Processing KODAK Motion Picture Films, Module 15

Processing Black-and-White Films

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15 PROCESSING BLACK-AND-WHITE FILMS

INTRODUCTION

This module contains specifications describing continuous machine processing of KODAK Black-and-White Motion Picture Films. It covers cine camera and print films for negative, positive, and reversal processes. The module is in *three* sections. *Section One* outlines general information for all black-and-white films and processes. *Section Two* is dedicated to negative and positive films. *Section Three* covers reversal films. We suggest that you look over the following list of modules for color processes. They also provide useful information on black-and-white processes. Many areas of process control, analytical procedures, equipment, chemical recovery, and environmental aspects are similar for all motion-picture processes. Be sure to carefully follow all process sequences and procedures to avoid adverse effects.

Module 1	*Process Control*
Module 2	*Equipment and Procedures*
Module 3	*Analytical Procedures (for Chemical Analysis)*
Module 4	*Reagent Preparation Procedures (for Chemical Analyses)*
Module 5	*Chemical Recovery Procedures*
Module 6	*Environmental Aspects*

For More Information

For more information on motion picture products, call or write to the Professional Motion Imaging office nearest you.

Or access Kodak's home page on the Internet, web site address—

http://www.kodak.com/go/motion

You may want to bookmark our location so you can find us more easily.

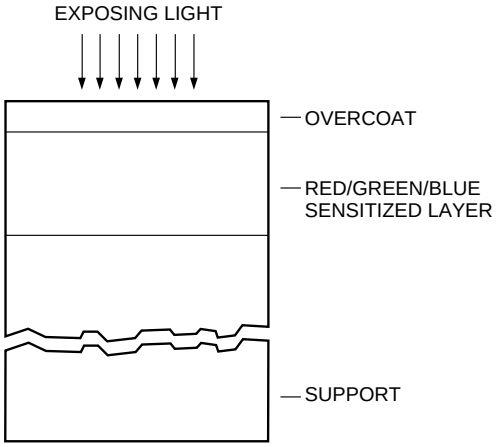
SECTION ONE—
GENERAL INFORMATION

Film Structure

All black-and-white Eastman cine camera films, and some laboratory films, have a gray antihalation safety base. The gray base reduces light piping during exposure, minimizing the halo effect and producing a sharper image. Some other films, such as print films, are coated on clear safety acetate or ESTAR Base.

Figure 15-1 is a cross section of a typical black-and-white panchromatic, motion-picture negative film on gray support. The structure of black-and-white, motion-picture print films is similar, except for fewer emulsion layers and on clear support. All Eastman Kodak black-and-white films are either panchromatic, orthochromatic, blue, or infrared sensitive.

Figure 15-1 Cross Section of Panchromatic Film



This drawing illustrates only the relative layer arrangement of panchromatic-sensitive film and is not drawn to scale.

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Spectral Sensitivity of Black-and-White Films

Panchromatic: These films are sensitive to all colors of light as well as ultraviolet radiation. Films that are panchromatic sensitive are primarily used as camera films, although there are a few panchromatic laboratory films. You must handle these films in total darkness until after they have been fixed during processing.*

Orthochromatic: These films are sensitive to ultraviolet radiation and blue and green light. They are used for sound recording and some laboratory films. They must be handled with appropriate safelights.*

Blue Sensitive: Films in this classification are sensitive only to ultraviolet radiation and blue light. They are usually used for duplicating or printing, and they require specific types of safelights for handling in the darkroom.*

Infrared: Infrared film is sensitive not only to infrared radiation, but to ultraviolet radiation and all wavelengths of visible light as well. It is least sensitive to green light. Intended primarily for technical applications (e.g., scientific, aerial, medical, etc.), it is also used for pictorial photography. Handle in total darkness until after the fixing step during processing.*

For information on the physical characteristics of Kodak motion picture films, including edge identification, perforations, and dimensional-change characteristics, as well as cores, spools, winding, and packaging, refer to KODAK Publication No. H-1, *KODAK Motion Picture Film*.

Black-and-White Laboratory Films

The production of finished black-and-white or color motion pictures requires a variety of black-and-white film products known as laboratory films. These films are necessary in most post production to complete the printing and special-effects process for the finished motion picture. Although the public is rarely aware of these products, no major black-and-white or color motion-picture production could be completed without them. Certain laboratory films are necessary for everything from special effects to the numerous duplicating steps required for all but low-budget motion pictures exposed on reversal stock. The following is a brief description of some of the black-and-white laboratory films available from Kodak for major color motion-picture and television productions. We are highlighting only the black-and-white products that are required for *color* production. For information about other black-and-white products, see the individual data sheets or contact the Kodak Entertainment Imaging Division offices listed in *KODAK LOCATIONS* on page 15-30.

EASTMAN Panchromatic Separation Film: The primary use of this film is the making of black-and-white separation positives (red, green, and blue) from color negative originals or duplicates. You can also make separation negatives from positive color masters or prints. Separations provide the best means for archival storage of the information in color motion-picture films. For example, you can print an edited color negative original, including special effects, onto separation positive film to make three separate prints—each print is a black-and-white record of one of the color layers in the original film. These three prints can be sequentially printed, in register and through the appropriate filter, onto an intermediate filmstock such as EASTMAN EXR Color Intermediate Film. Properly printed, processed, and stored, separations on ESTAR Base films can last hundreds of years.

* See the individual KODAK Film Data Sheets for safelight recommendations. Also see KODAK Publication No. K-4, *How Safe is Your Safelight?*

Another use for EASTMAN Panchromatic Separation Film is in travelling matte photography. Through a special optical-printing process, this film produces a color-difference matte that is used for very complex color optical effects. It is one of the essential ingredients of the many optical effects used in motion pictures. Process the film in KODAK Developer D-96, or if higher contrast is needed, in KODAK Developer D-97.

EASTMAN High Contrast Positive Film: A high-contrast, blue-sensitive material useful for making negative and positive titles, silhouette mattes for process work, and travelling mattes for printer light control. Process in KODAK Developer D-97.

EASTMAN High Contrast Panchromatic Film: A high-contrast, panchromatic film for the production of optical effects such as silhouettes and travelling mattes. Process in KODAK Developer D-97.

EASTMAN Direct MP Film: This is a low-speed, orthochromatic, direct-reversal film (one developer only) used for making black-and-white direct-reversal duplicates of conformed black-and-white or color print films. The black-and-white direct positive is less expensive and easier to produce than other reversal film. It is suitable for use in musical scoring, foley effects, or for editing purposes. Process in KODAK Developer D-97.

EASTMAN Sound Recording Film: A high-contrast, orthochromatic, black-and-white film for recording variable-area sound records. For use with either black-and-white or color print films. Process in KODAK Developer D-97.

EASTMAN Digital Sound Recording Film: A sound negative that allows movie makers to take advantage of six discrete channels of high-quality audio. This virtually eliminates distortion and expands the frequency range. Process in KODAK Developer D-97.

Cross-Modulation Sound Test

This is a method of measuring high-frequency distortion in variable-area photographic audio tracks of motion-picture release prints. Through measurements of distortion at various negative densities, the cross-modulation test makes it possible to choose a density that will produce prints with the best possible sound reproduction. The cross-modulation test does for the recording engineer what the light meter does for the photographer. It helps determine the proper exposure for a photographic audio track.

Ideally, a variable-area audio track would be completely opaque in the exposed areas and completely clear in the unexposed areas; the edges between the dense and clear areas would be perfectly sharp. In reality, this is not possible because photographic emulsions exhibit a degree of "image spread"—the image extends beyond the intended area of exposure. Image spread is even more pronounced with overexposure.

Image spread in the audio track distorts sound quality, especially sibilant speech sounds. The effect is minimized with controlled exposure when printing from the sound negative. Because the image spread in a properly exposed print is opposite to the image spread in the negative, properly balanced negative and print densities can effectively cancel the image-spread effect. This is where cross-modulation testing is so important. During the printing of the cross-modulation test, a series of exposures produces a variety of densities. Careful measurements of these determine which density results in minimum distortion and the best sound reproduction.

