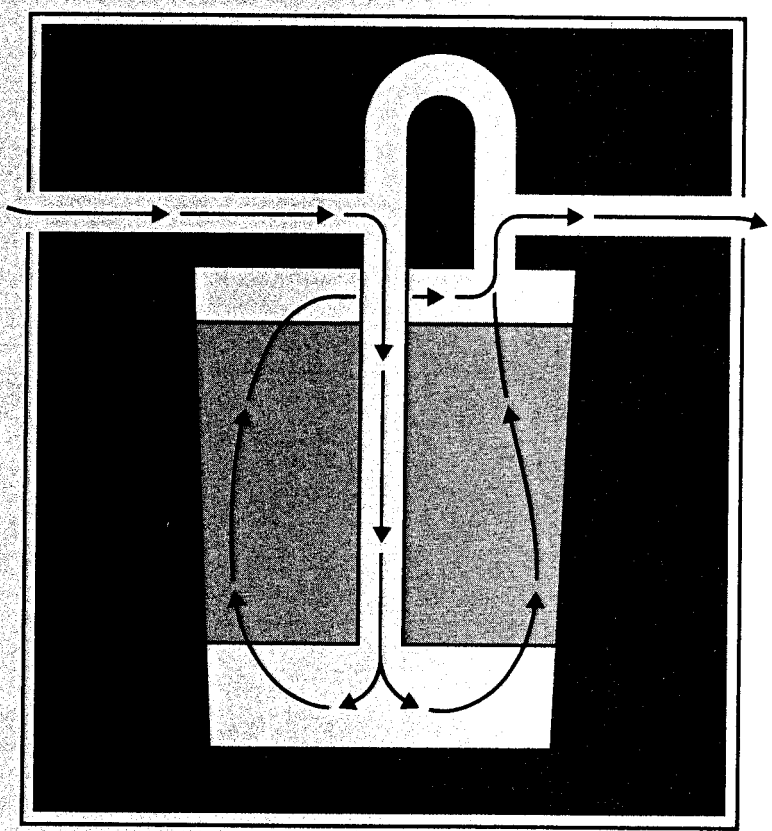
SILVER RECOVERY

with the

KODAK CHEMICAL RECOVERY CARTRIDGE, TYPE P



Introduction

The recovery of silver represents a valuable source of revenue for the photographic processor. This is particularly true with the current high silver prices. In addition, the enactment of new environmental laws by local, state, and federal governmental agencies has resulted in discharge limits for many materials. Heavy metals, such as silver, are some of the materials which are regulated. Silver is also one of the world's limited resources which is rapidly diminishing because of the great demands of a growing, technological society.

Silver has qualities which make it suitable for recovery and reuse. The recovery and reuse achieve all of the benefits mentioned: a profitable source of revenue, a means of achieving compliance with environmental regulations, and conservation of a valuable resource.

The KODAK Chemical Recovery Cartridge, which employs the metallic replacement principle, is designed to recover silver efficiently from used photographic fixers, bleach-fixes, certain stabilizers, and stop baths. In addition, it can be used under some conditions to recover silver from photographic wash water. Although this equipment was developed primarily for use with automatically replenished processors, it works equally well for batch- and hand-processing operations provided that sufficient quantities of a silver-bearing solution are available for treatment.

Information regarding the equipment, operation of the cartridge, installation, and silver yield is given on the following pages.

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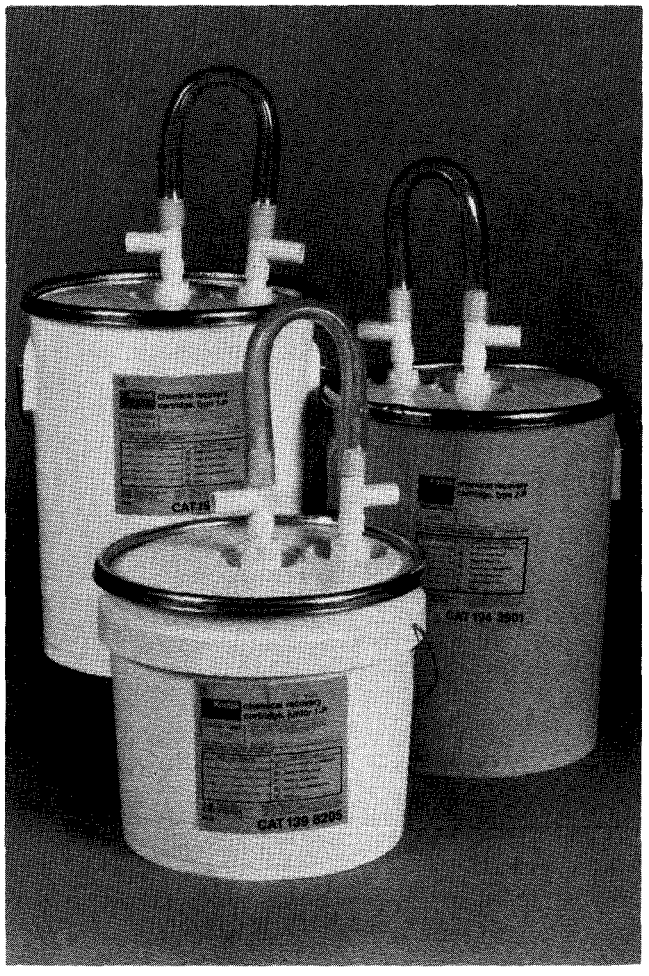


Basic Operation of the Chemical Recovery Cartridge

The metallic replacement method for silver recovery from spent solutions is based on the principle that the more active metal in the electromotive series of elements will replace a less active metal in solution. Metal ions such as those of zinc, iron, and aluminum have the ability to replace silver ions from a solution. The KODAK Chemical Recovery Cartridge employs iron in the form of steel wool to replace the silver ion of a silver thiosulfate chemical complex, which is formed in the fixing reaction of a photographic process.

The following chemical formula is a simplified expression of the chemical reactions that take place inside the chemical recovery cartridge when the silver-bearing solution comes in contact with the steel-wool filler.

$$2Ag(S_2O_3)^{-} + Fe \longrightarrow 2Ag + Fe^{++} + 2(S_2O_3)^{--}$$

Very simply stated, silver (Ag) is separated from its complex, and iron (Fe) takes the place of silver, which collects in the cartridge as a metallic sludge. Since cartridge performance and silver yield are directly affected by the successful completion of this chemical reaction, it is helpful to have an understanding of the concept involved.

If the unit fails to collect silver or the silver yield does not meet expectations, the condition may have several causes, which are discussed in the section "Factors That Affect Silver Concentration in Solutions."

Description of the Equipment

The Kodak silver recovery method employs two equipment components: the KODAK Chemical Recovery Cartridge and the KODAK Circulating Unit. These components have no moving parts or electrical connections. Except for a hose-connection adapter at the appropriate processing tank, no special plumbing is required.

This equipment can be adapted for use with practically all processing machines and processing methods. All that is needed is a controlled flow of silver-bearing solution to the inlet of the recovery cartridge and a suitable drain to which the desilvered effluent can be discharged. The cross section drawing at the right illustrates the flow of solution through the cartridge.

KODAK Chemical Recovery Cartridge, Type P: This cartridge consists of a rigid plastic container with a factory-sealed cover. The cover has two threaded openings to which the KODAK Circulating Unit, Type P, is attached.

