buy the electrolytic unit. We also need to train process operators to keep the silver concentration about 500 ppm to reduce the potential for sulfiding.
5. **Could it have an adverse affect on image quality?**
   No, providing it's properly set-up and maintained.

Screening all the options you've identified will take time but it's time well spent. It's very important that you actually write out your answers. Doing your homework here makes the difference between a P2 plan that exists only in your head vs. one that is implemented and working.

Point system

You might find it useful to develop a point system for rating all the options. For example, you could assign a *plus* value to every potential benefit and a *minus* value to every negative impact.

Writing the P2 plan

Whatever system you use, you need to prioritize all of the options. Now you can begin to draft the P2 plan. For your first attempt at systematic pollution prevention, we recommend that you start with only the **high priority** options. Work at getting these into place and evaluate your success before addressing the medium and low priority options. Don't make too many changes as once — start with only three or four items.

Keep your P2 plan simple. Here is the information you should include:

- **Spell out each option and its purpose**
- **State a specific date when the option will be implemented**
- **List who is responsible**
- **Note if a record will be kept**

Review the example below. A blank Pollution Prevention Plan Worksheet is included in Appendix G. Make copies as you need them and leave the originals in this guide.

Pollution Prevention Plan Worksheet **Date** 11/10/96

Option or activity: (example) Install the in-line unit on the film processor in order to reduce the amount of silver in the wash water.

Implementation date: The unit will be installed during the December preventive maintenance check.

Responsibility: Joe Smith, maintenance supervisor, will arrange to buy the unit, ensure it is installed and be responsible for seeing it is maintained. He will also train the process operators how to maintain the unit and harvest the silver.

Record: In-line electrolytic maintenance will be added to the preventive maintenance checklist.

6.4 Put the Plan in Place

Now that you have a P2 plan it's time to put it into action. These are the steps:

1. Make the plan known - Post it, explain its purpose and details to the staff, and talk it up. Through both your words and actions, make all employees aware of how committed the management is to pollution prevention. Keep employees updated on both the successes and failures of the plan.

2. Provide training and education - Make sure that anyone who is given responsibility in the P2 plan has the training and knowledge to carry out his/her tasks.

3. Provide the necessary resources - Make sure that anyone who is given responsibility in the P2 plan has the time and materials required to fully implement the P2 plan.

6.5 Track Your Results

Your P2 plan isn't a "Now I've done it so I can forget about it" kind of thing. You need to periodically review it, evaluate which elements are working, which need to be modified and which need to be discontinued. A review every six months should be often enough.

As you evaluate your P2 plan, keep in mind your original intent for pollution prevention: minimizing or eliminating waste for both environmental and economic benefit.

Answer each of the following questions for each pollution prevention option or activity listed in your plan:

- **How much waste has been reduced or eliminated as a result of this activity?**
- **How much has it cost?**
- **How much money has it saved?**

In some cases, it may be hard to get exact answers to these questions. But try. It's important that you fully evaluate every P2 option implemented in your diagnostic or industrial X-ray film processing operation. Once again, let's look at installing an in-line unit as an example.

Worksheet for Evaluating P2 **Date** 5/17/96

Option: (example) Installing and maintaining an in-line electrolytic silver recovery unit on the film processor

1. Waste reduction results

Using colorimetric testing, we found the concentration of silver in the wash tank went from 95 ppm to 28 ppm. Over the 6 month period, we estimate this is 386 troy ounces of silver.

2. Costs

Materials: unit = $1,240. Labor: installation 1-1/2 hours x $20/hour = $30. Daily maintenance: 1 minute at $12/hour = $.20 daily or $24 for 6 months. Total costs = $1,294.

3. Savings

386 troy oz. of silver at $5.40 tr. oz. = $2,084. This was the amount of silver diverted from the wash. Total savings realized were $2,084 - $1,294 = $790.00 in six months.

A *successful* P2 option or activity is one that reduces waste and saves more money than it costs. Consider whether changing it would make it even more successful or whether to let it continue as is.

An *unsuccessful* option or activity is one that doesn't reduce waste, or it costs more money than it saves. With an unsuccessful option, consider whether changing it would make it successful or whether to discontinue using it.

Once you've done this evaluation for every option, you can also consider whether it's time to put some of those **medium priority** options in place. Remember not to make too many changes at once.

Spread the word

Every time you evaluate the success of the P2 plan, let the staff know the results — both the positive and the not so positive. When you decide to make changes or implement new P2 activities, remember to train the staff if there are any new procedures.

Include your P2 success stories in your facility's annual report or newsletter. If there's no environmental section in the report, now is a good time to start one.

With pollution prevention, everyone's a winner: the impact of your business on the environment is reduced and the cost savings from lower waste means more money in your pocket.

