

**Processing
KODAK
Motion Picture Films,
Module 2**

Equipment and Procedures



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2 Equipment and Procedures

INTRODUCTION

This module provides more detailed support information and specifications for the equipment and procedures required to operate the processes for Eastman color films. The following Modules describe the processes:

- Module 7 Process ECN 2 Specifications
- Module 9 Process ECP-2D Specifications
- Module 11 Process VNF-1 Specifications
- Module 13 Process RVNP Specifications

Modules describing other aspects of the processes are:

- Module 1 Process Control
- Module 3 Analytical Procedures (for Chemical Analyses)
- Module 4 Reagent Preparation Procedures (for Chemical Analyses)
- Module 5 Chemical Recovery Procedures
- Module 6 Environmental Aspects
- Module 8 Effects of Mechanical and Chemical Variations in Process ECN-2
- Module 10 Effects of Mechanical and Chemical Variations in Process ECP-2D
- Module 12 Effects of Mechanical and Chemical Variations in Process VNF-1
- Module 14 Effects of Mechanical and Chemical Variations in Process RVNP

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EQUIPMENT

Crossover Squeegees

Crossover squeegees minimize the loss and dilution of processing solutions resulting from the carry over of solution or wash water by the film from the preceding tank. They remove solution from both sides of the film strand. The normal position for a squeegee is just above the machine tank so that the solution removed from the film returns to the tank. Common squeegees include: wiper blade, rotary buffer, air stream, venturi air stream, vacuum, and wringer sling.

1. **Wiper blade squeegees*** consist of two blades, one touching the emulsion side and one touching the support side of the film, which by means of slight pressure, remove adhering solution from the film and direct the solution back into the tank. The correct pressure of the wipers against the film will remove all visible solution, but will not damage either the emulsion or the support.

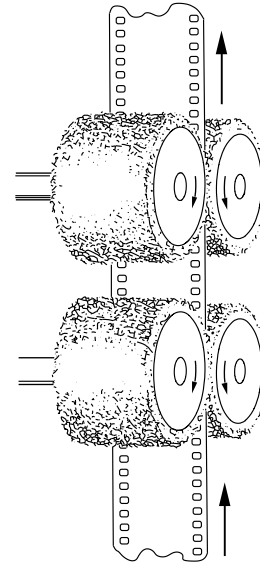
The wiper-blade squeegee has several advantages over other types of squeegees. It is inexpensive, quiet, requires no air or electrical connections, has no critical tolerances to set and maintain, and no bearings to corrode or stick. Maintenance is simply cleaning, replacing worn blades, and adjusting mounting brackets.

2. The **rotary buffer squeegee** consists of two or more pairs of plush-covered rollers, one roller on each side of the film. They rotate at high speed, opposite to the direction (counter rotation) of the film motion, lightly contacting and wiping both surfaces of the film. See Figure 2-1. The liquid whisked from the film by the fast-moving plush is immediately thrown away from the rollers by centrifugal force. The fibers on the roller surface are dry and clean when they touch the film on the next revolution.

A rotary buffer squeegee unit consists of a pair of driven rollers. Complete removal of the liquid on the film surface usually requires more than one squeegee unit. The number of units necessary depends upon the speed at which the film or machine is running and upon the amount of squeegeeing needed. Rotary buffer squeegee units are commonly used to remove surface water before film drying and before sound track application. They can be modified for rem-jet removal and for lubrication of film. See Figures 2-4, 2-5, 2-6 and 2-13.

* L. I. Edgcomb and J. S. Zankowski, "Molded Squeegee Blades for Photographic Processing," *Journal of the SMPTE*, 79:123-126, February 1970; also J. C. Boutet, "Spring-Loaded Wiper-Blade Squeegees," *Journal of the SMPTE*, 31:792-796, October 1972.

Figure 2-1 Rotary Buffer Squeegee



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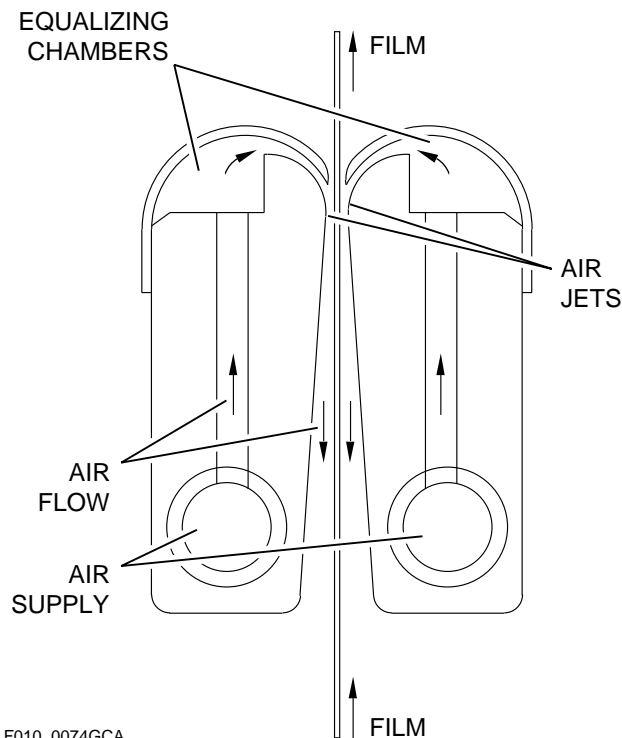
Another variation of the rotary buffer squeegee uses sponge or other synthetic media to cover the rollers. For rem-jet removal the buffers are sometimes rotated in the same direction as the film travel (coronation), and sometimes at slower speeds than the film travels.

3. The **air squeegee** (air knife) directs an air stream to both sides of the film by two stationary air compartments which the film passes between. Each compartment contains a narrow slot that permits the pressurized air to exit. Air squeegees operate at 5 to 10 psig (34.5 to 69 kPa) of pressure. They must be operated so that misting and/or splattering of processing solutions does not occur. Air squeegees may be required at the front or rear of the racks, depending on the location of the crossover. Filter the air to eliminate dirt particles that might damage the film or plug the squeegee orifice.
4. The **venturi air squeegee**† supplies a jet of high velocity air to both sides of the film. The squeegee consists of two movable, symmetrical air compartments each having a narrow air slot. A spring holds the two compartments together at a set distance

† H. R. Ott and R. C. Lovick, "High-Efficiency Air Squeegee and Sound Track Developer Applicator for Color Films," *Journal of the SMPTE*, 63:191-194, November, 1954.

from the film. The spring permits the passage of splices by allowing the two compartments to be pushed apart by a splice as it passes through the squeegee. When the film enters the squeegee, the largest drops of water are blown off by air jets in a direction opposite that of the film. As the film approaches the jets, more water is removed; and at that point where the film is closest to the jets, the air velocity is sufficient to carry off the remaining surface moisture. See Figure 2-2.

Figure 2-2 Venturi Air Squeegee



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To eliminate any dirt particles that might plug the narrow slits, an air filter should be used in the air supply line (just ahead of the squeegee) even though there may be another filter in the air line. This filter should be inspected frequently and replaced when dirty.

For efficient operation, the recommended specifications for one common venturi air squeegee are:

Air slot	0.0035 ± 0.0005 in. (0.0889 ± 0.0127 mm)
Film gap	0.012 ± 10.001 in. (0.3051 ± 0.025 mm)
Air pressure	10 to 20 psig (69 to 138 kPa) depending on the film speed in the machine.
Air entrance temperature	room temperature*

* The air temperature should be 100°F (38°C) or greater for the air squeegee before the Process ECP-2D sound developer. A squeegee using heated air at this temperature is essential for proper sound track application. If heated air is not used the film will not be adequately dry and sound track developer can spread into the picture area.

An air squeegee can screech loudly if improperly adjusted. It also must be operated so that misting and splattering of processing solutions do not occur.

5. The **vacuum squeegee** works like an air stream squeegee in reverse. A vacuum is created to draw air into the head of the squeegee positioned close to the film surface. As air is drawn into the head, the moisture on the surface of the film is taken along with it.
6. The **wringer-sling squeegee*** is operated by the movement of the film as it passes between two rollers. One flangeless roller wrings the liquid back down the film strand and displaces it to the large flanges of the other roller which then slings it away by centrifugal force. The liquid is collected by two cups and directed back into the tank. The efficiency of the wringer-sling squeegee improves as the speed of the film increases. The practical minimum speed for 16 mm film is about 60 ft/min (18.3 m/min).

For more information on the location of squeegees, see the applicable Process Module machine schematic.

* *Journal of the SMPTE*, 76:797-800, August 1967.

Rem-Jet Backing Removal Equipment

There are two major classifications of rem-jet backing removal equipment available from processing equipment manufacturers. They are the In-line Rem-Jet Removal Rack and the Rotary Buffer Rem-Jet Removal Unit*. In both cases, the removal equipment must accomplish the following:

1. Transport the film from the prebath to the removal unit without allowing rem jet to accumulate on the guide rollers.
2. Angle the stream of water from the spray nozzles to flush rem jet off the side of the film and away from the film.
3. Directly oppose and balance each water spray jet aimed at the film base with a spray jet aimed at the emulsion to prevent rem jet from depositing on the emulsion surface or in the perforations.
4. As much rem jet as possible should be removed by the water jets prior to contact with the backing removal media.
5. Provide good contact between the film base and the backing removal media to remove any residual binder.
6. During use, flood the backing removal media with water to reduce rem-jet dirt and chemical buildup.

In-Line Rem-Jet Removal Rack

The basic design incorporates a rack-like structure with slowly rotating cylinders of backing removal media located between the top and bottom rack rollers. In addition to water sprays, some designs call for water to be plumbed to the inside of the cylinder and exit through a porous core and the removal media. The film base contacts the removal media as it passes through the rack in a normal helical path. The mechanical action is more physical and takes place over a longer time period than with the rotary buffer rem-jet removal unit described below. For those reasons the in-line design tends to work better, particularly at higher machine transport speeds. See Figure 2-3.

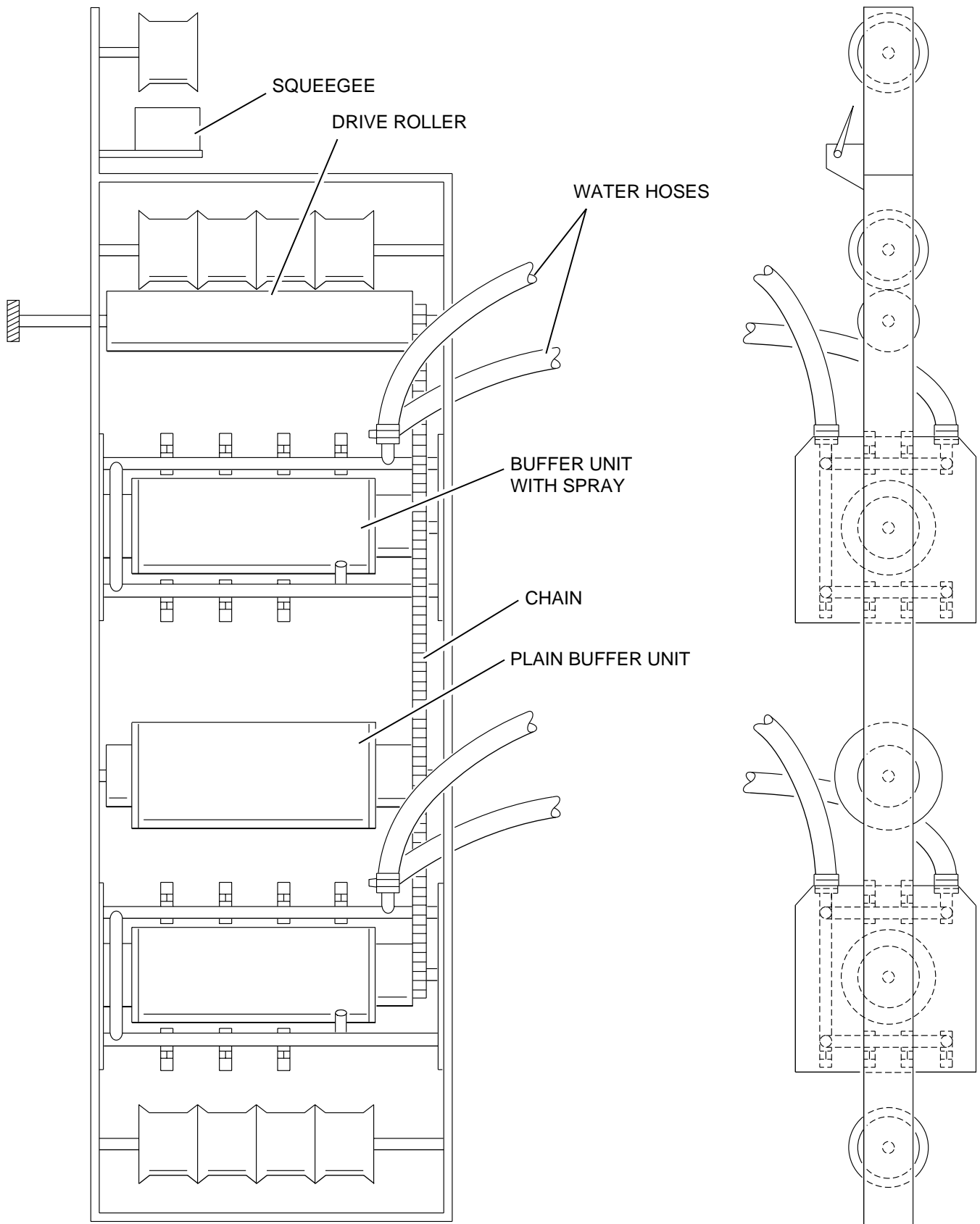
Typical backing removal media in current use include sponges, felt and other synthetic material placed or wrapped around an inner core. Replacement of the backing removal media should be a part of the regular maintenance schedule of the machine.

The example shown is representative. Some designs have only one rotating cylinder, others may not have as elaborate a water spray system as shown.

This type of design has been found suitable for both print and negative processes.

* Both classifications allow a good deal of flexibility in the mechanical design and structure.

Figure 2-3 In-Line Rem-Jet Removal Rack

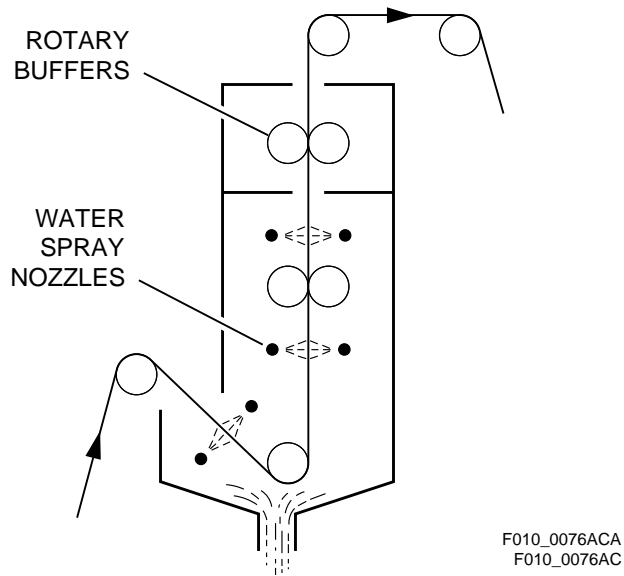


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Rotary Buffer Rem-Jet Removal Unit

One design for a rotary buffer rem-jet removal unit*, that has been used successfully for the print process is illustrated in Figure 2-4. Film from the prebath enters the chamber near the bottom and is immediately sprayed on both sides by a pair of high-velocity water jets.

Figure 2-4 Rotary Buffer Rem-Jet Removal Unit



The film then travels upward through a set of water jets, a rotary buffer unit, and another set of high-velocity water jets. Both sides of the film are wiped by the buffer rollers which spin counter to the direction of the film. The pairs of spray jets are balanced so that the spray hits both emulsion and support sides of the film simultaneously. Buffing the emulsion side of the film as well as the base side keeps the emulsion clean and keeps pressure on the support-side buffer.