The cross-modulation test requires the following equipment: photographic recorder, cross-modulation signal generator, cross-modulation analyzer, and plotting paper. For the complete test method, obtain a copy of the SMPTE "Recommended Practice; Cross-Modulation Tests for Variable-Area Photographic Audio Tracks, RP 104-1987."

Safelights and Darkroom Illumination

We recommend loading and handling all unprocessed cine camera films and panchromatic laboratory films in *total* darkness. During the processing of negative and positive films, maintain total darkness until after the fix step. For reversal processes, maintain total darkness until after the bleach step. You can use certain safelights with black-and-white orthochromatic films and some laboratory and print films. In all cases, refer to the film data sheets for specific safelight recommendations. For additional information, see KODAK Publication No. K-4, *How Safe is Your Safelight?*

Film Storage and Handling

Store processed black-and-white film at 21°C (70°F) or lower, and 40 to 50 percent relative humidity, for normal short-to-medium term storage, up to 10 years. For extended storage, refer to KODAK Publication No. H-23, *The Book of Film Care*.

Be careful when handling all films to avoid scratches and/or dirt that will be noticeable on projection. Film handlers should use lint-free gloves and handle the film only by the edges as much as possible. Further suggestions on how to keep camera or preprint films clean are in Module 2, *Equipment and Procedures*.

Water Quality

A supply of good quality water is very important to motion-picture processing. Although tap water may contain some impurities, most impurities have no photographic effect. Those you should be most careful of include large quantities of suspended organic matter, hydrogen sulfide, particles of finely divided sulfur, and soluble metallic sulfides. These can cause serious trouble with developers. Fortunately, these impurities are not common to most municipal water supplies.

Organic matter usually precipitates on mixing the developer, but biological growths and bacteria can thrive in developer solutions, forming a slime or scum on the walls of the tank. Certain types of these growths act on the sulfite in the developer and change it to sodium sulfide, a chemical which fogs the emulsion. Proper agitation and cleaning the developer tank frequently will prevent this. If alum carries into the wash water from the fixer, organic matter already in the water coagulates and settles on the film. You can avoid this by filtering the water, or by adding boric acid to an acid fixing bath (up to a maximum of 15 grams per litre).

Extremely hard water may produce a finely divided precipitate when you mix the developer solution. The precipitate usually settles on standing, but even if it remains in suspension, it has no adverse photographic effect. If the precipitate is objectionable, add KODAK Anti-Calcium or Quadrofos. You may also see a fine precipitate when you use certain developers even though they were clear when mixed. This is normal and does not indicate poor mixing or impure water. Again, it has no adverse photographic effect.

A chemical analysis of the water supply usually reveals very little concerning its photographic usefulness. The most useful test is to prepare the required photographic solution with the suspect water sample and actually try it. Compare your results with those obtained with the same solution prepared with distilled water. In most cases, both of the solutions will be alike in their photographic effect, even if not in appearance.

Processing Machine Design and Construction

Machine Design

You should process black-and-white motion picture film only in continuous-travel processing machines with the film going through the solution tanks emulsion side up on a series of mechanically driven spools. These spools are mounted in racks that fit into the processing tanks. The film threads over the spools in a continuous spiral so that no part of the film touches any part of the machine. This avoids damage to either the film support or to the emulsion.

The number of racks for the various solutions and washes determines the treatment or solution time for a specific film transport speed. The size and number of racks are determined by the machine manufacturer. Figure 15-2 shows a typical layout of processing machines for black-and-white negative or positive processing. Figure 15-3 shows a typical layout of processing machines for black-and-white reversal processing. Be sure that solution crossover devices are at all the locations shown in the illustrations. The solution crossover devices reduce contamination and minimize the loss of solution by carry-over into subsequent solutions. Locate the machine in an area that allows plenty of working room for operation and maintenance.

When it is necessary to force (push) process film (see *Push and Pull Processing* on page 15-16) to increase the effective film speed, the machine must be able to allow additional first development through adjustment of the processing time or temperature.

We do not recommend processing black-and-white motion-picture films in equipment other than the type we've described. Severe non-uniformity or physical damage can occur with reel-and-trough or rack-and-tank equipment.

Eastman Kodak Company does not market processing machines or auxiliary equipment suitable for black-and-white motion-picture films. You can request a list of some manufacturers of processing equipment through the Eastman Kodak Entertainment Imaging Division offices listed in *KODAK LOCATIONS* on page 15-30.

Figure 15-2 Machine Schematic for Black-and-White Negative or Positive Process

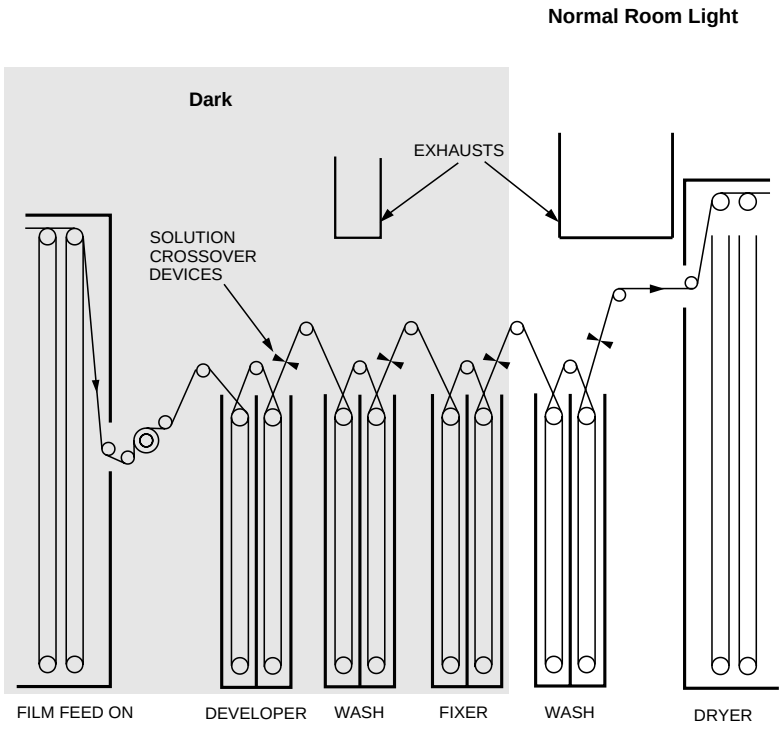
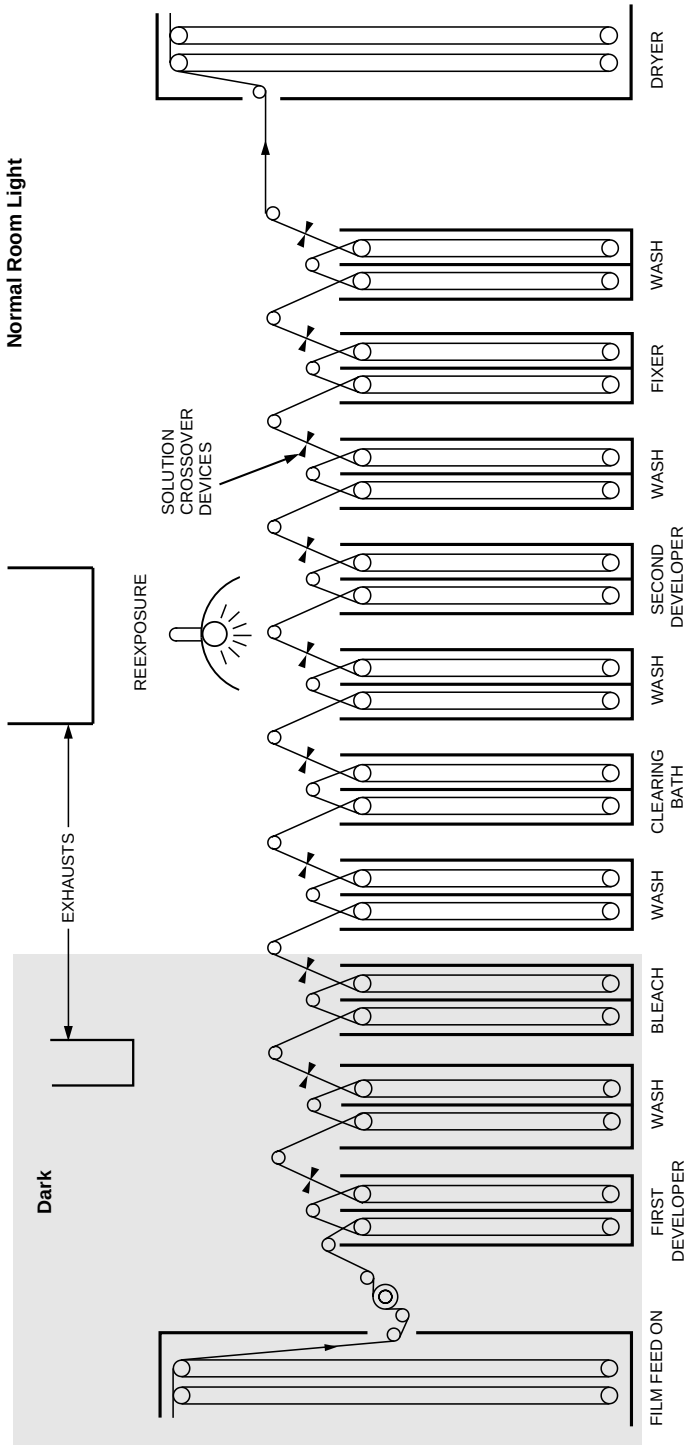


