

**Processing
KODAK
Motion Picture Films,
Module 7**

**Process ECN-2
Specifications**



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7 Process ECN-2 Specifications

INTRODUCTION

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MODULE 7

This module contains specifications describing continuous machine processing of Kodak color camera and laboratory films. The following modules are also used in conjunction with Process ECN-2.

Module 8 *Effects of Mechanical and Chemical Variations in Process ECN-2*

Module 1 *Process Control*

Module 3 *Analytical Procedures (for Chemical Analyses)*

Module 4 *Reagent Preparation Procedures (for Chemical Analyses)*

Other modules application to Process ECN-2 are:

Module 2 *Equipment and Procedures*

Module 5 *Chemical Recovery Procedures*

Module 6 *Environmental Aspects*

FILMS AND PROCESS SEQUENCE

Designated Films

Camera Films

KODAK VISION 320T Color Negative Film
5277TM / 7277TM

KODAK VISION 500T Color Negative Film
5279TM / 7279TM

EASTMAN EXR 50D Film 5245TM / 7245TM

EASTMAN EXR 100T Film 5248TM / 7248TM

EASTMAN Color Negative Film 5247TM

EASTMAN EXR 200T Film 5287TM / 7287TM

EASTMAN EXR 200T Film 5293TM / 7293TM

EASTMAN EXR 500T Film 5298TM / 7298TM

EASTMAN EXR 500T Film 5296TM

KODAK PRIMETIME 640T Teleproduction Film
5620TM / 7620TM

For information on exposure index, lighting, color balance, required filters, image structure, sensitometric curves, film storage, and types of rolls available, see the KODAK Publication relating to the film: H-1-5277, H-1-5279, H-1-5245, H-1-7248, H-1-5247, H-1-5287, H-1-5293, H-1-5297, H-1-5298, H-1-5296, H-1-5620, and H-1-7620.

Laboratory Films

EASTMAN EXR Color Intermediate Film
5244TM / 7244TM

EASTMAN Color Internegative II Film
5272TM / 7272TM

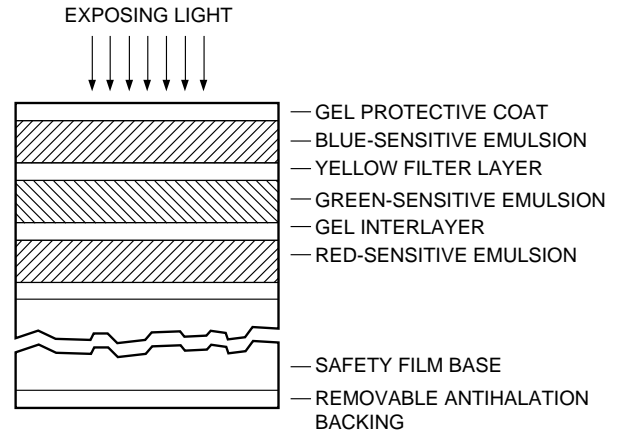
For information on Laboratory Aim Density (LAD), safelights, image structure, sensitometric curves, film storage, and types of rolls available for each laboratory film, see the KODAK Publication relating to the film: H-1-5244 and H-1-5272. Also refer to KODAK Publication No. H-61, *LAD—Laboratory Aim Density*.

Film Structure

Kodak color negative, intermediate, and internegative films are multilayer films with incorporated color couplers.

Figure 7-1 is a diagram of the film structure.

Figure 7-1 Cross Section of Unprocessed KODAK Color Negative and Intermediate Films



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

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The upper blue-sensitive layer contains a colorless coupler, which is converted to yellow dye during development, proportional to blue-light exposure. A yellow filter layer prevents blue light from reaching the two layers beneath, which are somewhat sensitive to blue light. The next layer is green-sensitive and contains a colorless coupler and a yellow-colored coupler, both of which form a magenta dye during development, proportional to green-light exposure. The residual yellow-colored coupler becomes a mask to correct for the unwanted blue absorption of the magenta dye. The bottom emulsion layer is red-sensitive and contains a colorless coupler and a pink-colored coupler, both of which are converted to a cyan dye during development, proportional to red-light exposure. The residual pink-colored coupler forms a mask to correct for the unwanted absorption of blue and green light by the cyan dye. A removable black antihalation layer (rem-jet) is coated on the back side of the film support.

Process ECN-2 Steps

Process ECN-2 has four bleaching alternatives, Ferricyanide Bleach (SR-29), “UL” Bleach (SR-33), Ammonium “UL House” Bleach (SR-35), and Potassium “UL House” Bleach (SR-34). The “UL” bleaches can be used by laboratories having to comply with local environmental laws governing the amount of ferricyanide in the process effluent.

Ferricyanide and Various “UL” Bleach Sequences

Step	Function
1. Prebath	Softens rem-jet for removal.
2. Rem-Jet Removal and Rinse	Removes softened rem-jet backing.
3. Developer	Reduces exposed silver halide grains in all three light-sensitive layers. The developing agent is oxidized by the exposed silver halide, and the oxidation product couples with the particular dye coupler incorporated within each layer to produce dye images. A silver image is formed simultaneously at the exposed silver-halide sites.
4. Stop	Stops the development of silver-halide grains and washes Color Developing Agent CD-3 from the film.
NOTE: The film can now be handled in white light.	
5. Wash	Removes excess acid stop.
6. Bleach (SR-29, SR-33, SR-34, or SR-35)	Converts metallic silver from the silver picture image, formed during color development, to silver-halide compounds that can be removed by the fixer.
7. Wash	Removes residual bleach from the film, preventing contamination of the fixer.
8. Fixer	Converts silver-halide compounds formed in the bleach to soluble silver thiosulfate complex salts that are removed from the film in this fixer and subsequent wash.
9. Wash	Removes residual soluble silver thiosulfate complex salts and unused hypo from the film.
10. Final Rinse	Prevents water spots and controls biological growths.
11. Dryer	Dries film for subsequent handling.

Safelights for Darkroom Illumination

When handling film in a darkroom, safelights are used to provide as much light as possible without fogging the film. Handle the designated films in total darkness until after the stop. The remaining operations can be carried out in a lighted room. A safelight equipped with KODAK 3 Safelight Filter / dark green can be used to illuminate dials, meters, etc., during development, but do not allow the light to shine directly on the film.

Film Storage and Handling

Store processed film at 21°C (70°F) or lower, and 40 to 50 percent relative humidity for normal or commercial use. For long-term storage conditions, see KODAK Publication No. H-23, *The Book of Film Care*.

Exercise care when handling negative films to avoid scratches and/or dirt that will be noticeable on the final print. Have film handlers use lint-free nylon or dacron gloves and handle the film the by edges. Further suggestions on how to keep camera or preprint films clean are in Module 2, *Equipment and Procedures*.