All nozzles are set at an angle to the film path to sweep the rem jet off the film and down the drain. A rotary buffer squeegee removes the surface moisture from the film before it enters the developer.

The prebath time, the number of rotary buffer units, the distance between sprays, and the water flow rates can be varied to obtain optimum rem-jet removal with various film-transport speeds.

Two shortcomings are: limited path length and possible scratching of the surfaces by particles adhering to the rapidly rotating plush buffers. The limited path length may provide too little time for action by the water jets, limiting effective removal to machine speeds near 250 ft/min.

For the negative process, a rem-jet removal unit without buffer contact on the emulsion side is recommended as shown in Figure 2-5. Such a unit is also satisfactory for use with Process ECP-2D and thus would be practical for a combination negative/ positive machine.

The removal units are typically located above the processing machine tanks at about eye level. Backing removal media commonly used to cover these buffers are Mohair, and Dacron plush. Make replacement of the buffers a part of the regular maintenance schedule of the machine.

Table 2-1, *Rem-Jet Removal Equipment Design Guidelines*, gives required specifications for design of backing removal equipment.

* Bard and Dunn, *Journal of the SMPTE*, 80:564-569, July 1971.

Table 2-1 Rem-Jet Removal Equipment Design Guidelines

Parameter	In line Removal Rack or Rotary Suffer Unit	
Spray Nozzles*	"Spraying Systems" 1/8 VVSS 11002* or "V" jet 1/8 VV 11002 (both have 0.036-inch diameter orifice)	
Spray Jet to Film Distance	Typical Range: 1/2 inch to 1 inch	
Water Pressure	30 psi or greater	
Flow Rate (16 or 35 mm)	500 mL/100 h of film per spray nozzle†	
	In line Removal Rack	Rotary Buffer Unit
Total Flow‡ (16 or 35 mm)	10 to 30 L/100 feet processed	2 to 4 L/100 feet processed
Removal Media Materials	Sponge§, Felt-wrapped Core etc.	Mohair or Dacron Plush
Rotation: Base Side Emulsion Side	CW or CCW CW or CCW	CCW¶ CW
Rotational Speed	Typical Range: 20 to 100 rpm	Typical Range: 2000 to 4000 rpm
Number of Mechanical Contact Points	Acetate: 4** ESTAR Base: 8 to 12	Usually 2††
Transport Speed	Can be used at any speed	Less than 250 ft/min‡‡
Water Residence Time§§	Can be made long¶¶	Usually very short***

* There are no particular spray nozzles that must be used. The design criteria mandates that the flow rate must be adequate (i.e., 500 mL/100 feet at 30 psi) to wash off the rem jet and/or keep the emulsion clear of rem jet. The spray pattern should be wide enough at the spray jet-to-film distance to cover the width of the film.

† This is a typical flow rate which is commonly achieved with the type of spray nozzles listed above in the table.

‡ Total flow depends on the number of nozzles used. Typically 6 to 8 are used in the Rotary Buffer Units. In-line Removal Racks typically use anywhere from 20 to 60 spray nozzles.

§ Many design specifications call for a water sponge. A water sponge is one that is internally fed with water. The water continually exits the sponge from within, helping to keep it clean.

¶ In the Rotary Buffer Figures 2-1, 2-4, 2-5 and 2-6 the buffers are counter-rotating, i.e., the buffer surface and film surface at the point of contact are moving in opposite directions. The CW (clockwise) and CCW (counterclockwise) designations are from the reference point of looking at the rotation through the front glass plate of the unit.

** The number of mechanical contact points refers to the points at which the film backing touches the removal media. If the contact points are efficient (i.e., optimized wrap, media material, transport speed, rotational speed, etc.) then fewer of them are required for excellent removal.

†† Most designs have two contact points (2 sets of buffers).

‡‡ At speeds greater than 250 ft/min, it is possible that multiple units will be required. Another option is to install a buffer box which has three or more sets of buffers and the associated water sprays.

§§ The water residence time refers to the elapsed time from when the rem-jet backing is first sprayed with water and when it hits the first mechanical contact point.

¶¶ Some designs have a truncated cylinder which does not provide mechanical contact points on the first loop of the rack. This increases the water residence time.

***Water residence times are usually very short in the Rotary Buffer Unit—usually on the order of 1/4 to 1/4 second.

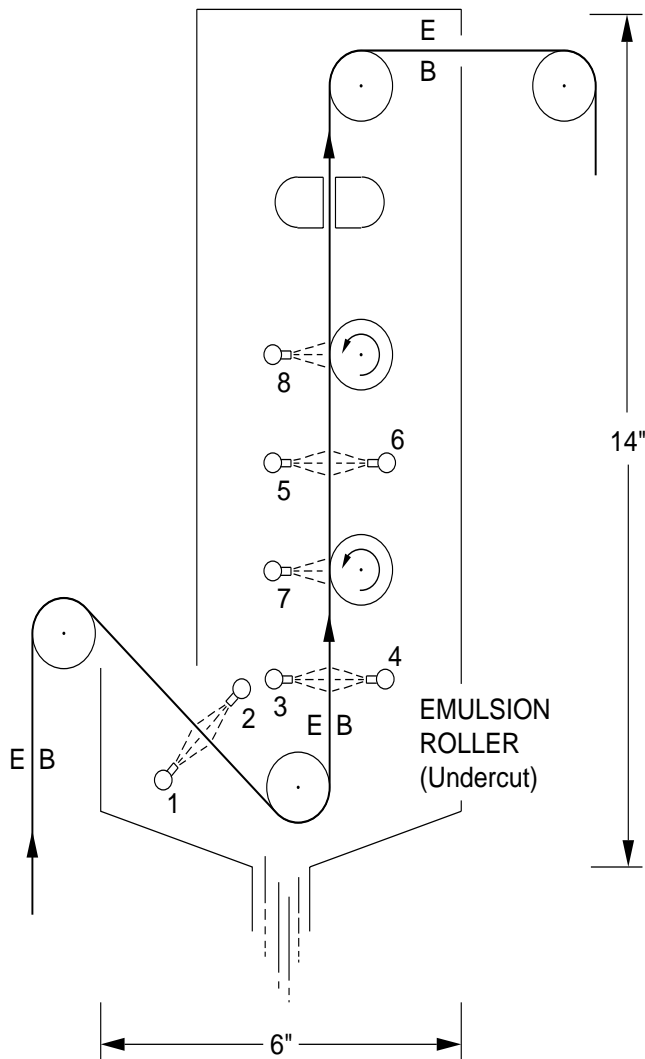
Rem-Jet Removal Characteristics

When removing the backing from acetate or ESTAR support, the initial sets of water sprays are most important since most of the rem-jet backing is removed at this point. Spray nozzles must have a sufficient flow rate to wash the backing off the film and should be angled to allow the backing to flow down without danger of re depositing on the emulsion surface.

The in-line removal rack should have initial water sprays angled to the tank wall away from the adjacent strand of film. Take care to direct the rem-jet stream to the bottom of the tank without allowing emulsion-side deposits. Emulsion-side sprays should always oppose base-side sprays.

Most designs of the rotary buffer units have the first set of water sprays isolated as shown in the diagrams.

Figure 2-5 Modified Rotary Buffer Rem-Jet Removal

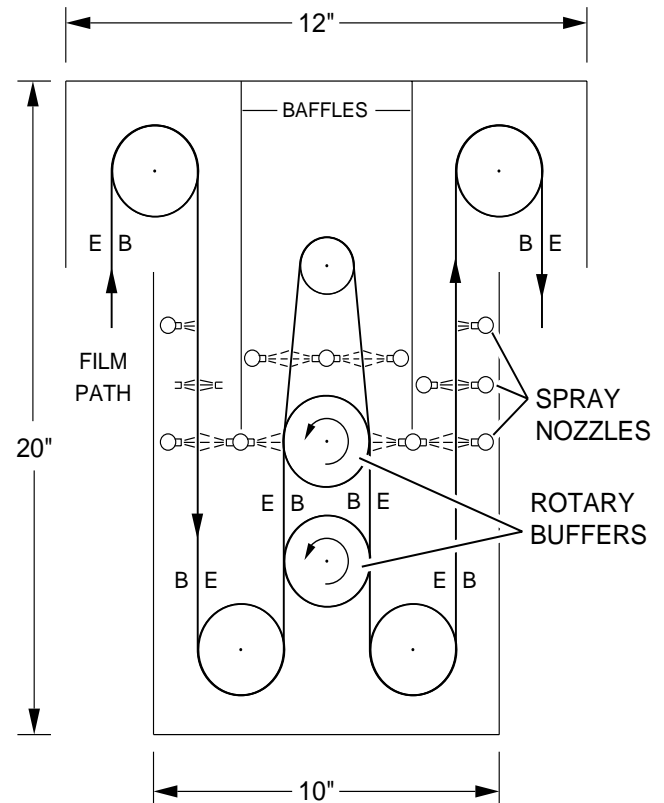


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Points to consider in the rotary buffer design illustrated in Figure 2-5.

1. Emulsion-side buffers should not be used.
2. An air knife or vacuum squeegee is needed at the exit of the unit. Depending on the efficiency of the air knife and the design of the removal unit, a second air knife may be needed to remove the additional water that the emulsion buffers would normally remove.
3. Spray nozzles 7 and 8 are added (Figure 2-5) and are positioned such that each is directly opposite a base-side buffer. Some units have two opposing nozzles between the two sets of rotary buffers. If the design of the units makes it impossible to position the additional nozzles properly, nozzle No. 5 can be removed, but the five remaining original nozzles must be retained.
4. Angle nozzles 7 and 8, 15° downwards and 15° towards the back of the unit.
5. The spray nozzle-to-film distance of nozzles 7 and 8 should be between 1/2 and 1 inch.
6. If backing removal is inadequate, the efficiency of the unit can be improved by realigning the top or bottom film rollers to increase the wrap or pressure on the base-side buffers. Take care not to increase pressure to the point of causing abrasions on the film base.
7. Figure 2-6 shows another type of design which is suitable for Process ECN-2.

Figure 2-6 Alternate Rotary Buffer Rem-Jet Removal Unit



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Recirculation Equipment

A recirculation system includes the filtration, replenishment, distribution, turbulence, and temperature control of a processing solution. A recirculation system is beneficial for all processing solutions for maintaining process quality and uniformity. A typical recirculation system is represented schematically in Figure 2-7.

Filter recommendations for each process are presented in the corresponding Process Specifications Module.

1. Replenisher Tanks

After a replenisher solution has been mixed and chemical analysis shows it to be within specification, pump it into a replenisher holding tank. From the holding tank, replenisher is fed into the recirculation pump. The replenisher holding tanks should be larger than the mixing tank so that new mixes can be added without first completely draining the holding tanks of old solution.

A replenisher holding tank should have a dust cover, a floating cover, an inlet, an outlet to the appropriate machine tank, and a drain.

- a. Floating cover: The cover reduces solution exposure to air, and possible oxidation of some mix components, as well as evaporation. The cover is usually made of polyethylene or polypropylene. It should fit close to the tank side walls without wedging as the cover rises and falls with solution levels. The dust cover loosely fits over the top of the tank keeping dust, drips and splashes out.

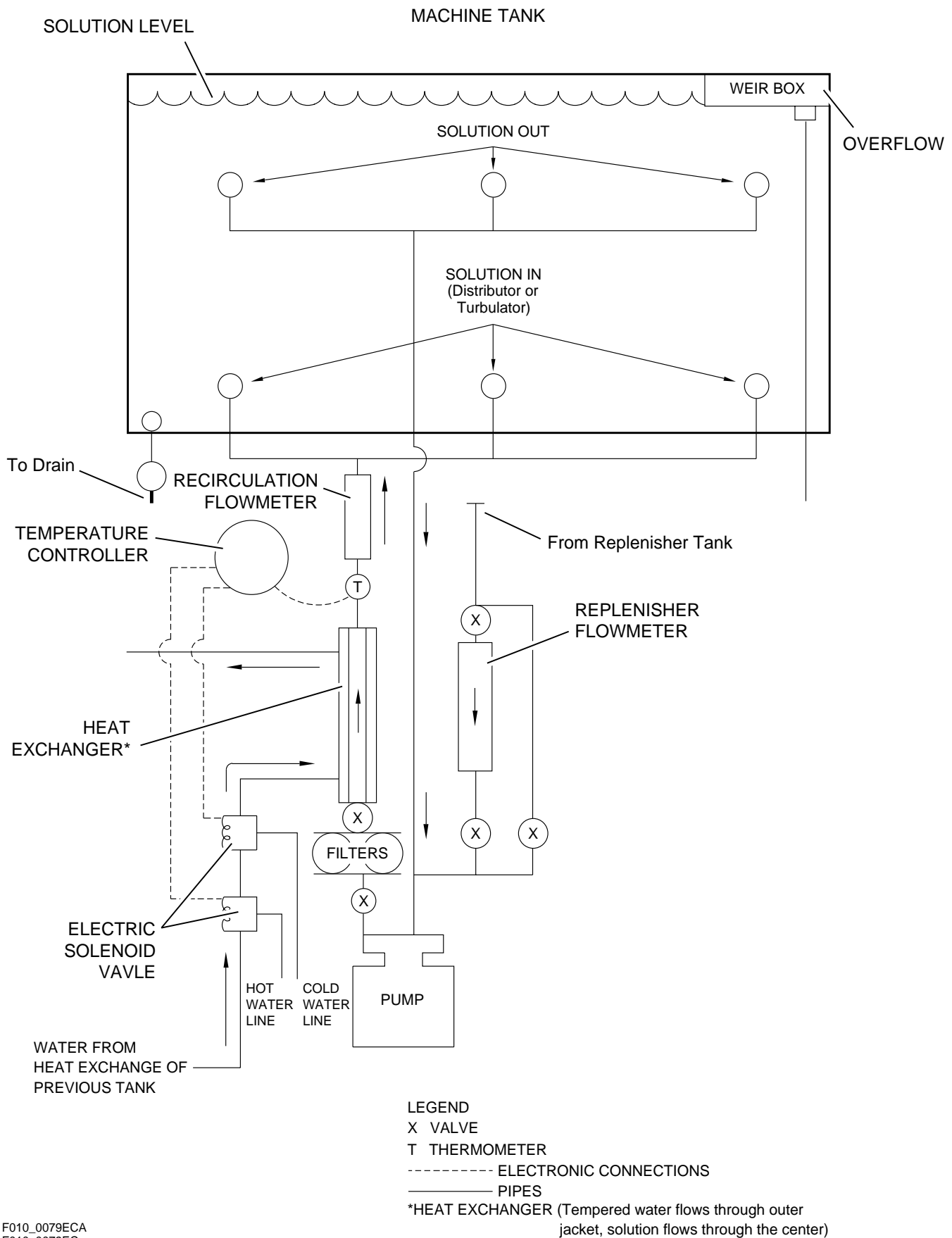
- b. Inlet: The inlet should be in the wall of the tank as close to the bottom as possible and below the outlet to the machine. With the inlet in this position, the incoming solution will not flow above the floating cover or splash over the top of the tank.

Each holding tank should be connected by means of a transfer line directly to the mixing tank. A common header should not be used because of the chance of contaminating one solution with another.

- c. Outlet: A separate outlet is needed to deliver the solution to the machine. It should be in the wall of the tank, positioned about 1 or 2 inches above the inlet. This arrangement leaves solution in the tank and thus prevents the floating cover from resting on the bottom of the tank. Solution entering the tank will then flow under the cover. Also this position of the outlet traps any solid material, thus limiting the amount of solids entering the machine. The sludge that collects on the bottom can be removed through the drain outlet.
- d. Drain: The drain should be located at the lowest point of the tank in order to completely empty the tank when necessary.

Construction materials for replenisher tanks are listed in the appropriate Process Specifications Module.