Figure 15-3 Machine Schematic for Black-and-White Reversal Process



Construction Materials

The construction materials recommended for the developer, bleach, clearing bath, and fixer solutions are listed in the table below. The permanganate bleach is quite corrosive. Titanium, Hastelloy C, and engineering plastics such as PVC are, therefore, recommended materials for permanganate bleach. Use of plastics compatible with low pH solutions (less than pH 5) may be acceptable depending upon their application. Some materials such as Polypropylene and Nylon are not recommended for use with this permanganate bleach. Certain plastic materials, such as ETFE (Ethylene Tetrafluoroethylene), PVDF, and Kynar, etc., are more resistant to this particular bleach and better used in certain applications such as pumps.

Additional information on materials construction and information on their use are given in KODAK Publication No. K-12, *Construction Materials for Photographic Processing Equipment.* You may also contact the Kodak Information Center at 1-800-242-2424.

Table 15-1 Construction Materials for B & W Reversal Process

Solution	Plastics (Polyvinyl Chloride or ETFE)	Titanium	Hastelloy C	Austenitic Stainless Steel AISI Type 316[1]
Permanganate Bleach				
Tanks and Racks	[2]	X	X	
Mixing Tanks	[2]	X	X	
Replenisher Holding Tanks	[2]	X	X	
Piping, Pumps, Valves, and Filter Cores	[2]	X	X	
Overflow Holding Tank	[2]			
Others:				
Tanks and Racks	X	X	X	X
Mixing Tanks	X	X	X	X
Replenisher Holding Tanks	X	X	X	X
Piping, Pumps, Valves, and Filter Cores	X	X	X	X

1 AISI Type 316 Stainless Steel has been extensively tested and is satisfactory for the uses listed in the table above. Refer to *The SPSE Handbook of Photographic Science and Engineering, Materials for Construction for Photographic Processing Equipment Section* for information on other Austenitic Stainless Steels.

2 Plastics compatible with pH solutions should be used (e.g., polyvinyl chloride, ETFE, PDVF, Kynar). The compatibility of other plastics should be evaluated under actual use.

The new permanganate bleach should not be used with pumps that have polypropylene components. Polypropylene has been found to exhibit stress fractures when exposed to the permanganate bleach. It is very likely that a pump constructed with polypropylene components would suffer damage that would result in catastrophic failure of the pump. It is strongly recommended that other materials be considered for use with pumps and in other applications where stress fractures may develop. Plastic materials such as PFC, ETFE (Ethylene Tetrafluoroethylene), PVDF, and Kynar, etc., are more resistant to permanganate bleach and should be used in place of polypropylene.

Filters

Filters are required in replenisher lines, recirculation systems, and wash-water lines because these solutions usually contain some insoluble material in the form of solids and tars. If this material is not removed, it can adhere to the film, machine tank walls, rollers, lines, etc. The ideal porosity rating of the filters should be 10 microns or less. Filters with porosity ratings higher than 30 microns are of little value in removing insoluble material. In some cases, you may need to use two or more filters in series.

Establish and follow a definite replacement schedule for filters. Polypropylene, fiberglass, or bleached cotton should be useable as filter media for all solutions. You should test any filter you select to determine whether it produces any adverse photographic effects. Also, while the filter media itself may not be photographically active, the core could be.

Solution Crossover Devices

Processing solution loss and dilution are minimized by various devices that wipe or remove solution off both sides of the film strand. These devices can consist of plastic blades, air streams, vacuum, buffer plush, or other mechanical means. When located at solution crossovers, these devices direct solution back into the originating tank and minimize the carryover of processing solution.

Such a device should be located on the exit strand between stages of all countercurrent washes, and on all solutions of the black and white processes. Some processing machines have used wiper-blade squeegees (30 to 40 durometer hardness) in the past; but the use of wiper-blade squeegees has steadily declined due to their inherent potential to cause damage to film. Currently, wiper-blade squeegees are no longer recommended for use on black and white processing machines. Even when carefully maintained, wiper-blade squeegees still have a greater propensity to cause damage to film than other types of carryover limiting devices at solution crossovers. Air knives are recommended for use with black and white processes since they are least likely to cause damage to film.

Dryer Cabinet

Carefully control film drying. If not dried thoroughly, the film emulsion remains soft and sticky. This can attract dirt that could become embedded in the emulsion. Taking up wet film can also cause ferrotyping, a physical imperfection which appears as nonuniform glossy areas on the film. Drying film too much makes it brittle, causes excessive curl, and generates static that attracts dirt. Proper drying leaves the film dry without tackiness when the film is about one-half to two-thirds of the way through the dryer cabinet. The film should be at about room temperature before windup. After cooling, the film's moisture content should be in equilibrium with air at about 50 percent relative humidity. Use either impingement or convective drying, controlled to the least amount of heat necessary to properly dry the film. You probably will also have to control the humidity of the drying cabinet.

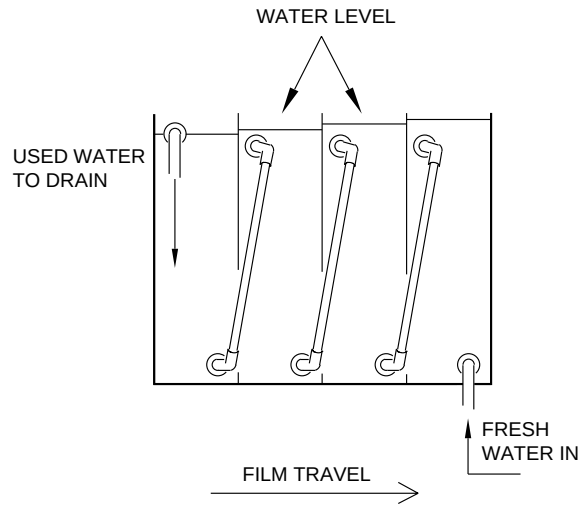
Machine Exhaust and Room Ventilation System

Install local exhausts at specific locations on the processing machine and at specific work areas to provide for the safety and comfort of the laboratory personnel. Supplement local exhausts with a room ventilation system having a capacity of 10 air changes per hour. Vent the discharge air from these systems outside of the building so that discharged air does not contaminate incoming air. Place local exhausts over chemical mixing tanks to remove any irritating chemical dust and vapor produced when mixing processing solutions from all chemicals.

Countercurrent Washes

Multitank, countercurrent wash methods provide great savings in water. With a countercurrent wash, fresh water enters the last tank, flows to the previous tank, and so on to the first tank, in a direction counter to that of film travel. As the film advances through the wash, it enters cleaner and cleaner water. A countercurrent wash can have as little as two tanks. Figure 15-4 illustrates a four-stage countercurrent wash.