Other Film Characteristics

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

PROCESSING MACHINE DESIGN AND CONSTRUCTION

Machine Design

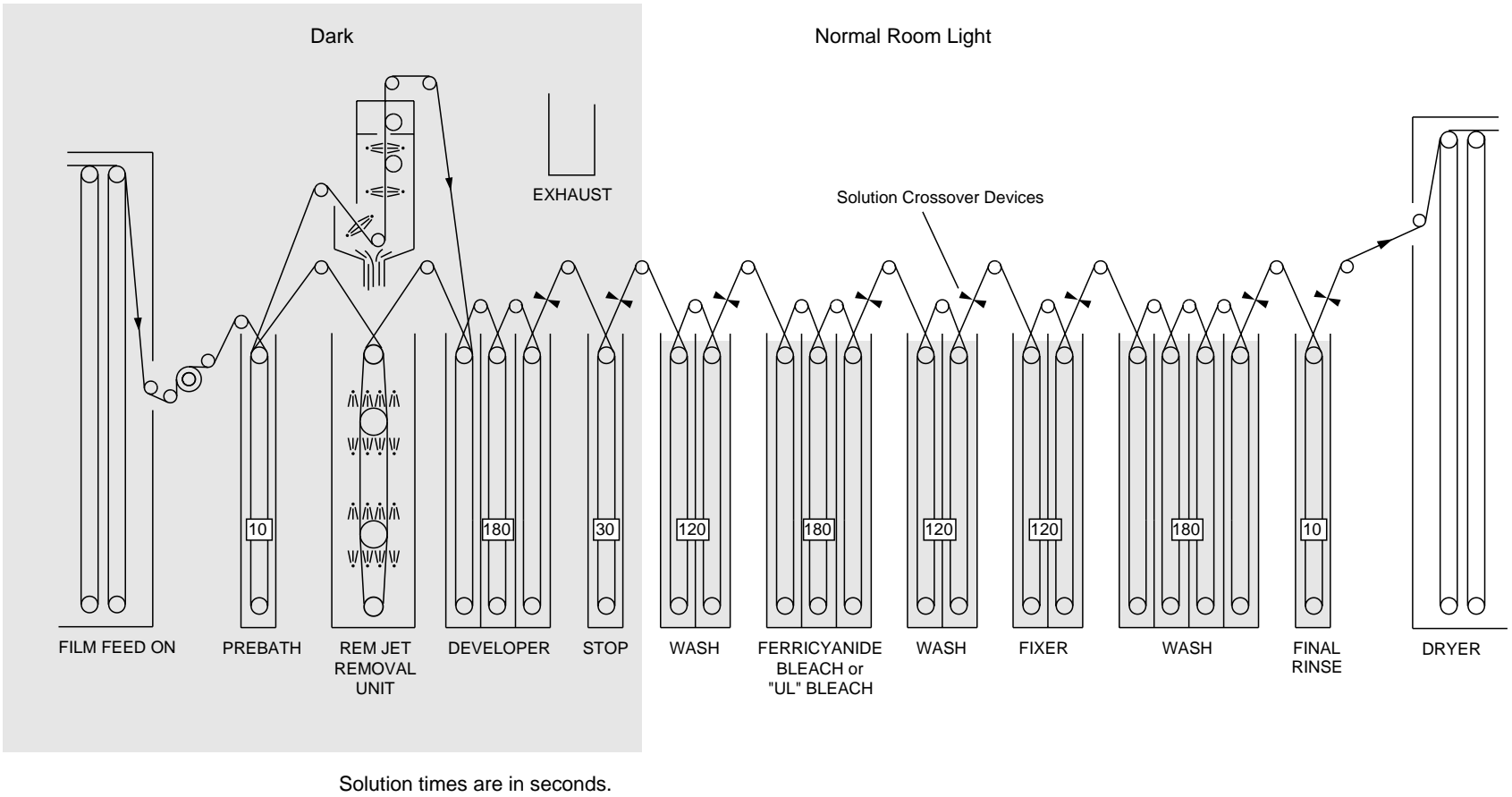
Films intended for Process ECN-2 are processed in roll form in a continuous processing machine. Film is transported through the various solution tanks, emulsion side out, on a series of spools. These spools are mounted in racks that fit into the tanks, and film is threaded over the spools so that it travels in a continuous spiral on each rack. The film should not be allowed to contact any part of the machine that can damage either the support or the emulsion side of the film.

The required treatment time for each processing step is obtained by installing racks in the solutions and washes that will transport a length of film for the required number of minutes at the machine transport speed. To provide adequate agitation of the developer at the emulsion surface, the developer tank is equipped with a turbulator. A turbulator is a submerged series of tubes, having nozzles or drilled holes at various locations along the tubes, opposite the film strand. For more information on turbulator design, see Module 2, *Equipment and Procedures*.

The processor chosen for Process ECN-2 should be a conventional deep-tank machine for 35 mm and/or 16 mm films. Submerged rollers and rack-drive assemblies are recommended for all solutions to minimize the splattering of solutions and aerial oxidation of the developer and fixer. Figure 7-2 is a simple schematic of a typical processing machine for Process ECN-2 using ferricyanide or "UL" bleach. Solution crossover devices should be used at all the locations shown in the schematics to reduce contamination and minimize loss of solution by carry-over into subsequent solutions.

Eastman Kodak Company does not market processing machines or auxiliary equipment suitable for Process ECN-2. However, a list of some manufacturers of processing equipment can be obtained through the Professional Motion Imaging offices.

Figure 7-2 Machine Schematic for Process ECN-2 with Recommended "UL" Bleach or Ferricyanide Bleach Sequence



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Construction Materials

The construction materials recommended for the developer, stop, fixer, and bleach solutions are listed in Table 7-1. All the bleaches are quite corrosive. The "UL" bleach is slightly more corrosive than ferricyanide bleach. Titanium, Hastelloy C, and engineering plastics such as PVC are, therefore, recommended materials for UL or ferricyanide bleach. Use plastics compatible with low pH solutions (less than pH 5).

Red brass is commonly found in ferricyanide bleach systems, it will quickly be dissolved by "UL" bleach. In addition to machine tanks, it is often found in fittings, flowmeters, heat exchangers, and valves. Small red-brass parts have been found even when the bleach tank is constructed of titanium, Hastelloy C, or PVC.

It is a good practice to avoid extended exposure of staples to any bleach solution.

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

Table 7-1 Construction Materials for Process ECN-2

Solution	Plastics (Polyvinyl Chloride or Polyolefins)	Titanium	Hastelloy C	Austenitic Stainless Steel AISI Type 316 ^a
Bleach ("UL" or Ferricyanide):				
Tanks and Racks	• b	•	•	
Mixing Tanks	• b	•	•	
Replenisher Holding Tanks	• b	•	•	
Piping, Pumps, Valves, and Filter Cores	• b	•	•	
Overflow Holding Tank	• b	•	•	
Stop:				
Tanks and Racks	• b	•	•	
Mixing Tanks	• b	•	•	• c
Replenisher Holding Tanks	• b	•	•	• c
Piping, Pumps, Valves, and Filter Cores	• b	•	•	
Others:				
Tanks and Racks	•	•	•	•
Mixing Tanks	•	•	•	•
Replenisher Holding Tanks	•	•	•	•
Piping, Pumps, Valves, and Filter Cores	•	•	•	•

- a 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 of Construction for Photographic Processing Equipment Section for information on other Austenitic Stainless Steels.
- b Plastics compatible with low pH solutions should be used (e.g., polyvinyl chloride, polypropylene, and high-density polyethylene). The compatibility of other plastics should be evaluated under actual use.
- c Provided the concentration of sulfuric acid specified for the stop is not exceeded.

Filters

Filters are used to remove any insoluble material in the form of solids and tars from processing solutions and wash waters. If this material is not removed, it can adhere to the film being processed, machine tank walls, rollers, lines, etc. Filters are required in replenisher lines, recirculation systems, and wash-water lines.

The ideal porosity rating for filters is 10 microns, but the back pressure of a 10-micron filter is sometimes too great to permit adequate flow unless oversize pumps or parallel filters are used. Increasing the filter area will decrease the back pressure, but also increase the cost of filters. Filters with porosity ratings larger than 30 microns will produce low-back pressure, but are of little value in removing insoluble material. Another option is using high-porosity filters in series. The high-porosity filters will slow the clogging of the low-porosity filters.

Establish and follow a definite replacement schedule for filters. Change filters every week or two, or whenever the pressure differential across the filter pot exceeds 10 psig (69 kPa).

Polypropylene, fiber glass, or bleached cotton are acceptable filter media for all Process ECN-2 solutions. *Viscose rayon is not recommended* with the prebath, developer, or bleaches since it can cause adverse photographic effects. Table 7-1 lists acceptable construction materials for filter cores. Test all filters for adverse photographic effects before use. Before a change of filter materials or vendors is made, a photographic effect screening test should be run.

Backing Removal Equipment

All Process ECN-2 compatible films with rem-jet antihalation backing must have it removed prior to development. As the film enters the machine, a prebath softens the backing for removal. The removal must be done so that none of the backing material sticks to the emulsion surface. The removal unit is designed so the combined action of water jets and buffers remove all of the backing and residual haze. Either a wet sponge or high-speed rotating buffers may be used. The buffers should only contact the film support side. Locate a film solution crossover device after the last water spray before entering the developer.

For details and specifications on removal units for acetate and ESTAR Base films, see Module 2, *Equipment and Procedures*.

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 flush, or other mechanical means. When located at solution crossovers, these devices direct solution back into the originating tank and minimize the carryover of processing solutions.

Such a device should be located on the exit strand between stages of all countercurrent washes, and on all Process ECN-2 solutions except the prebath. 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 ECN 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 the ECN-2 process since they are least likely to cause damage to the film.

Dryer Cabinet

Carefully control drying of processed film to avoid a soft, sticky emulsion which leads to a physical defect called *ferrotyping*. If the film is over-dried, the emulsion becomes brittle and the film tends to blister. Satisfactory drying leaves the film dry without tackiness one half to two thirds of the way through the drying cabinet. Allow the film to cool to room temperature before windup. After cooling, the film should have a moisture content in equilibrium with air at 50 percent relative humidity.

Either an impingement or convection (nonimpingement) dryer can be used. The impingement dryer dries film in a shorter time and occupies less space than most nonimpingement dryers. Regardless of the type, the drying equipment must produce adequate and uniform drying to prevent deformation of the film support or emulsion. Filter the input air to the dryer to remove dust particles that can stick to the film. A high-efficiency particulate air (HEPA) filter, such as the Micretain Equi Flo* filter (95 percent efficient at 0.3-micron particle size) is recommended.

* A product of Cambridge Filter Corporation, 7645 Henry Clay Blvd., Liverpool, NY 13088

Machine Exhaust and Room Ventilation Systems

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 the building so that discharged air does not contaminate incoming air.