Figure 2-7 Recirculation System For a Machine Tank



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2. Flowmeters

Flowmeters for the replenisher solutions should have a precision of at least ± 5 percent and flowmeters used to regulate the recirculation of the solutions should have a precision of ± 10 percent.

Flowmeter Check and Calibration: Check the flowmeters once a month by measuring the flow with a graduated cylinder (500 mL) and stopwatch. Disconnect the feed line at a convenient place between the flowmeter and the machine. Collect the fluid in the cylinder for 30 to 60 seconds with the flowmeter set at the recommended value, and the replenisher or wash water running. Measure the volume collected and compare it with that expected for the given flow rate. If the measured volume does not agree within 5 percent of the expected volume, run a second check. If it still does not agree, clean the flowmeter and then recheck again. If cleaning is not successful, recalibrate the flowmeter by measuring the flow at four different settings near the desired flow. Plot the volumes obtained versus the corresponding meter settings and draw the best straight line through the points. The calibrated flowmeter setting can then be determined from the calibration line as illustrated in Figure 2-8.

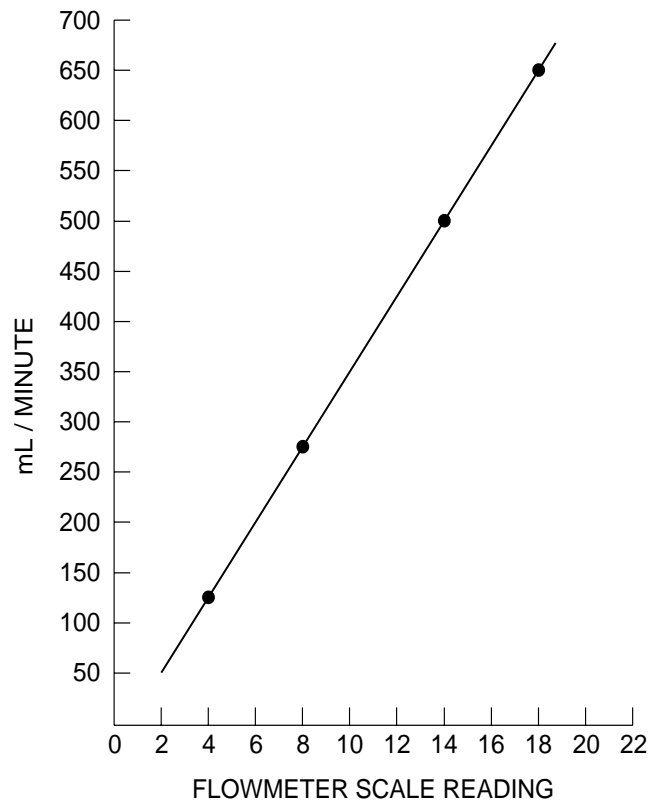
3. Pumps and Lines

The pumps and lines must be sized for each flow rate which, in turn, depends on type of distribution or turbulence and machine speed. Corrosion-proof pumps made of polyethylene, PCV, titanium, or Hastelloy C should be used for all bleaches.

4. Temperature-Control Equipment

Temperature-control equipment must hold the Process ECN-2 and ECP-2D developers within $\pm 0.2^\circ\text{F}$ ($\pm 0.1^\circ\text{C}$), other solutions within $\pm 2^\circ\text{F}$ ($\pm 1^\circ\text{C}$), and washes/rinses within $\pm 5^\circ\text{F}$ ($\pm 3^\circ\text{C}$) of the recommended temperature. Process VNF-1 first developer within $\pm 0.5^\circ\text{F}$ ($\pm 0.3^\circ\text{C}$), color developer within $\pm 1.0^\circ\text{F}$ ($\pm 0.6^\circ\text{C}$), other solutions within $\pm 5^\circ\text{F}$ ($\pm 3^\circ\text{C}$), and washes/rinses within $\pm 2^\circ\text{F}$ ($\pm 1^\circ\text{C}$). However, do not underestimate the importance of the secondary solution tolerances. Solution temperatures should be checked every day with a very accurate thermometer whose calibration is traceable to NIST (National Institute of Standards and Technology, formerly NBS).

Figure 2-8 Flowmeter Check and Calibration

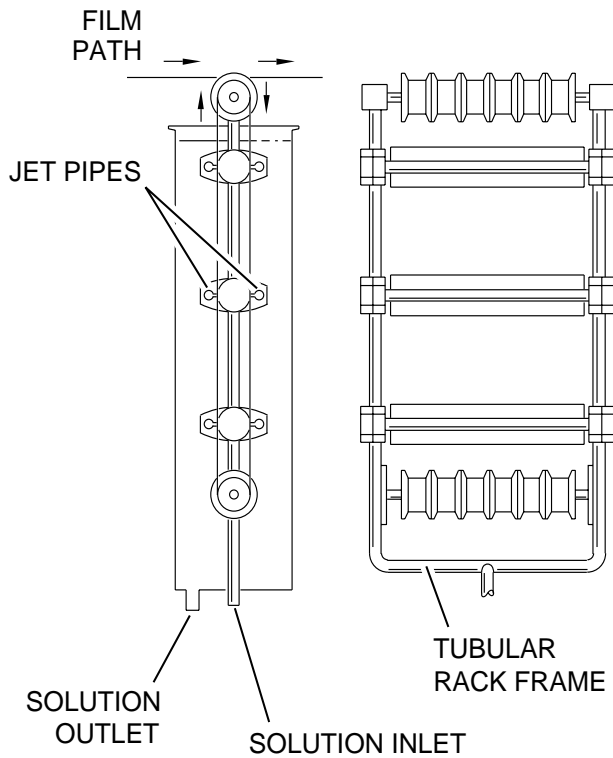


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5. Turbulators

Developer turbulation is accomplished by a series of submerged jets or drilled headers that apply recirculated solution directly to the surface of the emulsion. Figure 2-9 illustrates a simple turbulator design. The turbulator pipes run perpendicular to the film strands at a distance of $\frac{1}{2}$ inch or less. Backup rollers at the jet impingement points make certain that the desired spacing between jet and emulsion surface is maintained and prevents film striking the rack, eliminating possible film damage.

Figure 2-9 Typical Developer Turbulator



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The jets are formed by spray nozzles or holes drilled in the turbulator pipes. Detailed turbulator specifications for Process ECN-2 and ECP-2D are given in Tables 2-2 (see page 2-15).

- a. **Nozzles:** Two common nozzle designs are designated A-1* and M-5†. These nozzles have a front slot and an orifice drilled from the back. The submerged spray patterns of these nozzles are illustrated in Figure 2-10. For adequate spray coverage of 35 mm film, the A-1 must be $\frac{1}{2}$ inch from the film while the M-5 can be as little as $\frac{1}{4}$ inch from the film.

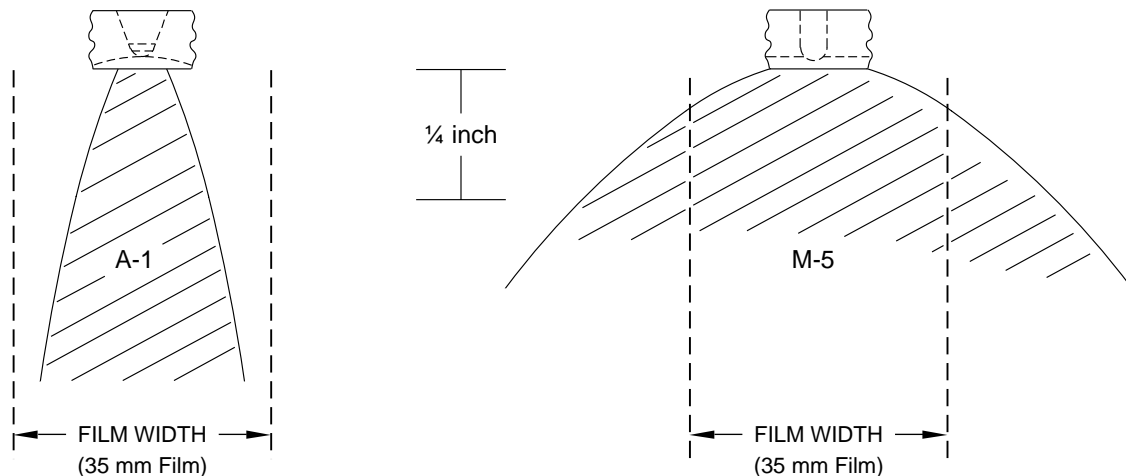
If the processing tank is wide enough to install them, the A-1 type nozzles do a good job. The M-5 nozzle is satisfactory for closer installations, although its spray coverage is slightly less uniform than that of the A-1.

- b. **Drilled holes:** An alternative to spray nozzles is the drilled hole turbulator. In this system, a row of holes is drilled in the turbulator cross-header so that the emerging solution strikes the film emulsion. Compared with nozzles, drilled holes have the advantages of easy fabrication, no alignment problems, lower cost, less likely to clog or scratch film, and suitability for film width above 35 mm. However, drilled hole distributors have higher flow rates and hence require larger pumps and pipe sizes than nozzles.

* A 1-inch long nozzle with an A-1 type spray pattern is manufactured by Treise Engineering, Inc., 1941 First Street, San Fernando, CA 91340.

† One manufacturer is the Carter Equipment Company, 15430 Condon Ave., Lawndal, CA 90260

Figure 2-10 Submerged Spray Patterns of A-1 and M-5 Nozzles at 12 PSI



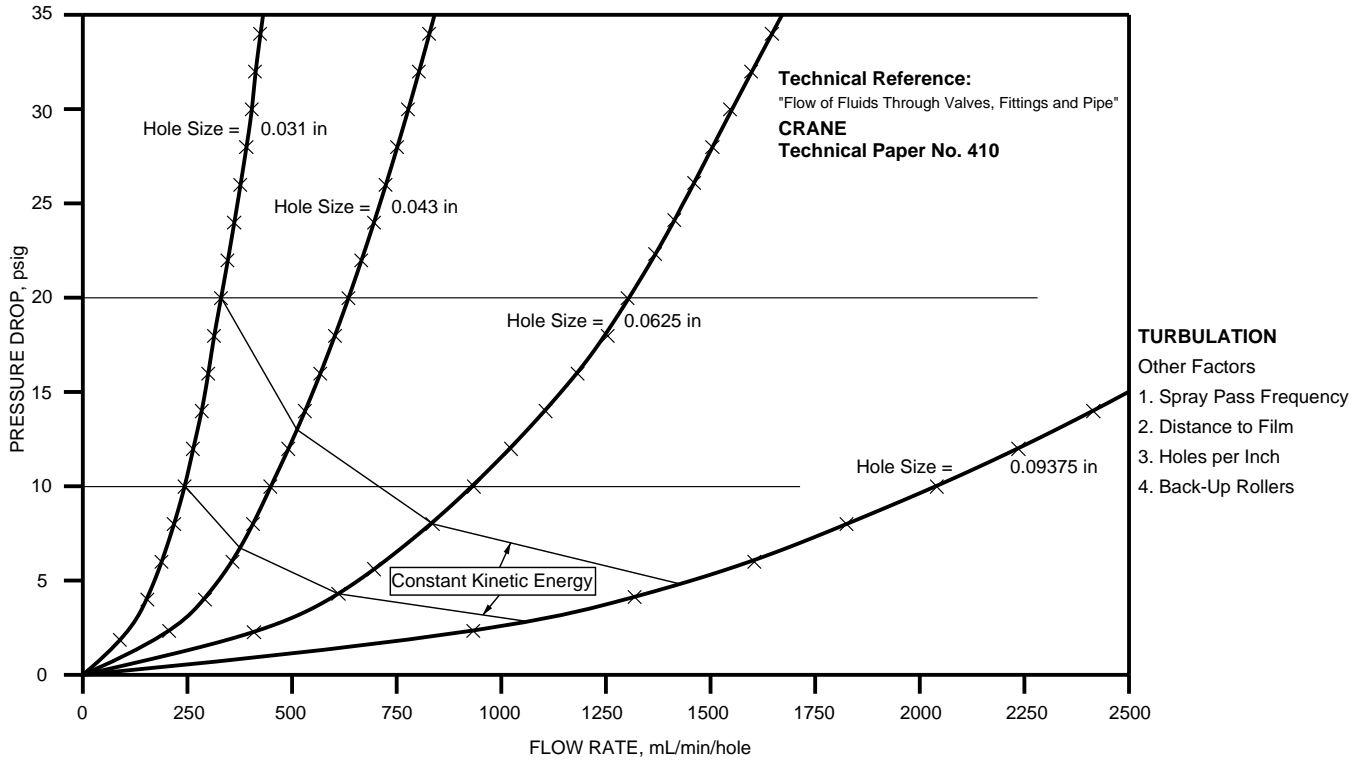
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Table 2-2 Developer Turbulation Design Guidelines, Process ECN-2, ECP-2D, D-96 and D-97

Parameter	Spray Nozzle	Drilled Header
Design	Nozzle designs (e.g., A 1 or M 5) that provide adequate spray coverage must be used. Approx. 120-180 nozzles will be needed depending on the spray pass frequency.	Five or more holes per inch (25 mm) Each hole must be at least 0.031 in. (0.79 mm) in diameter. (Larger hole sizes require higher flow rates.)*
Pressure	For A-1 nozzles, 15-20 psig (approx. 100-140 kPa) measured in the nozzle header. (Available data indicate other commonly used nozzle designs will work well in this pressure range.)	For 0.031 inch holes, 10-20 psig (approx. 70-140 kPa) measured in the drilled header.
Spray Pass Frequency	1.0-1.5 sec	1.0-1.5 sec
Film-to-Nozzle (Hole) Distance	For A-1 nozzles, 1/2 to 3/4 in. (13-19 mm). Some nozzle designs (e.g., M-5) may require closer film-to-nozzle spacing for efficient film coverage	1/4 to 1/2 in. (6-13 mm)
Flow per Nozzle (Hole)	A-1 nozzle at 15 psig: 1800 mL/min A-1 nozzle at 20 psig: 2300 mL/min (Flow rates for other designs may vary significantly.)	Each 0.031 in. hole at 10 psig: 250 mL/min Each 0.031 in. hole at 20 psig: 350 mL/min
Total Flow	200-400 litres/min (53-106 gal/min), depending on number of A-1 nozzles and pressure. (Total flow for other nozzle designs may vary significantly.)	325-450 litres/min, (86-119 gal/min) depending on number of 0.031 in. holes and pressure.

* See Figure 2-11, *Pressure Drop Vs. Flow Rate for Various Diameter Holes.*

Figure 2-11 Pressure Drop Vs. Flow Rate for Various Diameter Holes



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Chemical Mixing Equipment

A general chemical mix area should contain chemical storage areas, a weighing area and a mixing area.

1. In the chemical storage area provide:
 - a. Adequate access for delivery of large-quantity lots of chemicals.
 - b. Proper equipment for handling large-size containers of chemicals.
 - c. General organic and inorganic chemical storage.
 - d. Oxidizer chemical storage.
 - e. Reducer chemical storage.
 - f. Solvent storage vault isolated from the other work areas by fireproof walls.
 - g. Fire extinguishers and automatic fire alarms.
 - h. Water tap and a floor drain.
 - i. Emergency procedures.

Store dry flammable solid chemicals in the solvent storage vault. Keep all chemical storage areas cool and dry since some chemicals are heat or moisture sensitive. The Material Safety Data Sheet (MSDS) for each chemical contains proper storage information.

2. The weighing area requires accurate scales, safety equipment and ventilation.
 - a. Use scales with easily read dials, capable of weighing to an accuracy of 1 percent for fast, accurate weighing. Both heavy and light capacity scales are needed.
 - b. Provide safety equipment such as:
 1. Emergency overhead shower.
 2. Face and eye water spray.
 3. Impervious gloves, eye protection, and self-contained breathing apparatus.
 4. Fire extinguishers.
 5. Material Safety Data Sheets for each chemical.