Figure 15-4 Four-Stage Countercurrent Wash



Agitation

Good agitation is necessary to produce uniform development throughout the length of the processed film. Agitation can be done mechanically in conjunction with a recirculation system (described in the next section) or with air. Do not use air to agitate developer solutions because of oxidation, but air is acceptable with the reversal bleach where vigorous agitation is necessary for uniform picture results. Continuous processing equipment is capable of providing some agitation, but the effect is minimal at machine speeds lower than 200 feet per minute.

Agitation is necessary to bring fresh solutions to the film surface. Without proper agitation, oxidized chemicals adhere to the film surface and prevent proper chemical action with the film. This causes underdevelopment and non-uniformity, particularly with the reversal bleach.

Recirculation System

Recirculation keeps the solution moving in the processing machine tank and maintains a more uniform chemistry and even temperature. A basic recirculation system includes piping, replenisher solution, flow meters, pumps, filters, heat exchanger, temperature controller, temperature sensors, electric solenoid valves, solution distributors or turbulators and tank. Figure 2-7 in Module 2, *Equipment and Procedures*, shows a basic system.

Leader Requirements

Machine leader is necessary for maintaining thread-up and continuous processing operations. You can use various types of leaders, depending upon your requirements. EASTMAN Black-and-White Opaque Leader is satisfactory for many types of processing machines and is also very good for checking if there is a twist in the thread-up sequence that could cause film transport damage. EASTMAN Green Leader is transparent and is widely used where long leader life is desired. EASTMAN Processing Machine Leader (ESTAR Base) has the greatest strength and is very durable.

Bulk Chemicals

Precautions and Procedures

Be sure the mixing area is well ventilated, and wear proper protective clothing and apparatus such as gloves and goggles. There are no shortcuts to safety. See Module 2, *Equipment and Procedures*, for further information.

Following the correct procedure is very important when mixing various solutions. Mix the solutions in the order in which they are listed in the process sequence. This minimizes the possibility of contaminating a solution with the previously mixed one. You are also less likely to place solutions in the wrong holding or machine tanks. As an added precaution, and if possible, mix developers in their own tank to prevent contamination. Even a small amount of hypo in the developer is very detrimental.

Read and follow the instructions regarding the safe handling of bulk chemicals. This information is available from the chemical supplier, or is found on the chemical-container labels and in the appropriate Material Safety Data Sheets (MSDS). MSDS information is available from chemical suppliers and Eastman Kodak Company. Footnotes with each formula provide further precautionary information.

Before mixing, rinse the mix tank with water, and run fresh water through the pump. Drain the tank and pump. Fill the tank to the mixing level with water at the appropriate temperature and start the mixer. Be sure that the mixer is large enough to provide adequate agitation for the volume of solution. The starting mixing level should be about 80 percent of the final volume. Allow at least one minute to agitate the water between the time the mixer starts and when you add the first chemical. This helps remove air from the water and better disperses the first chemical addition.

Premeasure all chemicals, but *do not* combine the dry chemicals before adding them to the mixing tank. This can cause unwanted chemical reactions producing toxic and noxious fumes. The formula for each processing solution lists the chemicals in the proper mixing order. Add and dissolve the chemicals in the order given, and dilute the solution to volume with water.

After diluting a solution to volume, agitate it for a few minutes for complete and uniform dissolution of the chemicals. Analyze the mixed solution for its critical constituents; then place the certified solution into the appropriate storage tank.

Carefully rinse the mixing tank and any pumps used to transport the solutions. It is best to clean the mixing equipment immediately after emptying the tank and before salts and tars have time to form. Numerous small-volume rinses clean the equipment more efficiently than a few large-volume rinses.

Formulas and Analytical Specifications

Maintain the fresh tank formula specifications as given in the following sections or as adjusted for your particular equipment. Immediately correct any significant deviations from tank specifications, as noted by chemical analysis, by making appropriate additions or cuts to the tank solution. The procedure for making additions or cuts is described in Module 3, *Analytical Procedures*, under "Diagnosing and Correcting Off-Specification Chemical Composition of Processing Solutions, Method XVII".

Correct any long-term tendency to deviate from the tank-analytical specifications (e.g., slowly increasing pH) by adjusting the replenisher. Use the replenisher-formula specifications as starting points for typical operations.

Note: Observe the precautionary information on the product labels and on the Material Safety Data Sheets.

Obtaining Bulk Chemicals

Photographic-grade chemicals are critical to some solutions such as developers. All chemicals in this publication noted by ([1]) are photo grade. The following chemical list does not include all suppliers, nor are the suppliers listed in any order of preference. The mention of a supplier is not an endorsement by Eastman Kodak Company. Most of the chemicals listed are available from local supply houses. For additional suppliers, consult *Chemical Week*, *Chemical Buyers*, or *Thomas Register* in public libraries.

Table 15-2 Bulk Chemical Suppliers

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers
Acetic Acid, Glacial	CH_3COOH	Eastman Kodak Company
		Brown Chemical Company
		Union Carbide Company
Ammonium Bromide	NH_4Br	AC Industries, Inc.
		Ameribrome, Inc.
Ammonium Thiosulfate	$(NH_4)_2S_2O_3$	Eastman Kodak Company
		General Chemical Company
		E.I. du Pont de Nemours & Company, Inc.
Beta-Aminopropionic Acid (Beta-Alanine)	—	Ajinomoto U.S.A., Inc.
		Chemical Dynamics Corporation
		U.S. Biochemical Corporation
Borax, Decahydrate[1]	$Na_2B_4O_7•10H_2O$	Eastman Kodak Company
		Ashland Chemical Company
		Stauffer Chemical Corporation
		U.S. Borax and Chemical Corporation
Borax, Pentahydrate[1]	$Na_2B_4O_7•5H_2O$	Ashland Chemical Company
		Stauffer Chemical Corporation
		U.S. Borax and Chemical Corporation
Calgon S	CAS No. 68915-31-1	Astaris LLC
		Rhodia
DTOD	$C_6H_{14}O_2S_2$	Goldshmidt
		Eastman Kodak Company
Ethylenediamine[12] (98% Assay)	$NH_2CH_2CH_2NH_2$	Eastman Kodak Company
		Ashland Chemical Company
		Union Carbide Corporation
		Dow Chemical USA
Hydroquinone[1]	Paradihydroxybenzene	Eastman Kodak Company
		Aceto Corporation
		Aldrich Chemical Company, Inc.
Potassium Permanganate	$KMnO_4$	Riverside Chemicals
Sodium Acetate, Anhydrous[1]	CH_3COONa	Ashland Chemical Company
		Brown Chemical Company, Inc.
		Mallinckrodt, Inc.
Sodium Bromide, Anhydrous[1]	NaBr	Allen Chemical Company
		Dow Chemical USA
Sodium Carbonate, Anhydrous[1]	Na_2CO_3	Ashland Chemical Company
		Brown Chemical Company, Inc.
		Stauffer Chemical Company
Sodium Chloride[1]	NaCI	Ashland Chemical Company
		American International Chemical Company
		J.T. Baker Chemical Company
Sodium Hydroxide[1]	NaOH	Eastman Kodak Company
		Ashland Chemical Company
		Brown Chemical Company
		Dow Chemical USA
Quadrofos (Sodium Tetraphosphate[1])	—	Essex Chemical Company
		FMC Corporation, Ind Chemical Group

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers
Sodium Phosphate (TSP)	$Na_3PO_4 \cdot 12H_2O$	Ashland Chemical Company
		Brown Chemical Company
		FMC Corporation
Sodium Sulfite, Anhydrous[1]	Na_2SO_3	Eastman Kodak Company
		Ashland Chemical Company
		Stauffer Chemical Company

1 These chemicals must meet the ANSI/ACS specifications. An index of ANSI specifications for "Photography—Chemicals" is available from American National Standards Institute, Inc., 550 Mamaronek Ave., Harrison, New York 10528.

2 Solutions of several concentrations of ethylenediamine are available from various manufacturers. You can determine the purity of the solutions by method 612C for "Ethylenediamine Assay," in Module 3, *Analytical Procedures*.