Locate local exhausts over chemical mixing tanks to remove irritating chemical dust and vapor produced when processing solutions are mixed.

Processing machines need local exhausts at the stop tank. A slot-type exhaust, for example, on the far side of the stop tank will carry away any sulfur dioxide or hydrogen sulfide generated by developer carried over into the stop.

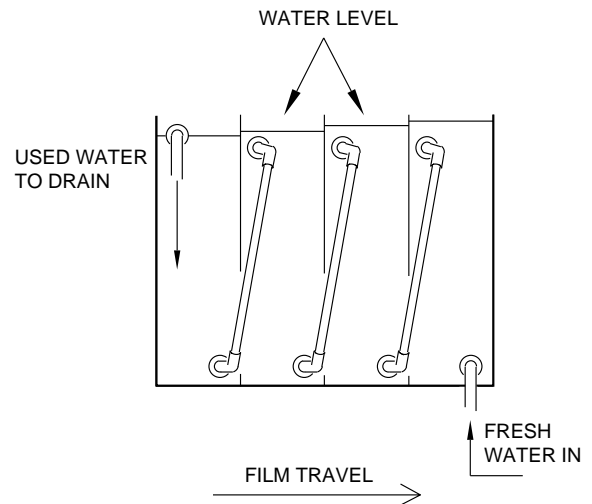
Exhaust hoods need not fit tightly over tanks, and slots should be placed to draw air away from the operator. The exhaust system should provide an air flow of 175 ft³/min (5 m³/min) for every square foot (0.09 m²) of solution surface, and provide 50 to 75 ft/min (15 to 23 m/min) control velocity over the surface of the tank.

Countercurrent Washes

Multitank, countercurrent wash methods provide a great savings in water. In this technique, 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 four-stage countercurrent final wash is illustrated in Figure 7-3.

Figure 7-3 Four-Stage Countercurrent Wash



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Conversion to “UL” Bleach

The advantages of converting to the “UL” bleach (SR-33), from ferricyanide bleach (SR-29) are:

- “UL” bleach maintains a cleaner tank
- “UL” bleach forms no Prussian blue
- “UL” bleach is easier to regenerate
- “UL” bleach regenerates into a cleaner replenisher

The advantages of converting to the “UL” bleach, from persulfate bleach are:

- “UL” bleach has more bleaching power
- “UL” bleach has a longer solution life
- “UL” bleach is less sensitive to process variations
- “UL” bleach maintains the same D-min and film look as ferricyanide

Mechanical changes are minor; just adjust controls to keep the bleach at 27°C (80°F). Solution times and replenishment rates do not change.

If using the ferricyanide bleach currently, first remove any red brass from the system, then clean up the bleach system. A high pH wash (10 to 12) will help eliminate any prussian blue in the system. Three cleaning cycles are recommended.

OPERATING SPECIFICATIONS

Mechanical Specifications

The recommended mechanical specifications for Process ECN-2 are shown in Table 7-2 for ferricyanide bleach and 7-3 for various “UL” bleaches. Included are temperatures and tolerances, processing solution times, replenisher rates, and other pertinent information.

Use the processing times and drying conditions shown in tables 7-2 and 7-3 as a guide for preliminary machine design. The processing times actually used may differ slightly from the ones shown in the tables because of machine design variables, such as film velocity, degree of solution agitation, and amount of solution carry-over. You must determine those specifications necessary to produce satisfactory quality for your installation. Optimum drying conditions (air volume, temperature, and relative humidity) also vary with each dryer design.

Use the replenishment data listed with the mechanical specifications as a starting point for determining exact requirements to maintain the tank chemical analytical specifications.

Handle the exposed stock designated for Process ECN-2 in total darkness during machine loading and processing until after the stop. The processing steps after the stop can be performed in normal room light.

Three “UL” Bleach formulations are available to fill various laboratory operating and environmental needs. They are:

1. Ammonium “UL” Bleach, SR-33. This is the original formulation for Process ECN-2 and has been in use since about 1990. This formulation contains the highest percentage of ammonium ion which maximizes bleach activity. Because the least amount of active ingredients are necessary, this is the least expensive of the UL Bleach varieties to operate. The use of ammonia in a laboratory may present some handling and odor considerations and is restricted in some sewer districts. The next two formulations have been derived to minimize these considerations.
2. Ammonium “UL House” Bleach, SR-35. This formulation was derived to allow for a common tank and replenisher to be used for both Processes ECN and ECP. This formula contains about half the ammonium ion as the original formula. Its advantages are reduced ammonium ion and less mixing and solution handling between the two processes.
3. Potassium “UL House” Bleach, SR-34, combines the advantages of a non-ammonium formulation with a house system where one replenisher feeds tanks for both Processes ECN and ECP. Through replenisher rate manipulation, the tanks for Processes ECN and ECP are maintained at appropriate levels so bleaching is completed while excess carryout is avoided.

Selecting a Bleach Formulation

Experimentation has shown that an all-ammonium bleach is the most active and, therefore, needs the minimum amount of iron (and the associated amount of PDTA) for adequate bleaching. When potassium cations are substituted for ammonium, about 20% more iron is needed to complete bleaching in a given time. If all sodium cations are used, about another 5% more iron is needed to maintain the same level of activity. The best formulation for use in a given lab should be determined based on several operating factors.

Some of the factors to consider are:

- Local chemical cost and availability
- Laboratory ventilation factors
- Restrictions on sewer discharge.

Controlling Tank Concentration with Replenisher Rate

Since bleach systems are subject to evaporation in the machine, overflow and replenisher holding tanks, system evaporation often plays a significant part in striking a balance between replenisher concentration, replenisher rate, and tank concentration. The best way to adjust between these factors, especially in a house system, is to vary the replenisher rate to maintain the desired tank concentration. Allowing the tank concentration to run high creates waste due to carryout. A low tank concentration presents the danger of inadequate bleaching. A new system should be started up using the suggested replenisher rates given for each bleach version. As the process or system seasons, the rates may be adjusted to give the desired tank concentrations. Bromide, iron, and pH are the critical parameters and should stay within limits given. If bromide or iron is too high, no harm to the process or film will occur, but expensive chemicals will be wasted due to carryout.

Chemical Supplies and Substitutions

Ferric nitrate is supplied in crystalline form as nonahydrate or dissolved in water as a 35 or 45% solution. Various bromides, carbonates, and hydroxides may be used interchangeably provided attention is given to effluent requirements and various molecular weights and activities are compensated. The following multipliers may be used to calculate between formulations:

One gram of ferric nitrate nonahydrate = 1.31 mL of 35% = 0.93 mL of 45% solution

One gram of ammonium bromide = 1.21 grams KBr = 1.05 grams NaBr

One mL of 50% NaOH = 1.64 mL 45% KOH

If the odor or handling of acetic acid is a problem or undesirable, solid chemicals may be substituted. They are added as follows:

One mL of glacial acetic acid is equivalent to 1.05 grams of glacial acetic acid. One millilitre of glacial acetic acid can then be replaced by 1.35 grams of ammonium acetate. In potassium formulations, the one mL of glacial acetic acid can be replaced with 1.71 grams of potassium acetate. The ammonium formulation is compensated by removing 2.2 mL of 28% ammonium hydroxide per mL of acetic acid from the formulation. The potassium formulation gets compensated by 1.49 mL of 45% potassium hydroxide for each mL of glacial acetic acid removed. This calculation is illustrated in the following example:

Formula calls for 10 mL of glacial acetic acid and 30 mL of 28% ammonium hydroxide. Substituting for 10 mL of acetic: 10 mL x 1.35 grams ammonium acetate per gram acetic = 13.5 grams ammonium acetate. The amount of ammonium hydroxide to subtract is: 2.2 mL ammonium hydroxide per mL of acetic or $2.2 \times 10 = 22$ mL. The formula becomes zero acetic acid, 13.5 grams of ammonium acetate and 8 mL of ammonium hydroxide.

Mixing Instructions

The preparation of UL bleaches from raw chemistry involves the reaction of iron with ammonium or potassium hydroxide and PDTA to form bleaching agent. Since a reaction is involved, take care to ensure that the solution is ready for each sequential addition so the reaction proceeds correctly. To get experience in the look and feel of mixing, it is recommended that you make a small mix and observe it in the chemical laboratory prior to making the first large mix. Optimum mixing practices should yield the correct pH after the ferric nitrate addition, thereby avoiding expensive and time-consuming adjustments.