- c. Local exhaust over the scales with a capture velocity of 100 ft/min, and adequate room ventilation.
- d. Emergency procedures.

3. In the mix area provide mixing tanks and mixers, solution storage, safety equipment and ventilation.

- a. Mixing tanks and mixers: Construct mixing tanks from AISI Type 316 stainless steel or other materials listed in the table "Construction Materials," in Modules 7, 9, 11 and 13. Because of the corrosive nature of all bleaches, prepare them in tanks made of plastic, or one of the more corrosion resistant metals listed in the tables. If a stainless steel tank is used, the bleach must be removed immediately after mixing and the tank rinsed several times with water.

Use the on-center mixing technique since it provides adequate mixing of the solutions with minimum aeration. Mount a sufficiently powerful mixer over the mixing tank so that the shaft is vertical at the center of the tank with the mixing impeller $\frac{1}{3}$ the tank diameter above the bottom of the tank. Tack weld four dams vertically to the inside of the tank, 90 degrees apart and extending from a point several inches from the tank bottom to within 1 inch of the top. The width of each baffle is $\frac{1}{10}$ the tank diameter. A tank depth-to-diameter ratio of 1.5 to 1.0 provides good mixing. Having an adequate number of mix tanks will provide greater flexibility in scheduling the preparation of solutions.

Calibrate the mixing tank at the most used mixing volumes. The calibration must be accurate to ± 1 percent.

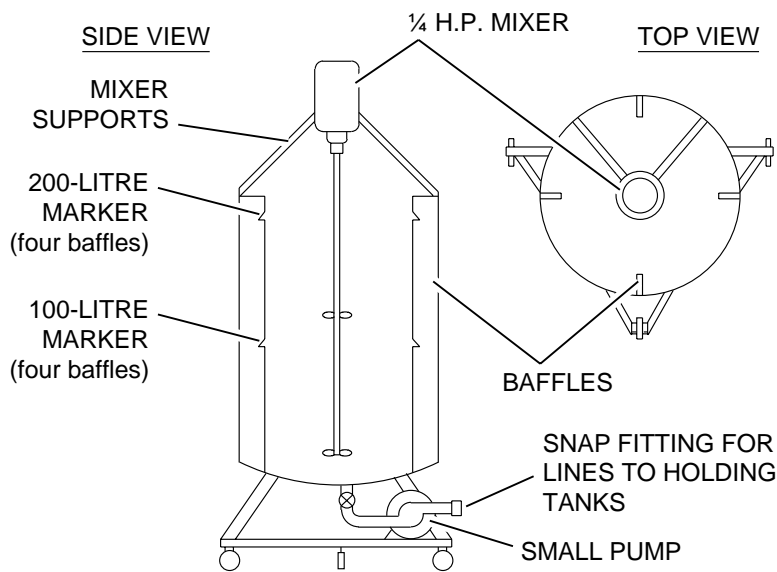
A suggested installation is shown in Figure 2-12. Mount small tanks on a dolly for mobility. A mixer mounting that allows for easy attachment and removal gives the tank more utility. Use a small corrosion proof pump to transfer solution from the mixing tank to the appropriate holding tank.

For convenience and efficiency when dissolving large quantities of solid and liquid chemicals, use a chemical hopper which draws the chemicals into the mixing tank with strong jets of water. Locate the hopper on the floor of the mixing room near the mixing tanks with its bin at the working level of the operator. This reduces the amount of lifting of chemicals by the person making the mix and also minimizes spillage of

chemicals. A booth-type exhaust should be installed over the hopper which will draw air away from the person putting chemicals into the hopper. The air flow rate should provide 100 ft/min face velocity at the operator side of the booth.

Keep all parts of the chemical mix area clean, orderly and well lighted. Keep aisles open and uncluttered. Keep floors and stairs in good condition, and preferably with a hard, unbroken, and impervious finish. Chemicals allowed to soak into the floor reduce floor life and constitute a health hazard to personnel. Since chemical spills are best removed by flushing down the affected floor area with water, a water tap and floor drains are essential.

Figure 2-12 On-Center Mixing Equipment



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F010_0083BC

- b. Solution storage:
 1. Provide tanks and space for storage of mixed solutions.
 2. Provide floating covers and dust covers for replenisher storage tanks.
 3. Establish a minimum distance for transferring replenisher solutions from the replenisher storage tanks to the processing machine.
- c. Safety equipment:
 1. Emergency overhead shower.
 2. Face and eye water spray.
 3. Eye protection.
 4. Impervious gloves.
 5. Self-contained breathing apparatus.
 6. Safety carrier.
 7. Hand-cleanser dispenser.
 8. Carboy.
 9. Tippers and filters.
 10. Dispensing systems and pumps.
 11. Aspirator pump.
 12. Proper grounding of containers for volatile and flammable chemicals.
 13. Material Safety Data Sheets for each chemical.
 14. Fire extinguishers.
 15. Railings and guards.
 16. Emergency procedures.

The *Safety Equipment* section (page 2-21) describes much of the above safety equipment recommended for the chemical mix area.
- d. Provide local exhausts with a capture velocity of 100 ft/min over the mixing tank. A split cover, with attached local exhaust, on the mixing tank is very effective. 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.
- e. If the total local exhaust ventilation is less than ten room volumes per hour, supplement it with a general room ventilation system having enough capacity to bring the total to ten air changes per hour. Vent the discharge air outside the building where it will not contaminate incoming air.

4. Mixing technique

Problems from contamination during solution preparation will be minimized by following these guidelines.

- a. If you mix only chemicals for NEGATIVE-type processes, use two tanks: one for the developer and another for all other processing solutions.
- b. If you mix chemicals for both NEGATIVE and REVERSAL processes, use four mix tanks: one for the negative developer and the reversal first developer, one for the color developer, one for the bleach, and one for all other solutions.

Control Laboratory Facilities and Equipment

1. Space Requirements and Location

A control laboratory for motion picture film processing should have two separate rooms: one for chemical control and one for sensitometric control. A space of about 100 ft² (9.3 m²) for each of these rooms should be adequate for most installations. Proper ventilation of these rooms is required to minimize problems from chemicals (dust, vapors and gasses), as an aid in certain operations requiring temperature control, and for the general welfare and comfort of personnel.

Since chemical analyses must be made on fresh replenisher mixes as well as on machine tank solutions, locate the chemical control laboratory convenient to both the mix room and the processing machine room. Locate the sensitometric control laboratory near the processing machine room also.

2. The Chemical Control Laboratory

Construct the floor of acid-proof tile or brick, with suitable wall aprons. Provide a central floor drain for easy cleanup of spills. Cover walls with an acid-proof paint, or some other chemically inert material, to protect them from accidental splashes.

Construct work benches from wood, with tops made from cast epoxy resin, monolithic mineral fiber and Portland cement, or natural quarried stone. Install wall outlets for gas and air lines at convenient locations. Locate shelves and cabinets for storage of standard reagents on adjacent walls.

Include an exhaust hood for the analytical work where there is danger from explosive or toxic vapors. Construct the hood with a metal or wood frame and sheets of corrosion resistant vinyl-clad steel, fiberglass or plastic laminate. Install a sliding door with a shatterproof tempered safety glass or plexiglass window at the front of the hood. Supply the hood-enclosed area with gas, air (low pressure), and electrical lines.

Use explosion-proof types of exhaust fan, motor, electrical wiring, and lighting, in compliance with the National Electrical Codes for flammable liquids having a flash point below 80°F (26.5°C). The fan should produce an air velocity through the face of the hood, with the door fully open, of 100 ft/min (30.5 m/min). In order to assure good capture of air contaminants, the shape and size of the face and the location of the slots in the plenum should minimize the variability of the air velocity at various points across the hood. The goal is to keep velocity between 90 and 110 ft/min. Ground all the metal parts of the hood, sink drain, fan, and duct work.

Use stainless steel (AISI, Type 316) or cast epoxy resin laboratory sinks. Include the usual hot and cold water taps. Provide similar taps for a water bath used for sample pH and specific gravity measurements at specified temperatures. For operations requiring suction filtering, include a cold water tap fitted with an aspirator pump. Dispense distilled water using suitable tin, glass, or stainless steel lines and valves.

Provide an eye wash, overhead safety shower and fire blanket in an accessible place in the event that chemicals accidentally come in contact with laboratory personnel.

The *Safety Equipment* section (page 2-21) lists safety equipment needed in both the chemical mix area and the analytical laboratory.

A list of the various types and sizes of laboratory glassware needed for analytical work can be compiled by reference to the individual methods in Module 3, *Analytical Procedures*, and Method *ULM-0005/1*. Required glassware includes beakers, graduated cylinders, flasks, burets, transfer pipets, tip-up pipets, reagent bottles, etc.

Other essential equipment includes an analytical balance, a pH meter (with suitable electrodes), thermometers, hydrometers, magnetic stirrers, a constant-temperature water bath, and a spectrophotometer.

A spectrophotometer equipped for making measurements in the ultraviolet and visible regions of the spectrum, provides a rapid means for making certain chemical analyses. Some models can also be used to check filters for sensitometers, densitometers, printers, etc.

3. Sensitometric Control Laboratory

Equip this room with standard tables and work benches having tops covered with vinyl sheeting or plastic laminate and properly grounded and fused electrical outlets for all instruments. Provide a ceiling fixture for general room illumination.

Equip the laboratory with a photoelectric color densitometer; ample storage cabinets for lamps, filters, and other accessories; and a freezer for storage of control strips. Build an illuminator into one of the work benches for use in the visual inspection of processed control strips. Make working space available in the room for plotting sensitometric and chemical control data.

4. Mechanical Control Facilities

The mechanical controls for the processing machine are usually located in the processing machine room itself. The mechanical control equipment required are: accurate temperature indicators and temperature controls for the various tank solutions, machine speed indicators, flowmeters, valves and piping for replenishers, and appropriate devices for sampling of the tank and replenisher solutions.

5. Personnel

For a small processing laboratory, one properly trained person can handle all of the work associated with adjustment and control of the process. This includes sampling and analyzing fresh mixes and machine tank solutions, processing and reading sensitometric strips, tabulating mechanical operating data, plotting control charts, and interpreting the results. Since a considerable amount of responsibility is associated with these combined duties, it is advisable to employ an analytical chemist or chemical engineer for this position.*

In larger installations, where it seems feasible to employ two or more individuals, the routine work associated with preparation of mixes, sampling of solutions, simple chemical analyses, processing and evaluating sensitometric strips, etc., could be handled by a person of high school graduate level who has had some experience in chemical analytical work. The supervisory activities, however, including the responsibility of process adjustment, interpretation of control data, training of operators and analysts, etc., should be delegated to someone having considerably more training, preferably an analytical chemist or chemical engineer.

6. Laboratory Cleanliness and Personnel Training

In the interests of avoiding contamination of film products, analytical reagents, and film tests; and in protecting employees from dermatitis and other hazards, keep both the chemical control laboratory and the sensitometric control laboratory spotlessly clean at all times. Instruct all employees in the importance of laboratory cleanliness and in the safe handling of chemicals. See [“Safe Handling of Processing Chemicals” on page 2-34.](#)

* L. E. West, “The Role of the Chemist in the Processing Laboratory,” *Journal of the SMPTE*, 65:133-136, March 1956.

Safety Equipment

Train everyone who handles chemicals, such as mixing equipment operators and analytical laboratory personnel, in the use of all safety equipment in the chemical handling areas, and in the exact location of the safety equipment. Material Safety Data Sheets for each chemical used in film processing solutions are available from the chemical supplier. The sheets contain information on safe handling and storage of each chemical. The data sheets are required to be on file in the work place by U.S. Federal Law. Following are some of the common devices recommended for the safe handling of chemicals. Most devices are available from laboratory supply houses.

1. Aspirator Pump

Use a water faucet aspirator, or an aspirator bulb to provide low-vacuum suction for pipetting hazardous liquids.

2. Safety Carrier

Use a safety carrier for carrying all bottles containing hazardous liquids up to 1 gallon in size. Safety carriers can be as sophisticated as a padded safety carrier or as simple as a plastic bucket. Transport larger volumes of such liquids in carboys.

3. Carboy

A carboy is a large receptacle for liquids that is made of glass, plastic, or metal and is usually cushioned in a protective container. Carboys are used for transporting large quantities (5 to 15 gallons) of hazardous solutions and solvents. Use a hand truck to carry carboys from one location to another.

4. Tippers and Tilters

An inclinor cradle or bottle filter is a valuable aid for pouring liquids from large containers. Tippers for large drums or barrels are available.

5. Dispensing Systems and Pumps

Use closed pumping and calibrated delivery systems for adding large and accurately measured amounts of hazardous solutions to a mix. Such special dispensing systems are commonly used for acetic acid, sulfuric acid, hydrochloric acid, ammonium hydroxide, and formalin.

Dispensing small quantities of toxic or corrosive liquids from a carboy or drum can be accomplished safely by means of a portable pneumatic or mechanical pump. The parts of such a pump must be immune to attack by the liquid being dispensed. It may be necessary to remove the pump from the liquid and rinse it after each use.

6. Eye Protection

Wear safety glasses with side shields in all laboratory areas. For protection from spills and splashes, coverall safety goggles or full face masks are available to fit over ordinary safety glasses

7. Eye Spray and Emergency Shower

A hand- or foot-operated eye bath is essential to provide rapid and complete flushing of eyes that have contacted chemicals. Be sure such eye baths are easily accessible in all chemical handling areas.

Provide a shower head or water nozzle located in the ceiling and activated by a pull chain in all chemical handling areas. Use this shower whenever significant quantities of a chemical have been spilled on skin or clothing. Test the spray washes and showers at least once a week to make certain they are in good working order. Turning them on will flush out any rust or dirt that has collected in the spray holes or lines.

8. Exhaust Hoods

Weigh finely divided, dusty chemicals and chemicals that give off flammable vapors, in an exhaust hood. The air current must be sufficiently powerful to carry any chemical dust, vapors and gasses away from the operator. Be sure the hood is equipped with an explosion-proof fan and electrical fittings.

9. Respiratory Protection

Selection of respiratory protection is a complicated task which should be done in consultation with an industrial hygienist. Use a respirator only in the context of a complete respirator program including:

- a. Coordinated central administration.
- b. Selection of the mask according to the hazard.
- c. Provision for maintenance by qualified personnel.
- d. Inspection and cleaning of the equipment.
- e. Assignment of respirators to individuals.
- f. Training of users and supervisors.
- g. Clean uncramped storage.
- h. Fit testing of masks on the wearer.
- i. Medical approval of users.
- j. Record keeping regarding training, selection and maintenance.
- k. Written procedures for use

10. Hand-Cleanser Dispenser

Frequent use of a slightly acidic liquid hand cleanser may offer some protection from dermatitis by removing allergenic agents from the hands or gloves. Provide the cleanser in special dispensers located in all areas with wash basins and spray washes.

11. Gloves

Gloves have varying resistance to penetration by liquids depending on the liquid, glove material and manufacturer. More reputable manufacturers publish literature to guide in selection of the best glove for use with a given liquid. For general use, medium weight neoprene gloves offer very good protection. The importance of gloves to prevent chemical burns and dermatitis cannot be over-emphasized. Use waterproof impervious gloves with cotton liners for handling chemicals and for cleaning solution tanks or equipment. After each use, and before removal from the hands, thoroughly wash off the gloves with water and hand cleanser to reduce the absorption of chemicals into the rubber. Put on and remove gloves so that the liners are not contaminated with chemicals.

Change gloves at least once a day and whenever contamination of the inside of a glove is suspected. Use gauntlet-type or shoulder-length impervious gloves in the handling of strong acids and caustic solutions.

12. Fire Extinguishers

Provide properly selected portable fire extinguishers in all lab areas.

13. Railings and Guards

Protect hazardous areas around tanks, pipes, motors, stairways, and platforms by railings or guards.

