10 ROTARY-TUBE PROCESSORS

STEPS AND CONDITIONS

Table 10-1 Steps and Conditions—Rotary-Tube Processors

Step	Time* (Minutes:Seconds)	Temperature °C (°F)	Comments
Turn on processor		40.0 (104.0)	Turn on heaters and leave on throughout the processing cycle. No film in processor.
Warm-up with running water (7.5 L/min [2 gal/min])†	6:00‡	38.0 ±1.0 (100.4 ±1.8)	
Perform these steps in total darkness.			
Film warm-up	4:00‡	38.0 (100.4)	Load tube with film and insert tube in processor.
PrewetJ			
First Developer	7:00¶	38 ±0.3¶ (100.4 ±0.5)¶	Prepare first developer as tank solution.
Wash	2:00	38.0 ±1.0 (100.4 ±1.8)	Running water (7.5 L/min [2 gal/min]).
Reversal Bath¶**	2:00	38.0 ±1.0 (100.4 ±1.8)	Prepare as 60 percent of replenisher solution.¶
Color Developer††	4:00	38.0 ±1.0 (100.4 ±1.8)	Prepare color developer as tank solution.
Remaining steps can be done in room light.			
Pre-Bleach	2:00	20 to 40 (68 to 104)	Prepare pre-bleach as tank solution.
Bleach	6:00	33.3 to 40 (92 to 104)	Prepare bleach as tank solution.
Fixer	4:00	33.3 to 40 (92 to 104)	Prepare fixer as tank solution.
Wash	1:00	33.3 to 40 (92 to 104)	Three 1-minute running-water washes (7.5 L/min [2 gal/min]) with a 10- to 20-second drain after each wash.
Wash	1:00		
Wash	1:00		
Final Rinse	0:30	Ambient	Use separate tank outside processor.
Dry	As needed	Up to 60 (140)	
Post-Cycle Wash	5:00	24 (75)	

* All times include a 10- to 20-second drain time.

† This step may not be necessary with a water-jacketed processor.

‡ Determine the exact time and temperature for your processor.

J If the processor manufacturer recommends a film prewet, note that a prewet can cause a slight sensitometric effect with some emulsions. Since some emulsions are affected more than others, your control strip may not reflect the results you get with all films.

¶ You can vary this time from 5 to 8½ minutes to produce an in-control process at a selected temperature. Once you have chosen the time, maintain it within ±5 seconds; once you have selected a temperature from the 36 to 40°C (97 to 104°F) range, control it within ±0.3°C (±0.5°F).

¶ Mix the reversal bath or reversal bath replenisher to 60 percent of the normal concentration used for conventional processing, e.g., if the instructions tell you to use 50 millilitres per litre of reversal bath concentrate, use only 30 millilitres per litre. If the instructions tell you to dilute one bottle of reversal-bath concentrate to prepare 19 litres (5 gallons) of solution, use the concentrate to prepare 31.5 litres (8.3 gallons) of solution.

**Although you can open the processor after the reversal-bath step, it is best to leave it closed until after the color-developer step to avoid heat loss in the processing chamber.

††See the comments under “Yellow D-min Stain” on page 10-4.

CHEMICALS

You can use any Process E-6 chemicals with your rotary-tube processor.

Mix and use the KODAK PROFESSIONAL Single-Use Chemistry Kit or the 1-gallon-size chemicals for rotary-tube processors according to the instructions packaged with the chemicals. With larger sizes, first mix replenisher solutions according to the instructions; for pre-bleach, fixer, and final rinse, use the replenisher solutions as mixed. Use reversal bath replenisher at 60 percent of the normal concentration for your reversal bath. For first and color developers, mix developer starter with the replenisher according to the instructions to prepare a tank solution. For bleach, dilute the replenisher with water, and add bleach starter.

Depending on your processor, you may need to add 1 to 4 mL per litre of 5N NaOH (sodium hydroxide) to the color developer to adjust the color balance (see "Color-Balance Control" on page 3-3.