P2

Appendix A
Glossary of Terms

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.

Anode: The positively charged electrode. When electrolytically desilvering film processing solutions, the thiosulfate is oxidized at the anode.

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

Biocide: A chemical that discourages the growth of bacteria.

Cathode: The negatively charged electrode. When electrolytically desilvering film processing solutions, metallic silver is deposited on the cathode.

Code of Management Practice (CMP): 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.

Cradle-to-Grave: A phrase used to describe the tracking system for hazardous waste. All parties in the waste chain — generator, transporter, storage and disposal facilities — use a common manifest that identifies them, the waste, and the final disposition of the waste.

Diagnostic or Industrial X-Ray Film Processing Facility: A facility using the photographic process in creating diagnostic or industrial images.

DOT: Department of Transportation

Effluent: The solution exiting a process or piece of equipment.

Electrolytic Silver Recovery: A method of recovering silver in which a direct current is applied across two electrodes immersed in a silver-rich solution. Silver plates onto the cathode and the thiosulfate is oxidized at the anode.

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

Influent: The solution entering a process or piece of equipment.

In-Line Silver Recovery: A method of recovering silver in which fixer is circulated between the processor fixer tank and an electrolytic unit. An in-line unit continuously recovers silver and maintains it in the fixer at a reduced level, typically between 500 ppm - 1,000 ppm. This method of silver recovery is also called closed-loop or recirculating silver recovery.

Ion Exchange: A reversible exchange of ions between a solid (resin) and a liquid (water containing ionized salts). When used with film processing solutions, ion exchange removes the silver ion from solution and replaces it with non silver ion.

Large Diagnostic or Industrial X-ray Film Processor: A processor which produces on average more than 20 gallons per day (GPD) of silver-rich solution and uses more than 10,000 GPD of process wash water.

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

Medium Diagnostic or Industrial X-Ray Film Processor: A processor which produces on average less than 20 gallons per day (GPD) of silver-rich solution and uses less than 10,000 GPD of process wash water.

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).

Milligrams per Liter (mg/L): mg/L is the same measurement as parts per million (ppm).

MRC: A metallic replacement cartridge is a device which recovers silver through a process known as metallic replacement.

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

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

Pollution Prevention: Any practice that reduces or eliminates waste at the source.

POTW: Publically owned treatment works. A wastewater treatment facility owned by the public (municipality or service authority).

Preventive Maintenance: A set of procedures routinely 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 five percent or more of the average dry weather hydraulic or organic capacity of the POTW, or, 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.

Silver Recovery: The process of reclaiming silver from silver-rich solutions such as fixers.

Silver-Rich Solution: A solution containing sufficient silver that cost effective recovery could be done either on-site or off-site. Fixer is a silver-rich solution.

Silver-Estimating Test Paper: A test paper coated with cadmium sulfide which changes color on reacting with silver in solution. A reference color code allows users to estimate the amount of silver in solution.

Small Diagnostic or Industrial X-Ray Film Processor: A processor which produces on average less than 2 gallons per day (GPD) of silver-rich solution and uses less than 1,000 GPD of process wash water.

Source Reduction: A decrease in the production of the volume, concentration or toxicity of liquid waste.

Spill: Unintended release of liquid that is not in the ordinary course of events.

Squeegee: Physical device (e.g. rollers, blades) 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 wastewater to a POTW.

The Silver Council: A national group supported by the photographic chemical and equipment manufacturers and associations and representing more than 360,000 users. The purpose of the group is to encourage communications between the regulatory and regulated communities, to support scientific research, and to share current scientific, technical and economic information about silver so that the common goals of pollution prevention, recycling, water conservation, and compliance can be met.

Appendix B
Electrolytic Silver Recovery

Electrolytic recovery is an efficient and cost-effective silver recovery technology first used in 1931. Since then the equipment has evolved and been refined so that today's electrolytic units are reliable and consistent. The equipment is continuously reused and few, if any, additional chemicals are required to perform the recovery operation.

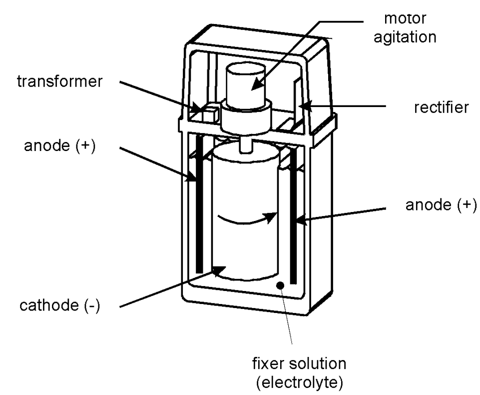
B.1 How it Works

Throughout this discussion, refer to the diagram in the right-hand column. In electrolytic silver recovery two electrodes are immersed in silver-rich solution. Electric current reduces the silver-thiosulfate complex in the solution and plates almost pure silver metal onto the cathode — the negatively charged electrode. The cathode is typically made of stainless steel. The amount and quality of the silver plated out depends upon the operating amperage and the length of time the solution is exposed to the current.