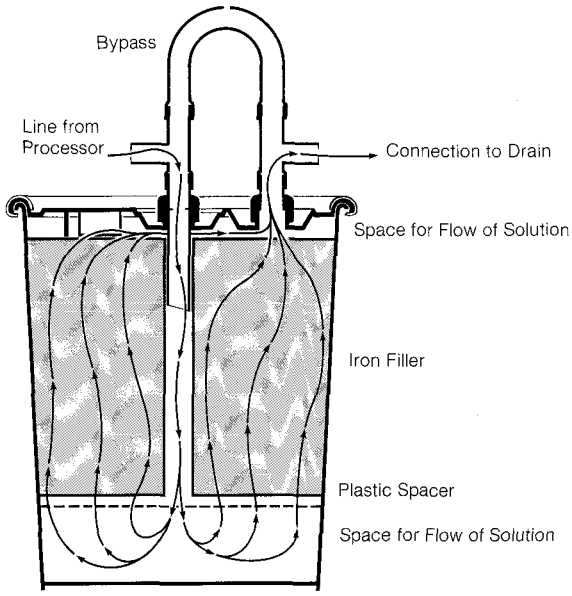
The cartridge is packed with steel wool, a material that reacts with certain metal ions in solution. When the silver-bearing solution passes through the steel wool, metallic silver is released and iron from the steel wool replaces it in the solution.

Three types of cartridges are available; two hold 5 U.S. gallons and the third holds 3½ gallons. These cartridges are used for the following conditions:

1. KODAK Chemical Recovery Cartridge, Type 1-P, has a coarse steel-wool filler (No. 2 grade) and is used for desilvering most black-and-white fixers and bleach-fix solutions.

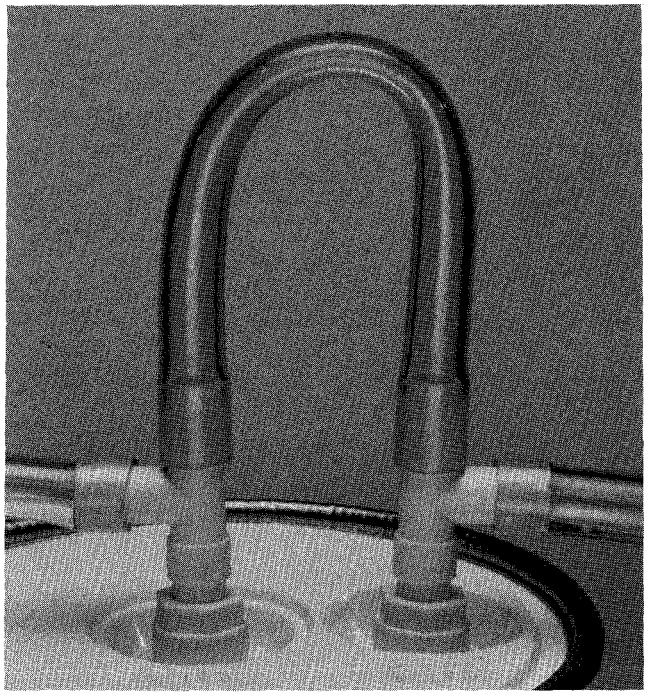
2. KODAK Chemical Recovery Cartridge, Type 2-P, has a fine steel-wool filler (No. 0 grade) and is used for desilvering color negative fixers and color reversal fixers.

3. KODAK Chemical Recovery Cartridge, Junior 1-P. This cartridge is similar to the Type 1-P and is used for desilvering the same solutions. Its smaller capacity and lower profile make it suitable for low-volume processors or for machines in which the fix tank overflow is lower than the inlet of the Type 1-P.



Cross Section of a KODAK Chemical Recovery Cartridge.

KODAK Circulating Unit, Type P: This unit consists of two plastic fittings connected by a length of tubing. It is used to direct the flow of solution from the processor or holding tank to the recovery cartridge and from the cartridge to the drain.



The circulating unit directs the flow of solution into and out of the cartridge and provides a bypass in case of blockage in the cartridge.

A bypass loop in the circulating unit allows the solution to flow directly to the drain if an obstruction forms within the cartridge. A small opening in the bypass loop provides a siphon break to prevent solution from being accidentally drained from the processor tank, or an air lock forming in the cartridge.

Approximately 4 feet of ¾-inch ID plastic tubing is supplied with the unit.

The flow rate through the cartridge should not exceed the rate given in the table of "Recommended Operating Conditions." Most automatic processors are not replenished at a rate exceeding those recommended rates. However if a holding tank is used to collect silver-bearing solution or if recovery from wash water is attempted, the flow rate must be controlled by a restricting orifice in the inlet tubing to the cartridge.

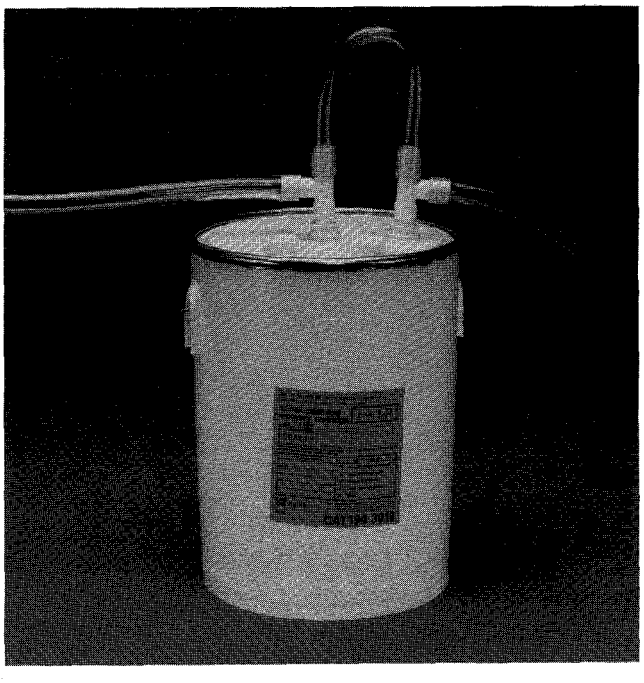
Adapter Kits: Certain fittings, which are supplied as adapter kits, are needed for some processors to connect the circulating unit to the supply of silver-bearing solution. This supply may be from the fixer tank of an automatic processor, a holding tank, a flexible container, or some other suitable receptacle.

In making the connection to an automatic processor, the point at which the fixer overflows the processor tank is where the connection should be made. The adapter kits listed in the various Kodak product catalogs contain such items as hose adapters, hose clamps, special lightproof tubing, grommets, and caps. Because of the variety of processor tank configurations and overflow designs, it is important that the appropriate adapter kit be used for a particular processor.

If the connection is to be made to a holding tank, the adapter kit consists of a bulkhead fitting, a spigot, and a restricting orifice to control the flow rate of solution.

The materials from which the adapter kits are made are inert to photographic solutions. The holding tank should also be made of such materials.

A list of adapter kits and instructions on how to order is given on page 14 of this publication.



A single KODAK Chemical Recovery Cartridge is shown with a circulating unit attached. The center opening is the outlet of the cartridge and should be connected from the cartridge to the drain. The opening near the rim is connected to the processor.

Installation Procedure

Installation of the cartridge is a very simple procedure and usually can be done in a few minutes. Some processing machines may, however, first require installation of an adapter kit. Instructions for installation of an adapter kit are included either with the adapter kit or in the processor manual. Once the adapter kit has been installed, the KODAK Chemical Recovery Cartridge is installed in the same manner for all machines:

1. Remove the KODAK Circulating Unit and the KODAK Chemical Recovery Cartridge from their cartons.

2. The carton containing the circulating unit should also contain two washers and a length of tubing. Place the washers inside the two basket nuts of the circulating unit.