Storing Processing Solutions

The storage temperature of processing solutions is very important. Developers oxidize readily at elevated temperatures with a resultant loss in activity and an increased propensity for staining. A developer which normally keeps for two or three weeks at 18 to 21°C (65 to 70°F) may be unsatisfactory in a few days at 32 to 35°C (90 to 95°F). However, Kodak liquid concentrate developers are quite stable for extended storage (up to two years) in the original sealed package at room temperature.

Low storage temperatures can also be undesirable. Some concentrated solutions crystallize readily at temperatures below 13°C (55°F) and redissolve with great difficulty or not at all, even when heated. Kodak pre-packaged chemistry is not affected by temperatures as low as 4°C (40°F). Liquid solutions should not be left on docks or in uncontrolled-temperature storage rooms in cold or hot weather. Check with the delivery carrier during cold- or hot-weather transportation conditions, as the chemicals may already have been damaged because of exposure. Repeated temperature changes may shorten the life of many photographic solutions.

Wherever possible, protect solutions in tanks with floating lids and dust covers. in addition to preventing contaminants from entering solutions, floating lids and dust covers help minimize oxidation and evaporation of the solutions. Evaporation results in more concentrated and overactive solutions, and the temperature drop associated with evaporation can cause precipitation of some of the less soluble solution constituents.

Do not attempt to bring aged solutions (tank or replenisher) to the formula level. You cannot eliminate decomposition products that form as the solution stands. These compounds become concentrated enough to cause adverse photographic effects. See Tables 15-11 and 15-21 *Storage Life of Mixed Solutions.*

Push and Pull Processing

You can alter the film processing to increase or decrease the effective film speed. This is also a way to compensate for over- or underexposure. Push (forced) or pull (under) processing may reduce quality. For example, push processing generally increases grain and reduces the maximum density in shadow areas. For a negative film, it also increases contrast. You and your customer must decide what degree of quality loss is acceptable.

Push processing *increases* the effective speed of negative or reversal films. When you push process, you increase the time or the temperature (or both) in the first developer. You can also *decrease* the effective speed with pull processing by decreasing the time or temperature. In either case, adjusting the time is preferable—it is usually easier and the results tend to look better than when you adjust the temperature.

For black-and-white negative or positive films, the rule of thumb for push processing is to *increase* development time by two minutes for each camera stop (.30 log e) of underexposure (processing at 21°C [70°F]). For each stop of overexposure, pull process to *decrease* the development time one minute. If you adjust the temperature, use a 6°C (10°F) *increase* for each camera stop of underexposure (at 21°C [70°F]; for each stop of overexposure, *decrease* the temperature 3°C (5°F). If normal processing temperatures are higher than 21°C (70°F), both the time and the temperature will be shorter for push and upll processing to achieve the desired results. For reversal camera films, time of development curves indicate that a full stop change would require changing the first developer time fo 30 seconds at 24.4°C (76°F). Experimentation is required and necessary to determine the proper conditions for your particular situation.

Since a negative film requires a print, you can usually adjust the print exposure time to compensate for either over- or underexposure. This lets you use normal processing for up to plus or minus one stop, if you desire. Push or pull processing affects negative contrast, so you must decide whether adjusting the exposure or the processing is best. Two stops of over- or underexposure will usually require processing changes. These are suggested times and temperatures only. Conduct your own tests before push- or pull-processing large amounts of film. For best results, we do not recommend push processing of reversal or negative films underexposed beyond two stops. Use pull processing to compensate for no more than one stop overexposure.

SECTION TWO—
NEGATIVE AND POSITIVE FILMS

Process Sequence

Table 15-2 contains a general description of what happens during the processing steps of typical black-and-white negative or positive motion picture films. You will find the exact sequence for specific Kodak developers in the following section under *Processing Specifications*.

Table 15-3 Negative-Positive Process Steps

Step	What Happens
Developer	Develops the exposed latent-image silver halide to metallic silver—especially important to obtaining desired contrast and density.
Wash	Removes developer from film.
Stop (option in place of wash)	A stop bath terminates development more quickly than a wash and will give tighter control to the developing time. Also prevents excessive emulsion swelling.
Fixer	Removes unexposed and underdeveloped silver halide from the film.
Wash	Removes fixer from the film.
Dryer	Dries the processed film in preparation for printing, editing, or projection.

Processing Specifications

Use the processing times and drying conditions shown in the tables below as a guide for preliminary machine design. Actual processing times may differ from the ones shown in the tables because of machine-design variables such as film-transport speed, degree of solution agitation, amount of solution carry-over, etc. Use the listed temperatures and times as a starting point to determine the specifications necessary to produce quality films in your installation. Optimum drying conditions (air volume, temperature, and relative humidity) will also vary with each dryer design.

Use the replenishment rates indicated in the tables as a starting point for chemical-analytical specifications.

Table 15-4 Processing Specifications for Negative Films

KODAK D-96 Developer

Process Steps	Time 21°C (70°F)	Replenishment per 100 ft of 35 mm film[1]	Recirculation (R) Agitation (A) Filtration (F)
D-96 Developer	Will vary with each film. Consult the Data Sheet	1200 mL[2]	R, A, F
Wash[3]	3 min		
Fixer	11 min	900 mL[2]	R
Wash[4]	10 min		

1 Use these replenishment rates as starting points. Determine actual rates by chemical analysis after processing a significant amount of film.
2 Use 40 percent of these rates for 16 mm film.
3 A stop bath may be used in place of the wash.
4 The efficiency of the water application and the permissible residual hypo concentration for the intended use determine the actual wash time. ANSI PH 4.8-1985 is a worldwide standard for determining residual hypo. The ANSI recommendation for extended life expectancy storage is .2—.4 µg/cm².

Table 15-5 Processing Specifications for Positive Films

KODAK D-97 Developer

Process Steps	Time 21°C (70°F)	Replenishment per 100 ft of 35 mm film[1]	Recirculation (R) Agitation (A) Filtration (F)
D-97 Developer	Will vary with each film. Consult the Data Sheet	650 mL[2]	R, A, F
Wash[3]	3 min		
Fixer	9 min	600 mL[2]	R
Wash[4]	10 min		

1 Use these replenishment rates as starting points. Determine actual rates by chemical analysis after processing a significant amount of film.
2 Use 40 percent of these rates for 16 mm film.
3 A stop bath may be used in place of the wash.
4 The efficiency of the water application and the permissible residual hypo concentration for the intended use determine the actual wash time. ANSI PH 4.8-1985 is a worldwide standard for determining residual hypo. The ANSI recommendation for extended life expectancy storage is .2—.4µg/cm2.

Processing Chemicals and Formulas

Bulk Chemical Formulas for Negative and Positive Processes

Table 15-6 KODAK Developer D-96 (Negative)

Constituent	D-96 (tank)	D-96R (replenisher)
Water, about 50°C (125°F)	750 mL	750 mL
KODAK ELON Developing Agent	1.5 g	2.0 g
KODAK Sodium Sulfite (Anhydrous)	75.0 g	80.0 g
KODAK Hydroquinone	1.5 g	2.0 g
KODAK Potassium Bromide (Anhydrous) or Sodium Bromide	0.4 g 0.35 g	– –
KODAK Borax (Decahydrated)	4.5 g	5.0 g
Water to make	1.00 L	1.00 L
pH at 25°C (77.0°F)	8.62 ± 0.05	8.72 ± 0.05
Specific Gravity at 25°C (77.0°F)	1.069 ± 0.003	1.074 ± 0.003

Table 15-7 KODAK Developer D-97 (Positive)

Constituent	D-97 (tank)	D-97R (replenisher)
Water, about 50°C (125°F)	750 mL	750 mL
Quadrofos or Calgon[1]	1.0 g[2]	1.0 g[2]
KODAK ELON Developing Agent	0.5 g	0.7 g
KODAK Sodium Sulfite (Anhydrous)	40.0 g	70.0 g
KODAK Hydroquinone	3.0 g	11.0 g
KODAK Sodium Carbonate (Monohydrated)	20.0 g	20.0 g
KODAK Potassium Bromide (Anhydrous) or Sodium Bromide	2.0 g 1.75 g	1.50 g 1.30 g
KODAK Sodium Hydroxide	–	2.0 g
Water to make	1.00 L	1.00 L
pH at 25°C (77.0°F)	10.17 ± 0.05	10.27 ± 0.05
Specific Gravity at 25°C (77.0°F)	1.053 ± 0.003	1.084 ± 0.003

1 Both Quadrofos and Calgon (Calgon, Inc.) are sequestering agents.
2 May need to be adjusted, depending on water condition.