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 a significant amount of the silver from the silver-rich solutions.

In addition, there are batch units and flow-through units. In the batch unit, the solution is collected within a chamber inside the electrolytic unit until there is sufficient quantity to constitute a batch. The solution is then pumped into the desilvering chamber where the silver is removed. When the batch is completed, it is pumped out all at once, usually to a secondary silver recovery system. In a flow-through unit, the silver is recovered continuously as it flows into the unit. This solution is then displaced as more processor overflow enters the electrolytic unit. Electrolytic units should be used in conjunction with another system.

Electrolytic Unit



In-line electrolytic silver recovery
By using in-line electrolytic silver recovery on fixer solutions, the amount of silver in solution is significantly reduced. This results in less silver carried over into the final wash water and subsequently discharged to the sewer. Where the use of 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. Solution overflow from in-line systems should be treated by another system to further reduce the silver concentration.

B.2 Operation/Maintenance

The electrolytic unit must have enough capacity to treat peak volumes of silver-rich chemical effluent produced by the film processor. The manufacturer/supplier of the electrolytic unit can help the diagnostic or industrial X-ray film processor choose the appropriate equipment and provide preventive maintenance information. Generally electrolytic units are monitored for the following: pH, silver concentration, sulfite concentration, time and amperage, and, mechanical operation. All of these are discussed below.

a. pH

Fixer solutions from film processes are easy to desilver electrolytically and require little, if any, pH adjustment.*

b. Silver concentration

The concentration of silver in the overflows from diagnostic and industrial X-ray film processing operations will typically range from 2,000 - 3,000 ppm ***prior*** to electrolytic recovery but can reach as high as 6,000 ppm.

Recovery efficiency is directly related to silver concentration; the higher the silver concentration, the higher the plating efficiency. Replenishment rates play an important role in determining this concentration level. Over replenishment dilutes the amount of silver. When silver concentration falls below 500 mg/L, plating efficiency decreases significantly thus reducing the recovery rate of the electrolytic unit.

It's very important to calibrate replenishment rates routinely on the processors.

c. Sulfite concentration

In the plating process, sulfite is consumed as silver is plated out of solution. It's necessary, therefore, to have sufficient sulfite in the solution. This is particularly important in in-line electrolytic silver recovery where the fixer solution is continually recirculated through the processing tank. Any degradation of the fixer can affect the final product. Check with the equipment manufacturer or chemical supplier to find out if you should be using a fixer with an increased level of sulfite.

d. Time and amperage

Many of the electrolytic silver recovery units sold today are automatic so the operator doesn't have to set plating current and batch times — two critical factors in electrolytic silver recovery. The correct plating current must be maintained to drive the silver out of solution and onto the cathode. If the plating current is too high or the plating time too long, the silver deposited on the cathode will be black and sludgy, with much of it falling off the cathode and collecting on the bottom of the electrolytic unit. This situation, known as *sulfiding*, results in a low quality silver

* It is highly recommended not to exceed a pH of 8.5. Above this level significant ammonia air emissions are released.

and a mess to clean. To avoid sulfiding, follow the manufacturer recommendations for setting both the plating time and amperage.

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

e. Mechanical operation

General mechanical preventive maintenance should be conducted periodically to ensure the plating current is correct, the cathode is rotating or the pump is working, and the color of the silver on the cathode is creamy-grey rather than black or white. The silver should be harvested (removed from the cathode) periodically and sent to the refiner.

The most common mechanical problem with electrolytic units is a poor electrical connection to either the anode or the cathode. It is important that terminals and wires do not come in contact with solutions. Corroded terminals or cables will result in poor plating.

The person who is responsible for silver recovery should follow all manufacturer recommendations for preventive maintenance and keep accurate records of any maintenance performed.

- **Make sure you receive the operations and maintenance manuals for your silver recovery equipment. These manuals are part of the purchase price of your equipment and you are entitled to them.**

- **Obtain data from the silver recovery equipment manufacturer/ supplier demonstrating the performance capability of the equipment. For example, if you are required to recover silver to 99 percent efficiency, ask the manufacturer to provide you with data showing the equipment can achieve this level.**

Appendix C
Metallic Replacement

Metallic replacement is a relatively low cost method of achieving a fairly high level of silver recovery.