EQUIPMENT MAINTENANCE

Feed Section

Periodically check all rollers in the feed section for alignment and freedom of rotation. Check alarms for proper operation.

Squeegees

Frequently check squeegees for proper operation, alignment, and cleanliness. If squeegees are not properly adjusted and maintained, they will not adequately remove solution from the film. They can also scratch the film and spray or drip processing solution, causing damage to the film and machine.

Dryer Cabinet

Because the film is wet and tacky when it is in the dryer, it is essential that the dryer cabinet and air be free of dirt and lint. Therefore, carry out the following maintenance program at regular intervals.

1. Vacuum and damp wipe the inside of the cabinet to remove any dust, lint, etc., that may have collected.
2. Examine all rollers for buildup of emulsion or gelatin.
3. Check doors and latches.
4. Check rollers and floaters for freedom of operation, and lubricate (sparingly) if necessary
5. Test all alarms for proper working condition.
6. Inspect heating coils and check for proper output.
7. Check air filters and replace if dirty
8. Replace any rubber roller rings that show signs of deterioration.
9. Clean flanges that show emulsion buildup.
10. Clean the dryer cabinet drive-roller assembly (outside of the dryer), and carefully wipe off any excess oil.

Drying Specifications

Factors affecting film drying are: time in the dryer, geometry of the dryer, air flow pattern (impingement or indirect), air flow volume, air temperature and humidity in the drying cabinet, and final squeegee efficiency before the dryer. The optimum conditions for drying film must be determined for each processor, making allowance for film moisture content and static buildup.

Starting-point specifications for control of the above factors are given in Table 2-3.

Table 2-3 Impingement Type Film Dryer Specifications

Geometry	Negative Film	Print Film
Hole Diameter	0.06 in. (1.52 mm)	0.25 in. (6.35 mm)
Spacing Between Holes	0.5 in. (12.7 mm)	2.25 in. (57.2 mm)
Film-to-Plenum Distance	0.56 to 1.5 in. (14.2 to 38.1 mm)	0.81 in. (20.6 mm)
Input Air		
Temperature	90 to 117°F (32 to 47°C)	135°F (57°C)
Relative Humidity	30 to 50%	15 to 25%
Air Flow	1000 ft ³ /min (28 m ³ /min)	5000 ft ³ /min (140 m ³ /min)
Time	5 to 7 min	3 to 5 min

Extending the dryer time one to two minutes beyond the above values allows for a wider range of drying conditions and dryer geometry (including nonimpingement drying), but with less stringent control of drying conditions.

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.

Control of Biological Growths

Algae, fungi, and bacteria tend to grow on the inside walls of prebath, wash and rinse tanks. Their presence is indicated by a slippery and slimy feel on the tank walls. Fungus may also grow in ferricyanide bleach. Fungus growth can reduce ferricyanide to ferrocyanide and cause insufficient bleaching action.

The formation of algae, fungi, and bacteria in the tanks usually can be controlled by draining and rinsing the tanks and letting them dry out as part of the daily and weekly shutdown procedure. Use of good housekeeping practices is also important. If algae, fungi, or bacteria form, add about 2 mL/L of a 5 percent solution of sodium hypochlorite to each tank as the tank is being filled with fresh water. This solution is a common household chlorine bleach, such as Clorox, Sunny Sol, Purex, etc. Use this method intermittently to prevent the buildup of microorganisms.

Note: Be certain that the hypochlorite solution is completely removed from the tank before film enters, or reticulation and/or emulsion stripping may result.

Any tank with significant slime or growth should be scrubbed with a 3 percent to 5 percent solution of sodium hydroxide using a scouring pad and then rinsed with water. Wear full face shield, impervious gloves and clothing for protection from the caustic solution.

Equipment Lubrication

A processing machine, like any other mechanical equipment, requires lubrication.

All mechanical friction points on the machine should be lubricated as required. The friction points include bushings, chain drive, idler rollers, bearings, etc.

Oil and grease should always be used sparingly to avoid transferring any to the film. Film areas covered with oil or grease will not be wetted by the processing solutions they contact.

Rack Cleaning

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

Cleaning solutions contain strong chemicals. Observe all federal, state or local codes when disposing of cleaning solutions.

Clean machine racks and check for ease of operation regularly. Solid materials and tars must be removed from the racks. Their presence can cause dirt, scratches, and abrasions on the film, as well as interfere with the drive mechanism of the machine. A method of cleaning removable machine racks is given below. For racks that cannot be removed, see the section on *Tank and Line Cleaning*.

1. Procedure

- a. Remove the racks from the machine, and immediately rinse with hot water for 2 minutes. If racks are permitted to stand without rinsing, chemicals will dry on them and make cleaning very difficult.
- b. Scrub the rack with a stiff bristle brush.
- c. If deposits still remain, submerge the racks in the Sulfamic acid cleaning solution for 20 minutes.

Sulfamic Acid Cleaning Solution	
Water (room temperature)	800 mL
Sulfamic Acid	50 g
Water to make	1 L

- d. Rinse the racks again in hot water for 2 minutes.
- e. Scrub the racks with a stiff bristle brush to remove any remaining deposits.

2. Safety Precautions

Under no circumstances should hydrochloric acid, nitric acid or sulfuric acid be used in place of sulfamic acid. Do not add household cleaning agents or organic solvents to the cleaning solution because toxic fumes may be liberated. Do not add hypochlorite bleach to the cleaning solution because toxic chlorine gas will be liberated.

Sulfamic acid solutions are harmful to skin and clothing. A hand spray, face spray and shower must be available in the areas where these solutions are used. Eye protection, impervious gloves, rubber boots, and aprons should be worn at all times by personnel using these solutions.



Caution

The residue on processing racks, especially the racks used in the color developer solution, may cause dermatitis by contact with bare skin.

Tank and Line Cleaning

Solid materials and tars must be removed occasionally from the processing tanks, recirculation system, and supply lines. A suggested cleaning method follows:

In general, dirt, sediment, and sludge are removed from the tanks and lines by flushing them with hot water. This treatment does not, however, remove carbonate scale, which can accumulate in developer tanks and lines. Carbonate scale is a white or gray solid that bubbles when contacted with acid and is easiest to remove by means of a sulfamic acid cleaning solution.

Note: Acid cleanup, if not done correctly, can affect processing results later.

1. Machine Tank and Line Cleanup—Hot-Water Cleanup

- a. Disconnect or remove sensing elements of the temperature controller and any recording equipment to prevent damage. Remove filter media.
- b. Slowly drain the tanks and lines. Drain the solution in the tanks and lines into a holding tank. Immediately fill the tanks with hot water 140°F (60°C) and scrub the tanks with long-handled bristle brushes.
- c. Drain the tanks and lines. Refill the tanks and lines with hot water and recirculate for 1 hour.
- d. Drain the water to the sewer.
- e. Check for carbonate scale in the developer tank and lines. The frequency of an acid cleanup depends on the rate at which the scale forms.
- f. Change the filters and reassemble the temperature controller and any recording equipment.

2. Machine Conversion Cleanup

- a. When converting your machine from ferricyanide bleach or persulfate bleach to “UL” Bleach, the following special clean-up procedures are required.
 1. Conversion from ferricyanide bleach: first remove all red brass from the system, then clean up the bleach system as described above under *Machine Tank and Line Cleanup—Hot-Water Cleanup*. A high pH wash (10 to 12) will help eliminate any prussian blue in the system. Three cleaning cycles are recommended.
 2. Conversion from persulfate bleach: first use a series of hot water rinses in the accelerator and bleach tanks. Since the accelerator tank will become a wash tank, the initial series of rinses is enough. Fill the bleach tank with hot water and turn on the recirculation and replenishment system. Three to five cleaning cycles are recommended.

- b. Conversion from ferricyanide bleach to persulfate bleach:

Installing bleach accelerator in a wash or stop tank requires no special cleanup procedures. A simple water rinse is sufficient after discarding the tank solution. If biological growth is observed in the wash tank, add approximately 59 mL (2 fl oz) of 5 1/4 percent solution of sodium hypochlorite per 50 L to the wash tank when rinsing it.

Installing the persulfate bleach in the ferricyanide bleach tank requires cleanup. First remove all of the ferricyanide bleach from the replenisher tank, lines, sumps, pumps, and machine tank. A poor cleanup will result in a contamination of the persulfate bleach which may, in turn, cause non-bleaching. Use the following procedure to cleanup the ferricyanide bleach tank. (Caked-on material will still require scrubbing. Check the bottom of the holding tank and the machine tank for ferricyanide residue.)

1. Drain the ferricyanide bleach and dispose of the solution.
2. Rinse the tanks, racks, and lines of the bleach system, with water and drain.
3. Rinse the system with a 10 percent solution of fixer in water, and drain. If the rinse water shows a distinctive green color, repeat this step.
4. Rinse the system with a 10 percent solution of persulfate bleach in water and drain.
5. Fill the system with fresh persulfate bleach.

3. Replenisher Supply Line Cleanup—Hot-Water Cleanup

- a. Disconnect the supply lines at the replenisher tank and flowmeters. Flush the lines with hot water for one hour.
- b. At convenient places, disconnect sections of the developer replenisher supply line and check for carbonate scale. The frequency of an acid cleanup depends on the rate at which scale forms.
- c. Drain and reconnect the supply lines.

4. Machine Developer Tank and Line Clean Up—Acid Cleanup

- a. Disconnect or remove the temperature-controller sensing elements and any recording equipment to prevent damage.
- b. Pump developer replenisher and tank solutions into their respective storage tanks. A portion of the developer tank solution is used to prepare a conditioning solution used in the cleanup procedure described under step (h) below. Remove the racks and turbulators from the machines. Depending on design, it may be appropriate to leave racks with turbulators in the machine to clean jets, etc.
- c. Mix the sulfamic acid cleaning solution in the central mix tank. Use the formula is given above under Rack Cleaning. Use hot water 140°F (60°C).
- d. Pump the cleaning solution into the replenisher storage tank and then to the machine through the replenisher lines.
- e. Recirculate the cleaning solution in the system for about 2 hours. Replenish the solution at the rate of 250 mL per minute per machine to maintain solution pH and temperature. Do not use filters while the cleaning solution is being recirculated. Brush machine tanks with the cleaning solution where required.
- f. Drain the cleaning solution from the system into a holding tank. Slowly discharge it into the municipal sewer system according to municipal sewer use codes. Flush the mix and reserve tanks, replenisher lines, machine tank, and recirculation system with water. Fill the machine with water and recirculate for 30 minutes. Use the recirculation system filters.
- g. Dump the rinse water into the sewer and change the filters.
- h. Fill the recirculation system with developer conditioning solution, which is used developer tank solution diluted 1:1 with water. Recirculate this solution for 30 minutes.
- i. Drain the conditioning solution from the system into a holding tank from which it can be slowly discharged into the municipal sewer system if allowed by municipal sewer use codes. Replace the turbulators, racks and change the filters. Reassemble the temperature control and recording equipment.
- j. Fill the system with fresh developer tank solution.

Note: For efficiency, the entire system, from the mix tank to the recirculator, can be cleaned at one time. The night before the cleanup, mix the sulfamic acid cleaning solution in the central mix tank and pump it into the replenisher holding tank for overnight storage. Perform steps (d) through (j) the following day.

5. Safety Precautions for Use with Sulfamic Acid Cleaning Solution

The work area must be well ventilated. Under no circumstances should nitric acid or sulfuric acid be used in place of the sulfamic acid. Do not add household cleaning agents or organic solvents to the cleaning solution because toxic fumes may be liberated. The sulfamic acid cleaning solution is harmful to skin and clothing. A hand spray, face spray, and shower must be available in the areas where this solution is used. Eye protection, impervious gloves, rubber boots, and aprons should be worn at all times by personnel using this cleaning solution.

6. Ferricyanide Bleach Systems



Warning

Do not use the sulfamic acid cleaning solution on the ferricyanide bleach systems.

Only hot water is used to clean this equipment. Tanks and supply lines are flushed as described above.



Warning

Acid cleanup of a ferricyanide bleach system can result in the evolution of hydrogen cyanide, HCN, an extremely toxic gas.

7. Cleaning Central Mix Tanks

Mix tank cleaning is minimized by pumping solutions out of them as soon as possible. In this way, tar does not have time to form and adhere to the sides of the tank.

- a. Remove the solutions from the mix tank as soon as possible.
- b. Rinse the tank immediately with hot water 140°F (60°C).
- c. Remove any residue which may remain in the tank by scrubbing the tank with a brush dipped in the sulfamic acid cleaning solution.
- d. Rinse with hot water 140°F (60°C).

Disposal of Cleaning Solutions

Disposal of used cleaning solutions into municipal sewers must be done in accordance with the municipal sewer codes. Never discharge large quantities of cleaning solution directly into a sewer system or into a receiving body of water. The use of holding tanks and a timed-release device is recommended for sewer cleaning solution unless directed otherwise by the code. If discharge is not permitted, contact a Chemical Disposal Service such as one of those listed in the *Hazardous Waste and Environmental Services Company Directory*. The directory is part of publication, *Chemical Week-Buyers Guide Issue*, published yearly, and available in larger public libraries.

Sound Track Processing Equipment

The procedures for sound track processing on EASTMAN Color Print Film, are described in Module 9, *Process ECP-2D Specifications*. A close-up of the required equipment is shown in Figure 9-6. Because sound track processing is a precision operation, the required equipment must be kept in top operating condition.

Alignment

Maintain the venturi air squeegees in alignment, and the gaps specifications.

To keep the applicator sound developer in the sound track area of the film, maintain the proper alignment between the guide rollers and backup roller relative to the applicator wheel. Also maintain alignment in the idler roller assembly to eliminate vibration and film twists.

Keep the spray jets and squeegees aligned in the wash box to prevent contamination of the picture area with sound track developer.

Align the sound-track application detector, if used.

Check the alignment of the application equipment each time the processing machine is prepared for sound track development. Check the gaps between the backup roller and the applicator wheel during normal machine maintenance.

Equipment Lubrication

Use a lubricant, such as Alvania No. 2* mixed with Microsize Molykote†, for idler-gear sleeve bearings. Lubricate ball bearings lightly every 2 or 3 months with a light (SAE 10) turbine oil. Replace any malfunctioning bearings.

Cleanliness

Keep all equipment clean, especially moving parts.

1. Carefully rinse the applicator wheel, wiper blades, and solution tray with warm water immediately following the use of the applicator. Do not deluge the applicator with water.
2. Keep the applicator tray and developer supply lines clean.
3. Keep the backup roller, guide rollers, and other parts free of any foreign deposits.
4. If the applying wheel does not turn freely, or if the stripe is not applied with the correct center line, the applicator may need to be disassembled and repaired.
5. Clean and lubricate idler rollers regularly.

* Alvania No. 2 is a product of Shell Chemical Co., One Shell Plaza, Houston, TX 77002. It is a lithium soap, multipurpose lubricant of an NLGI No. 2 type.

† Microsize Molykote is a product of Dow Corning Corp., PO Box 0994, Midland, MI 48686.

PROCEDURES

Machine Start-Up

Use a definite start-up procedure when preparing the machine for processing film. The procedure will vary somewhat, depending on the length of time the machine has been idle. If the machine has been idle only overnight, the procedure is called a Daily Start-Up; if the machine has been idle for an extended period, the procedure is called a Weekly Start-Up.

1. Daily Start-Up

Leave the machine threaded with leader for short shutdowns, such as overnight. To avoid breakage on start-up, do not leave splices in the bleach.