Table 15-8 KODAK Fixer F-5

Constituent	F-5 (tank and replenisher)
Water, about 50°C (125°F)	600 mL
KODAK Sodium Thiosulfate Anhydrous (Hypo)[1]	153.0 g
KODAK Sodium Sulfite (Anhydrous)	15.0 g
KODAK 28 Percent Acetic Acid[2]	48.0 mL
KODAK Boric Acid (Anhydrous Crystals)[3]	7.5 g
KODAK Potassium Alum	15.0 g
Water to make	1.00 L
pH at 25°C (77.0°F)	4.25 ± 0.25
Specific Gravity at 25°C (77.0°F)	1.134 ± 0.003
Note: Kodak Fixer or KODAK Rapid Fixer (Solutions A and B) are available in prepared form and can be used instead of the above formula.	

1 A different quantity of Sodium Thiosulfate Pentahydrate (Hypo) can be used in place of KODAK Sodium Thiosulfate Anhydrous (Hypo). The corresponding weight of Sodium Thiosulfate Pentahydrate can be calculated by multiplying by the weight of Sodium Thiosulfate Anhydrous (Hypo) by 1.57. In this formula 153 g of KODAK Sodium Thiosulfate Anhydrous (Hypo) is equivalent to 240 g of KODAK Sodium Thiosulfate Pentahydrate (Hypo).
2 To make approximately 28 percent acetic acid from glacial acetic acid, add 3 parts of glacial acetic acid to 8 parts of water.
3 Use crystalline boric acid as specified. Powdered boric acid is difficult to dissolve and you should avoid using it. In some cases, the odor of sulfur dioxide given off by KODAK Fixer F-5 may be objectionable. To eliminate this odor, almost completely, omit the boric acid and substitute twice its weight in KODAK Balanced Alkali. This modified solution is KODAK Fixer F-6. It has less hardening action then F-5, but it washes out of the film more easily.

Table 15-9 KODAK Stop Bath SB-1a

Constituent	SB-1a[1] (tank and replenisher)
Water, about 50°C (125°F)	1.00 L
KODAK 28 Percent Acetic Acid[2]	125.0 mL

1 May be used as an option following the developer in place of the wash.
2 To make approximately 28 percent acetic acid from glacial acetic acid, add 3 parts of glacial acetic acid to 8 parts of water.

Table 15-10 KODAK Stop Bath SB-5

Constituent	SB-5[1] (tank and replenisher)
Water, about 50°C (125°F)	500 mL
KODAK 28 Percent Acetic Acid[2]	32.0 mL
Sodium Sulfate (Anhydrous)[3]	45.0 g
Water to make	1.00 L

1 May be used as an option following the developer in place of the wash. This formula provides additional hardening.
2 To make approximately 28 percent acetic acid from glacial acetic acid, add 3 parts of glacial acetic acid to 8 parts of water.
3 If crystalline sodium sulfate is preferred to the anhydrous form, use $2\frac{1}{4}$ times the amount listed.

Rewashing of Negative and Positive Films (cleaning and healing)

Rewashing is the common practice of running processed film through a complete process one or more additional times. This removes dirt and can heal slight emulsion scratches and digs. Rewashing black-and-white films produces minimal changes in the original quality and may remove residual silver halide that was not removed in the original process. To clean film by rewashing, use the entire process, ensuring that the final wash and drying are optimum (for archival storage). You can bypass the other solution steps and use just the final wash to produce the same effect. Check the Data Sheet for the recommended process temperature; too high a temperature can cause the emulsion to blister, reticulate, or lift from the base. For information about rewashing reversal films, see *Rewashing of Reversal Films (cleaning and healing)* on page 15-26.

Storing Mixed Solutions

Do not use any solution that has been stored at normal room temperature of 21 to 24°C (70 to 75°F) for longer then the times given in Table 15-11. Storage temperatures higher than 24°C (75°F) will decrease the storage life of the solutions. Storage below 16°C (60°F) can cause some solution constituents to precipitate.

Do not attempt to bring aged solutions to the formula level. Decomposition products that are formed as the solution stands cannot be eliminated from the solution. These compounds can build up to a concentration that will adversely affect your results.

Table 15-11 Storage Life of Mixed Solutions

at 21° to 24°C (70° to 75°F)		
Solution	**Floating Cover**	**Open Tank**
Developer	2 weeks	1 week
Fixer	8 weeks	4 weeks
Stop	Indefinite[1]	8 weeks

1 If solution is kept clean.

Troubleshooting

Table 15-12 is a troubleshooting guide for negative and positive processing. The table covers many common occurrences and can be very helpful if you encounter any processing difficulties. For assistance or further information, contact the Kodak Entertainment Imaging Division offices listed in *KODAK LOCATIONS* on page 15-30, or call the Kodak Information Center at 1-800-242-2424, Monday through Friday, 8 a.m to 9 p.m. (eastern time).

Table 15-12
Negative and Positive Process Variations

Problem	Possible Cause
High overall density and/or contrast	Excessive development • Long time • High temperature • Overreplenishment • Improper mixing • Light fog
Low overall density, low contrast and D-max	Insufficient development • Short time • Low temperature • Underreplenishment, solution exhaustion • Improper mixing • Excessive oxidation • Insufficient agitation
Nonuniform density	• Poor developer agitation • Retained silver halide (poor fixing) • Poor solution crossover devices • Oil on film before processing
Curtains—faint lengthwise streaks	• Improper developer turbulation • Poor solution crossover devices
Repeating, equally spaced dots	• Emulsion in contact with soft-touch tire on a processing machine roller.
Scallops on the film edge, repeating	• Dropped roll of film on a hard surface • Intermittent high tension during processing
Fine streaks	• Worn or misaligned solution crossover devices • Scratches
Fuzzy spots	• Air bubbles adhering to the emulsion in the developer preventing developer action
Pressure marks (light or dark)	• Pinching, buckling, or excessive physical pressure on unprocessed film, before or after exposure
Static marks	• Rapid rewinding of film in low relative humidity • Non-grounded camera or printer
Scratches	• Old, hard, worn, crystal-laden, maladjusted solution crossover devices or spools • Cinching a roll of film before or after processing • Improper loading of camera magazine or processing machine • Machine spools that are not rotating freely or are out of line • Improper machine threading (film twisted or off the rollers)
Reticulation—random pattern of lines or cracks on the emulsion surface	• High solution temperature • Dryer temperature too high or relative humidity too low • Large temperature differences between solutions
Increased D-min, increased density in low-density areas	• Light fog • Overdevelopment • Chemical fog • Creation of sodium sulfide in the developer
Particle—black lines and comets	• Flocculent silver flakes that were not removed from the fixer—the fixer solution crossover device smears adhering flakes into lines or comets
Dirt (on negative)	• Dust, cloth fragments, hair, skin flakes, chemical crystals, etc., most easily seen under high-intensity specular lighting, or as light speck on a projected print
Yellow specs on the emulsion surface	• Sulfur particles formed in the fixer caused by low pH • Sulfur from silver recovery cells
Emulsion skivings	• Small shreds of emulsion sheared from the film edges by machine spools that have burrs or are improperly aligned, and have been deposited on the base or emulsion
Irregular, shiny areas on the emulsion surface (ferrotyping)	• Very high windup tension on unprocessed film • Rewinding cold, unprocessed or processed film that has not reached room temperature (condensation moisture) • Wet or tacky emulsion at processor windup
Tacky film	• Inadequate final processing solution crossover device action • Inadequate drying conditions
Water spots	• Surface water carried into the dryer by the film • Hard water—add sequestering agent to final wash
Scalloped, fluted, or twisted film edges	• Excessive tension on the film
Small round craters on emulsion	• Differential drying—liquid being sprayed on the film after final squeegee
Shore line	• Excess water being carried into drying cabinet by perforations • Impingement drying—temperature too high

SECTION THREE—
REVERSAL FILMS

Process Sequence

Table 15-13 contains a general description of what happens during the processing steps of typical black-and-white reversal motion picture films. You will find the exact sequence with specific Kodak developers in the following section for *Processing Specifications*.