C.1 How it Works

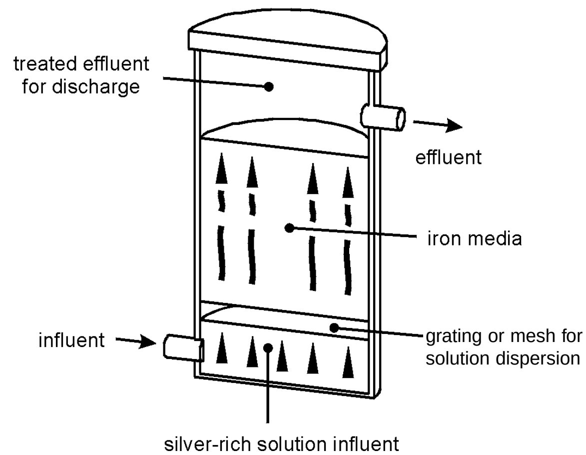
Metallic replacement is a process that occurs when a solution containing dissolved ions of an active metal, such as silver, contact a more active solid metal, such as iron. The more active metal, iron which is contained in a cartridge, reacts with the silver and dissolves in solution. The silver in solution is reduced to metallic silver and collects in the cartridge.

In essence, the dissolved silver in solution changes places with the solid iron in the cartridge. The exchange reaction is dependent upon the contact of the silver-thiosulfate in solution with the iron surface. To ensure good and controlled contact, metallic replacement is accomplished by metering the silver-rich solutions through a cartridge of iron. As silver is removed from the solution, the iron metal filler in the cartridge becomes depleted. The cartridge is then replaced with a new cartridge and the accumulated silver sludge is sent to be refined.

A typical metallic replacement cartridge (MRC) is shown in the diagram above.

There are a variety of MRCs on the market today. They contain iron in the form of

Metallic Replacement Cartridge



chopped steel wool, spiral wound steel wool, a heavy iron mesh similar to door screening material, or iron chips imbedded in a fiberglass support.

A properly designed and maintained single-cartridge MRC system is capable of recovering more than 95 percent of the silver from silver-rich solutions when used in accordance with manufacturer specified flow rates. A system utilizing two MRCs hooked in series is capable of recovering 99 percent of the silver.

Where the flow of solution through the cartridge exceeds its rated capacity, flow control must be used. While a metering pump is generally recommended, in extremely low volume situations a flow restrictor may be adequate.

C.2 Operation/Maintenance

The manufacturer/supplier of the MRC can help the diagnostic or industrial X-ray film processor choose the appropriate equipment. The manufacturer is also the best source of preventive maintenance information. Generally metallic replacement cartridges are monitored for the following: flow rate, channeling, obstruction, pH, and, cartridge capacity.

a. Flow rate

The length of time the silver-rich solution is in contact with the iron is critical for effective silver recovery. If the solution flows through the MRC too quickly, it will not contact the steel wool long enough for the iron/silver reaction to occur. The lower the flow rate, the better the recovery.

A pump may be used to meter the solution at a prescribed rate from the holding tank to the first MRC in the series. To ensure proper flow rate, calibrate the metering pump each time the MRCs are replaced. Consult the manufacturer for the optimum flow rate.

b. Channeling

As the recovery cartridge is exposed to fixer, the active surface area is used up and small channels will begin to develop in the iron material. This is known as *channeling*. It also occurs when an MRC is used only intermittently due to low volume or when the solution is introduced in batches. When a small volume of solution enters the MRC and sits on the surface, it slowly eats through the steel wool, forming a vertical shaft or channel as it goes. As more solution enters the MRC, it takes the path of least resistance and flows through the channel, thus contacting very little of the steel wool in the cartridge. This causes only a small amount of the iron to be used (that along the channel). When channeling occurs, only low levels of silver are recovered and high levels are discharged from the MRC.

To avoid channeling: (1) select the proper size MRC for the average volume of film processed through the machine, and (2) fill the MRC with water just prior to introducing chemical solutions into it.

c. Obstruction

When the iron in solution contacts air, iron hydroxide or rust forms. If the rust is allowed to build up in the lines leading into and out of the MRCs, it can eventually restrict the flow of solution causing the solution to back up. The MRC may also leak around the fittings and cover.

Obstruction also occurs when the center core of the MRC is crushed or damaged and the solution cannot pass through it. If this happens, replace the MRC with a new one. Consult the MRC supplier for information.

Finally, rust that passes through the MRC can eventually build up in the floor drain, requiring expensive drain cleaning.

Monitor the system regularly for obstruction. Remove the lines and rinse them with hot water each time the MRCs are replaced. Do this more often if there are several hours each day when no solution is flowing through the MRCs. Be sure to run the overflow system downhill so there's no chance of back-up.

d. pH

For best results with MRCs, the pH should be between 4.5 to 5.5. If the pH is too low, the steel wool is etched too quickly reducing the life of the MRC. If the pH of the solution is too high, etching does not occur so the silver/iron exchange reaction can't take place. Also, at higher pH levels, iron hydroxide (rust) is formed which can cause obstructions in the lines and drains.