Table 7-2 Mechanical Specifications for Process ECN-2 with Ferricyanide Bleach

Process Steps	Footnotes	KODAK Formula		Temperature		Time min:sec	Replenisher (Wash Rate) per 100 ft. (30.5 m) of 35 mm film	Recirculation (R); Filtration (F); Turbulation (T)
		Tank	Replenisher	°C	°F			
				(See Note)			(See Note)	
Prebath	a	PB-2	PB-2R	27 ±1	80 ±2	:10	400 mL	R & F @ 20 to 40 L/min
Rem-Jet Removal & Rinse	b	—	—	27 to 38	80 to 100	—	—	None
Developer	c, d	SD-49	SD-49R	41.1 ±0.1	106.0 ±0.2	3:00	900 mL	R, F, & T
Stop	e	SB-14	SB-14	27 to 38	80 to 100	:30	600 mL	R & F @ 20 to 40 L/min
Wash	f	—	—	27 to 38	80 to 100	:30	1.3 L	None
Ferricyanide Bleach	g	SR-29	SR-29R	38 ±1	100 ±2	3:00	200 mL	R & F @ 20 to 40 L/min
Wash	f	—	—	27 to 38	80 to 100	1:00	1.3 L	None
Fixer	h	F-34a	F-34aR	38 ±1	100 ±2	2:00	600 mL	R & F @ 20 to 40 L/min
Wash	i	—	—	27 to 38	80 to 100	2:00	270 mL	None
Final Rinse	j	FR-1	FR-1R	27 to 38	80 to 100	:10	400 mL	R & F @ 20 to 40 L/min
		Type		Temperature		RH	Air Flow	Time
Dryer		Impingement		32 to 47°C (90 to 117°F)		30 to 50%	1000 ft ³ /min	5 to 7 min.
		Nonimpingement		30 to 38°C (80 to 100°F)		30 to 50%	1000 ft ³ /min	6 to 8 min.

- a Use polypropylene, fiberglass, or bleached cotton as a filter medium in the developer. Viscose rayon is not recommended for prebath, developer, or bleaches because of undesirable photographic effects.
- b Rem-jet removal time and wash rate will vary with equipment design and method. See Table 2-1, Module 2, *Equipment and Procedures*.
- c Maintain close control of developer time and temperature, since small deviations can lead to severe contrast mismatch. Use an accurate thermometer for checking the temperature controller variability. The temperature should be uniform throughout the developer tank.
- d Design developer racks with submerged rollers and rack-drive assemblies to minimize solution aeration and splashing.
- e Install an exhaust over the stop tank, since developer carried over into the stop generates sulfur dioxide. The exhaust system should produce an air flow of 175 ft³/min (5 m³/min) for every square foot (0.09 m²) of solution surface and provide 50 to 75 ft/min (15 to 23 m/min) control velocity over the surface of the tank.
- f The wash preceding the ferricyanide bleach must not become acid enough to lower the bleach pH below 6.0. Low pH in a ferricyanide bleach can promote the formation of Prussian blue. Keep the wash after the bleach effective enough to prevent film mottle from the reaction products of bleach carry-over into the fixer. Two-stage countercurrent washes with solution crossover devices between stages are recommended for efficient washing. The wash rates given in the table assume the use of such two-stage washes. Single-stage washes require substantially greater wash rates.
- g Reconstitute and reuse the bleach to obtain the full economic advantage. See Module 5, *Chemical Recovery Procedures*, for a procedure for reconstituting and regenerating ferricyanide bleach.
- h Fixer replenisher requirements vary with silver recovery equipment, method, and operating conditions. If provision is made for continuous electrolytic desilvering of the recirculated fixer, the silver concentration should be maintained between 0.5 and 1 g/L. See Module 5, *Chemical Recovery Procedures*, for details. The fixer and replenisher should be kept separate from other processes.
- i The wash rate given in this table assumes that the final wash is composed of four countercurrent-wash stages with solution crossover devices between stages.
- j The final rinse contains a wetting agent to promote more uniform wetting of the film strand prior to drying. The Proxel GXL or Spectrus NX106 controls biological growth in the tank.

Note: Temperature--Celsius temperatures are rounded consistent with process-control requirements. Fahrenheit temperatures are primary.

Replenisher (Wash Rate) for 16 mm film--Use one-half the 35 mm rate. Since processing operations can vary greatly in respect to such factors as film-to-leader ratio, solution crossover device efficiency, and amount of film processed per unit of time, adjustments in replenisher rates and/or formulas may be required to maintain the recommended tank concentrations.

Table 7-3 Mechanical Specifications for Process ECN-2 with Various “UL” Bleaches (SR-33, SR-34, SR-35)

Process Steps	Footnotes	KODAK Formula		Temperature		Time min:sec	Replenisher (Wash Rate) per 100 ft. (30.5 m) of 35 mm film	Recirculation (R); Filtration (F); Turbulation (T)
		Tank	Replenisher	°C	°F			
				(See Note)			(See Note)	
Prebath	a	PB-2	PB-2R	27 ±1	80 ±2	:10	400 mL	R & F @ 20 to 40 L/min
Rem-Jet Removal & Rinse	b	—	—	27 to 38	80 to 100	—	—	None
Developer	a, c, d	SD-49	SD-49R	41.1 ±0.1	106.0 ±0.2	3:00	900 mL	R, F, & T
Stop	e	SB-14	SB-14	27 to 38	80 to 100	:30	600 mL	R & F @ 20 to 40 L/min
Wash	f	—	—	27 to 38	80 to 100	:30	1.3 L	None
“UL” Bleach: (Select one)	g, a	SR-33 SR-34 SR-35	SR-33R SR-34R SR-35R	27 ±1	80 ±2	3:00	200 mL 100 mL 400 mL	R & F @ 20 to 40 L/min
Wash	f, h	—	—	27 to 38	80 to 100	1:00	1.3 L	None
Fixer	i	F-34a	F-34aR	38 ±1	100 ±2	2:00	600 mL	R & F @ 20 to 40 L/min
Wash	j	—	—	27 to 38	80 to 100	2:00	270 mL	None
Final Rinse	k	FR-1	FR-1R	27 to 38	80 to 100	:10	400 mL	R & F @ 20 to 40 L/min
		Type		Temperature		RH	Air Flow	Time
Dryer		Impingement		32 to 47°C (90 to 117°F)		30 to 50%	1000 ft³/min	5 to 7 min.
		Nonimpingement		30 to 38°C (80 to 100°F)		30 to 50%	1000 ft³/min	6 to 8 min.

- a Use polypropylene, fiberglass, or bleached cotton as a filter medium in the developer. Viscose rayon is not recommended for prebath, developer, or bleaches because of undesirable photographic effects.
- b Rem-jet removal time and wash rate will vary with equipment design and method. See Table 2-1, Module 2, *Equipment and Procedures*.
- c Maintain close control of developer time and temperature, since small deviations can lead to severe contrast mismatch. Use an accurate thermometer for checking the temperature controller variability. The temperature should be uniform throughout the developer tank.
- d Design developer racks with submerged rollers and rack-drive assemblies to minimize solution aeration and splashing.
- e Install an exhaust over the stop tank, since developer carried over into the stop generates sulfur dioxide, and UL Bleach tanks which have an ammonia or acetic-acid odor. The exhaust system should produce an air flow of 175 ft³/min (5 m³/min) for every square foot (0.09 m²) of solution surface and provide 50 to 75 ft/min (15 to 23 m/min) control velocity over the surface of the tank.
- f Two-stage countercurrent washes with solution crossover devices between stages are recommended for efficient washing. The wash rates given in the table assume the use of such two-stage washes. Single-stage washes require substantially greater wash rates.
- g Reconstitute and reuse the bleach to obtain the full economic advantage. See Module 5, *Chemical Recovery Procedures*, for a procedure for reconstituting and regenerating “UL” Bleach.
- h “UL” Bleach and the wash after the bleach are prone to biogrowth. Addition of Proxel GXL or Spectrus NX106 to the bleach controls this growth. Frequent dumping and changing of this wash tank may prove necessary.
- i Fixer replenisher requirements vary with silver recovery equipment, method, and operations conditions. If provision is made for continuous electrolytic desilvering of the recirculated fixer, the silver concentration should be maintained between 0.5 and 1 g/L. See Module 5, *Chemical Recovery Procedures*, for details. The fixer and replenisher must be kept separate from other processes.
- j The wash rate given in this table assumes that the final wash is composed of four countercurrent-wash stages with solution crossover devices between stages.
- k The final rinse contains a wetting agent to promote more uniform wetting of the film strand prior to drying. Proxel GXL or Spectrus NX106 are added to control biological growth in the tank.

Note: Temperature--Celsius temperatures are rounded consistent with process-control requirements. Fahrenheit temperatures are primary.

Replenisher (Wash Rate) for 16 mm film--Use one-half the 35 mm rate. Since processing operations can vary greatly in respect to such factors as film-to-leader ratio, solution crossover device efficiency, and amount of film processed per unit of time, adjustments in replenisher rates and/or formulas may be required to maintain the recommended tank concentrations.

Drying Specifications

Drying photographic film depends on time in the dryer, the geometry of the dryer, the pattern of air flow and/or impingement on the film, the volume of air flow, the humidity and temperature of the air in the drying cabinet, and the efficiency of the final solution crossover device before the dryer. The optimum conditions for drying film must be determined for each processor, making allowance for film moisture content and static buildup.

