

3 PROCESS MONITORING AND TROUBLESHOOTING

Process Monitoring

This section describes

- Terms used in process monitoring
- How to use control strips
- Troubleshooting your process

If you use the correct replenishment rates for the process cycles, your processes should plot in control, and your minilab will produce high-quality customer orders—provided that your printer is set correctly. Deviations from standard conditions in the processing solutions, time, temperature, agitation, replenishment, filtration, or drying can cause processing problems.

Deviations from normal conditions produce either under- or overdevelopment.

- *Underdevelopment* in the film or paper process will result in a decrease in density in your control strips for your film or paper process. It may also produce a color shift, depending on the cause of the problem.
- *Overdevelopment* will produce an increase in density in your control strips. It may also produce a color shift, depending on the cause of the problem.

When the control plot shows a problem, you may also see the problem in customer orders. However, remember that customer orders reflect the entire system—i.e., the film process, paper process, and printer settings. For example, too much activity in the film process (overdevelopment of negatives), too little activity in the paper process (underdevelopment of prints), an incorrect printer setting, or a combination of these factors may cause the prints to be light. Checking only the control plots may not always isolate the problem, because using the wrong control strip or improperly stored strips may give false information. Therefore, to find the cause of any problem, check the control plots of your film and paper processes and the quality of customer orders.

Contamination Can Ruin a Process—Dirt and contamination can reduce the life and photographic quality of processing solutions. Avoid conditions where solutions can come in contact with other chemicals. Developers are especially sensitive to contamination. Small amounts of bleach, fixer, or bleach-fix solution can contaminate developer solutions and cause adverse photographic effects. Be careful not to drip solution into other tanks when you remove racks for cleaning. Wash and rinse processing and mixing equipment thoroughly before reusing it. The most common causes of contamination are—

- solution splashed or dripped into another solution
- pipes and tanks made of materials that react with the chemicals

Process Monitoring Terms

The following terms are frequently used in process monitoring.

Action Limits—The action limits are the boundaries of the desired operating range of the process. As long as the density values remain between the upper and lower action limits, your process is operating correctly. If a density value exceeds the action limit, it is an “early warning.” You can still safely process customer work, but you should check for the cause of the shift and correct it.

Aim Values—These are the values to which you compare your control-strip densities. To obtain aim values, read the reference-strip densities; then apply the correction factors to the density readings. Enter these values in the spaces provided on the left side of your control chart.

Color-Balance Spread Limits—A color spread is the density difference between the two most widely separated densities of the HD – LD plot. If the process exceeds the color spread limit, stop processing customer work, and take corrective action.

Control Limits—The control limits define the maximum tolerances that are acceptable for processing customer work. If any density value of your process plots beyond the control limit, the process is out of control, and results will be unsatisfactory for color, density, and/or contrast. Stop processing customer work until you find the cause and correct it.

Control Strips—Precisely exposed strips used to monitor your process.

Correction Factors—Numbers used to adjust the densities of the reference strip to obtain aim values. They are printed in the instruction sheet packaged with each box of control strips.

Reference Strip—A control strip that is precisely processed by Kodak at standard conditions. A reference strip is packaged with each batch of control strips. To obtain aim values, measure the reference-strip densities and apply correction factors for that batch of control strips.

Tolerances and Limits—These are density variations permitted before you must take corrective action. These tolerances and limits include an aim-value adjustment tolerance and action and control limits. See page 3-2 for more information on limits and adjustment tolerances.

Table 3-1 Tolerances and Limits for KODAK Control Strips, Process C-41

Measurement	Aim-Value Adjustment Tolerance	Action Limits	Control Limits	Color-Balance Spread Limit
D-min	+ 0.03	+ 0.03	+ 0.05	NA
LD	± 0.04	± 0.06	± 0.08	NA
HD – LD	± 0.03	± 0.07	± 0.09	0.09
D-max _B – Y _B	± 0.07	+ 0.10	+ 0.12	NA

NA = Not Applicable

Table 3-2 Tolerances and Limits for KODAK Control Strips, Process RA-4

Measurement	Aim-Value Adjustment Tolerance	Action Limits	Control Limits
D-min	—	—	0.02
LD	± 0.04	± 0.07	± 0.10
HD – LD	± 0.03	± 0.07	± 0.10
BP	± 0.05	– 0.10	– 0.15