3. Attach the unit to the inlet and outlet ports of the cartridge and tighten the basket nuts finger tight.

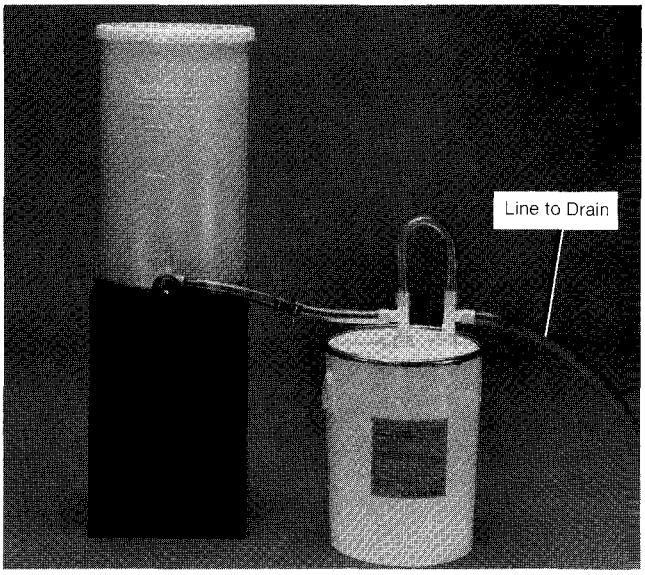
4. With a length of ¾-inch ID plastic tubing, attach the overflow outlet of the fixer or bleach-fix tank to the inlet of the circulating unit (the portion connected to the cartridge port labeled "in").

5. For a single cartridge installation another length of ¾-inch ID plastic tubing is connected to the outlet side of the circulating unit (the portion connected to the cartridge port labeled "out"). The unconnected end of the tube is then run to a drain.

Installation for Batch Solution Recovery: When the processing solutions are discarded in part (or as entire tank or tray changes), install the recovery system as illustrated above right. Use a receiver tank for the processor solutions. The size of the tank is dependent on the amount of solution handled each day, but a tank capacity of less than 5 gallons is not recommended. A 7- or 14-gallon KODAK Chemical Storage Tank is suggested. A device to restrict flow must be used to control the rate of solution flow from the tank to the circulating unit. This device must have a hole no larger than 1/16 inch in diameter, and it must be held in position in the line with two hose clamps.

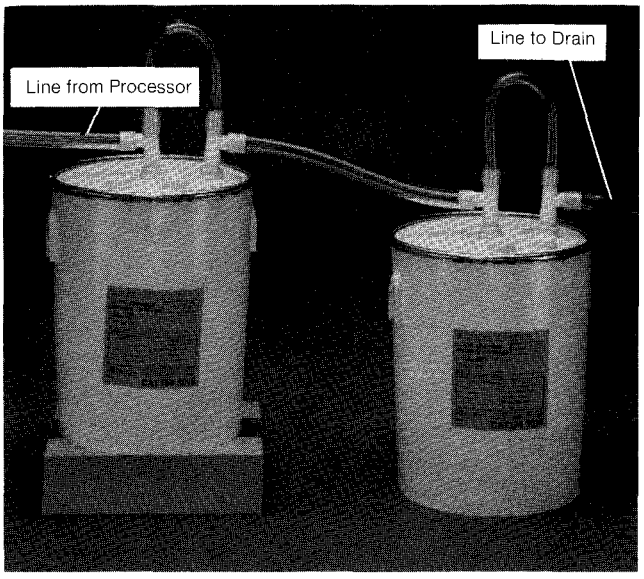
To facilitate an installation of this type, Adapter Kit No. K-2695 should be used.

Installation for Multiple Cartridge Applications: Because the chemical recovery cartridge relies on gravity feed to move solution through the cartridge, a small platform about 4 inches high will be needed to raise the first of the two cartridges in the series as shown below. Take care that the first cartridge is not placed higher than either the overflow of the processing tank or the outlet from a holding tank, if one is used.



A KODAK Chemical Recovery Cartridge being fed from a raised holding tank. The tank outlet should be placed slightly higher than the inlet of the circulating unit as shown.

Another circulating unit is required for the second cartridge. The inlet side of this unit is connected directly to the outlet T-fitting of the first circulating unit. Then, the outlet from the second unit is connected to a suitable drain.



These two cartridges are connected in series. The cartridge on the left is in the No. 1 position and is connected to the processor. The cartridge on the right is connected to the drain. The left-hand cartridge is raised to maintain gravity flow.

Multiple Cartridge Applications

The single cartridge applications suggested in the table of Recommended Operating Conditions will remove 95 percent of the silver passing through the cartridge under normal conditions. The current price of silver makes it economically advantageous to use two cartridges in series where a single cartridge is considered adequate, however. While the yield per cartridge may be lower, the total amount of silver recovered by both cartridges will exceed that of a single cartridge installation. Note that where the table recommends two cartridges in series this type of installation is not an option but is necessary for efficient silver recovery.

The following are other specific processing situations where multiple cartridge installations are beneficial.

Excessive Flow Rate: If the flow rate of the solution passing through the cartridge exceeds that given in the table of "Recommended Operating Conditions," the solution will not remain in contact with the steel wool long enough for the desilvering reaction to take place. As a result, silver will be lost to the drain. By installing a second cartridge in series with the first one, the solution has effectively twice the time to react with the steel wool and desilvering will be more complete.

When the first cartridge in the series is exhausted, remove it and transfer the second cartridge to the No. 1 position. Then, place a fresh cartridge in the No. 2 position. In this application, the silver estimating test paper will be a more useful guide to cartridge condition than relying on the capacities given in the table of "Recommended Operating Conditions." This is because a quantity of desilvered solution from the first cartridge has passed through the second one. How much steel wool has been consumed in this way is difficult to estimate. The desilvering capacity of the second cartridge operating in the No. 1 position may be slightly lower than that of a fresh cartridge.

Backup Insurance: With installations serviced by dealers, their service personnel may not be on hand at exactly the right time to change the cartridge and prevent silver-bearing solution from being wasted. In a case such as this, two cartridges in series would provide backup capacity if the first cartridge were not changed in time.

In this application of the two-cartridge setup, testing is not usually carried out. The replacement cycle is often governed by the serviceman's schedule or by the amount of solution that has been treated. However, some kind of routine for changing the second cartridge should be established. The second cartridge should be changed when three or four cartridges in the No. 1 position have been exhausted. Experience will indicate when this should be done. This second cartridge may not contain as much silver as the first cartridge, but its use makes sure that little or none has been lost. Each of the cartridges used in the No. 1 position can be expected to yield the amount of silver that is normal for the particular installation.

Reducing Silver Content of Effluent: In a reasonably well managed two-cartridge installation, the concentration of silver in the effluent from the second cartridge may be as low as 20 milligrams per litre. Lower concentrations have been achieved, but only under the most favorable conditions. At these concentrations, sewer code requirements can more easily be met, especially when combined with other silver-free effluents.

In reducing the silver content of effluent to very low levels, test the first cartridge regularly with silver estimating test papers using the method described in KODAK Publication No. Z-98, *Getting More From Color-Process Monitoring With Chemcal Control Techniques.* As the exhaustion point is reached, remove the first cartridge and replace it with the second cartridge. Then, place a fresh cartridge in the No. 2 position. Since the purpose of this application is to achieve a very low level of silver in the effluent, periodic tests of the effluent from the second cartridge should be made by laboratory analysis.

Removal of Silver from Wash Water and Mixed Bleach-Fix and Wash Water: The metallic replacement principle is suitable for recovery of silver from wash water or mixed bleach-fix and wash-water effluent. The Type P cartridges are not recommended for his purpose, however, since the plastic container is not designed to withstand the pressure resulting from the higher flow rates of wash waters. Instead, use a KODAK Chemical Recovery Cartridge, Type 3. The Type 3 cartridge uses a steel drum container which holds 15 gallons. More detailed information about this cartridge is contained in KODAK publication No. J-9A, *Silver Recovery with the KODAK Chemical Recovery Cartridge, Type 3.*

The success of this application depends on the amount of silver in the wash water and on proper control of the flow rate. By treating wash water in this manner, it is possible to reduce the silver concentration in the effluent to less than 1 mg/L.