SOLUTION VOLUME

For best sensitometric results, use no less than the minimum solution volumes given in Table 10-2. Some film holders or tubes may require more solution to produce better uniformity or to compensate for solution oxidation. Check your processor manual for the solution volume recommended for your processor.

Table 10-2
Minimum Solution Volumes

Solution	Minimum Volume	
	mL/m^2 (mL/ft^2)	fl oz/ft^2
First and Color Developers	2,750 (250)	8½
Reversal Bath, Pre-Bleach, Bleach, and Fixer	1,650 (150)	5

SOLUTION STORAGE

For best results, store solutions according to the conditions given in the table on page 2-6.

PRE-CYCLE STEPS

The pre-cycle steps and conditions recommended are designed to compensate for solution heat loss during processing. The processor warm-up and film warm-up steps minimize changes in the first-developer temperature by raising the temperature of the processing chamber. Although you don't need to raise the temperature of the chamber to the processing temperature, you will get more repeatable results if you keep it consistent for each run. If your processor heater cannot provide a consistent chamber temperature, don't use it. If your processor has not been used for several hours, you may need to pre-warm the chamber to minimize variations in film speed.

POST-CYCLE STEP

The post-cycle step is simply a cleaning operation. Thoroughly rinse all inner surfaces of the processor tray, tube, and film holders to remove all traces of chemicals—especially fixer. If you intend to run another processing cycle immediately, you may need to keep the post-cycle temperature at approximately 24°C (75°F). If you have dried your processor with a hot-air-dryer, allow it to cool to room temperature to minimize film-speed variations. With some processors, the tube, tray, and processor cabinet may have to be at the same temperature before each run.

AGITATION

Rotation of the processor tube provides agitation. Good agitation is necessary for good film uniformity.

MONITORING YOUR PROCESS

Each processor may provide slightly different results. The design of the tube, film holder, processing tray, and means of rotating the tube can affect agitation, heating capacity, and amount of solution oxidation. To check the process with your equipment, process a KODAK Control Strip, Process E-6.

1. Attach a KODAK Control Strip, Process E-6, in the tube or on the drum near the center of the tube or drum. You may need to staple the control strip to an acetate sheet that you have cut to fit the film clips. The sheet should be dimpled or ridged so that it allows solution to drain from behind the control strip. In smaller processors, load the control strip on a processing reel.

   Run all processes with the control strip in the same position.

2. Follow your normal processing cycle to process the control strip.

3. Measure the D-max, HD, LD, and D-min densities of the control strip. Calculate and plot the differences from aim for that batch of control strips on a *KODAK Process Record Form*, KODAK Publication No. Y-55.

   If the differences from aim plot within the control limits, and the processed transparencies are acceptable, the process cycle you used is satisfactory. Include a control strip with each run, and plot the differences from aim for each strip.

   If the differences from aim plot outside the control limits, analyze the results (see "Analyzing and Adjusting Your Process," below).

Analyzing and Adjusting Your Process: If the differences from aim plot outside the control limits and your processed transparencies are not acceptable, modify your processing cycle. The most common out-of-control situations and possible remedies are described below.

Fast Speed—The green densities of the LD step plot below the control limit. Properly exposed transparencies appear light.

1. Decrease the first-developer time in 15-second increments until the densities of the LD step plot within the action limits. Modify your normal processing cycle to include this change. **Do not** decrease your first-developer time below 6 minutes.

2. Reduce your starting process temperature by 0.5°C (0.9°F) by decreasing the processor heater thermostat setting, and the first-developer, first-wash, reversal-bath, color-developer, and pre-cycle running water temperatures by 0.5°C (0.9°F). Continue to reduce the temperatures until the densities of the LD step plot in control or until you reach the minimum process temperature of 36°C (97°F).

   If your first-developer temperature is 36°C (97°F), **do not** decrease it to match the aim. Other conditions, such as contamination, storage, or mixing errors may be causing the problem. **Do not** reduce the temperature to less than 36°C (97°F) or the time below 6 minutes.