Process Monitoring Methods

To begin process monitoring you will need—

- KODAK Control Strips, Process C-41
- KODAK Control Strips, Process RA-4
- An electronic densitometer equipped with Status M filters to read the film-process control strips and Status A filters to read the paper-process control strips
- KODAK Process Record Form Y-55 or similar graph paper
- Red, green, and blue pencils

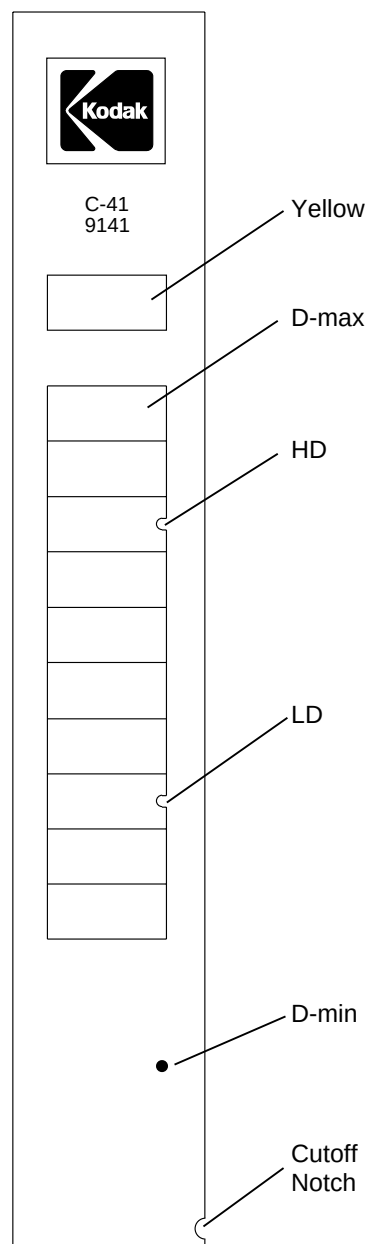
Control Strips

KODAK Control Strips are the Basic Control Material

KODAK Control Strips are available for monitoring your processes. For your SM film process, use KODAK Control Strips, Process C-41. For your SM paper process, use KODAK Control Strips, Process RA-4. A pre-processed reference strip is packaged with each type of control strip.

KODAK Control Strips, Process C-41 (35 mm)—

Available in 100-foot rolls of approximately 120 strips with cutoff notches at 9 ½-inch intervals. The rolls are wound *emulsion side* in, with the D-min end of the density scale toward the outer end of the roll. Each strip contains 12 steps.

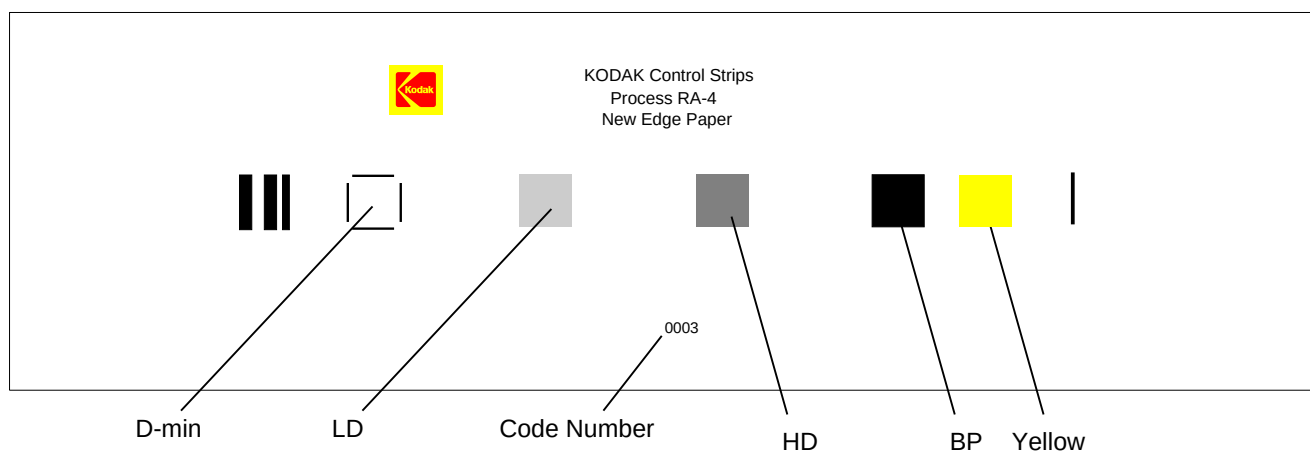


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KODAK Control Strips, Process RA-4—Use these strips to monitor Process RA-2SM. They are available in a box of ten moisture-resistant envelopes that contain five strips each. Each control strip, reference strip, and box label is marked with a code number. The code number identifies the strips as part of a particular batch. Each box contains correction factors for that particular code number. Use these factors to calculate the aim values for this batch of strips. Each strip contains five patches; measure four of them to obtain the density values for LD (low density), HD (high density), BP (black patch), and D-min (unexposed area). Use the yellow patch as a visual indicator of retained silver caused by low bleach-fix activity. When retained silver is present, the yellow patch will appear brown and less saturated than normal.