With careful control of the above factors, adequate drying of Process ECN-2 films can be achieved in times as short as 5 ½ minutes when using an impingement-type dryer.

Extending the dryer time to 6 to 8 minutes allows for a wider range of drying conditions and dryer geometry (including nonimpingement drying) and less stringent control of drying conditions. General specifications for both impingement and nonimpingement drying are shown in Tables 7-2 and 7-3 . Upon cooling to room temperature after leaving the dryer, the film should have a moisture content in equilibrium with air at 50 percent relative humidity and show minimum curl.

Turbulation Specifications

Turbulators are essential in the recirculation system for Process ECN-2 developer to provide uniform film processing. The turbulators are used submerged in the solution and are located in such a way that the recirculated solution impinges uniformly over the full width of the film strand.

Turbulation at the emulsion surface must be provided along the film path at a suitable frequency. Backup rollers opposite the turbulators are necessary in most processors when adequate turbulator pressures are used. Design guidelines for Process ECN-2 developer turbulation, along with typical solution flow information, are given in Module 2, *Equipment and Procedures*. Precise turbulation design must be determined specifically for a particular processing machine to promote good uniformity of development. The guidelines in Module 2 provide starting points for such designs.

Wash-Water Flow Rates

Adequate washing in conjunction with conservation of wash water is a matter of concern for all processors. Ways of reducing wash-water usage while maintaining adequate washing include: 1. using multi-stage countercurrent-flow washes (see Figure 7-2); 2. installing solution crossover devices between wash stages as well as before the wash (see Figures 7-2); and 3. shutting off wash water when the machine is not transporting film or leader. The last alternative can easily be accomplished by installing solenoid valves in the wash-water supply lines that are opened when the machine drive is running. The water saving from the use of solution crossover devices and countercurrent stages can be substantial. A three-stage countercurrent final wash with solution crossover devices before and after each stage requires approximately 1/25 of the water of a single-stage wash with entrance and exit solution crossover devices.

Overflow from one wash step should never be used in any other wash step.

Decreased water flow in the final wash may increase the propensity toward biological growth. See Module 2, *Equipment and Procedures*, for information on control of biological growth. Temperature control can also be a concern at lower flow rates. After establishing the final flow rate, check to be sure the process stays within the temperature tolerances specified in Tables 7-2 or 7-3.

The wash-water flow rates in Tables 7-2 and 7-3 have been found to be satisfactory in a 75 ft/min (23 m/min) processor, using two-stage countercurrent washes (four-stage final wash) with efficient solution crossover devices between stages. The optimum wash rates for a particular installation must be determined after the film transport rate, the number of countercurrent stages, and the solution crossover device efficiencies have been established.

Experimentation is necessary to determine minimum wash-water flow rates that will provide adequate washing. Inadequate washing could result in significant contamination of the solution after the wash with the solution before the wash and/or loss of image stability.

Stop Wash

An inadequate stop wash in the ferricyanide bleach sequence will cause a low pH in the ferricyanide bleach which, in turn, will increase the formation of prussian blue. The prussian blue can contaminate the film in the form of blue dirt or scum. For adequate safety from Prussian blue, the final stage of the stop wash should have a pH greater than 3.0.

Bleach Wash

If the ferricyanide bleach wash is inadequate, the processed film may be mottled from reaction products of bleach carry-over in the fixer.

Final Wash

The final wash must remove most of the thiosulfate (hypo) from the film. Retained hypo levels of 4 $\mu\text{g}/\text{cm}^2$ or greater can cause serious dye fading. If the recommended four-stage countercurrent wash and wash rate are used, residual hypo in the designated films processed in Process ECN-2 should be barely detectable (0.2 to 0.4 $\mu\text{g}/\text{cm}^2$) by Analytical Method ULM-0004/1 in Module 3, *Analytical Procedures*.

Rewashing

For many years, the term rewashing referred to the common practice of running processed film through a complete process for a second time. This operation removes dirt and/or heals slight emulsion scratches and digs. Rewashing a film once in the original process produces minimal changes in the dye stability and sensitometry. However, several rewashings may cause changes in green (or other) density over the full exposure scale of the film. After several rewashings, subsequent print orders can require the green light printer exposure (or other) to be changed from the original setting.

Rewash RW-1 is designed to avoid these sensitometric and dye stability changes, and at the same time to produce similar emulsion swells to that obtained by going through the original developer.

Table 7-4 Rewash RW-1 Sequence

Step	Function
1. Prebath PB-6	Swells the emulsion, causing the scratches to be filled in and embedded dirt particles to be released.
2. Wash	Removes unwanted chemicals, which, if left in, affect dye stability.
3. Final Rinse FR-1	Contains a wetting agent to help prevent water spots while the film is being dried.
4. Dry	Dries film for subsequent handling.

The rewash machine consists of a loading elevator, tanks for the prebath, wash, and final rinse solutions, and a dryer. Submerged rollers and rack-drive assemblies will minimize spattering of solutions and aerial oxidation of sulfite in the prebath. Type 316 stainless steel is suitable for tanks, racks, and recirculation equipment. Use 10-micron filters of polypropylene, fiberglass, or bleached cotton in the recirculation system. Use no solution crossover devices, except after the final rinse, where a high efficiency final solution crossover device is needed.

Table 7-5 Mechanical Specifications for Rewash RW-1

Process Steps	KODAK Formula Tank and Replenisher	Temperature ^a		Time min:sec	Replenisher (Wash Rate) per 100 ft. (30.5 m) of 35 mm film ^b	Recirculation (R); Filtration (F)
		°C	°F			
Prebath	PB-6	21 ±1	70 ±2	2:00	600 mL	
Wash	—	21 to 38	70 to 100	3:00	300 mL ^c	
Final Rinse	FR-1	21 to 38	70 to 100	:10		
	Type	Temperature		RH	Air Flow	Time
Dryer	Impingement	32 to 47°C (90 to 117°F)		30 to 50%	1000 ft ³ /min	5 to 7 min.
	Nonimpingement	30 to 38°C (80 to 100°F)		30 to 50%	1000 ft ³ /min	6 to 8 min.

a Celsius temperatures are rounded consistent with process-control requirements. Fahrenheit temperatures are primary.

b For 16 mm film, use one-half the 35 mm film replenishment and wash rates.

c Use a two-stage countercurrent wash.

PROCESSING CHEMICALS

Prepackaged Chemicals

There are prepackaged kits available for preparing the processing solutions used in Process ECN-2. For information on EASTMAN ECN-2 Kit Chemicals, see Kodak's *Professional Motion Imaging Price Catalog*. As an alternative to kit chemicals, each solution can be prepared according to formulas, using chemicals purchased in bulk.

Bulk Chemicals

The list of suppliers below is not intended to be all-inclusive, nor are the suppliers listed in any order of preference. The mention of a supplier is not intended as a recommendation by Eastman Kodak Company. Most of the chemicals listed are available from local chemical supply houses. For additional suppliers, consult *Chemical Week*, *Chemical Buyers*, or *Thomas' Register* in public libraries.

Information on the known hazards and safe handling of the following chemicals is available from the supplier of the chemical in the form of chemical container labels and Material Safety Data Sheets (MSDS) as required by the OSHA Hazard Communication Standard Act and many state laws.

Table 7-6 SUPPLIERS OF PROCESSING CHEMICALS

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers	Supplier Phone Number
Acetic Acid, Glacial	CH ₃ COOH	Eastman Kodak Company	800-225-5352
		Brown Chemical Company	201-337-0900
		Union Carbide	203-794-5300
Ammonium Bromide	NH ₄ Br	AC Industries, Inc.	800-736-7893
		Ameribrome, Inc.	212-286-4000
Ammonium Hydroxide (28% Solution)	NH ₄ OH	Eastman Kodak Company	800-225-5352
		J.T. Baker Chemical Company	201-859-2151
		McKesson Chemical Company	415-983-8300