   When you find a temperature that produces an in-control process, use this as your normal temperature for future processes.

Slow Speed—The green densities of the LD step plot above the control limit. Properly exposed transparencies appear dark.

1. Make these changes, one at a time. Process a control strip after each change.

   a. Increase the processor warm-up time by 2 minutes.

   b. Increase the film warm-up time by 1 minute.

   c. Increase the volume of the first and color developers by 25 percent.

2. If any one of these changes increases the densities of the LD step significantly, modify your cycle to include the change.

3. Increase the first-developer time in 15-second increments until the densities of the LD step plot within the action limits. Modify your normal processing cycle to include this change. **Do not** increase the first-developer time beyond 8½ minutes.

4. If none of these steps corrects the slow speed, increase your process temperature by 0.5°C (0.9°F). Continue to increase the temperature until the control values plot in control. **Do not** increase the processing temperature beyond 40°C (104°F). If all of these steps do not correct the slow speed, check for chemical-mixing or storage errors, and solution contamination.

Variable Speed—Control strips from successive processing runs plot out of control with some results plotting above the aim (too slow) and some results plotting below the aim (too fast). Properly exposed transparencies appear too dark from some processes, and too light from other processes.

Your operating conditions may be inconsistent. Variable speed can also be caused by inconsistent mixing of the first developer. If more consistent operating procedures do not eliminate the speed variations, you may need to modify the pre-cycle step. Try the following changes one at a time. If any change reduces variability, include it in your normal process cycle.

1. If the first process you run after the processor has been idle for more than a few hours is consistently slower than other runs, increase the machine warm-up time for the first run by 2 minutes. Then return to your normal warm-up time.

   If the processes you run immediately after other processes are consistently faster, increase the post-cycle wash time to 10 minutes.

2. If process-speed variability seems to be random, try the following steps—one at a time.
   a. Increase the processor warm-up time (with running water) by 2 minutes.
   b. Increase the film warm-up time by 2 minutes.
   c. Use the modified pre-cycle steps for the processor, but turn the heaters off during the processing cycle.

Yellow D-min Stain—The green and especially the blue D-min densities plot high. The D-min is yellow overall, and there are yellow streaks and patches of varying densities from run to run. This problem is most apparent in large-format sheet films, and in large areas of low density. The problem is usually caused by color-developer oxidation. To eliminate yellow D-min stain, try the following modifications—one at a time.

1. Use twice the amount of color developer.
2. Decrease the tube rotation rate, particularly during the reversal-bath, color-developer, and pre-bleach steps (e.g., if your processor rotates at 32 rpm, reduce the speed to 20 rpm).
3. Blow nitrogen into the processing chamber during the color-developer step.
4. Increase the amount of pre-bleach used by 50 percent.
5. Add a 30-second spray or flowing wash between the color-developer and pre-bleach steps and replace the final rinse with KODAK FLEXICOLOR Stabilizer III Replenisher.

   Important: Adding a wash between the color developer and pre-bleach steps, without the corresponding change to Stabilizer III, will result in unsatisfactory magenta-image stability.

6. If any of these changes reduces the D-min, include it in your normal process cycle. If none of the changes corrects the problem, check for chemical-mixing or storage errors, and solution contamination.

   If you have a large processor, the yellow D-min stain may be most evident in the film that is farthest from the solution inlet. Sometimes the solution flow may leave pre-bleach at the inlet while color developer collects at the opposite end. To minimize this, move the position of the inlet to the center of the tray or install inlets at the ends as well as at the center. This change will also produce more consistent results with the other processing steps.