Chemical Recovery Cartridge Tailing an Electrolytic Recovery Unit: In processing installations where an electrolytic silver recovery unit is used, it may be economically feasible to install a chemical recovery cartridge as a tailing or secondary device to recover most of the silver that escapes the electrolytic process. The electrolytic unit functions in a similar manner to the first cartridge in a multiple-cartridge installation. The comments given apply whether the electrolytic unit is operating in the terminal or the recirculation mode.

The economics of this application should be determined by evaluating the silver content of the effluent treated by the electrolytic recovery unit. Variations in the processor work load throughout the operating day may result in silver input rates that exceed the capacity of the electrolytic unit. There may be lengthy periods, therefore, when the tailing cartridge will recover a considerable amount of silver.

Aside from economy, the tailing cartridge has possibilities as an aid in effluent management. If the intent is residual silver removal from an effluent at relatively low cost, the inclusion of a chemical recovery cartridge as a tailing unit may be justified.

Changing the Chemical Recovery Cartridge

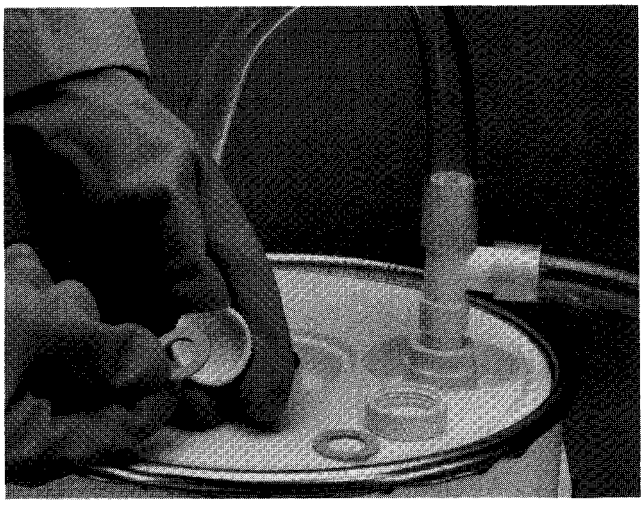
When tests indicate that the cartridge is exhausted, install a new one by following this procedure:

1. Choose a time when the processor will not be in operation, because if the processor is operating when the cartridge is disconnected, spillage will result from the replenishment of the processor tank.

2. Open the carton containing the new cartridge and remove the two plastic caps from the top of the

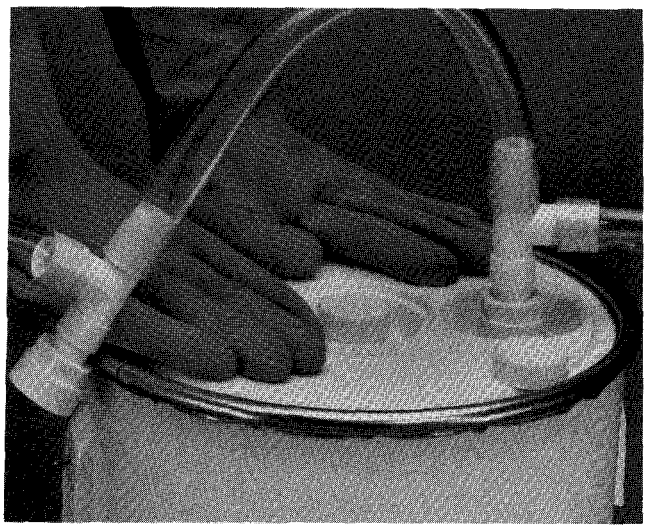
Remove the plastic caps from the new cartridge.

cartridge. Remove the flat washers from inside the caps and set these aside. Lift the supply hose to drain any solution it contains into the cartridge. Disconnect the supply side of the circulating unit first. Then, cap the inlet side of the used cartridge, using the *old* washer from under the basket nut of the circulating unit fitting and one of the new caps from the fresh cartridge.



Remove the washers from the caps from the new cartridge.

3. To pump solution remaining in the circulating unit into the drain hose, press firmly but slowly on the cover of the used cartridge. Be sure that solution does not back up through the bypass loop and spill onto the floor.



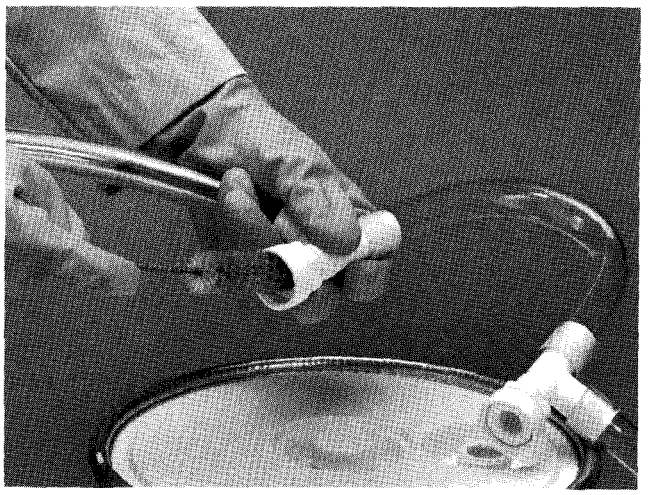
Press down firmly to pump out the solution in the circulating unit.

4. To absorb possible spillage, place some waste cloth or paper on the floor. Disconnect the circulating unit from the outlet side of the cartridge. Again, use the *old* washer from the outlet side of the circulating unit and the other *new* cap to close the outlet of the used cartridge.

Disconnect the circulating unit from the outlet side of the cartridge.

5. Remove the new cartridge from its carton and replace it with the used one. Set this aside for shipping preparation.

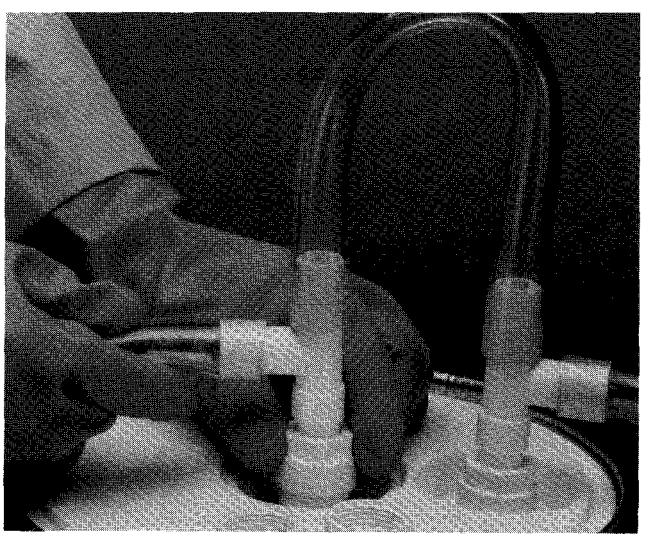
6. Before connecting the new cartridge, examine the T-fittings in the circulating unit for dried chemicals or other obstructions. These can be removed simply with a bottle brush or a similar tool.



Clean the T-fittings of the circulating unit.

7. Locate the new cartridge under the circulating unit. Use the *new* washers to reconnect the circulating unit. Make sure that the center hole in the cartridge cover is connected to the inlet side of the circulating unit. Also, make sure that the washers are correctly placed in the basket nuts; otherwise, leakage may result.