Try to maintain a consistent pH in the influent going to the MRCs. This is best accomplished by plumbing the silver-rich overflow directly from the processors to the silver recovery system. Manually emptying waste tanks tends to introduce pH variation into the system. Normally, a solution containing fixer will not require pH adjustment. Work with your equipment supplier to determine the best pH for your MRCs.

e. Cartridge capacity

Each type of MRC has a limited capacity to recover silver depending on the type and amount of iron used and conditions in the film processing lab. Manufacturers generally rate the capacity of their MRCs in both gallons of solution and time. For example, depending on the silver concentration of the influent, an MRC might have the capacity to desilver 100 gallons of solution or last 12 weeks, whichever comes first. Ask the manufacturer to help you in selecting MRCs appropriate for your lab.

Keeping a log

Keep a silver recovery log to record all of the checks and testing you do on your silver recovery equipment. As soon as the weekly check (done with silver-estimating test papers) shows color, you know the metallic replacement cartridge has failed and it's time to change it. When you install a new MRC, mark the installation date on the cartridge.

Check with your local POTW authorities to find out how long to keep these records on file.

The person who is responsible for silver recovery should follow all manufacturer recommendations for preventive maintenance and keep accurate records of any maintenance performed.

- **Make sure you receive the operations and maintenance manuals for your silver recovery equipment. These manuals are part of the purchase price of your equipment and you are entitled to them.**

- **Obtain data from the silver recovery equipment manufacturer/ supplier demonstrating the performance capability of the equipment. For example, if you are required to recover silver to 99 percent efficiency, ask the manufacturer to provide you with data showing the equipment can achieve this level.**

Appendix D
Off-Site Management

The following information applies only to diagnostic and industrial X-ray film processors that ship waste off-site.

In some situations, off-site silver recovery is the best option. For example:

- Diagnostic and industrial X-ray film processing operations required to meet excessively restrictive silver concentration limits may be forced to ship the solutions off-site for treatment.

- For diagnostic and industrial X-ray film processing facilities discharging to a septic tank and leach field, there is no option; they must haul. ***Diagnostic and industrial X-ray film processing chemicals must not be discharged to septic systems.*** This could cause an upset that would destroy the microorganisms responsible for breaking down the wastewater.

F.1 Off-Site Requirements

Solutions containing 5 ppm or greater of silver are currently classified as hazardous waste. In order to transport these solutions off-site, the facility must fulfill the requirements for transporting hazardous waste. In this section, we're going to discuss the Federal requirements for off-site silver recovery. **Since individual states may enact stricter regulations, make sure you check with your state agency for its specific requirements.**

a. Generator category

If you're shipping waste diagnostic or industrial X-ray film processing solutions containing 5 ppm or more of silver, it's important that you know how to determine your hazardous waste category. The specific requirements for accumulation, storage, and manifesting vary depending on the category.

The chart on the next page shows the three categories of waste generators established in the federal Resource Conservation and Recovery Act (RCRA). These categories, as shown across the top of the chart, are:

- Conditionally exempt small quantity generator

- Small quantity generator

- Large quantity generator

To determine your category, track the monthly volume of waste film processing solutions containing 5 ppm or more of silver produced in your facility to be sent off-site. This amount must be added to the amount of any other hazardous waste produced by your facility, in determining the generator category.

For example, if you process film in several locations within your facility and the solutions are accumulated and taken off-site, add all the fixer produced in all

Hazardous Waste Category*		
Conditionally Exempt Small Quantity Generator (CESQG)	*Small Quantity Generator (SQG)*	*Large Quantity Generator (LQG)*
Facility that generates no more than 100 kilograms of hazardous waste per month	Facility that generates greater than 100 but less than 1,000 kilograms of hazardous waste per month	Facility that generates greater than 1000 kilograms of hazardous waste per month
* Any film processing waste containing 5 ppm or more of silver is considered hazardous under the Resource Conservation and Recovery Act (RCRA). Most states and municipalities have additional regulations for the discharge and transport of silver and silver-bearing wastes. For more information contact your local state hazardous waste agency.		

locations for one month. If it's not more than 100 kilograms (approximately 220 pounds or 25 gallons), and you have no other hazardous waste, your facility falls into the category of conditionally exempt small quantity generator.

b. Generator identification number

SQGs and LQGs must obtain an EPA identification number before shipping waste off-site. This 12-character number identifies both your site where the waste is produced and the type of waste. It's a key element of tracking the waste from *cradle-to-grave*. Your state hazardous waste agency can provide you with the proper paperwork.

In some states, CESQGs do not have to obtain an ID number.

c. Accumulation and storage

CESQGs must not accumulate more than 270 gallons of waste at any time.