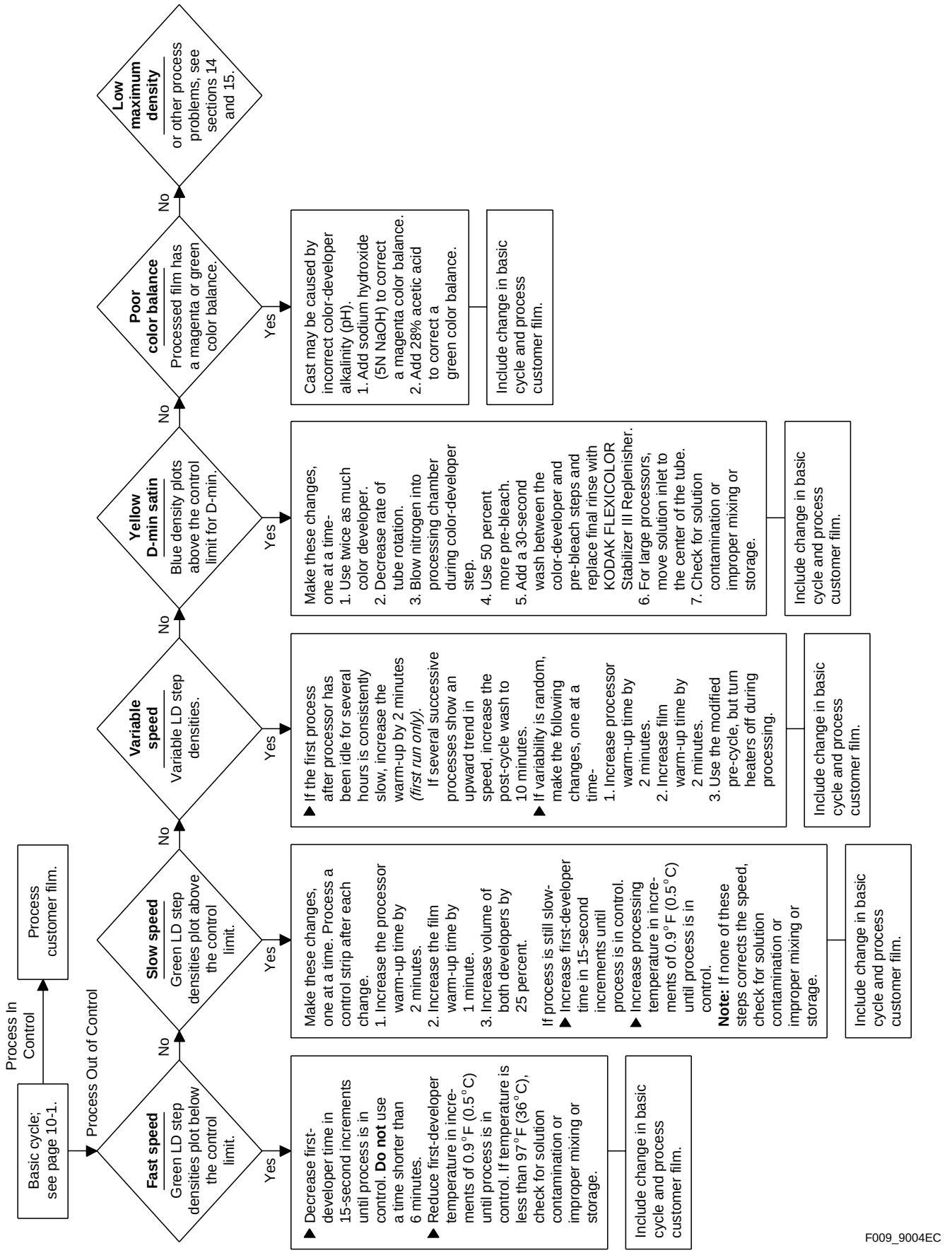
7. Be sure that you are mixing and reusing the bleach and fixer according to the instructions.

Poor Color Balance—A green or magenta color balance can be caused by color-developer alkalinity (pH) that is too low or too high, or by incorrect mixing of the color developer. You can adjust color-developer alkalinity (pH) by adding small amounts of sodium hydroxide (5N NaOH), sulfuric acid (5N H_2SO_4) or 28% acetic acid. Adding sodium hydroxide increases alkalinity and corrects a magenta color balance; adding sulfuric acid or acetic acid decreases alkalinity and corrects green color balance.