In tightening the basket nuts on the circulating unit, finger tightening only should be sufficient. Tightening with a wrench may split the nut, and then the entire T-fitting on the circulating unit would have to be replaced.



Tighten the basket nuts only finger tight.

Monitoring the Chemical Recovery Cartridge with *Kodak* Silver Estimating Test Papers

These paper strips are impregnated with a chemical substance that changes color according to the amount of silver present in the solution. The test papers are supplied with a color step chart for estimating by color comparison the approximate silver content of a solution.

To test the effluent from the cartridge, cut a small slit in the top of the plastic drain line near the outlet fitting of the circulating unit. Insert a single test paper strip in the solution flow for a few seconds. Withdraw the strip and shake off any excess liquid. After about 15 seconds, compare the moist strip with the color step chart. If the test indicates a concentration of silver greater than 1 gram per litre, the cartridge should be replaced.

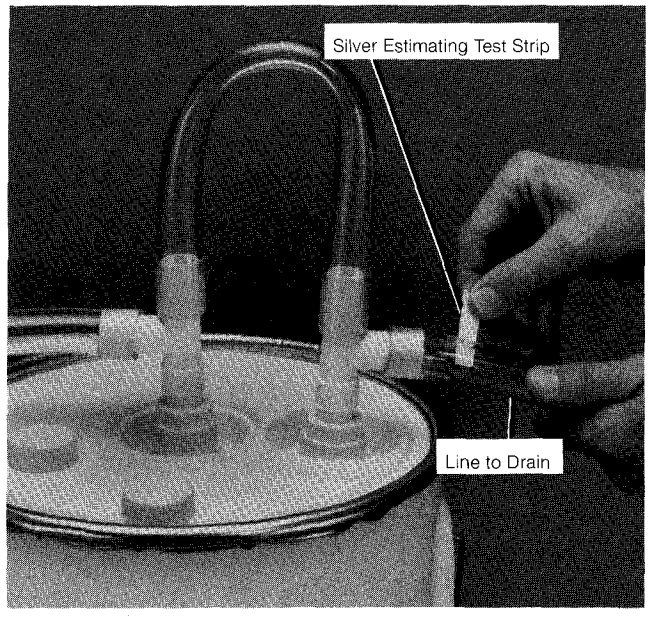
Test the effluent from each cartridge daily to be sure that the cartridge is functioning properly and that excessive amounts of silver are not being lost to the drain. Based on the volume of solution processed by the cartridge, as indicated by the table of "Recommended Operating Conditions," it may be appropriate to make the test daily or perhaps more frequently as the cartridge nears the exhaustion point. After some experience with a particular installation and its operating conditions, the user will be able to judge the frequency with which the tests should be made.

To avoid the possibility of a misleading test result, always make the test after the processor has been processing sensitized material for a reasonable period, say, 1 hour. This precaution will make sure that the solution being tested has not been standing in the cartridge for a number of hours. Such solution would not be representative of that leaving the cartridge under operating conditions, and therefore the test would be invalid.

With this method, silver estimating test papers are only sensitive for measuring silver concentrations greater than 1 gram per litre.

To measure the lower silver concentrations found in wash waters, the test paper should be soaked for 1 hour. A wash with 10 mg/L of silver will significantly darken the test paper, while a wash water with 0.5 mg/L will cause no more than a barely perceptible darkening.

These methods are discussed in greater detail in KODAK Publication No. Z-98, *Getting More From Color-Process Monitoring With Chemical Control Techniques.*



In this illustration, the desilvered solution is being tested with silver estimating test paper.

Useful Life of the Cartridge: As steel wool is consumed, there will be a time when the cartridge no longer removes silver from the solution. This condition assumes that all of the steel wool is used up. However, extensive experience and laboratory testing have indicated that when approximately 85 percent of the filler material has been consumed, the cartridge no longer operates efficiently, and a significant amount of silver may pass to the drain. The cartridge, therefore, is considered exhausted before the steel wool is completely used up. It is preferable to waste some steel wool rather than to allow partially desilvered solution to be lost.

The practical exhaustion point is reached when the effluent from the cartridge contains about 1 gram per litre of silver as determined by the use of silver estimating test papers.

Intermittent or infrequent use of a chemical recovery cartridge causes conditions under which the steel-wool filler oxidizes, or rusts, just by standing in a solution such as a fixer. Since rust is not a suitable material for the chemical reaction necessary to precipitate silver, less iron is available for the reaction. The silver yield from the cartridge, therefore, will be less than would normally be expected.

Because conditions of use vary greatly, no specific time can be given for the useful life of a cartridge used intermittently. To be sure that the unit is operating properly, it should be monitored at appropriate intervals with silver estimating test papers, as described in the previous section.

If a cartridge is used over a long period of time a layer of rust can occur which may exert sufficient pressure on the side of the cartridge to cause it to split. This may occur anytime during a 6- to 10-month period, depending upon use. If a ridge or bulge appears on the side of the cartridge the recovery cartridge should be replaced. This condition is not dangerous but will create a cleanup problem should the split occur.

Determining the Potential Yield: A simple method for determining the amount of silver that a recovery system should yield is based on multiplying the silver concentration of the solution entering the recovery cartridge by the volume of solution being treated. For example, if the average concentration of silver in the solution is ½ troy ounce per gallon and 200 gallons of solution are treated, the potential recovery is 100 troy ounces of silver.

Under controlled laboratory conditions, somewhat more than 95 percent of this potential has been recovered; however, under ordinary processing conditions, a more realistic figure would be about 85 percent with good maintenance. With poor maintenance, the amount will, of course, be less.

The capacity of the KODAK Chemical Recovery Cartridge is limited by the flow rate of solution through the cartridge. Most recommended flow rates do not exceed 300 mL per minute, a figure which is within the range of replenishment rates for practically all processors with automatic replenishment systems. For recommended flow rates, refer to the table "Recommended Operating Conditions."

The silver yield that a user can expect from a chemical recovery cartridge depends on three factors: (1) the concentration of silver in the solution being desilvered, (2) the volume of solution treated, and (3) the efficiency of the recovery installation.

If the expected yield is not realized, one or more of the conditions discussed in the section "Factors That Affect the Silver Concentration in Solutions" are probably responsible for the deficiency.

Factors That Affect Silver Concentration in Solutions:

Type of Film Being Processed: the silver content of photographic emulsions varies with the type of film. For example, the thin-emulsion films used in the graphic arts industry contain less silver than double-coated x-ray films and therefore will yield less recoverable silver. In processing color films, all of the silver is removed by the fixer to yield a dye image, and so nearly all of the silver is available for recovery.

Exposure Level: In processing black-and-white materials, the ratio of exposed and developed silver to soluble silver halide has a considerable influence on the amount of recoverable silver in the fixing bath. This ratio depends largely on subject matter. For example, if negatives of a line drawing on white paper are processed, the emulsion contains a large proportion of exposed and developed silver and a small proportion of soluble silver halide. On the other hand, if positives of the same drawing are processed, the emulsion contains a small proportion of exposed and developed silver and a high proportion of soluble silver halide. The positive-line image, therefore, yields much more recoverable silver than the negative image since less silver is retained in the film.

Processing Work Load: The quantity of material processed in a solution is, of course, a major factor affecting the amount of silver in that solution. Processing work loads vary considerably in many operations, and the load often peaks at certain periods during the working day. If the flow rate at these periods is greater than the recovery unit can handle, silver will be lost to the drain.

Replenishment Rate: In processing systems that require replenishment, always observe the recommended replenishment rates. Overreplenishment dilutes the silver-bearing solution going to the recovery cartridge and so results in a lower silver yield than expected. The cartridge becomes exhausted by the passage of solution with a low silver content. Silver is not lost by overreplenishment, but the cartridge requires more frequent replacement and replenisher solution is wasted as well.