- a. Turn on the power, air, and water supplies to the machine, and start the exhaust system.
- b. Drain to the sewer and rinse, any tank being treated with hypochlorite solution.
- c. Fill the wash tanks and check solution levels in the other machine tanks. If a solution level is slightly low, check the specific gravity. If the specific gravity is normal, add replenisher. If the specific gravity is high, add water. With recirculation systems that draw solution from the top of the machine tank, the solution must be high enough in the weir boxes to prevent air from being drawn into the recirculation system.
- d. Check the replenisher supply; mix solutions if necessary.
- e. Turn on the recirculation pumps and water to the wash tanks.
- f. Check the turbulation system for proper operation.
- g. Turn on the temperature control systems for all solutions and washes. Frequently check the temperatures of all solutions and adjust when necessary.
- h. Start the dryer blowers.
- i. Turn on the replenishers and adjust the flow rates for leader. Start the machine and check the machine drive. Bring the machine up to speed gradually. If the machine is equipped with adjustable racks, check the racks for correct solution times.

- j. Check all squeegees for proper operation and cleanliness.
- k. Check the leader for twists.
 - l. Turn off the white lights and turn on the safelights.
- m. Splice in a control strip of the appropriate film or films.
- n. While the control strips are being processed, check the room for emergency buckets, dispenser levels of acid-type hand cleaner, machine leader, stapler and staples, etc. All of these items should be available before any production film is spliced into the machine.
- o. As the control strips reach the takeoff, remove them for evaluation. Interpretation of the control strips will indicate if any corrective action is required, see Module 1, *Process Control*. If the control strips indicate that the process is in sensitometric control and shows no evidence of physical damage, the machine is ready for film processing.
- p. Splice in the production film.

2. Weekly Start-Up

If the machine has been idle longer than overnight, use the following procedure:

- a. Install fresh filter cores in the following systems: solution recirculation, wash water, replenisher supply and compressed air (for air squeegees).
- b. Remove any scum on the surface of the solution in the tanks.
- c. Clean out the dryer cabinet and install clean air filters in the drying system.
- d. Check all alarm and warning systems.
- e. Check all air squeegees and adjust, if necessary.
- f. Follow steps (a) through (p) in the *Daily Start-Up* procedure.

3. Sound Track Start-Up

Use the following procedure when changing from a silent to a sound process.

- a. Thread the sound track equipment with leader.
- b. Feed the leader into the machine until any film being processed is beyond the sound track developer applicator. Stop the machine briefly, cut the machine leader after the bleach wash, and splice in the length of leader that has been prethreaded in the sound equipment. Turn the machine back on, continuing to feed leader into it, until steps (c) through (f) have been completed.
- c. Turn on the air supply to the venturi air squeegees and set at the recommended pressure and temperature for sound processing.
- d. Turn on the wash box or water squeegee and check for proper operation.
- e. Turn on the sound developer to fill the applicator tray.
- f. Check the film path for any irregularities that could cause a film break or scratch.
- g. Splice in the production films.
Note: Because the 16 mm sound film may be either A- or B-wound, attention must be given to the position of the perforations in relation to their required position in the applicator.
- h. Before the film arrives at the sound track developer station, set the equipment to the required specifications.

4. New Machine Start-Up

Use the following steps for a machine's first start-up, in addition to the steps mentioned above under daily and weekly start-up.

- a. Before the start of operations, make sure that all the necessary materials and equipment for chemical and sensitometric control are ready. Equipment includes a pH meter, proper electrodes, glassware, reagents, a densitometer, etc. Materials include KODAK Publication Nos. Y-55, *KODAK Process Record Forms*, E-64, *KODAK Curve Plotting Graph Paper*, and KODAK Process Control Strips. *Analytical Procedures* are in Module 3 of this manual, and *Analytical Reagent Preparations* in Module 4.
- b. Fill the machine tanks with water to check for possible leaks. Check the machine transport.
- c. Check the machine for mechanical fitness, for solution times by actual measurement, and for temperature control by accurate thermometers.

- d. Clean the machine following the procedures given above. Check for metal chips, miscellaneous machine parts, and foreign materials that could cause oxidation or catalytic decomposition of developers (zinc, tin, copper, some phenolic plastics, etc.) or degradation of the bleach (iron, etc.).
- e. Mix solutions and pump them into the machine. Mix normal quantities of prebath, fixer, bleach, and final rinse (or stabilizer) replenishers, but only a small amount of developer replenisher in the event that developer formula modification is required.
- f. Run a development series using control strips. Suggested starting times are given below. The developer times specified in each Process Module are used only as guides for preliminary machine design. With the developer properly mixed and its temperature correct, run a developer series to select a development time that is optimum for the particular film and processor. If the best development time determined by your tests differs by more than about 10 percent from the time specified in the Process Module, some other mechanical or chemical factor is probably out of specification and should be corrected.
 1. Color Negative Process:
At 106°F (41.1°C): 2:45, 3:00, 3:15
 2. Color Print Process:
At 98°F (36.7°C): 2:45, 3:00, 3:15
 3. Color Reversal Process—VNF-1:
First Developer at 100°F (37.8°C): 2:55, 3:10, 3:25
Color Developer at 110°F (43.3°C): 3:20, 3:35, 3:50
 4. Color Reversal Process—RVNP:
First Developer at 111.2°F (44.0°C): 1:45, 2:00, 2:15
Color Developer at 114.8°F (46.0°C): 2:01, 2:16, 2:31
- g. After the best development time is selected and the process is stable, the machine is ready to process production footage. After about 5,000 feet of production footage has been processed, analyze the developer for bromide, CD-2 or CD-3, and pH. Make any final adjustments to the replenisher concentration and replenishment rate. Once in stable operation, set up a recommended schedule of solution analysis similar to the one given as the first table in the appropriate "Effects Module." For example in Process ECN-2, see Table 8-1, "Critical Chemical Analyses," in Module 8, *Effects of Mechanical and Chemical Variations in Process ECN-2*.

Machine Shutdown

Shutdown procedures vary with the length of time a processing machine is to be idle.

1. Daily Shutdown

Leave the machine racks threaded with leader for overnight shutdowns, and leave the processing solutions in the tanks. To prevent breaks on start up, avoid leaving splices in the bleach.

- a. Splice leader to the last roll of production film and allow it to thread through the machine.
- b. As the production film leaves each tank, shut off the recirculation and replenishment systems for that tank.
- c. After the film passes through the dryer cabinet, turn off the machine drive and take-up.
- d. Using a water filled squeeze bottle, rinse off all exposed areas such as leader, racks and squeegees. Dried-on processing solution could form chemical residue and scratch the film.
- e. Drain the wash-water tanks.
- f. Turn off all services to the machine.

2. Weekly Shutdown

On weekend shutdowns use this more extensive shutdown procedure. This provides an opportunity to perform preventive maintenance, which will help keep the machine operating at peak efficiency.

- a. When the last production film enters the load accumulator, splice on leader.
Note: If the machine tanks and racks are to be cleaned or if the racks are to be removed from the machine, try the following. As the end of the production film leaves the color developer, break the leader where it leaves the load accumulator. This allows the leader to strip out of the machine. As the leader strips out of a rack, remove the rack from the tank and rinse it with water.
- b. Shut off the replenishment and recirculation systems.

- c. Drain the prebath, stabilizer and wash-water tanks. If biological growths are a problem, add 2 mL of sodium hypochlorite solution for each litre of water filling the tank.
- d. Remove the filters.
- e. Remove all squeegees and soak them in water.
Note: It is especially important for squeegees to be operating clean and scratch-free when processing preprint films.
- f. Remove and soak wiper-blade squeegees in water.
- g. Wash rollers from rotary buffer squeegees in detergent, rinse with water, air-dry and fluff.
- h. Lubricate any spools or rollers used with the squeegees once a week with a small amount of Vaseline petroleum jelly or its equivalent.
- i. Clean the machine and adjacent areas.
- j. Shut off all controls, alarms, warning systems, etc.
- k. Shut off all power and services to the machine.

3. Sound Track Shutdown

Shutdown procedure for sound track developer:

- a. As the leader that follows the coated film threads through the applicator, widen the gap between backup roller and applicator wheel until developer application stops.
- b. When the applicator is completely threaded with leader, stop the machine briefly and cut the leader at either end; then splice the two ends in the machine together. Start the machine and continue running until it is completely threaded with leader.
- c. Turn off the developer replenisher, air supplies, water supplies, and heaters.
- d. Rinse the applicator with water and remove all solution deposits. The applicator should not be deluged with water.
- e. Set the sound-developing equipment aside still threaded with leader. It is imperative not to leave the equipment threaded with film because the emulsion will stick to the squeegees, thus freezing up the apparatus.

Hand Splicing

When repairing breaks, etc., it is important that the splices be properly made. They must be strong and smooth to avoid causing trouble as they run through the machine.

When splicing leader to leader, the ends should overlap about 4 in. (10 cm). Be sure the ends are properly aligned. Two staples in the leading end and one in the trailing end of the splice are generally used to hold these edges down so that trimming is unnecessary.

When making a splice between ends of film or between leader and film, the overlap is limited to about 1 in. (25 mm) so that the staples will not enter the picture area.

Avoid allowing steel staples to sit in the bleach overnight or longer.

Film Handling

1. Breaks

Film breaks can occur anywhere in the processing cycle, and usually result from too much tension, poor splicing, a torn film edge, etc. It is essential to minimize the hazard of film breaks by good processor design and maintenance, as well as by attention to proper film splicing and handling.

A preprocessing inspection may be helpful in finding poor splices and torn film edges before the film enters the processing machine. Such an inspection involves rewinding the film and leader in the dark and feeling both edges for tears and catches. Care must be taken to avoid putting pressure, strain, dirt, or finger prints on the film. Wearing lint-free white gloves and keeping the inspection area spotlessly clean are recommended. The rewind equipment should be grounded to reduce static which can discharge and fog the film.

A procedure for handling breaks under different circumstances should be developed by every processing laboratory. This procedure should be established before emergencies occur. The right procedure to follow when a break occurs is influenced by all of the following factors:

a. Machine Design

The physical design of the processing machine and the speed at which it runs will determine the accessibility of various areas and whether it is possible to splice broken film ends together without interrupting operation. The ease or difficulty of rethreading the machine is a very important consideration.

b. Type of Film Being Processed

Whether the film is replaceable or not is important. For example, an intermediate film is very critical sensitometrically and also replaceable. If it breaks in the developer, perhaps the machine should be shut down, the break repaired (to avoid rethreading the machine), and the intermediate reprinted. On the other hand, if camera negative film breaks in the developer, every effort should be made to recover it because a speed shift resulting from standing in the developer may be better than losing the film completely. It may be advisable to have large rolls of leader on hand to splice to the trailing end of a break (if the machine is not stopped) to avoid having to rethread the machine.

c. Part of Machine in Which Break Occurs

A break in the dark part of a machine is very difficult to handle quickly. If the film must be salvaged, it may be necessary to shut the machine down until the loose ends can be found and spliced together. Shutting down the machine should be used only as a last resort.

A break in the light part of a machine is usually easier to handle than one in the dark. The loose ends can often be spliced together without shutting down the machine.

A break in the dryer cabinet is dangerous because the emulsion is still soft and vulnerable to physical damage. Any film that is removed from the dryer while it is still wet should be placed in water if salvage will be attempted. Film taken out of the cabinet and placed in water should be rewashed or reprocessed in the machine to minimize the accumulation of dirt or scratches.

After a break has been repaired, leader should be fed into the machine until the machine has been checked for and cleared of any twists, scratches, etc.

2. Twists

Where possible, processing machines are designed so that, when properly threaded, only the base side of the film comes in contact with transport rollers. If the film should become twisted (turned over), the emulsion side would contact the film transport rollers and possibly become damaged. Twists in the film can be caused by mistakes in threading, mistakes in splicing, too much slack, etc.

Twists are detected by the physical appearance and “feel” of the film as it passes from rack to rack. With experience, the operator can tell the difference between the base and the emulsion side of the film. EASTMAN Black-and-White Opaque Leader 5981 and 7981 is available to make twists easier to spot. Black on one side and white on the other, this leader makes it easy to locate the position of a twist in the machine.

3. Scratches

Scratches can occur on the base side or the emulsion side of the film.

Scratches are caused by the film being pulled over or against a rough or dirty surface. Carefully inspect film at the dryer cabinet. If scratches are apparent, the film should be traced back through the machine until the cause is found.

Regular and careful preventive maintenance, especially on racks, rollers, and squeegees, reduces the possibility of film damage.

Some auxiliary equipment, such as the backing removal unit, final squeegee, etc., may use a roller that comes in contact with the emulsion. Frequently inspect such rollers for freedom of rotation, cleanliness, alignment, etc., to minimize damage to the emulsion.

The more frequent causes of scratches are:

- a. Spools that are not rotating freely or that are out of line.
- b. Chemical crystals or other foreign material on spools.
- c. Old, hard, worn, dirty, or maladjusted squeegees.
- d. Foreign objects in machine tanks.
- e. Improper machine threading (a twist in the film).
- f. Deposits on the rem-jet buffer.
- g. Improper loading of camera magazine or processing machine.
- h. Cinching a roll of film before or after processing.
- i. Contact with spray nozzles in the developer turbulator.

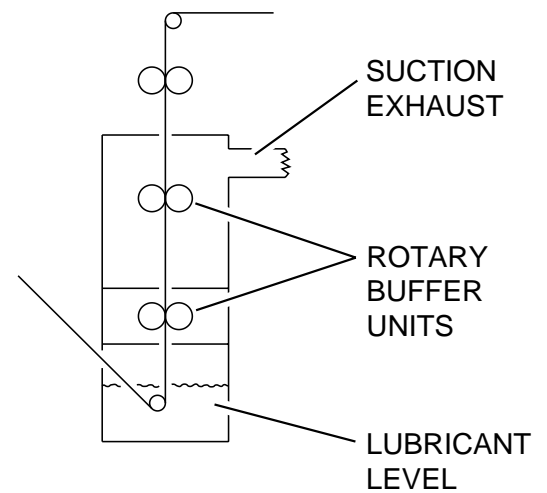
Film Lubrication

Lubrication* of motion picture print films prior to projection is beneficial. The treatment contributes to smooth performance during projection, helps prevent static charge build-up, as well as providing cleaning action and protection from scratches and cinch marks. Full-coat lubrication is used primarily on 8 mm and 16 mm films. Sometimes it is also used on wider films for the scratch protection and cleaning it affords. Edge coating (edge waxing) is necessary for larger formats.

1. Full Coat

Full-coat (overall) lubrication of Eastman films designated for projection, can be accomplished after drying by passing the film through a lubricant solution in a dip tank. The film can then be buffed on both emulsion and support surfaces by passing it through two or three buffer squeegee units. See Figure 2-1 and Figure 2-13. A buffer squeegee unit consists of a pair of plush-covered rollers that are motor driven at a high speed, counter to the direction of the film motion. The first one or two buffer squeegee units should be contained in a stainless steel housing that allows excess lubricant solution to return to the dip tank. A suction air vent should be mounted near the film exit from the metal housing to remove the excess volatile solvent (e.g., methyl chloroform). The buffer squeegee in the above lubricator is an effective film cleaner, removing loose processing dirt, including some dye, from the film surface. The bulk of this dirt becomes suspended in the lubricant solution in the tank. It is important that the solution in the dip tank not become dirty or change concentration appreciably; the dip tank should have an overflow to maintain an appropriate solution level and to continuously remove some of the dirty solution.

Figure 2-13 Rotary Buffer lubricator



F010_0084ACA
F010_0084AC

The lubricating equipment can be designed for any film format. The number of buffer squeegee units needed depends on the transport speed of the processor. Three pairs of buffer squeegee units have been found adequate for film speeds between 100 and 200 ft/min (30 and 60 m/min). Further details on this method of lubrication can be found in the paper, "The Rotary Buffer Squeegee and Its Use in a Motion Picture Film Lubricator," by H. F. Ott and J. E. Dunn, *Journal of the SMPTE*, 77:121-124, February 1968.

a. Lubricant Formula

Many oils and waxes are not suitable for full-coat lubrication of film because they form globules or mottle instead of a smooth, uniform coating. On prints, such mottle causes flicker or random variations in density. Hence the nature of the oil or wax used, as well as the solvent used to dissolve and coat it, is of critical importance. Before it is used, any lubricant formula must be carefully tested for its temporary and permanent effects on the film. One satisfactory formula for full-coat lubrication follows:

Film Lubricant Formula (full coat)	
PE Tetrastearate (Pentaerythritol tetastearate)*	0.59 g
Methyl Chloroform (inhibited)†	1 L

* Available as pentaerythritol tetastearate, Chemical No. P7421 from Kodak Laboratory and Research Products, Rochester, NY 14650, or as Hercules B-16 Synthetic Wax, from Hercules Inc., Hercules Plaza, Wilmington, DE 19894.