Table 15-13 Reversal Process Steps

Step	What Happens
First Developer	Develops the camera-exposed light-sensitive silver halide crystals to metallic silver (a negative image). Time and temperature control are critical for optimum results.
Wash	Removes first developer from the film.
Bleach	Dissolves the metallic-silver negative image produced in the first developer but does not affect the remaining silver halide.
Wash	Removes excess bleach from the film.
Clearing Bath	Removes any bleach left from the wash step and prepares the film for redevelopment.
Reexposure	Exposes the silver halide crystals that were not exposed in the camera.
Second Developer	Develops remaining exposed silver halide to produce a positive image.
Wash	Removes second developer.
Fixer	Removes any undeveloped silver halide grains. This step should yield minimal silver.
Wash	Removes fixer from the film.
Dryer	Dries the film in preparation for printing or projection.

Processing Specifications

Use the processing times and drying conditions shown in Table 15-14 as a guide for preliminary machine design. Actual processing times may differ from the ones shown in the table because of machine-design variables such as film-transport speed, degree of solution agitation, amount of solution carry-over, etc. Use the listed temperatures and times as a starting point to determine the specifications necessary to produce quality films in your installation. Optimum drying conditions (air volume, temperature, and relative humidity) will also vary with each dryer design. Use the replenishment rates indicated in the table as a starting point for chemical-analytical specifications.

Table 15-14 Processing Specifications for Reversal Films

Process Step	Time		Replenishment per 100 ft of 16 mm film[1]		Recirculation (R) Agitation (A) Filtration (F)
	20°C (68°F)	24.4°C (76°F)	Film	Leader	
First Developer	90 sec	60 sec	220 mL	45 mL	R, A, F
Wash[2]	30 sec	30 sec			
Bleach	60 sec	60 sec	145 mL	100 mL	Vigorous A
Wash	30 sec	30 sec			
Clearing Bath	30 sec	30 sec	195 mL	75 mL	A
Wash	30 sec	30 sec			
Reexposure	800 footcandle seconds				
Second Developer	50 sec	30 sec	75 mL	45 mL	R,A
Wash	30 sec	30 sec			
Fixer	50 sec	30 sec	100 mL	45 mL	R, A
Wash[3]	2 min	2 min			

1 Use these replenishment rates as starting points. Determine actual rates by chemical analysis after processing a significant amount of film.
2 A stop bath must not be used in place of the wash.
3 The efficiency of the water application and the permissible residual hypo concentration for the intended use determine the actual wash time. ANSI PH 4.8-1985 is a worldwide standard for determining residual hypo. The ANSI recommendation for extended life expectancy storage is .2—.4 µg/cm^2.

Processing Chemicals and Formulas

Packaged Chemicals

Packaged or kit chemicals for black-and-white reversal processing are available from some Eastman Kodak Company marketing and distribution centers. The chemicals are sold as liquid concentrates for processing all black-and-white reversal film products. Making solutions from liquid concentrates offers a number of advantages over solutions prepared from bulk chemistry. One of the most important is the ease of preparation; there are no dry chemicals to measure and dissolve. Additionally, the liquid solutions are especially formulated for improved non-sludging characteristics, and the bleach allows for about twice the footage that can be accommodated by some bulk-mixed solutions. All of the packaged chemicals have excellent stability and batch-to-batch uniformity.

Packaged or kit chemistry yields essentially the same quality that is obtained with the bulk chemicals mixed from formulas. It is possible that the performance of certain solutions mixed from bulk or packaged chemicals may differ somewhat because of differences in the chemicals that affect the exact make-up of each solution. These differences exist because not all chemicals readily lend themselves to making a concentrated form. The formulas for packaged chemicals are not published, and some of the chemicals may be proprietary. During manufacturing, the constituents of the packaged chemicals are adjusted where necessary for consistency from batch to batch. This is akin to mixing from bulk chemistry where an analytical chemist adds more or less of a certain chemical so the processed film product meets its control aim.

Packaged chemistry is most convenient for those facilities where a chemist and analytical apparatus are not available. Non variability of each solution batch is extremely important so the processed product does not vary. Kodak pre-packaged chemistry will consistently produce uniform results. Kodak reversal liquid chemicals for black-and-white reversal films are sold in 5-gallon concentrates for the first developer, second developer, clearing bath and bleach. The liquid fixer comes in two containers to make 5 gallons of solution, and the first developer starter is a one-quart concentrate.

Mixing Packaged Chemicals

All packages have clearly marked instructions. The only combining of chemicals is for the two parts of the liquid fixer and the addition of the first developer starter to the first developer replenisher for a fresh tank solution. The other solutions are a dilution of the concentrates. Observe all precautionary information on the container(s) and labels of each solution. Information on the known hazards and safe handling of these chemicals is available from Eastman Kodak Company in the form of Material Safety Data Sheets (MSDS), as required by the OSHA Hazard Communications Standard Act and many state laws. To obtain information on KODAK Chemicals and the solutions made from them, contact the nearest Eastman Kodak Entertainment Imaging Division offices listed in *KODAK LOCATIONS* on page 15-30, or call the Kodak Information Center at 1-800-242-2424.

Bulk Chemical Formulas for Reversal Processes

Table 15-15 KODAK Developer D-94A

KODAK Developer D-94A[1]		
Constituent	**D-94 (tank)**	**D-94R (replenisher)**
Water, about 50°C (125°F)	750 mL	750 mL
KODAK ELON Developing Agent	0.60 g	0.90 g
KODAK Sodium Sulfite (Anhydrous)	60.0 g	75.0 g
KODAK Hydroquinone	20.0 g	26.0 g
Sodium Bromide	7.0 g	1.7 g
DTOD	0.42 g	0.52 g
KODAK Sodium Hydroxide	20.0 g	34.0 g
Water to make	1.00 L	1.00 L
pH at 25°C (77.0°F)	12.81 ± 0.05	12.86 ± 0.05
Specific Gravity at 25°C (77.0°F)	1.079	1.106

1 KODAK Developer D-94 should not be used with permanganate bleach.

Table 15-16 KODAK Developer D-95

D-95 (tank)	Constituent	D-95R (replenisher)
Water, about 50°C (125°F)	750 mL	750 mL
KODAK ELON Developing Agent	1.0 g	2.2 g
KODAK Sodium Sulfite (Anhydrous)	50.0 g	50.0 g
KODAK Hydroquinone	20.0 g	50.0 g
KODAK Potassium Bromide (Anhydrous) or Sodium Bromide	5.0 g 4.5 g	– –
KODAK Potassium Iodide	0.25 g	–
KODAK Sodium Hydroxide	15.0 g	50.0 g
Water to make	1.00 L	1.00 L
pH at 25°C (77.0°F)	12.21 ± 0.05	12.36 ± 0.05
Specific Gravity at 25°C (77.0°F)	1.066 ± 0.003	1.104 ± 0.003

Table 15-17 KODAK Bleach R-10

KODAK Bleach R-10[1]		
Constituent	**R-10 (tank)**	**R-10R (replenisher)**
Water	750 mL	750 mL
Calgon S	20.0 g	24.0 g
Potassium Permanganate	2.5 g	12.0 g
Sulfuric Acid (96%)[2]	15.0 g	72.0 g
Water to make	1 L	1 L
Specific Gravity at 25°C (77.0°F)	1.024	1.066

1 KODAK Bleach R-10 should not be used with KODAK Developer D-94.
2 **CAUTION:** Always add the sulfuric acid to the solution slowly, stirring constantly, and never add the solution to the acid; otherwise, the solution may boil and splatter the acid, causing serious burns.