Solution Carryout: Varying amounts of silver-bearing solution are carried out of the processing tank on the surfaces of the photographic material. This solution is not available for silver recovery by the cartridge. Factors that affect solution carryout are machine speed and film area, as well as the incorrect adjustment or absence of squeegees and drive belts. Under normal circumstances, the volume of solution that may be carried out varies between 3 percent and 15 percent of the replenishment rate. Use of squeegees is an effective means of minimizing solution carryout.

Obstruction of Solution Flow: If the solution going to the cartridge contains an abnormal amount of solid precipitates or gelatinous matter, the steel-wool filler acts as a filter and eventually obstructs the passage of solution. The solution is then diverted through the bypass loop of the circulating unit and is discharged to the drain untreated.

Channeling: Solution may pass through a cartridge untreated when a vertical channel forms in the steel-wool filler. This channel is usually caused by low-volume or intermittent usage of the recovery unit. Channeling occurs as a result of solution dripping onto one place in the steel wool. Solution travels down through the vertical channel and out of the cartridge to the drain. Since most of the solution does not pass through the steel wool, very little of the silver is recovered.

This condition can be prevented by prefilling the cartridge when the cartridge is first installed. Water may be used if the effluent from the cartridge is going to the drain. If the solution is to be regenerated, as may be the case with the bleach-fix, then the cartridge should be filled with bleach-fix to avoid dilution of the bleach-fix.

Flow Rate: If silver-bearing solution flows through the cartridge too quickly, it does not remain in contact with the steel wool long enough for the desilvering reaction to occur. How much silver is recovered and how much is lost therefore depends on the flow rate. See other comments on excessive flow rate under "Multiple Cartridge Applications."

Incorrect Type of Recovery Cartridge: Two different types of cartridges are available for different applications. The KODAK Chemical Recovery Cartridge, Type 1-P, contains a coarse grade of steel wool and is for general purposes. The KODAK Chemical Recovery Cartridge, Type 2-P, contains a finer grade of steel wool, which is necessary for desilvering certain solutions. Fine steel wool presents a larger surface area to the solution than does the coarse type. For the proper applications of the cartridges, refer to the table of "Recommended Operating Conditions."

Incorrect Installation: If tests indicate that silver is not being recovered by a fresh cartridge, check to make sure that all hose connections to the recovery unit have been made properly and that the appropriate processor tank is connected to the inlet side of the circulating unit.

Chemical Condition of the Fixing Solution: If the fixer has been overworked or underreplenished, the fixing reaction will be incomplete, and some soluble silver will be retained in the processed material. Moreover, if the hardening capability of the fixer has been impaired either by exhaustion or excessive carryover of developer, the emulsion may be unusually soft. As a result, an abnormal amount of silver-bearing solution is carried out of the processor tank. In either case, some silver is carried away by the photographic material and is, therefore, not available for recovery.

pH of the Fixer: For the most efficient operation of the metallic exchange method of silver recovery, the solution passing through the cartridge should be acidic—specifically, within the range 4 to 6.5 pH. The acidity of most photographic fixers is within this range. Acidity of the silver-bearing solution is necessary for the continuous etching of the steel-wool surfaces so that fresh metal is presented to the solution continuously. If the solution is too acidic—below pH 4—the etching reaction is too rapid, and the steel wool will be depleted prematurely. If the solution becomes neutral or alkaline—that is, if the pH rises above 6.5—the necessary etching of the steel-wool surfaces slows down, and the silver/iron exchange reaction is reduced accordingly. Then, the solution will be only partially desilvered and the residual silver will be lost to the drain.

An exception to the pH range is bleach-fix solutions which have a pH between 7.2 and 7.8. The solution will be desilvered properly at this pH because of the presence of other components not normally found in conventional fixers.

Recommended Operating Conditions

SILVER RECOVERY FROM USED FIXER, BLEACH-FIX, AND STOP BATH SOLUTIONS, USING THE *KODAK* CHEMICAL RECOVERY CARTRIDGE

Type of KODAK Solution from Which Recovery Is Made	Type of Cartridge Recommended	Cartridge Capacity for Maximum Efficiency		Maximum Flow Rate for Maximum Efficiency (mL/min)
		Gallons	Litres	
Ammonium Thiosulfate Fixer (pH 5.5)	2-P	375	1420	300
Ammonium Thiosulfate Fixer (pH 6.5)	2-P	220	830	300
Color Film Liquid Fixer and Replenisher	2-P	220	830	300
Fixer and Replenisher, Process E-6	1-P①	150	570	500
EA-5 Fixer and Replenisher		Not Recommended		
EKTACHROME Movie Fixer and Replenisher	2-P	100	380	300
EKTAFLO Fixer	1-P①	220	830	300
EKTALINE 200 Stabilizers	1-P①	200	760	300
EKTALINE Stop Bath	1-P①	200	760	300
EKTAMATIC Stabilizers②	1-P①	160	610	500
EKTAPRINT R-100 Bleach-Fix and Replenisher, Type 1	Two Type 1-P in series	120	455	700
EKTAPRINT 2 Bleach-Fix and Replenisher	Two Type 1-P in series③	150	570	700
EKTAPRINT 2 Bleach-Fix and Replenisher NR	Two Type 3 in series④			
Fixer	1-P①	220	830	300
FLEXICOLOR® Fixer and Replenisher	2-P	220	830	300
FLOMATIC Stop Bath and FLOMATIC Fixer and Replenisher Combined⑤	1-P	350	1325	300
HI-MATIC Stop Bath and Replenisher and HI-MATIC Fixer and Replenisher Combined⑤	1-P①	350	1325	300
INDUSTREX Fixer and Replenisher	1-P①	220	830	300
INDUSTREX Instant Stabilizer②	1-P①	160	610	300
KODAFIX Solution	1-P①	220	830	300
ME-4/ECO-3/VNF-1/RVNP Liquid Fixer and Replenisher	2-P	375	1420	300
Microfilm Fixer and Replenisher	1-P①	220	830	300
ROYALPRINT Fixer	1-P①	200⑥	760	300
Rapid Fixer	1-P①	220	830	300
DACOMATIC DN-3/DR-5 Fixer and Replenisher	1-P①	160	610	300
PROSTAR Fixer②	1-P①	200⑥	760	300
RP X-OMAT Fixer and Replenisher	1-P①	160	610	300
22 Fixer	1-P①	160	610	500
24 Fixer	1-P①	160	610	500
VERSAMAT Fixer and Replenisher, Type A	1-P①	160	610	300
VERSAMAT 641 Fixer and Replenisher	1-P①	160	610	300
VERSAMAT 885 Fixer and Replenisher	1-P①	160	610	300
X-ray Fixer	1-P①	220	830	300

①The Junior 1-P cartridge may be used for any application where a Type 1-P cartridge is recommended. The cartridge capacity and flow rates are ½ those given for the Type 1-P cartridge. A Type 3 cartridge may be used for all Type 1 applications. Capacity and flow rates are 3 times those given for the Type 1-P cartridge.

②Adjust pH range to 4.0 to 6.5.

③Used with the KODAK Bleach-Fix Regeneration Unit, Model 1.

④The bleach-fix effluent must be combined with the wash effluent for recovery with a Type 3 cartridge. See Kodak publication J-9A for further information.

⑤The fixer overflow should be combined with the stop bath overflow for the most efficient silver recovery.

⑥If batch replenishment is being used, thirty 5-gallon batches may be treated.

NOTE: KODAK Chemical Recovery Cartridges are not intended for use with bleach or reducer solutions or for use with black-and-white reversal film processing. Recovery of silver from Verilith or any diffusion-transfer products, such as KODAK PMT® Materials, should not be attempted since no silver is released for recovery from these processes.