SQGs must not accumulate more than 1,620 gallons of hazardous waste in any 180 day period.

LQGs must not accumulate hazardous waste on-site longer than 90 days.
In all cases, wastes must be stored in tanks and containers suitable for film processing waste. In addition:

- Clearly mark each container with the words *Hazardous Waste* and with the date you began to collect waste in that container.
- Use only containers in good condition.
- Keep containers closed except when you fill or empty them.
- Inspect areas where containers are stored, at least weekly, looking for leaks and deterioration.
- Provide secondary containment where it's required.

d. Labels and marks

Containers of silver-rich chemicals must be properly labeled and marked. The label shown on the next page contains the six required elements:

HAZARDOUS WASTE

Federal Law Prohibits Improper Disposal

If found, contact the nearest police or public safety authority, or the U.S. Environmental Protection Agency

Accumulation Start Date: ❶ Dec. 5, 1996 EPA Waste #: ❷ D011

Generator Name: ❸ Film Processor Inc.

Address: ❸ 1500 Main Street

City: ❸ Your Town State: ❸ NY Zip Code: ❸ 02143

EPA ID #: ❹ XXXXXXXXXXX Manifest #: ❺ YYYYYY

DOT Proper Shipping Name, Class, UN#, and packing group:

❻ RQ Hazardous waste liquid, n.o.s. (silver), Class 9, NA 3082, Packing group III

❶ accumulation start date,

❷ EPA waste identification number (silver is D011),

❸ site name and address where the waste was produced (generator name),

❹ EPA generator identification number,

❺ manifest number, and

❻ Department of Transportation (DOT) shipping name for the waste. (this is the correct shipping name for silver-bearing waste.)

e. Manifests

The manifest is a multi-copy document used to track the waste from the time it leaves the generator (the diagnostic or industrial X-ray film processing facility), to the time the receiver treats, recycles or disposes of it. Each party in the link — generator, transporter, receiver — have EPA identification numbers and each must complete its portion of the manifest.

The generator is responsible for obtaining numbered manifest forms from the state hazardous waste agency. All links in the chain keep a copy of the manifest and receive copies from the other links to acknowledge receipt of the waste. Manifests must be kept on file by the generator for at least three years. Manifests are not required for CESQGs. Some transporters, however, may still ask that they be used to help the transporter and receiver fulfill their requirements.

f. Spill response and training

SQGs and LQGs are required to develop emergency plans and train employees on emergency response so that if a spill or accident occurs, the facility is ready. Generally, the plans must include procedures and identify the necessary spill control/response equipment.

F.2 Precautions

One important element of the *cradle-to-grave* waste management system is liability. Once you've generated the waste, you retain some responsibility even after turning it over to a licensed transporter and a licensed receiver. This means you should choose your waste management partners carefully.

Talk with your colleagues, trade associations and state hazardous waste agency to get the names of licensed companies that could handle silver-bearing film processing wastes. Choose a firm with a good reputation. Verify their EPA identification numbers and any required permits. Keep copies of their permits on file. Visit their site to look at their equipment and the general condition of their operation. Choose carefully and with confidence.

Appendix E
Ion Exchange

Ion exchange technology can be used to recover silver from dilute processing solutions and wash waters. Keep silver levels as low as possible in wash water by installing and maintaining equipment and monitoring replenishment rates.

Ion exchange is recommended for use only to remove silver from wash water. It is ***not generally recommended*** for use with fixer solutions.

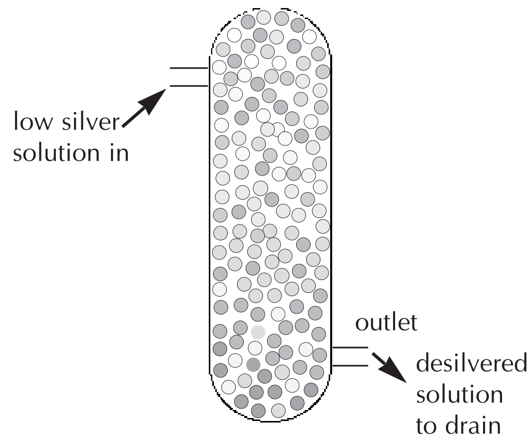
G.1 How it Works

Ion exchange is a reversible exchange of ions between a solid (resin) and a liquid (water containing ionized salts). When ion exchange is used with low-silver solutions, the silver thiosulfate in solution is adsorbed to the resin in the column. Periodically, under a service contract, the column is removed and the resin is rinsed with a dilute sulfuric acid solution to decompose the silver thiosulfate to silver sulfide, which remains in the ion exchange column. The resin is reused for many cycles and is then incinerated to recover the silver accumulated in it.