Table 15-18 KODAK Clearing Bath CB-2

Constituent	CB-2 (tank)	CB-2R (replenisher)
Water	750 mL	750 mL
KODAK Sodium Sulfite (Anhydrous)	210.0 g	240.0 g
Water to make	1.00 L	1.00 L
pH at 25°C (77.0°F)	10.31 ± 0.20	10.71 ± 0.10
Specific Gravity at 25°C (77.0°F)	1.176 ± 0.003	1.204 ± 0.003

Table 15-19 KODAK Clearing Bath (alternate)

Constituent	CB-2 (tank and replenisher)
Water	750 mL
KODAK Potassium Sulfite (45%)	132.0 g
Water to make	1.00 L
pH at 25°C (77.0°F)	8.73 ± 0.10
Specific Gravity at 25°C (77.0°F)	1.149 ± 0.003

NOTE: Each of these clearing bath formulas will fulfill its intended function. One may perform better than the other in some installations, so experimentation may be necessary.

Table 15-20 KODAK Fixer F-10

Constituent	F-10 (tank)	F-10R (replenisher)
Water, about 50°C (125°F)	500 mL	500 mL
KODAK Sodium Thiosulfate (Hypo)	330.0 g	420.0 g
KODAK Sodium Sulfite (Anhydrous)	7.5 g	10.0 g
KODAK Balanced Alkali	30.0 g	30.0 g
KODAK Glacial Acetic Acid	19.5 mL	33.0 mL
KODAK Potassium Alum	22.5 g	22.5 g
Water to make	1.00 L	1.00 L
pH at 25°C (77.0°F)	4.40 ± 0.10	4.25 ± 0.10
Specific Gravity at 25°C (77.0°F)	1.193 ± 0.003	1.204 ± 0.003

Rewashing of Reversal Films (cleaning and healing)

Rewashing is the common practice of running already processed film through the processor again to remove dirt and to heal slight emulsion scratches and digs. When done properly, rewashing produces minimal, if any, changes in the film quality.

Caution

CAUTION! Process black-and-white films (negative, positive, or reversal) **must not** go through the entire black-and-white **reversal** process a second time. The bleach in the reversal process will *remove the entire image.* You can reprocess films with the reversal process only if you bypass the bleach step. You can also bypass all of the other solution steps and use just the final wash to produce the same results. Still another alternative is to use negative or positive processes (they don't have a bleach step) for rewashing. Check the Data Sheet for the correct processing temperature. For information on rewashing negative or positive films, see *Rewashing of Negative and Positive Films (cleaning and healing)* on page 15-21.

Storing Packaged Chemicals

You can keep unmixed-packaged liquid concentrates in their original, unopened containers at temperatures between 4° to 38°C (40° to 100°F), although room temperature, about 21°C (70°F) is preferable. At room temperature, the shelf life of unopened concentrated solutions is about two years. At temperatures around 38°C (100°F), the shelf life is 6 months or less.

If some concentrate remains in its original container, collapse the container (pushing out all the air) and cap it tightly. The shelf life of the concentrate in a partially full container with the air removed, will be about half of that for an unopened container.

Table 15-21 Storage Life of Packaged Concentrate and Mixed Solutions

at 21° to 24°C (70° to 75°F)

Solution	Storage Tank with Close-Fitting Floating Cover	Open Tank
KODAK Reversal First Developer	2 weeks	3 days
KODAK Reversal First Developer Replenisher	2 weeks	3 days
KODAK Reversal Redeveloper	2 weeks	3 days
KODAK Reversal Redeveloper Replenisher	2 weeks	3 days
KODAK Reversal Clearing Bath	1 month	3 weeks
KODAK Reversal Clearing Bath Replenisher	1 month	3 weeks
KODAK Reversal Bleach	1 week	3 days
KODAK Reversal Bleach Replenisher	1 week	3 days
KODAK Rapid Fixer (liquid)	1 month	3 weeks
KODAK Stop Bath	Indefinite[1]	8 weeks

1 If solution is kept clean.

Troubleshooting

Table 15-22 is a troubleshooting guide for reversal processing. The table covers many common occurrences and can be very helpful if you encounter any processing difficulties. For assistance or further information, contact one of the Eastman Kodak Entertainment Imaging Division offices listed in *KODAK LOCATIONS* on page 15-30, or call the Kodak Information Center at 1-800-242-2424, Monday through Friday, 8 a.m to 9 p.m. (eastern time).

Table 15-22 Reversal Process Variations

Problem	Possible Cause
High overall density	First developer • Short time • Low temperature • Underreplenishment, solution exhaustion • Improper mixing • Excessive oxidation • Insufficient agitation
Low overall density	First developer • Long time • High temperature • Overreplenishment • Improper mixing • Light fog • Creation of sodium sulfide in the first developer
Low contrast or low D-max	Second developer • Short time • Low temperature • Underreplenishment, solution exhaustion • Improper mixing
Nonuniform density	• Oil on film before processing • Inadequate clearing bath • Poor bleach agitation • Too strong or too weak clearing bath • Retained silver halide • Poor solution crossover devices
Dark or light spots	• Bleach too concentrated in potassium permanganate • Bleach overreplenishment
Curtains (streaks)	• Improper developer turbulation • Bleach underreplenishment, solution exhaustion • Too strong a clearing bath
Repeating, equally spaced dots	• Emulsion in contact with soft-touch tire on a processing machine roller
Scallops on the film edge, repeating	• Roll of film dropped on a hard surface • Intermittent high tension in processor
Fine streaks	• Worn or misaligned squeegee • Scratches
Fuzzy spots	• Air bubbles on the film surface in the first developer
Pressure marks (light or dark)	• Pinching, buckling, or physical pressure on unprocessed film, before or after exposure
Static marks	• Rapid rewinding of film in low relative humidity • Improper grounding of equipment
Scratches	• Old, hard, worn, crystal-laden, maladjusted solution crossover devices or spools • Cinching a roll of film before or after processing • Improper loading of camera magazine or processing machine • Machine spools that are not rotating freely or are out of line • Improper machine threading (film twisted)
Reticulation—irregular lines, resembling a net	• High solution temperature • Dryer temperature too high or relative humidity too low • Large temperature differences between solutions
Normal low density, low upper densities, low D-max	• Light or chemical fog • Reexposure inadequate, uneven, or omitted • Time too long in strong clearing bath
Increased D-min, and density in low-density areas	• Inadequate clearing • Insufficient wash after first developer • Bleach underreplenishment, solution exhaustion
Dirt (on original)	• Dust, cloth fragments, hair, skin flakes, chemical crystals, etc.—most easily seen under high-intensity specular lighting or as dark specks on a projection
Yellow specs on the emulsion surface	• Sulfur particles formed in the fixer caused by low pH • Sulfur from silver recovery cells
Emulsion skivings	• Small shreds of emulsion sheared from the film edges by machine spools that are improperly aligned or have burrs, and deposited on the base or emulsion
Irregular, shiny areas on the emulsion surface (ferrotyping)	• High windup tension on unprocessed film • Rewinding cold, unprocessed or processed film that has not reached room temperature (condensation moisture) • Wet or tacky emulsion at processor windup
Tacky film	• Inadequate final processing solution crossover device action • Inadequate drying conditions
Water spots	• Surface water carried into the dryer by the film • Hard water—add sequestering agent to the final wash
Scalloped or fluted edges	• Excessive tension on the film
Small round craters on the emulsion	• Differential drying—a liquid being spraying on the emulsion surface after the final vacuum squeegee or solution blowback device
Shore line	• Too much water being carried into drying cabinet in perforation area • Impingement drying—temperature too high
Particles—black lines and comets	• Flocculent silver flakes that were not removed from the fixer—the fixer exit solution crossover device smears adhering flakes into lines of comets

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Outside of the United States and Canada, contact Kodak in your country or contact Entertainment Imaging Division, Eastman Kodak Company, Rochester, NY 14650, U.S.A.

Other information on standards or recommended practices is available from The Society of Motion Picture and Television Engineers, 595 West Hartsdale Avenue, White Plains, NY 10607, telephone (914) 761-1100; or American National Standards Institute, 1430 Broadway, New York, NY 10018; telephone (212) 354-3300.

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