Troubleshooting Chart

PROBLEM	CONDITION	CAUSE	REMEDY
Leak at connection of circulating unit and chemical recovery cartridge	Split or cracked basket nut	Basket nut overtightened, probably by using a wrench	Replace T-fitting
	Cross-threading	Circulation unit T-fitting not properly aligned	Loosen T-fitting, align circulating unit correctly, and finger-tighten nut
	Damaged or improperly seated washer	New washer from fresh cartridge not used at time of cartridge change	Replace washer carefully with new washer
		Washer not centered on flat surface of threaded nipple in cartridge cover	Replace washer carefully with new washer
Solution flowing over bypass tube	Internal blockage so that solution cannot flow through the cartridge	Blocked T-fitting on circulating unit	Remove circulating unit, examine T-fittings for foreign matter or crystallization
		Precipitate in solution has plugged steel wool	Correct chemical condition in processor. Replace plugged cartridge with new one.
		Wrong chemical recovery cartridge type installed for that particular solution	Check table of Recommended Operating Conditions in this publication and replace with correct cartridge
	Damaged core of steel-wool roll (Core is the exit path for solution.)	Cartridge was dropped or jarred heavily during use	Sometimes by using a wood dowel the path can be reopened. If unsuccessful, replace cartridge
Flooding	Solution overflowing processor tank	Solution not getting to cartridge	Check tubing and fittings between fixer tank and cartridge for kinks or foreign matter
		Cartridge inlet above processor tank outlet	Cartridge operates on gravity flow. Locate cartridge inlet below level of processor tank outlet. It may be necessary to install a pump between processor and cartridge

PROBLEM	CONDITION	CAUSE	REMEDY
Flooding (cont)	Solution overflowing from vent hole in circulating unit	Solution not flowing to drain	Check tubing and fittings between cartridge and drain for kinks or foreign matter
		Cartridge outlet below drain inlet	Cartridge operates on gravity flow. Locate cartridge outlet above drain inlet.
	Solution backing up from drain	Drainpipe stopped up	See next section on "stopped-up drain"
Stopped-up drain	Reddish black or brownish black material caking in pipe	Biological growth in drainpipe	Use algicide control on processor effluent
		Iron hydroxides formed as steel wool dissolves in the acid fixer and precipitated in an alkaline medium. This may occur if effluent is mixed with developer or other alkaline solutions (such as floor-cleaning chemicals) after entering the drain.	Use *acid-type* drain cleaner once a week
		Condition may be aggravated by drainpipe diameter, angle of slope, low volume, or flow of other waste	Separate drain or holding tank for fixer effluent
Unpleasant odors	Cartridge effluent encounters other chemicals in the drain which may release gas	Processor effluent may contain sulfur compounds which break down chemically and produce odors such as that of hydrogen sulfide.	Insert drain hose from cartridge further down drainpipe. Install drain pipe trap. Ventilate area adequately.
Cartridge leaks around cover	Solution seeps out under lip of cartridge and runs down side of container	Faulty cartridge	Replace cartridge and contact dealer or Kodak representative for adjustment instructions
Bulge in sidewall of cartridge	Defect forms around circumference of cartridge about 3 inches from bottom	Accumulation of iron oxide layer due to peculiar local usage condition	Replace cartridge
Split in sidewall of cartridge	Same as above	Same as above	Replace cartridge and contact dealer or Kodak representative for adjustment instructions

Adapter Kits

Kits are available for adapting processors and equipment such as the following:

Processor or Equipment	Part No.
KODALITH Film Processor, Model 324 KODAK VERSAMAT Processor, Model 17	K-2675
KODAK VERSAMAT Film Processor, Models 11, 11A, 11C, 411, and 317	K-2685
KODAK X-OMAT Processor, Model M5 KODAK *RP* X-OMAT Processor Models M6, M6A, and M6A-N	K-3275
KODAK *RP* X-OMAT Processor, Model M7	K-5325
KODAK VERSAMAT Film Processor, Models 5 and 75	508430
Flexible container adapter	K-3715
Chemical storage tank adapter	K-2695
KODAK ROYALPRINT Processor, Model 417	583129

Spare Parts

for KODAK Chemical Recovery Cartridges, Types 1-P and 2-P.

Part	Part No.
Plastic shipping cap	764773
Washer for cap of circulating unit	764616
T-fitting for circulating unit	764774
Restricting orifice (300 mL/min) for ¾-inch ID tubing	463114
Plastic tubing, ¾-inch ID*	760477
Pail support for 2-cartridge installation	542067
Tubing clamp (Corbin type) suitable for ¾-inch ID, 1-inch OD plastic tubing	452638
Sight glass (bleach-fix system)	527065

*Specify number of feet when ordering.

These items may be ordered through your dealer. If you have a Kodak Customer Identification Number, you may order directly from:

Eastman Kodak Company
Parts Services
800 Lee Road
Rochester, New York 14650

Telephone orders: area 716-722-2635

Kodak Information for a Cleaner Environment Publications

The following priced Kodak publications can be obtained through photo dealers, or by sending a prepaid order (including state and local taxes and $2.95 per order for handling) to Eastman Kodak Company, Department 454, Rochester, N.Y. 14650. Prices shown are suggested prices only and are subject to change without notice. Actual selling prices are determined by the dealer.

J-10
Recovering Silver from Photographic Materials
Discusses various methods of recovering silver from waste sensitized goods and used processing solutinos. 3/80 List price is $4.00.

J-53
The Use of Water in Photographic Processing
Discusses the theory of photographic washing, and explains ways of improving the efficiency of washing, as well as other water conservation techniques. 2/8 List price is $1.00.

J-54
Analysis, Treatment, and Disposal of Ferricyanide in Photographic Effleunts—A Compendium
Contains eleven comprehensive articles on various aspects of hexacyanoferrates in photographic processing wastes. 1/80 List price is $5.75.

J-55
Disposal and Treatment of Photographic Processing Solutions—In Support of Clean Water
Describes the various methods available for treating the effluent from photographic processing operations. Also summarizes the local, state and federal regulations affecting photoprocessing effluent discharges. 10/82 List price is $4.25.

Complimentary single copies of the following Kodak publications can be obtained by writing to Eastman Kodak Company, Department 412-L, Rochester, N.Y. 14650.

J-8
The Kodak Silver Recovery Program
The details of Kodak's silver recovery and refining services for users of the KODAK Chemical Recovery Cartridges are described. 9/82

J-9A
Silver Recovery with the KODAK Chemical Recovery Cartridge, Type 3
A description of this model cartridge, intended for large scale processing operations, is described in this publication. 8/80

J-10A
Potential Silver Yield from KODAK Photographic Products
A listing of potentially recoverable silver from various KODAK Film and Paper Products. Figures are included for both silver recovered during processing and silver from scrap film. 7/81

J-10B
Directory of Silver Services
Names and locations of over 200 firms throughout the United States and Canada that supply silver recovery services. 5/82

J-41
BOD_5/COD
Presents five-day biochemical oxygen demand and chemical oxygen demand values for Kodak photographic-processing chemicals. 2/81

J-47
Chemical Composition of Photographic Processing Solutions

Provides concentrations of compounds or ions in various types of processing solutions. Solution pH ranges are also given. 7/81

J-48
Glossary of Terms/Index

Lists and defines chemical, photographic, and water-pollution terms as they are used in this "Information for a Cleaner Environment" literature series. Specific publications in the series and the page numbers on which the terms are used are included in order that the reader may find a more extensive discussion of the terms. 9/78