Beginning with control strip code 0001, KODAK Control Strips, Process RA-4 will be made from KODAK EKTACOLOR Edge 8 Paper. KODAK EKTACOLOR Edge 8 Paper is designed so that a visually neutral patch, e.g. the LD patch on the control strip, will have approximately

balanced red, green, and blue densities when measured with densitometers that conform to ANSI Status A responses. Some densitometers that do not conform to ANSI Status A responses may yield non-matched red, green, and blue readings for a visually neutral patch on this paper. For example, the LD patch of control strips manufactured from EKTACOLOR Edge 7 Paper and EKTACOLOR Edge 8 Paper may both measure 0.80 red, 0.80 green, and 0.80 blue on a densitometer that complies with ANSI Status A responses. However, if a lab uses a non-Status A densitometer, the LD patch on EKTACOLOR Edge 7 Paper will measure 0.80 red, 0.80 green, and 0.80 blue while the LD patch on EKTACOLOR Edge 8 Paper measures 0.65 red, 0.80 green, and 0.80 blue. This will not cause problems with process control or print quality, because each control strip is compared with a reference strip to determine control values, and any bias from the densitometer will be cancelled out.



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Storing, Handling, and Processing Control Strips

Store unused control strips at -18°C (0°F) or lower. Handle unprocessed strips in total darkness. Remove only a day's supply from one package at a time; reseal and return the package to the freezer as quickly as possible. (Do not keep the package out of the freezer for more than 1 hour per day.) Store your daily supply of control strips in a lighttight container at room temperature. At the end of the day, discard any unprocessed strips that you removed from storage.

Handle control strips by the edges to prevent fingerprints and surface damage. If film sticking, static marking, or moisture mottle occurs, allow the strips to warm up to room temperature before you process them.

Store the reference strip in its envelope when you are not using it.



Important

When beginning a new box of KODAK Control Strips, Process RA-4, allow the reference strip to warm up to room temperature before you remove it from its envelope (about 15 minutes). Exposing a frozen RA-4 reference strip to warm, moist air can cause low readings, particularly in the higher-density patches. If this occurs, wash the reference strip in warm water to return the readings to normal values.

Processing Control Strips

Each time you process a control strip, position it in the same location in your processor. When you process KODAK Control Strips, Process C-41, be sure that the D-min end of the strip enters the processor first. Process a control strip—

- At the beginning of the day or shift, before processing customer work
- At regular intervals with customer work
- At the end of the day or shift

Plotting Control-Strip Densities

Create a control chart by using the KODAK Process Record Form Y-55 or similar graph paper. Follow the procedure given below.

1. Draw in the action and control limits given in the table on page 3-2. Use black for the action limits and red for the control limits.
2. Remove the reference strip from the box of control strips. If you removed the box from cold storage, allow the reference strip to warm up to room temperature before you remove it from its envelope (about 15 minutes). Exposing a frozen Process RA-4 reference strip to warm, moist air can cause low readings, particularly in the higher density patches.
3. Measure the red, green, and blue densities in the center of each patch with a precision electronic densitometer. Do not move the strip as you make the density readings or you may affect the precision and repeatability of the measurements.

If you have several boxes of strips with the same code number, average the readings of all the reference strips. A code number on the box label and the reference and control strips identifies each batch.

For the film process, measure the densities of the reference strips listed in Table 3-3. Set your densitometer to the transmission mode, and use the Status M filters.

Table 3-3 Measurements for Control Strips and Reference Strips

Measurement	Step	Filter
D-min	clear area next to black dot	red, green, blue
LD	notched step closest to D-min	red, green, blue
HD	notched step closest to D-max	red, green, blue
D-max _B	maximum density patch	blue
Y _B	yellow patch	blue

For the paper process, measure the following densities of the reference strip. Set your densitometer to the reflection mode, and use the Status A filters.