Ion exchange should not be used for recovering silver directly from silver-rich fixer solution.

These concentrated thiosulfate solutions will strip silver from the resin, and can actually result in *more* silver being

Ion Exchange Column



discharged from the resin column than is present in the feed solution. Ion exchange, therefore, 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 a single-column system. Two-columns used in series can provide 99 percent silver removal efficiency.

G.2 Operation/Maintenance

Converting equipment to incorporate in-line silver recovery greatly reduces the silver content of the final wash water. Ion exchange technology is most effective when used in conjunction with an in-line silver recovery unit for the preceding fixer solution.

Factors affecting the efficiency of ion exchange include: thiosulfate concentration, flow rate, and biological growth control.

a. Thiosulfate concentration

The capacity of the resin to retain silver is very dependent on the concentration of thiosulfate in the influent. The higher the thiosulfate, the lower the capacity. That's why ion exchange is not recommended for recovering silver from fixer. These solutions are high in thiosulfate.

If you operate under such severe discharge restrictions that you must use ion exchange to recover silver from silver-rich solutions, two steps are required:

1. desilver the silver-rich solutions through an electrolytic unit, and

2. meter the desilvered solutions into the collected wash water overflow at a rate not exceeding their replenishment rate.

These procedures will reduce the silver concentration prior to ion exchange and ensure the thiosulfate levels are controlled.

b. Flow rate

The low-silver solutions must be metered through the ion exchange columns at a prescribed rate in order to allow for the exchange between the silver and the resin to occur. Generally, this should never exceed 1 bed volume of resin/minute.

c. Biological growth control

Algae, bacteria and fungi grow quite readily in ion exchange columns and feed on the dilute film processing chemicals. This growth causes two problems: 1) it forms a film on the resin beads, thereby blocking the silver exchange reaction, and 2) it obstructs the flow of solution through the column.

To eliminate the problem of biological growth, the ion exchange column(s) must be flushed routinely with biocide.

Appendix F
Testing for Silver

You should routinely monitor your silver recovery system to make sure it's operating correctly. There are two different testing methods recommended: approximations utilizing test papers are performed frequently, and exact analytical testing is performed every three months, six months or annually, depending on the size of the diagnostic or industrial X-ray film processor.

H.1 Silver-Estimating Test Papers

Silver-estimating test papers are used to provide only an *approximation* of how much silver is in a solution. The test strips are coated with yellow cadmium sulfide that forms brownish-black silver sulfide when it comes into contact with silver. The higher the concentration of silver in solution, the greater amount of brownish-black silver sulfide will be formed. The color formed on the test strip after it has been in solution, therefore, reflects the amount of silver contained in that solution.

Generally, the procedure for using the test strips is as follows:

1. Dip the test strip in the sample solution for two (2) seconds so that the strip is properly wetted.

2. Remove the test strip from solution, shake off any excess liquid, and place the strip on a white card.

3. After about 15 seconds, compare the color of the moist test strip with the color key provided with the test strips. Find the color that most closely matches. That is approximately the concentration of silver in solution.

4. When evaluating a solution that has color, such as seasoned fixer, rinse the test strip briefly under running water toward the end of the 15-second waiting period. Take the color of the solution into consideration when you're making the comparison with the color key.

A typical color key scale is shown below. As you can see from the scale of numbers ranging from 0 to 10 g/L* (0 - 10,000 mg/L), the silver readings are only approximations of the actual silver in solution. Note that the lowest detection point is 0.5g/L or 500mg/L (500 ppm).

Silver Content of Film Processing Solution									
Grams per Liter	0	0.5	1	1.75	2.5	3.5	5	7	10
Comparison Color Patches									

The test strips are helpful in *estimating* the amount of silver in the solution exiting the silver recovery system. Once the solution has gone through primary silver recovery, the concentration of silver should be below

* Silver-estimating papers are generally scaled in grams per liter (g/L) rather than parts per million (ppm). Remember: mg/L and ppm are the same measurement.

the 500 mg/L (ppm) mark. Since the lowest range on the silver-estimating test papers is 500 ppm, you should see no color change on the paper. **These papers are only useful for finding major problems with the silver recovery system.**

For example, if you are using metallic replacement cartridges, you should test the cartridge effluent using test strips to determine the presence of silver. **The effluent should be below 500 ppm and therefore, not change the color of the test strip.** The only thing you've learned from testing the effluent with a test strip is that there are no major problems with the metallic replacement cartridges. Periodically, use a more exacting measurement to verify the percentage of silver the system is recovering.

H.2 Analytical Testing

Only an exact analytical measurement using EPA protocols can verify whether the silver recovery system is achieving a specific percentage recovery. Use an outside analytical laboratory to analyze the solution samples.