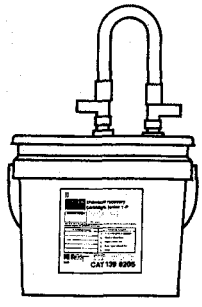
J-51
Silver in Photoprocessing Effluents

Describes the various silver compounds found in photographic processing and their effect on treatment plants and aquatic organisms. 10/80

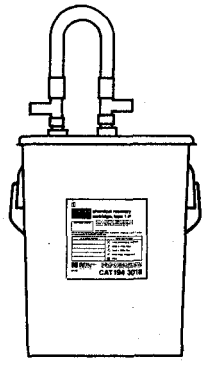
J-52
Disposal of Small Volumes of Photographic Processing Solutions

This publication contains information for the proper disposal of small amounts of photographic chemicals. 4/81

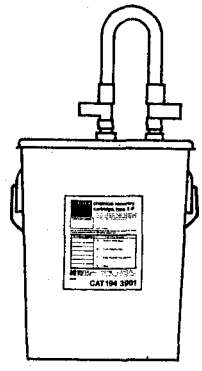
Four Different KODAK Chemical Recovery Cartridges Available



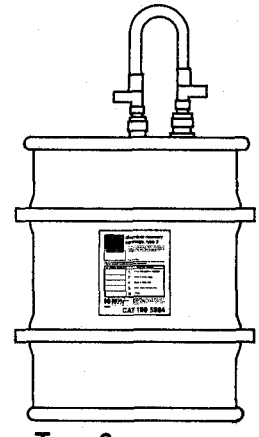
Type Junior 1-P
3½-gallon size
for bleach-fix
and B/W fixer
overall height—19″
(with bypass loop)
height to inlet—12¼″
overall width—12″



Type 1-P
5-gallon size
for bleach-fix
and B/W fixer
overall height—23″
(with bypass loop)
height to inlet—16¼″
overall width—12″



Type 2-P
5-gallon size
for color negative and
EKTACHROME Fixer
overall height—23″
(with bypass loop)
height to inlet—16¼″
overall width—12″



Type 3
15-gallon size
for bleach-fix
and B/W fixer
overall height—31½″
(with bypass loop)
height to inlet—24″
overall width—17¾″

Shown above, the complete family of Kodak cartridges. One, or more, may be best for your operation. For information, see your dealer or call your Kodak TSR.

Here are just a few of the advantages you get with a KODAK Chemical Recovery Cartridge:

Reliable. Kodak cartridges are made of quality corrosion-resistant materials and engineered for reliable, consistent performance. Kodak backs them with a warranty.

Dependable KODAK Refining Service. Users of Kodak cartridges are eligible to take advantage of Kodak's reasonably priced silver recovery service for sampling, assay, and refining.

Efficient. Kodak cartridges use a metallic replacement technology that provides one of the most efficient and practical means of silver removal in use today. Kodak recovery cartridges regularly recover 90 percent or more of the potentially recoverable silver from processing solutions.

Low Cost. The cost and operation of Kodak cartridges is very low, especially when compared with the equipment and operation used with other methods of silver recovery.

Versatile. Kodak recovery cartridges can be used to recover silver from virtually all processing machines and processing methods.

Easy Installation and Replacement. No electrical hookup is necessary, and plumbing requirements are limited to simple gravity flow to a drain. Cartridges can be installed easily or replaced in just a few minutes by just one person with no special tools or experience.

Low Maintenance. There are no moving parts. A bypass loop shows clearly if the cartridge is plugged, or operating normally. And a simple test-paper procedure shows the concentration of silver in the effluent and shows when a cartridge is exhausted and ready to be sent to the refinery.

Easier Effluent Management. Silver recovery with the Kodak cartridge helps make waste treatment a more easily managed task by reducing silver concentrations in effluent to more acceptable levels.

Secure. Sealed Kodak cartridges are serially numbered for positive identification. Also, the bulk material is not conducive to pilfering and has little value until it has been refined.

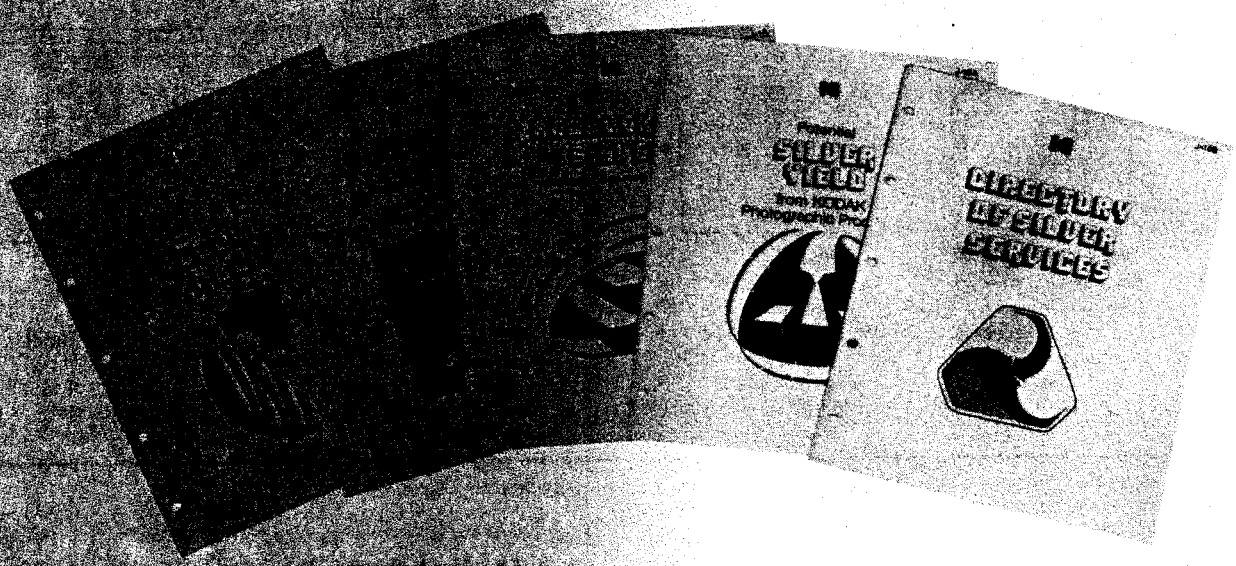
Low-Volume Application. Intermittent or infrequent use of a silver recovery cartridge can cause inefficient operation or even a malfunctioning unit. With the introduction of the Junior 1-P model, it's no longer necessary to use a cartridge with a larger capacity than you really need.

Special Applications. On certain installations involving film processor: the fixer tank overflow point is lower than the inlet to a standard 5-gallon recovery cartridge. The low-profile Junior 1-P cartridge permits the fixer to flow by gravity to the recovery cartridge, thus eliminating the need for a collection tank and transfer pump.

For More Information. Your dealer, or your Kodak TSR, will be glad to provide you with information about any Kodak silver recovery product. Or you may write to: Photographic Chemicals Markets, Eastman Kodak Company, Rochester, New York 14650.

ABOUT THIS PUBLICATION...

The KODAK Chemical Recovery Cartridge provides an inexpensive and efficient means of recovering silver from photographic solutions. This pamphlet describes the basic operation of this cartridge and its installation and application. It is intended to be the basic guide for the photographic processor using this method and equipment to recover silver in his laboratory.



OTHER *KODAK* PUBLICATIONS RELATING TO THE RECOVERY OF SILVER WHICH MAY ALSO BE OF INTEREST TO YOU.

Consumer/Professional & Finishing Markets
EASTMAN KODAK COMPANY • ROCHESTER, N.Y. 14650

Silver Recovery with the
KODAK Chemical Recovery Cartridge, Type P
KODAK Publication No. J-9

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Printed in the United States of Am