Sometimes, a blue-bias process could be corrected by increasing the process volume by 30%. If this option is chosen, the process temperature should be reduced by 0.5°C (0.9°F).

Other Problems—Use the diagnostic charts (section 14) and control-chart examples (section 15) to diagnose other problems.

Figure 10-1
Analyzing and Adjusting Your Process



SMALL ROTARY-TUBE PROCESSORS

You may have to modify the normal processing cycle for some small rotary-tube processors (i.e., processors that have a tank capacity of approximately 1 litre). If the instructions for your processor recommend a prewet, it may have a slight sensitometric effect with certain emulsions. The effect is greater with some emulsions than with others, so your control strip may not reflect the result with all emulsions.

Usually, you can use these processors without a prewet. However, maintaining good control in these processors without a prewet requires long warm-up times (approximately 30 minutes). If you can't afford these long warm-up times, use the prewet as recommended by the manufacturer.

To use these processors without a prewet, closely follow the recommendations for first-developer time and temperature, cabinet temperature, and warm-up times.

You can usually correct speed problems by adjusting the first-developer time and/or temperature, or by modifying the warm-up time (see Figure 10-1). For repeatable results, maintain a consistent cabinet temperature and monitor all temperatures closely.

Be sure to clean the tube and all drum surfaces thoroughly between processing runs. Small rotary-tube processors are particularly subject to solution contamination. Chemical spills, solution carry-over, and residual chemicals left in lines and holding tanks can be sources of contamination.

Use reversal bath replenisher at 60-percent concentration. Use the color developer prepared as a tank solution.

BLEACH EFFLUENT

You can collect used Process E-6 bleach and reconstitute it for reuse to reduce processing effluent and chemical costs.

To reuse the bleach, collect the bleach from your processor drain. Minimize contamination from other processing solutions by allowing an adequate drain time after the color-developer and pre-bleach steps. Collect the bleach before you drain any fixer from the processor. Discard any used bleach that you think contains greater-than-normal amounts of color developer, or that contains *any* amount of fixer; these chemicals can affect keeping or reuse.

You can reconstitute the bleach immediately or store it and then reconstitute it.

To reuse your bleach, you must replace the chemicals lost through dilution, carry-over, and chemical reaction. First measure the specific gravity of the used bleach at 27°C (80°F); see section 3. "Monitoring and Controlling Processing Solutions." Stir the used bleach thoroughly before you take the sample.

After you have measured the specific gravity of the used bleach, determine the amount of bleach replenisher that you need to add from Table 10-3.

Table 10-3
Additions for Reconstituting Used Bleach

If the Specific Gravity (at 27°C [80°F]) of Your Used Bleach is	Add this Amount of Process E-6 Bleach Replenisher (mL/L)
1.123 or greater	80
1.120 to 1.123	110
1.118 to 1.120	140
1.115 to 1.118	170
1.113 to 1.115	200
below 1.113	The bleach is too dilute. Discard it. Check your pre-bleach drain time.

After you add bleach replenisher to the used bleach, stir the solution thoroughly. Then measure the specific gravity of the reconstituted bleach at 27°C (80°F). The specific gravity should be greater than 1.130. If it is not, you will need to add more bleach replenisher. If your bleach is not properly reconstituted, bleaching will be inadequate, and your transparencies will have a high D-min from retained silver. If your transparencies have a low red D-max density, aerate the reconstituted bleach for 1 hour before using it.

SILVER RECOVERY

You can recover silver from used fixer by collecting the solution, and then passing it through a KODAK Chemical Recovery Cartridge, Junior Model II (3½-gallon size, CAT No. 166 9431), a KODAK Chemical Recovery Cartridge, Model II (5-gallon size, CAT No. 173 4953), or an equivalent cartridge.