† Available as 1,1,1-Trichloroethane, Chemical No. 3613 from Kodak Laboratory and Research Products, Rochester, NY 14650, or from Dow Chemical USA, 2020 Dow Center, Midland, MI 48674.

CAUTION! Harmful if inhaled.

KODAK Movie Film Cleaner (with lubricant) may also be used for full-coat lubrication.

* F. J. Kolb and E. M. Weigel, "Lubrication of Motion-Picture Film" *Journal of the SMPTE*, 74:297-307, April 1965. Also R. S. Perry and L. Mino, "Lubrication of 35 mm Release Prints for Extended Print Life," *Journal of the SMPTE*, 92:1051, October 1983.

2. Edge Coat

The 35 mm and 70 mm films for theatrical projectors need additional waxing for satisfactory projection life. This additional wax is coated on the film edges since theatrical projectors require an amount of lubricant that would cause mottle on the picture area and in the sound stripe.

The edge coat waxing equipment described by Perry and Mino is recommended. Variations of these units can easily be made an integral part of the processing machine to reduce handling costs and increase the speed of production. In the basic design, rotating discs apply the lubricating solution to the area of the film that lies outside the picture area along the perforations and edges. These discs usually rotate in a lubricant tray and they depend on surface wetting to pick up and transfer the solution to the film. The applicator discs should be coupled into the main drive to assure that film speed and applicator speed remain equal.

Wax is usually applied only to the emulsion side of the film. The drying rate of the edge coat formula should be low enough to allow transfer of wax to the support side of the roll. Some laboratories lubricate both sides of the film directly.

A solution of paraffin wax dissolved in inhibited methyl chloroform is a satisfactory edge lubricant. As a general rule, the life of frequently projected film is proportional to the concentration of wax in the edge coating solution.

Film Lubricant Formula (Edge coat)	
Paraffin Wax	50 g
Methyl Chloroform (inhibited)*	1 L

* Available as 1,1,1-Trichloroethane, Chemical No. 3613 from Kodak Laboratory and Research Products, Rochester, NY 14650, or from Dow Chemical USA, 2020 Dow Center, Midland, MI 48674. **CAUTION!** Harmful if inhaled.

The edge coat is applied at both edges of the emulsion surface at a rate of 33 mL per 500 feet of film, resulting in a deposit of 1.65 g of wax on each 500 feet of 35 mm film.

Safe Handling of Processing Chemicals

To reduce accidents and lost time, it is essential that laboratory personnel be trained in proper procedures and safety precautions for handling specific processing chemicals, as well as general classes of chemicals. Such training should be given to all individuals who have anything to do with handling chemicals, whether at the receiving dock, in storage areas, mix areas, processing rooms, cleaning and inspection rooms, or laboratories. Material Safety Data Sheets contain information on the proper manner of handling specific chemicals. These sheet must be on file in the laboratory according to U.S. Federal Law.

Eye irritation and dermatitis, are the major hazards associated with handling photographic processing chemicals. Employees handling or mixing any chemical solutions should wear protective clothing such as coveralls, long-sleeved jackets, rubber aprons, impervious gloves, and eye protection to avoid direct physical contact with the chemicals. Personal breathing apparatus may be needed under certain use conditions as noted in the Material Safety Data Sheets. General safety principles and information on dermatitis follow.

1. Handling of Liquids

With a few exceptions, employees handling liquids or concentrated solutions should wear impervious gloves and tight-fitting goggles for eye protection. This is especially important when dispensing, measuring, or transporting quantities of liquids. Use mechanical pumps or metering devices whenever possible to dispense liquids from drums or carboys. An inclinor cradle or bottle filter is useful for pouring solutions from carboys.

When opening glass-stoppered bottles of ammonium hydroxide, nitric acid, and other solutions with toxic fumes, wrap a paper or cloth towel around the neck of the bottle and over the stopper before tapping the stopper to loosen it. Rinse and dry the outside of acid bottles before they are opened. Never leave bottles open for extended periods of time on the bench top. Do not leave stoppers in a place where someone might accidentally contact them. Securely stopper bottles before they are transported from one location to another.

Never carry concentrated acids, such as sulfuric or glacial acetic, or alkalis, such as ethylenediamine or caustic solutions, in open pails or in unprotected glass bottles. A padded safety carrier can be used for carrying bottles up to 1 gal (4 L) in size. Larger volumes should not be carried in glass bottles other than protected carboys. Store large bottles containing corrosive liquids on the floor or on shelves that are no higher than 2 ft (0.6 m) from the floor.

Never pipette liquids by mouth. A variety of pipetting aids are available from laboratory supply houses.

Always dilute acids by adding acid slowly to water. Some concentrated acids evolve considerable heat when mixed with water. When acid is added to water, the heat is dissipated throughout the water; whereas, if water were added directly to acid, the rapid formation of steam and vapors could spatter the acid, and the heat may even be great enough to break the container.

Dilute and flush all spillage of corrosive solutions immediately with large quantities of water. A single drop of acid can cause a severe burn. See the Material Safety Data Sheets for proper procedures.

Any area of skin or eyes contacted with corrosive chemical solutions should be flushed immediately with large amounts of running water. Flush the skin for at least 10 minutes and the eyes for at least 15 minutes. Remove all contaminated clothing or shoes. In the case of eye contact, hold open the lids and flush the eyeball with a gentle stream of water from an eye bath or a hose. Obtain prompt medical attention for all skin and eye burns.

2. Handling of Solvents

Several flammable and hazardous solvents are used in analyzing and using photographic processing solutions. Keep flammable solvents in approved self-closing metal containers away from sources of ignition. Maintain containers at ground potential to prevent ignition of vapors from any static discharges generated by the operator. Attach a grounded wire to the handle or other convenient part of the container by means of a battery clip. Do not permit smoking in areas where such solvents are used, and remove any open flame or apparatus that generates sparks from those areas. Provide adequate fire protection. Complete precautions to be taken against fire and explosion in the handling of solvents are outlined in a handbook and various pamphlets published by Fire Protection Research International, 60 Batterymarch Street, Boston, MA 02110.

Most organic solvents are toxic if swallowed. Such solvents like corrosive solutions, should never be pipetted by mouth. Use a rubber bulb or an aspirator pump.

Some of the solvents used, such as methyl chloroform, give off vapors that are toxic. Breathing these vapors can cause eye, nose, and throat irritation.

The safe handling of solvents requires well-ventilated storage and mix room areas; the use of hoods and closed containers for volatile materials; and the use of impervious gloves, eye protection, and proper respirators where necessary. Lubricating, lacquering, and cleaning of film must also be done in enclosed ventilated machines in properly ventilated areas.

The emergency treatment of splashes on skin, clothing, and eyes is the same as for acids and alkalis, namely, immediate and thorough flushing with running water, followed by medical attention. Prolonged or repeated contact with solvents tends to defeat the skin's natural protection and predispose an individual to dermatitis.

3. Handling of Solids

The basic principle for the safe handling of solids is the same as that for handling liquids and solvents, namely, avoiding direct physical contact with any part of the body and not breathing the dust.

Do all bulk weighing and transferring of solids from their original containers in a weighing hood designed to remove dust from the breathing zone of the worker and to reduce the chances for contamination of the worker's clothing. Keep all hood surfaces and adjacent areas clean, and remove all spills promptly by vacuuming. Wear gloves and eye protection whenever possible. Make frequent changes of uniform mandatory in all chemical mix and processing areas. One of the most frequent causes of difficulty in this respect is the contamination of the cuffs on jackets and trousers. Personal breathing apparatus may be needed

under certain use conditions as noted in the Material Safety Data Sheets.

Some of the potentially hazardous solids used in motion picture processing are discussed below. KODAK Color Developing Agents, CD-2 and CD-3, are chemicals that, even in solid form, can cause skin sensitization. Sodium hydroxide, other solid alkalis, and silver nitrate are capable of causing severe skin and eye burns. Emergency treatment for accidental skin contact with hazardous solids is the similar to that of liquids; first, brush off the loose solid, followed by immediate and abundant application of water.

Observe the flammability and reactivity properties of chemicals. Flammable solids like KODAK Reversal Agent, RA-1, should be handled as carefully as flammable solvents, since these materials can ignite easily and burn vigorously. Do not use metal tools such as scoops or shovels with shock or impact sensitive materials such as the kit chemical KODAK VNF-1 Persulfate Bleach and Replenisher, Part A.

In summary all chemicals must be handled in such a way as to keep them off the skin, out of the eyes, lungs and stomach. This can be done by proper personal protective measures, mechanization of chemical handling, proper methods of transporting and storing, provision of properly designed exhaust hoods and good general ventilation, and proper cleaning of working areas and clothing. All of these factors are important in connection with the dermatitis problem discussed below.

4. The Nature and Cause of Dermatitis

Dermatitis is a broad term used to describe skin inflammation of any kind. Dermatitis may arise from contact with certain chemicals. These chemicals fall into two broad categories. The first category includes chemicals that cause irritation such as might be caused by acids or alkalis. The condition caused by such chemicals is called "contact irritant dermatitis."

The second category includes chemicals that cause an allergic reaction such as might be caused by poison ivy. This reaction is called "contact allergic dermatitis." Some chemicals may fall into both categories and be able to produce both a contact irritant and a contact allergic dermatitis.

Contact irritant dermatitis may be caused by acids, caustics and strong oxidizing agents which damage or destroy the skin by direct chemical action. Soaps, detergents and solvents may cause inflammation by removing the normal protective oils from the surface of the skin. These agents do not require an allergy or special sensitivity to produce an effect that all people react more or less alike to under similar degrees and conditions of exposure.

In contrast, substances capable of causing contact allergic dermatitis may be handled without problems for weeks or months and then suddenly even a small contact can cause skin inflammation in some people. This is because the skin itself has developed an altered reaction as a result of repeated exposures to the particular chemical; wherever the chemical touches the skin, swelling, redness, itching, and finally blisters may develop. This is the type of reaction that results when people develop a sensitivity to poison ivy.

While many chemicals have the ability to cause contact dermatitis, some may affect only one out a thousand people, while others may cause a rash in a large majority of the people who are exposed to them.

Also the length of time it takes to develop a sensitivity can vary greatly in different people. It can range from two or three weeks to several years or more. The degree of sensitivity may also vary, with some persons being only mildly affected and others showing severe inflammation at the slightest contact. With the latter type of response, the sensitization is often permanent and may limit further work with a given chemical. Other people may be able to continue their work with little or no trouble if they are careful.

Physicians occasionally test for sensitivity to a particular compound by placing a tiny amount of the chemical on some portion of the body. This is called a patch test. A positive result will be obtained only after the person has become sensitive. Hence it cannot be used to predict which employee might develop dermatitis. Since there is no known way of preventing a normal skin from becoming sensitive to certain chemicals after repeated contacts with them, every effort must be made to prevent the contacts from occurring.

5. Factors That Predispose to Contact Allergic Dermatitis

- a. Frequency and extent of skin contact are the most important factors in deciding whether a person will develop a sensitivity. Since the amount of contact necessary to produce sensitivity in any given person is unknown, the only safe procedure is to avoid all skin contact with such chemicals.
- b. Exposure to more concentrated solutions or exposure to certain forms of a chemical might be important. Simultaneous exposure to certain mixtures may be more damaging than exposure to single chemicals.
- c. The duration of any given contact is also very important. If the chemical is removed within a few minutes, the chance of penetration into the skin is less likely.
- d. Previous injuries to the skin, such as those caused by caustics, detergents, solvents, chapping, abrasions, cuts, or other skin diseases, can allow the chemical to penetrate more easily and quickly. Excessive sweating can also speed penetration.
- e. Persons who have a known history of contact allergic dermatitis, childhood eczema, should avoid exposure to known skin irritants and sensitizers. There are no differences among races, between sexes, or between blondes and brunettes in ability to develop skin allergies.

6. Specific Photographic Chemicals Causing Dermatitis

Developing agents, particularly Hydroquinone, KODAK Color Developing Agents, CD-2 and CD-3, either in solid form or in solution are very potent skin sensitizers, and they can cause dermatitis if handled carelessly KODAK Persulfate Bleach Accelerator, PBA-1, can also cause skin sensitization with repeated skin contact.

A certain amount of simple irritation can result from contact with alkalis in the developer or with other concentrated solutions. Check the Material Safety Data Sheets to determine which chemicals can cause allergic skin reactions.

7. Prevention of Dermatitis

Every laboratory should consider the possible occurrence of dermatitis among its employees as a serious threat to successful and profitable plant operation. Great emphasis should be placed on the prevention of dermatitis rather than on the cure. All employees, supervisors, and plant medical personnel must be quite familiar with the nature of skin problems; and they should realize that *protective measures must be carried out 100 percent of the time with no exceptions. They must be made a routine part of the job.*

It is not sufficient to outline to employees the necessary steps that should be taken to prevent dermatitis and then to take no further action to see that the program is carried out. Management should exercise constant vigilance to see that employees are cooperating at all times and to point out to them that the program is for their own welfare and protection as well as for the organization.

The following suggestions will be helpful in formulating a dermatitis-prevention program:

- a. Prevention of Contact with Chemicals
 1. Cleanliness of working areas: Keep all working areas clean and free from chemical dust and spilled solutions. Carry out bulk weighing of dry chemicals in appropriate areas with hoods designed to remove dust from the vicinity of the worker
 2. Use of impervious gloves: Always use impervious gloves with cotton inner liners when handling concentrated materials in the mix room and when cleaning tanks or equipment. It is surprising how many routine tasks can be performed successfully when gloves are worn. Change gloves at least once per day and always clean before reuse. Never touch the outside of gloves with bare hands in putting them on or taking them off. Before gloves are removed, wash their outer surfaces with an acid type hand cleaner and rinsed with warm water. At least once a day, both outer and inner surfaces of the gloves should be cleaned with an acid hand cleaner. The gloves should be inspected frequently for tears or holes without contaminating the inner surface.

3. Protective clothing: Change protective clothing, such as coveralls, long-sleeved jackets, etc., frequently or whenever any chemical is spilled on them. Keep work clothing in separate lockers from street clothing because of the danger of contamination.
 4. Protective hand creams: Protective hand creams have often been suggested for use in connection with dermatitis caused by chemicals. However, a long study of many types of hand creams has shown them to be relatively ineffective against potent skin sensitizers in photographic processing operations. Their use is not recommended at the present time for controlling dermatitis encountered in photographic processing.
- b. Removal of Chemicals from Skin

Experience has shown that *immediate* removal of chemicals from the skin, in case of accidental contact, is the most important single measure in reducing the number of dermatitis cases. All areas where chemicals are handled, mixed, or used must have convenient hand-washing facilities, preferably with foot-operated valves. Each area should be provided with a dispenser containing a slightly acid liquid hand cleanser that has a pH of 5.0 to 6.0. Such hand cleansers counteract the alkalinity of the developer solution, aid in removing the basic developer compounds and considerably reduce the likelihood for the development of dermatitis. They are commonly used for surgical skin preparation and cleaning in hospitals.

Within *minutes or possibly seconds* after contact with chemicals, especially color developer, the hands should be *thoroughly* washed with water and acid hand cleaner. This should be repeated after each known contact occurs. Ordinary bar, powder, or liquid soaps are ineffective for this purpose. *The acid-type cleanser is essential.*

8. Procedure in Case Dermatitis Occurs in Employee

If an employee develops a case of dermatitis, remove the employee from work for treatment by a physician or plant nurse. Self-treatment with ointments, etc., is not recommended.