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers	Supplier Phone Number
Ammonium Thiosulfate	(NH ₄) ₂ S ₂ O ₃	Eastman Kodak Company	800-225-5352
		General Chemical Company	201-515-0900
		E.I. du Pont de Nemours & Company, Inc.	800-441-7515
KODAK Anti-Calcium, No. 4	—	Eastman Kodak Company	800-225-5352
KODAK Antifoggant AF-2000	—	Eastman Kodak Company	800-225-5352
Beta-Aminopropionic Acid (Beta-Alanine)	—	Ajinomoto U.S.A., Inc.	201-592-8122
		Chemical Dynamics Corporation	908-753-5000
		U.S. Biochemical Corporation	216-765-5000
Borax, Decahydrate ¹	Na ₂ B ₄ O ₇ • 10H ₂ O	Eastman Kodak Company	800-225-5352
		Ashland Chemical Company	614-889-3333
		US Borax and Chemical Corporation	805-287-5400
Borax, Pentahydrate ¹	Na ₂ B ₄ O ₇ • 5H ₂ O	Ashland Chemical Company	614-889-3333
		US Borax and Chemical Corporation	805-287-5400
KODAK Chelating Agent, No. 1	—	Eastman Kodak Company	800-225-5352
KODAK Color Developing Agent, CD-3	—	Eastman Kodak Company	800-225-5352
Spectrum NX106	—	Betz Dearborn, Inc.	215-355-3300
(Ethylene-dinitrilo) Tetraacetic Acid, Tetrasodium Salt	—	Dow Chemical USA	800-447-4369
		BASF Corporation	201-397-4640
		Eastman Kodak Company	800-225-5352

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers	Supplier Phone Number
Ferric Nitrate Nonahydrate ¹	Fe(NO ₃) ₃ •9H ₂ O	J.T. Baker Chemical Company	201-859-2151
		Shepherd Chemical Company	513-731-1110
		General Chemical Company	201-515-0900
Gelatin	—	Atlantic Gelatin	617-933-2800
		American Gelatin Company	908-382-2212
Phosphoric Acid ¹	H ₃ PO ₄	Eastman Kodak Company	800-225-5352
		Albright & Wilson, Inc.	804-550-4300
		Ashland Chemical Company	614-889-3333
		Brown Chemical Company, Inc.	201-337-0900
Potassium Ferricyanide, Anhydrous ¹	K ₃ Fe(CN) ₆	Aceto Corporation	516-627-6000
		American International Chemical Company	508-655-5805
Proxel GXL	—	Arch Treatment Products—Biocides	800-523-7391
Sodium Acetate, Anhydrous ¹	CH ₃ COONa	Ashland Chemical Company	614-889-3333
		Brown Chemical Company, Inc	201-337-0900
		Mallinckrodt Inc.	800-828-0514
Sodium Bicarbonate, Anhydrous ¹	NaHCO ₃	Ashland Chemical Company	614-889-3333
		Eastman Kodak Company	800-225-5352
		Brown Chemical Company, Inc.	201-337-0900
		American International Chemical Company	508-655-5805

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers	Supplier Phone Number
Sodium Bisulfite, Anhydrous ¹	NaHSO ₃	Ashland Chemical Company	614-889-3333
		Eastman Kodak Company	800-225-5352
		Brown Chemical Company, Inc.	201-337-0900
		American International Chemical Company	508-655-5805
Sodium Bromide Anhydrous ¹	NaBr	Dow Chemical USA	800-447-4369
		Allen Chemical Company	201-592-8122
Sodium Carbonate, Anhydrous ¹	Na ₂ CO ₃	Brown Chemical Company, Inc.	201-337-0900
		Ashland Chemical Company	614-889-3333
Sodium Chloride ¹	NaCl	Ashland Chemical Company	614-889-3333
		J.T. Baker Chemical Company	201-859-2151
		American International Chemical Company	508-655-5805
Sodium Ferrocyanide, Decahydrate ¹	Na ₄ Fe(CN) ₆ •10H ₂ O	American Cyanamid Company	800-438-5615
		Eastman Kodak Company	800-225-5352
		Filo Chemical, Inc.	212-514-9330
		Degussa Corporation	201-641-6100
Sodium Hydroxide ¹	NaOH	Ashland Chemical Company	614-889-3333
		Brown Chemical Company	201-337-0900
		Dow Chemical USA	800-447-4369
		Eastman Kodak Company	800-225-5352

Chemical or Trade Name	Formula or Chemical Name	Some Suppliers	Supplier Phone Number
Sodium Hypochlorite	NaOCl	Ashland Chemical Company	614-889-3333
		Brown Chemical Company	201-337-0900
		Delta Chemical Company	410-354-0100
Sodium Metabisulfite Anhydrous ¹	Na ₂ S ₂ O ₅	Eastman Kodak Company	800-225-5352
		BASF Corporation	201-397-4640
		American International Chemical Company	508-655-5805
Sodium Phosphate, Monobasic, Anhydrous ¹	NaH ₂ PO ₄	AC Industries, Inc.	800-736-7893
		American International Chemical Company	508-655-5805
Sodium Sulfate, Anhydrous ¹	Na ₂ SO ₄	General Chemical Corporation	201-515-0900
		Eastman Kodak Company	800-225-5352
		American International Chemical Company	508-655-580
Sodium Sulfite, Anhydrous ¹	Na ₂ SO ₃	Ashland Chemical Company	614-889-3333
		Eastman Kodak Company	800-225-5352
KODAK Stabilizer Additive	—	Eastman Kodak Company	800-225-5352
Sulfuric Acid, Concentrated ¹	H ₂ SO ₄	Ashland Chemical Company	614-889-3333
		Eastman Kodak Company	800-225-5352
		E.I. du Pont de Nemours & Company, Inc.	800-441-7515

¹ These chemicals must meet the ANSI/ACS specifications. An index of all ANSI specifications is available from American National Standards Institute, 11 West 42 Street, New York, New York 10036.

Solution Mixing

Use the following mixing practices when preparing processing solutions with common mixing equipment. Mix solutions in the order in which the solutions occur in the process sequence. This order will minimize the effect of contamination of a solution by the previously mixed solution. The solutions are also less likely to be placed in the wrong holding or machine tanks. See Module 8, *Effects of Mechanical and Chemical Variations in Process ECN-2*, for sensitometric effects of contamination and solution concentration errors.

The mixing area should be well ventilated and have a local exhaust over the mixing tank to carry off fumes and chemical dust. See Module 2, *Equipment and Procedures*, for exhaust specifications.

Good mixing practices:

1. Observe all precautionary information on containers and packages of each chemical, and on the Material Safety Data Sheets available from the seller of the individual chemical. Footnotes with some formulas provide further precautionary information.
2. Rinse the mix tank with water, and run fresh water through the pump. Drain the tank and pump.

“UL” BLEACH: If converting from ferricyanide bleach, first remove all red brass from the system, then clean up the bleach system. A high pH wash (10 to 12) will help eliminate any prussian blue in the system. Three cleaning cycles are recommended.

If converting from persulfate bleach, a series of hot water rinses is needed in the accelerator and bleach tanks. Since the accelerator tank will become a wash tank, the initial series of rinses is enough. The bleach tank should be filled with hot water and the recirculation and replenishment system turned on. Three to five cleaning cycles are recommended.

3. Fill the tank to the mixing level with water at the appropriate temperature, and start the mixer. Be sure the mixer is large enough to provide adequate agitation for the volume of solution desired. Allow 30 seconds for agitating the water between the time the mixer is started and the first chemical addition is made. This action helps remove air from the water and disperse the first chemical addition.
4. Premeasure all chemicals,* but do not combine the dry chemicals together before adding them to the mixing tank. This practice can result in unwanted chemical reactions producing toxic and noxious fumes. The formula for each processing solution lists chemicals in the proper mixing order. Add and dissolve the chemicals in the order given, and dilute the solution to volume with water

DEVELOPER: To avoid problems in dissolving the KODAK Color Developing Agent, CD-3, agitate the developer mix for 15 minutes after the addition of the sodium bicarbonate and for 10 minutes after the addition of the CD-3 and before diluting to volume. Be sure the starting volume of water is 85% of the volume

to be mixed. If a water hopper is used, take care not to over dilute the solution.

FERRICYANIDE BLEACH: When the ferricyanide bleach is made with ferrocyanide and persulfate, the solution should be allowed to sit approximately an hour before final adjustments are made. This allows for complete reaction of the two chemicals.



Caution

CORROSIVE. Avoid contact with ammonium hydroxide solution and vapor. Avoid breathing vapor. Wear safety goggles and impervious gloves. Store in a cool place to prevent pressure build-up in the container.

“UL” BLEACH: When adding ammonium hydroxide to the mix tank, be sure to add it below, or at the surface of the solution to minimize the escape of ammonia vapor. Careless handling may require evacuation of the mix room.

5. Agitate the solution for a few minutes after it has been diluted to volume, to promote complete and uniform dissolution of all the constituents. The prebath, developer, stop, and final rinse should be agitated for at least 5 minutes after dilution to volume; the fixer for 10 minutes; and the bleach for 15 minutes.
6. Analyze the solution for its critical constituents after mixing. Then place the certified solution into the appropriate storage tank.
7. Carefully rinse the mixing tank and any pump used to transport the solution. Clean the mixing equipment immediately after the tank is emptied, before salts and tars have time to form. The tank is more efficiently rinsed with numerous small-volume rinses than with a few large-volume rinses.

* When preparing processing solutions, use photographic grade chemicals (passing ANSI or ANSI/ACS specifications). Kodak, as well as some other suppliers, provide such chemicals.