You may obtain a sample bottle and instructions from a suitable analytical laboratory. Generally, fill the bottle with a sample of the solution to be analyzed and bring the bottle to the laboratory. When they have finished the procedure, the analytical laboratory will report the results of the analysis to you.

Your best source of information concerning your sampling procedures and techniques is the analytical lab that's doing your work. Work with them closely to get your best results. Following are some general considerations for sampling:

a. Sample containers

- Obtain appropriate containers from the analytical laboratory. Don't use glass because silver precipitates more easily on the wall of a glass container.

- Make sure the laboratory knows that you are specifically testing for silver so they provide you with the correct size and type of container.

b. Sample preservation

- Tell the analytical laboratory NOT to use a nitric acid preservative with the sample. Nitric acid precipitates the silver out of solution, thereby providing an artificially low silver reading.

- Return the sample to the analytical laboratory as quickly as possible to avoid any change in the make-up of the sample.

c. Sampling methodology

- If you are asked to perform the sampling yourself, use the protocols specified by the analytical laboratory.

- Make sure that none of the equipment you are using to collect the sample has been contaminated with another solution or material.

d. Analytical test methods

There are two EPA-approved methods the analytical laboratory can use to detect silver in the sample:

1. Inductively coupled plasma spectroscopy (ICP)

2. Atomic absorption (AA)

Either test will provide the same result.

Appendix G
Forms

Film Processor Inc.*

SPILL CONTINGENCY PLAN

Spill Response Personnel

Name	pager/phone
Name	pager/phone
Name	pager/phone

Environmental Emergency Phone **(999) 999-9999** 24 hours a day 7 days a week

EQUIPMENT REQUIRED

- **Gloves**
- **Apron**
- **Goggles**
- **Bucket**
- **Mop**
- **Sponge**
- **Absorbent Materials**

SPILL RESPONSE PROCEDURES

1. Put on gloves, goggles and an apron.
2. Contain the spill with a mop or absorbent materials available.
3. Check the appropriate material safety data sheet (MSDS) for special handling, ventilation, personal protection or other pertinent data.
4. Clean up the spill, as directed, using generous amounts of water.
5. Use the mop and sponge to clean the area thoroughly.
6. Package and label all contaminated absorbent materials for off-site disposal.
7. Notify the supervisor or manager that a spill has occurred.
8. (If required) Notify the appropriate government agency that a spill has occurred.

* This plan will not meet the requirements in all states, including California.

Worksheet for Screening Options

Date ________

Option: ____

1. **What is the potential for reducing waste and providing other environmental benefits?**

2. **What is it going to cost in time and materials?**

3. **How much money will it save in time and materials?**

4. **How difficult is it to implement?**

Pollution Prevention Plan Worksheet Date _______

Option or activity: ____________________

Implementation date: ____________________

Responsibility: ____________________

Record: ____________________

Pollution Prevention Plan Worksheet Date _______

Option or activity: ____________________

Implementation date: ____________________

Responsibility: ____________________

Record: ____________________

Worksheet for Evaluating P2

Date _______

Option: ____________________

1. Waste reduction results ____________________

2. Costs ____________________

3. Savings ____________________

Worksheet for Evaluating P2

Date _______

Option: ____________________

1. Waste reduction results ____________________

2. Costs ____________________

3. Savings ____________________

Appendix H
Assumptions for Size Category

The Chart on page 5, entitled *Size Category Based on Type and Quantity of Film Processed Daily,* was created using the assumptions listed below. If your situation doesn't fit the assumptions used here, please consult with your suppliers and service providers to establish your category.

Dental

- The average daily run is 20 - 30 intraoral or extraoral films.
- The replenishment rate for both the developer and fixer is 10 ml per film. This is 0.00264 gallons per film.
- The wash water rate is 1.33 gallons per film.

General Purpose

- The average daily run is 50 - 100 sheets of intermixed size general purpose films.
- The fixer replenishment rate is 85 ml per film. This is 0.0224 gallons per film.
- The developer replenishment rate is 65 ml per film. This is 0.0172 gallons per film.
- The wash water rate is 1 gallon per minute.
- The process cycle time is 90 seconds.

Mammography

- The average daily run is 60 - 150 sheets of intermixed size mammography films.
- The fixer replenishment rate is 30 ml per film. This is 0.00792 gallons per film.
- The developer replenishment rate is 27 ml per film. This is 0.007124 gallons per film.
- The wash water rate is 1 gallon per minute.
- The process cycle time is 150 seconds.

Industrial X-ray (Nondestructive Testing)

- The film size is 14" x 17"
- The fixer replenishment rate is 180 ml per film. This is 0.0475 gallons per film.
- The developer replenishment rate is 96 ml per film. This is 0.0253 gallons per film.
- The wash water rate is 4 gallons per film.
- The process cycle is 12 minutes.