Require all employees to report any dermatitis at once and learn to observe their own hands for signs of redness or swelling around nails or between fingers. An employee should be particularly careful if they have any cuts or scratches or any other skin irritation on the hands or wrists. Most employees who have recovered from a mild case of dermatitis can continue to work in color processing unless they are unusually sensitive. This will depend on their skill in preventing all skin contact, however, and it should be allowed only after consultation with a physician.

Employing the measures described above should keep the incidence of dermatitis in any laboratory at a very low level, certainly on the average of less than 1 or 2 percent of the total number exposed. Many color processing laboratories have been able to go many months at a time with no reported cases. This kind of record will not come about unless unceasing attention is given to the problem.

Laboratory Cleanliness

1. Introduction

White spots noted during projection are commonly known as white dirt, windows, stars, sparkle, or snow. An objectionable amount of white dirt can be present in a print made from any camera or other preprint film. Such white spots may be caused by dirt particles or scratches on either side of the preprint film or lying between the preprint and print films during the printing operation. These dirt particles and scratches form unexposed images (white spots) on the print film. The source can be in the processing, in the editing and conforming, in the printing, or in any combination of the above.

Evaluation of the projected images for dirt is a judgment that depends upon scene content, scene density, scene magnification, and viewing distance. Therefore, determination of an acceptable dirt level is difficult. Of course, the smaller the film format, the more noticeable dirt particles become.

2. Sources of Dirt Particles

Important types of processing-related film dirt are: sulfur particles caused by a low fixer pH, silver particles caused by improper electrolytic silver recovery, tar caused by aerial oxidation of developer rem-jet particles that remain on the film because of improperly adjusted removal equipment, incorrectly mixed prebath, and biological growths from the water supply.

However, this section deals mainly with other dirt sources in the lab. Such dirt consists of dust, cloth fibers, hair, skin flakes, chemical crystals, corrosion particles, etc.

a. Air Supply

Any work area generates significant amounts of airborne dirt. Air ducts in buildings frequently end in ceiling outlets placed to distribute the incoming air uniformly throughout the room. The system creates turbulence and continuously stirs up dirt present in the room and keeps it in random motion so that it has many opportunities to contact clean film. Incoming air should be well filtered to remove particles larger than 5 microns, and should have nonturbulent (laminar) flow.

b. Construction Materials

Materials used in building construction are often dirt producers. Bare concrete floors, chipping paint, pipes and ducts, rough-textured surfaces, and some acoustic ceiling materials are all potential sources of dirt. Smooth, easily-cleaned materials should be used wherever possible (e.g., plastic laminate, vinyl flooring, stainless steel, ceramic tile, etc.)

Improper processing machine construction materials can be a significant source of dirt. Use of a stainless steel tank for ferricyanide bleach, for example, would lead to the production of large amounts of corrosion products such as prussian blue in the bleach. Any sources of friction causing undue wear of mechanical parts (such as spools, rollers, bearings, and plastic cores) will also generate dirt.

c. Laboratory Personnel

One of the primary sources of dirt in film-handling areas is personnel. Clothing usually contains a significant amount of loose dirt and lint. Workers move about constantly; and each time they return from a less clean area, they bring dirt of some sort with them. Dandruff, skin flakes and skin oils are also common forms of film dirt.

The lab layout should be organized to minimize traffic flow, and clean, lint-free smocks, uniforms and film-handler's gloves should be provided to film handlers.

d. Water Supply

Hard water is a source of dirt since it can cause the precipitation of carbonate and other ions in the form of calcium salt crystals. The municipal water supply may also contain suspended matter and biological growths (e.g., diatoms). Additional filtration and water-treatment by the lab may be necessary.

e. Film

Emulsion skivings and scrapings can result from improperly aligned spools in the processor, film cutting and splicing operations, and burrs or snags in the processor or printer. Rem-Jet may be abraded by rollers, generating dirt, and sprockets may generate dirt from the perforations.

3. Electrostatic Charge

Any film-winding or rewinding operation may put an electrostatic charge on the film. The amount of charge buildup depends on the relative humidity in the work area and the actual handling procedure and the equipment. Charged film attracts dirt particles in direct proportion to the magnitude of the charge, and this can be a serious problem during film-handling operations.

The surface conductivity of most film, (especially processed film) decreases rapidly with a decrease in the relative humidity. A reduction in the surface conductivity of film in turn reduces its ability to dissipate an electrostatic charge. Any residual electrostatic charge on film attracts dust and dirt, and it can even discharge (exposing unprocessed stock) if large enough. A relative humidity range that is acceptable for both static buildup and worker comfort at 70 to 75°F is 60 to 65 percent. Below 45 percent RH, it is difficult to keep film clean, even if film-cleaning devices are used. Relative humidity higher than 65 percent may cause rusting or corrosion of metal, and will cause the emulsion to soften or even promote mold, mildew and fungal growth.

a. Causes

All of the following can increase static buildup on film:

1. An increase in film winding tension.
2. An increase in the speed of film movement.
3. A decrease in relative humidity.
4. Slippage of film on transport rollers.

b. Techniques of Charge Reduction

Specially treated polyurethane or synthane rollers, which cause a minimal amount of static charging, should be used wherever charge buildup is a problem. Metal rollers, while not building a charge themselves, can impart a charge to processed film.

Since it is impossible to completely prevent static buildup on preprint film during the many handling operations commonly necessary for production, the use of static eliminators in conjunction with film cleaners is recommended. Several static eliminators are commercially available. Such static eliminators should be located at key points in the film-handling sequence, including the film windup on the processing machine. While the static eliminator may not completely remove the charge, in reducing the charge, it decreases future dirt attraction and increases the effectiveness of film cleaning devices.

Grounding metal rewind and film-handling equipment may also be helpful in reducing static charge.

4. Techniques of Dirt Reduction

a. Air Pressure

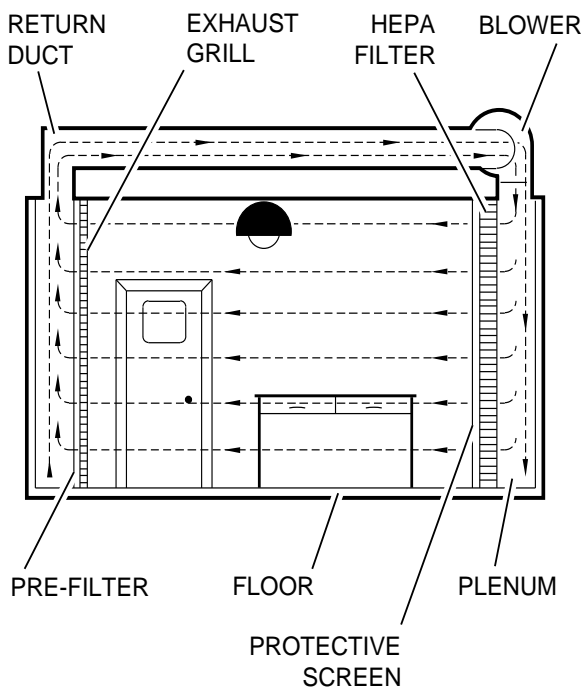
Maintaining positive room air pressure in all film-handling areas is essential for dirt reduction. This positive pressure prevents dirty air from entering the room when a door is opened. Unfiltered outside air should always be excluded (i.e., don't open windows).

b. Air Flow

An excellent way of supplying clean air to film-handling areas without creating turbulence is by laminar flow. Laminar flow is a controlled, unidirectional flow pattern of air which picks up any loose dirt and carries it directly to an exit. Hence, dirt particles have little opportunity to settle before they are moved to and trapped in the filtering system.

Laminar flow can be either horizontal or vertical. Horizontal is the easiest to use for general room ventilation. One wall can be a grid filled with filters through which air enters the room. The air then exits through the opposite wall and recycles through the laboratory conditioning system. See Figure 2-14. The air should be filtered twice (through a prefilter and an absolute filter) before reentering the room. The prefilter removes most of the larger dirt particles to prevent clogging of the absolute filter. The absolute filter passes only particles smaller than 0.3 micron in diameter. A laminar airflow rate of 15 to 30.5 metres per minute (50 to 100 feet per minute) should be adequate for most room installations.

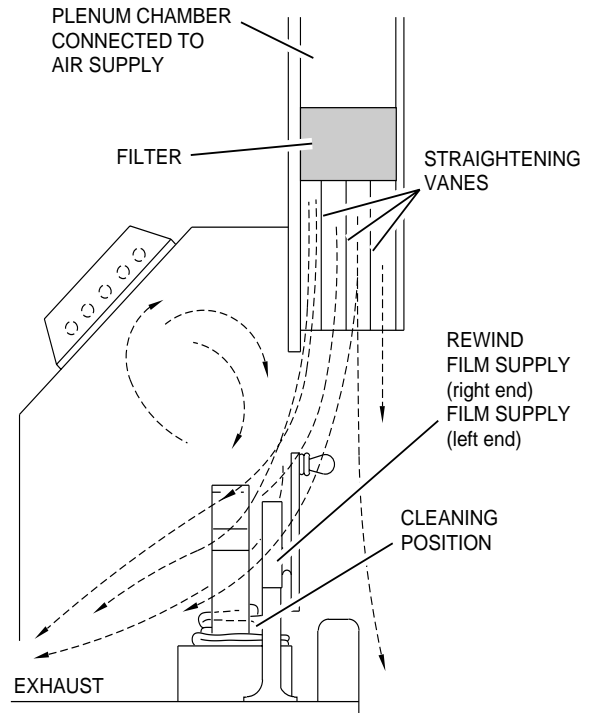
Figure 2-14 Wall-to-Wall Laminar Flow Clean-Room



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F010_0085GC

The concept of vertical laminar flow is usually applied to clean hoods*, which are commercially available for use with a single piece of film equipment (e.g., printer, splicer, rewind bench). See Figure 2-15. Several companies market complete built-in systems or portable units for almost any size room or work area.

Figure 2-15 Clean Hood for Film Handling



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F010_0086GC

Keep the dirt level in the processor drying cabinet very low because much of the film in it is wet and sticky. Even if the airflow in the processor room is laminar and the dirt count in the air is low, the drying cabinet should have a separate air filter. 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.

* For more information on the design of clean hoods, see "Dirt-Free Exhaust Hood for Cleaning Film," *Journal of the SMPTE*, 67:689-690, October 1958. B. Agnew, "Application of Aerospace Clean Room techniques in Photographic Laboratories," *Journal of the SMPTE* 76:111-114, February 1967. R. Westfall and E. Knutsen, "Factors Affecting the Cleanliness of Motion Picture Film," *Journal of the SMPTE*, 85:853, November 1976.

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

- c. **Relative Humidity**
Relative humidity has a pronounced effect on film, Newton's Rings, ferrotyping and emulsion keeping. Of more concern here, however, is the effect it has on the electrostatic properties of film. For reasons outlined in the section on electrostatic charge, the relative humidity in film-handling areas should be maintained in the range of 60 to 65 percent, and never less than 45 percent. Portable humidifiers (not vaporizers) have been found to be effective for small areas.
- d. **Shoe Cleaners and Air Showers**
Substantial reductions in room dirt can be achieved by means of shoe cleaners and air showers, which remove loose dirt from the clothes of lab personnel. Such devices should be located at the entrances to clean areas. Water baths or tacky-mats may be used to clean the bottoms of shoes.
- e. **Population Density and Traffic Control**
Since people are major dirt contributors, it is advisable to avoid crowded conditions in critical areas. A reasonable rule of thumb for such areas is no more than one person per 100 square feet of space. Equipment, too, should be given adequate space and positioned so as not to interfere with proper room airflow. Otherwise, it might trap and collect dirt.

Unnecessary traffic in clean areas should also be eliminated. To protect the film from contamination, clean areas should be off limits to those who do not work there.
- f. **Building and Equipment Maintenance**
Regular janitorial service in film-handling areas is essential. Frequency of room and equipment cleaning depends on individual laboratory circumstances. Pipes, ducts, walls, ceilings, and all equipment should be kept free of loose dirt by vacuuming or damp-wiping. Abrasive powders or pastes should be avoided, since they tend to leave a particulate residue. Industrial cleaning fluids that do an excellent job are now available. Vacuuming can actually increase dirt problems if the vacuum equipment discharges indrawn air through a filter and back into the room. Such equipment invariably discharges fine dust which travels over the room before setting. A central vacuum system avoids this problem. If floors are wet-mopped, a cellulose type of sponge mop should be used rather than a stringy cloth mop.

A regular program of equipment maintenance, as outlined above, is also essential to keep laboratory dirt to a minimum. Proper lubrication of moving parts is particularly important to reduce dirt generation. Where air squeegees are used on the processor, great care must be taken to keep them clean. The air jets can firmly embed dirt particles in soft, wet emulsion.

- g. **Solution Filtration**
Because of the many sources of dirt particles in processing solutions and wash water, both external and internal to the process, all solutions and water lines should be filtered. Filter porosity should be 15 microns or less. See specific recommendations in the process sections. If the local water is very hard, it may be necessary to add more sequestering agent to solutions or soften the water.

The insoluble material may originate from a number of sources. The water supply can contribute in two ways. It can contain solids and also have hardness high enough to produce sludge when used for preparing processing solutions. The processing chemicals themselves may contain impurities that will not dissolve in water. Such impurities are at a minimum if the chemical is sold as photographic grade under American National Standards Institute specifications. Emulsion skivings and antihalation backing are also sources of dirt and need to be controlled. The amounts of the materials in solution largely depend upon how well the processing equipment is designed and the attention paid to proper maintenance. Also, as a result of evaporation and aeration, solutions will contain some insoluble materials as tars and salts of crystallization. Some salts are slow to redissolve, while tars are usually insoluble.

h. Film Cleaning Devices

In spite of the above precautions, handling large amounts of camera negative and preprint films can lead to dirt accumulation. Hence film cleaning in an ultrasonic device, or by hand on a drum, or by rewinding through a soft cloth that is wet with solvent is necessary from time to time, especially after manual handling (e.g., splicing, color timing) or during long printing runs.

One of the best solvents found to date for nonmechanized film cleaning is inhibited methyl chloroform. It has relatively low toxicity, is nonflammable, evaporates quickly, removes most varieties of film dirt, is relatively inexpensive, and has antistatic properties. Because of its toxicity, the caution given by the film lubricant formula above is required.

Some labs have film cleaning devices on their printers. These are generally vacuum units through which preprint and/or print film passes before reaching the printer aperture. Newer designs of film cleaners have soft rotating brushes to improve their effectiveness with low risk to the film.

Never clean film by wiping with a dry cloth, since this will charge the film and may cause scratches. Always use proper safety precautions when handling, using or disposing of solvents.

5. Tracing the Sources of Dirt

Occasionally it may be necessary for a lab to track down the source of dirt contamination of the film it handles. In this event, a microscope can be used to examine samples of dirty film or samples of dirt gathered on adhesive tape or trapped by the tacky-dish technique.

Any dirt which has settled on work surfaces can be sampled easily with ordinary adhesive tape. The tape can then be mounted on a microscope slide. Many kinds of dirt (such as rust, paint, particles, emulsion skivings, and lint) are easy to identify visually

A shallow dish coated with tacky gelatin (a tacky dish) can be placed in various locations in the laboratory to collect dirt. The dirt in these areas can then be analyzed periodically for both type and quantity. Typical locations for such dishes in the processing room would be at crossover rollers, air squeegees, drying cabinet, and final windup. Film handling areas should also be tested.

Microscopic examination of dirt on an actual production roll of film may also be helpful in determining the source of dirt. The location of dirt particles relative to splices, relative to the start or end of rolls, or in repeating patterns can be helpful information. The photographic effect of the particles, if any, can also be helpful in identifying them. In addition, solubility and color reaction tests can be run on dirt particles to help identify them.



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