FORMULAS AND ANALYTICAL SPECIFICATIONS

Bulk Formulas

Each processing solution prepared from bulk chemicals must be prepared according to the formulas given below. After mixing, each solution should be analyzed to check conformity to pH, specific gravity, and analytical specifications given in the formula. Procedures for chemical analysis are given in Module 3, *Analytical Procedures*.

Maintain the fresh tank formula specifications exactly as given in the formulas. Immediately correct any deviations from tank specifications revealed by chemical analysis, by making appropriate additions or cuts to the tank solution.

Any long-term tendency to deviate from the tank analytical specifications (e.g., slowly increasing pH) should be corrected by adjustment of the replenisher. The replenisher formula specifications are to be used as starting points for typical operations.



Important

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

Prebath

Constituent	Fresh Tank	Fresh and Seasoned Tank ¹ Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Prebath ²	(PB-2)		(PB-2R)	
Water 27 to 38°C (80 to 100°F)	800 mL		800 mL	
Borax (Decahydrated) ³	20.0 g		20.0 g	
Sodium Sulfate (Anhydrous)	100 g		100 g	
Sodium Hydroxide	1.0 g		1.0 g	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F)		9.25 ± 0.10 1.094 ± 0.004		9.25 ± 0.10 1.094 ± 0.004

¹ If a precipitate tends to form, add 1 mL/L of KODAK Anti-Calcium, No. 4.

² If biological growth becomes a problem, Proxel GXL may be added at 0.07 mL/L.

³ Borax having 5 moles water of crystallization can be used at 15.0 g/L.

Developer

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Developer				
Water 21 to 38°C (70 to 100°F)	850 mL		850 mL	
KODAK Anti-Calcium, No. 4	2.0 mL		2.7 g	
Sodium Sulfite (Anhydrous) ¹	2.0 g	1.8 ± 0.2 g/L	2.5 g	2.2 ± 0.2 g/L
Sodium Bromide (Anhydrous)	1.20 g	1.20 ± 0.05 g/L	0.80 g	0.80 ± 0.05 g/L
Sodium Carbonate (Anhydrous)	25.6 g		25.0 g	
Sodium Bicarbonate	2.7 g		0.6 g	
KODAK Color Developing Agent CD-3 ¹	4.0 g	3.9 ± 0.1 g/L	5.5 g	5.2 ± 0.1 g/L
KODAK Antifoggant AF-2000	5 mL	5 ± 0.1 mL	5.30 mL	5.30 ± 0.1 mL
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F)		10.25 ± 0.05		10.32 ± 0.05
Specific Gravity at 25.0°C (77.0°F)		1.029 ± 0.003		1.028 ± 0.003
Total Alkalinity (5 mL sample)		25.6 ± 1.5 mL		23.6 ± 0.5 mL

¹ The difference between the mix levels and the analytical specifications for CD-3 and sodium sulfite are to compensate for aeration losses that occur during mixing and transfer of solution to the machine tank. The mix levels necessary to achieve the required analytical specifications will vary with mixing equipment and solution transfer techniques.

Because of the very good stability of AF-2000 in the color developer, no modification of the replenisher AF-2000 concentration is necessary even if the machine is idle for a long period of time.

Stop

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Stop	(SB-14)		h	
Water 21 to 38°C (70 to 100°F)	900 mL		Same as Tank	
Sulfuric Acid (7.0 N)	50 mL ¹			
Water to make	1 L			
pH at 25.0°C (77.0°F)		0.8 to 1.5		
WARNING! May cause eye and skin irritation and allergic skin reaction. Avoid contact with eyes and skin. In case of contact, immediately flush with plenty of water; for eyes, get medical attention.				

¹ 10 mL of concentrated sulfuric acid may be substituted for 50 mL of 7.0 N acid.

Recommended Process Bleach

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Ammonium "UL" Bleach	(SR-33)		(SR-33R)	
Water 21 to 38°C (70 to 100°F)	700 mL		700 mL	
Proxel GXL	0.07 mL		0.10 mL	
Ammonium Hydroxide Solution (28%)	30 mL		37 mL	
KODAK Chelating Agent No. 1	24.2 g		38.4 g	
Ammonium Bromide	32.5 g	32 ± 7.5 g/L	51.6 g	51.6 ± 10.0 g/L
Acetic Acid (Glacial)	10 mL		14.5 mL	
Ferric Nitrate (Nonahydrate) ¹	28.8 g		45.7 g	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F) ²		5.00 ± 0.20		5.00 ± 0.20
Specific Gravity at 25.0°C (77.0°F)		1.035 ± 0.003		1.062 ± 0.003
Total Iron		4.0 ± 0.50 g/L		6.35 ± 0.50 g/L
Ferric Iron		4.0 ± 0.50 g/L		6.35 ± 0.50 g/L
Ferrous Iron		<.5 g/L		<.5 g/L

¹ See *Chemical Supplies and Substitutions* for possible chemical alternatives.

² Adjust pH using glacial acetic acid, 7.0 N sulfuric acid, or 28% ammonium hydroxide.

Note: See *Chemical Supplies and Substitutions* for calculations regarding raw chemical concentrations and alternatives.

- It is especially important to follow the "Good Mixing Practices" when preparing this bleach.
- Follow exactly the mix order given above.
- Check the solution pH before starting the ferric nitrate addition. It should be between 8 and 8.5; adjust if necessary.
- Add the ferric nitrate solution slowly while mixing.
- The solution should be clear and yellow after completion of the ferric nitrate addition and subsequent mixing. A temporarily cloudy solution caused by too low a pH will clear during pH adjustment.
- A solution which stays red for a long time after mixing indicates an excess of iron or deficiency of chelating agent.
- pH correction can be made using sulfuric acid or ammonium hydroxide. Do not use phosphoric acid or strong bases such as potassium or sodium hydroxide.

Alternate Process Bleach

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Ammonium "UL House" Bleach	(SR-35)		(SR-35R)	
Water 21 to 38°C (70 to 100°F)	700 mL		700 mL	
Proxel GXL	0.07 mL		0.10 mL	
Ammonium Hydroxide Solution ¹ (28%)	54 mL		64 mL	
KODAK Chelating Agent No. 1	44.8 g		51 g	
Sodium Bromide	25 g	25 ± 3 g/L	32.3 g	32.3 ± 3 g/L
Acetic Acid (90% Solution)	10 mL		14.5 mL	
Ferric Nitrate (Nonahydrate) ²	53.8 g		61.2 g	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F) ³		5.30 ± 0.20		5.30 ± 0.20
Specific Gravity at 25.0°C (77.0°F)		1.056 ± 0.003		1.066 ± 0.003
Total Iron		7.50 ± 0.50 g/L		8.20 ± 0.50 g/L
Ferric Iron		7.50 ± 0.50 g/L		8.20 ± 0.50 g/L
Ferrous Iron		<1.00 g/L		<1.00 g/L

¹ Ammonium acetate may be substituted for ammonium hydroxide and acetic acid. See Section 4 for calculations.

² See *Chemical Supplies and Substitutions* for possible chemical alternatives.

³ Adjust pH using glacial acetic acid, 7.0 N sulfuric acid, or 28% ammonium hydroxide.

Note: See Chemical Supplies and Substitutions for calculations regarding raw chemical concentrations and alternatives.

- It is especially important to follow the "Good Mixing Practices" when preparing this bleach.
- Follow exactly the mix order given above.
- Check the solution pH before starting the ferric nitrate addition. It should be between 8 and 8.5; adjust if necessary.
- Add the ferric nitrate solution slowly while mixing.
- The solution should be clear and yellow after completion of the ferric nitrate addition and subsequent mixing. A temporarily cloudy solution caused by too low a pH will clear during pH adjustment.
- A solution which stays red for a long time after mixing indicates an excess of iron or deficiency of chelating agent.
- pH correction can be made using sulfuric acid or ammonium hydroxide. Do not use phosphoric acid or strong bases such as potassium or sodium hydroxide.

Alternate Process Bleach

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Potassium "UL House" Bleach	(SB-34)		(SR-34R)	
Water 21 to 38°C (70 to 100°F)	700 mL		700 mL	
Proxel GXL	0.07 mL		0.10 mL	
Potassium Hydroxide (45%) ¹	42.7 mL		83.8 mL	
KODAK Chelating Agent No. 1	30.6 g		60.1 g	
Potassium Bromide (Anhydrous)	51.5 g	51.1 ± 3 g/L	101 g	101 ± 6 g/L
Acetic Acid (Glacial)	7.65 mL		15 mL	
Ferric Nitrate (Nonahydrate) ²	35.7 g		70 g	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F) ³		5.30 ± 0.20		5.3 ± 0.20
Specific Gravity at 25.0°C (77.0°F)		1.070 ± 0.003		1.1420 ± 0.003
Total Iron		5.1 ± 0.5 g/L		10 ± 0.5 g/L
Ferric Iron		5.1 ± 0.5 g/L		10 ± 0.5 g/L
Ferrous Iron		<0.5 g/L		<0.5 g/L

1 DO NOT add more potassium hydroxide after ferric nitrate is added.

2 See *Chemical Supplies and Substitutions* for calculations.

3 Adjust pH with glacial acetic acid, potassium carbonate or 7 N sulfuric acid.

Note: See Chemical Supplies and Substitutions section for calculations regarding raw chemical concentrations and alternatives.

- It is especially important to follow the "Good Mixing Practices" when preparing this bleach.
- Follow exactly the mix order given above.
- Check the solution pH before starting the ferric nitrate addition. It should be between 8 and 8.5; adjust if necessary.
- Add the ferric nitrate solution slowly while mixing.
- The solution should be clear and yellow after completion of the ferric nitrate addition and subsequent mixing. A temporarily cloudy solution caused by too low a pH will clear during pH adjustment.
- A solution which stays red for a long time after mixing indicates an excess of iron or deficiency of chelating agent.
- pH correction can be made using sulfuric acid or potassium carbonate. Do not use phosphoric acid or strong bases such as potassium or sodium hydroxide after ferric nitrate addition.

Alternate Bleach

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Ferricyanide Bleach	(SR-29)		(SR-29R)	
Water 32 to 43°C (90 to 110°F)	900 mL		900 mL	
Potassium Ferricyanide (Anhydrous) ¹	40.0 g	40.0 ± 5.0 g/L	55.0 g	55.0 ± 2.0 g/L
Sodium Bromide (Anhydrous)	25.0 g	25.0 ± 2.0 g/L	35.0 g	35.0 ± 2.0 g/L
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F) ²		6.5 ± 0.5		8.0 ± 0.3
Specific Gravity at 25.0°C (77.0°F)		1.037 ± 0.003 ³		1.052 ± 0.003

1 One gram of this compound can also be obtained by mixing 0.41 gram of potassium persulfate and 1.47 grams of sodium ferrocyanide decahydrate. The reaction between potassium persulfate and sodium ferrocyanide takes about 1 hour, after which the final adjustments to the mix should be made. The specific gravity of a bleach prepared by the reaction will be higher than when using the formula, and will get higher with each regeneration using potassium persulfate.

2 To maintain pH control it may be necessary to add 1 to 2 g/L of Borax decahydrate. Adjust to proper pH with 2.5 N sodium hydroxide or 2.5 N sulfuric acid.

3 These specifications apply to a fresh (unseasoned) tank only.

Fixer

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Fixer	(SF-34a)		(F-34aR)	
Water 21 to 38°C (70 to 100°F)	700 mL		700 mL	
KODAK Anti-Calcium, No. 4	2.0 mL		2.8 mL	
Ammonium Thiosulfate Solution 58%	185 mL	185 ± 15 mL/L	200 mL	200 ± 15 mL/L
Sodium Sulfite (Anhydrous)	10.0 g	20.0 ± 2.0 g/L ¹	22.0 g	26.0 ± 2.0 g/L ¹
Sodium Metabisulfite (Anhydrous)	8.4 g		4.0 g	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F)		6.5 ± 0.2 ²		7.2 ± 0.2 ³
Specific Gravity at 25.0°C (77.0°F)		1.086 ± 0.003 ²		1.103 ± 0.003
Hypo Index (3 mL sample)		39.5 ± 2.5 mL		45.0 ± 2.0 mL

1 The analytical method measures the total sulfite content of the solution and reports it as sodium metabisulfite (Na₂S₂O₅). If a solution addition to the sodium metabisulfite level must be made but sodium bisulfite is to be used, multiply the sodium metabisulfite addition weight by the factor 1.09 to obtain the equivalent amount of sodium bisulfite.

2 These specifications apply to a fresh (unseasoned) tank only.

3 Fixer pH may decrease with certain operating conditions when electrolytically desilvering the fixer. If the fixer is not continuously desilvered or desilvered by the batch method and reused as replenisher, the replenisher pH should be 6.50 ± 0.2. If bleach regeneration is practiced, the fixer pH should never be allowed to fall below 5.5, since low fixer pH affects the dye stability of Kodak color negative films.

Final Rinse

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Final Rinse ¹	(SB-29)		(SR-29R)	
Water 21 to 38°C (70 to 100°F)	900 mL		900 mL	
KODAK Stabilizer Additive	0.14 mL		0.17 mL	
Water to make	1 L		1 L	

1 If biological growth becomes a problem, Proxel GXL may be added at 0.07 mL/L, or Spectrus NX106 at 0.7 mL/L.

Rewash Formulas

The final rinse formula (FR-1) is given above. Additional tank solution (FR-1) may be used in place of the replenisher solution (FR-1R) for the rewash operation.

Constituent	Fresh Tank	Fresh and Seasoned Tank Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Prebath	(PB-6)			
Water 21 to 38°C (70 to 100°F)	800 mL			
KODAK Anti-Calcium, No. 4	2.0 mL			
Sodium Sulfite (anhydrous)	8.4 g	18.0 ± 2.0 g/L		
Sodium Bisulfite (anhydrous)	10.0 g			
Water to make	1 L			
pH at 25.0°C (77.0°F)		6.5 ± 0.20		

Alternate Prebath¹				
Constituent	Fresh Tank	Fresh and Seasoned Tank¹ Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Sodium Carbonate Prebath²	(PB-C1)		(PB-C1R)	
Water 27 to 38°C (80 to 100°F)	800 mL		800 mL	
KODAK Anti-Calcium, No. 4	3.0 mL		3.0 mL	
Sodium Carbonate (anhydrous)	58.0 g		58.0 g	
Sodium Bicarbonate (anhydrous)	19.0 g		19.0 g	
KODAK Stabilizer Additive	0.5 mL		0.5 mL	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F)		10.0 ± 0.20		10.0 ± 0.20
Specific gravity at 25.0°C (77.0°F)		1.0660		1.0660

1 May be used in place of PB-2 for Process ECN-2.

2 If biological growth becomes a problem, Proxel GXL may be added at 0.07 mL/L.

Alternate Prebath¹				
Constituent	Fresh Tank	Fresh and Seasoned Tank¹ Analytical Specifications	Fresh Replenisher	Replenisher Analytical Specifications
Potassium Carbonate Prebath²	(PB-C2)		(PB-C2R)	
Water 27 to 38°C (80 to 100°F)	800 mL		800 mL	
KODAK Anti-Calcium, No. 4	3.0 mL		3.0 mL	
Potassium Carbonate (47%)	150.0 g		150.0 g	
Potassium Bicarbonate (anhydrous)	34.7 g		34.7 g	
KODAK Stabilizer Additive	0.5 mL		0.5 mL	
Water to make	1 L		1 L	
pH at 25.0°C (77.0°F)		10.0 ± 0.20		10.0 ± 0.20
Specific gravity at 25.0°C (77.0°F)		1.1410		1.1410

1 May be used in place of PB-2 for Process ECN-2.

2 If biological growth becomes a problem, Proxel GXL may be added at 0.07 mL/L.

STORAGE OF SOLUTIONS

Do not use replenishers that have been stored at normal room temperatures 21 to 24°C (70 to 75°F), longer than the times given in Table 7-7. Storage temperatures higher than 24°C (75°F) will decrease the storage life of the solutions. Storage temperatures below 16°C (60°F) can cause some solution constituents to precipitate.

Do not attempt to bring aged replenisher solutions to the formula level. Decomposition products that are formed as the solution stands cannot be eliminated from the solution. These compounds build up to a concentration that can cause adverse photographic effects.

Table 7-7 STORAGE LIFE OF REPLENISHER SOLUTIONS AT 21 TO 24°C (70 TO 75°F)

Replenisher	Floating Cover	Open Tank
Color Developer	2 weeks	1 week
Stop SB-14	Indefinite ¹	8 weeks
Others	8 weeks	4 weeks

¹ If solution is kept clean.

Discard the remaining few litres of replenisher before fresh replenisher is pumped into the holding tank. Replenisher remaining in the holding tank, even if kept under a close-fitting floating cover, usually has deteriorated to such an extent that it is unsatisfactory for further use.

For best process control, equip the holding tank for the color developer replenisher with a tight-fitting floating cover. The cover will minimize air oxidation of the solution, and absorption of carbon dioxide from the air, which would change the pH. Clearance between the cover and the tank wall should not be greater than 1/4 inch (6.4 mm). Polyethylene sheeting of 1/2 inch (12.7 mm) thickness makes adequate covers in sizes up to 3 feet (1 meter) in diameter. A dust cover, alone, permits air to contact more of the solution surface and allows air oxidation to take place. Dust covers should be used for non-developer solutions to minimize dirt in the replenisher tanks.

Processing KODAK Motion Picture Films, Module 7

Process ECN-2 Specifications