Measurement	Step	Filter
D-min	unexposed patch	red, green, blue
LD	low density	red, green, blue
HD	high density	red, green, blue
BP	black	red, green, blue

4. To calculate aim values, apply the correction factors supplied in the instruction sheet packaged with each box of control strips to the reference-strip densities. If you averaged the reference-strip readings from several boxes of the same code number, apply the correction factors to the average. These corrected density values are the aim values for that batch of control strips. Record them in the proper spaces in the left margin of Form Y-55.
 - To obtain the HD – LD aim values, subtract the adjusted LD values from the adjusted HD values.
 - For the film process, subtract the blue-filter density of the yellow patch from the blue-filter density of the D-max patch to obtain the $D_{\text{max}_B} - Y_B$ value.
5. Process a control strip and measure the same patches that you measured in step 3.
6. Calculate the variations from aim by subtracting the aim densities from your control-strip densities. Plot the variations on your control chart.
 - Plot differences that are **larger** than the corresponding aim values (+ values) **above** the aim line.
 - Plot differences that are **smaller** than the corresponding aim values (– values) **below** the aim line.
7. If any of the variations from aim plot beyond the action or control limits, process another control strip. If the second strip confirms the results of the first strip, determine the cause of the problem. The information on page 3-6 will help you troubleshoot your process problems.
8. Whenever you take corrective action, process another control strip to confirm that the change you made returned the process to control before you resume normal processing.

Changing to a New Batch of Control Strips

When you change from your current batch of control strips to strips with a different code number, make a crossover to confirm that both code numbers provide the same information. *Be sure that your process is stable and in control before you begin using a new batch of control strips.*

1. While you still have a week's supply of control strips of the current code, process one control strip from the new batch of strips with one strip from the current batch *in three separate runs*.
2. Read and record the densities of the processed strips.
3. Determine aim values for the new batch of control strips; follow steps 2 through 4 on pages 3-4 and 3-5.
4. For your current batch of strips, calculate the variations from aim by subtracting your current aim densities from the densities of the three strips. Plot the variations on your control chart.
5. For the new batch of strips, calculate the variations from aim by subtracting the new aim densities (calculated in step 3) from the densities of the three strips. Plot the variations on your control chart.
6. Calculate the differences between the variations from aim of the current strips and the new strips. Average these differences, and then divide the result by 2.
7. Depending on the sign of the difference, adjust the aim values for the new batch of strips by adding or subtracting the results from step 6. The amount of the adjustment should not exceed the aim-value adjustment tolerances given in the appropriate table on page 3-2. If the adjustment is greater than the tolerance, determine the cause. Check your calculations, densitometer, and control strips.
8. Record the new aim values and the code number of the new batch of strips on your control chart, and begin using the new strips.

Troubleshooting

When one or more process parameters exceeds the control limits, stop processing customer work until you find and correct the cause of the problem. It is important to become familiar with control-chart patterns and cause-and-effect relationships. Control-chart patterns can generally be separated into three categories.

High Activity—the process is out of control with process parameters plotting above aim. This condition can be caused by:

- Developer temperature that is too high
- Developer time that is too long
- Overreplenished developer (i.e., the solution is replenished at a rate that is too high) or improper proportion of developer concentrate delivery
- Fresh tank (start-up only)
- Developer contamination

Low Activity—the process is out of control with process parameters plotting below aim. This condition can be caused by:

- Developer temperature that is too low
- Developer time that is too short
- Underreplenished developer (i.e., the solution is replenished at a rate that is too low) or improper proportion of developer concentrate delivery
- Fresh tank (start-up only)
- Developer tank solution diluted with water
- Developer contamination

High D-min—this condition can be caused by:

- Developer oxidation caused by excessive aeration
- Developer contamination
- Bleach underreplenishment
- Fixer underreplenished or too dilute
- Contaminated stabilizer (paper only)

Check your control chart to determine if the process drifted out of control slowly or suddenly.

Slow Drift—An out-of-control condition that has occurred slowly over a long period signals a problem such as:

Improper replenishment—caused by a replenishment rate that is not set correctly or a defective replenisher pump.

Contamination—caused by photographically active materials that leach slowly into the solutions and cause the process to drift out of control. The contaminant may be in any material the solutions contact, such as the filters, plumbing, etc.

Evaporation or oxidation—caused by low utilization or air drawn into the processing solutions by a bad pump or a poorly placed ventilator fan.

Sudden Change—Causes of a sudden out-of-control condition are:

Control strip—using a control strip with a different code number or a strip that has not been properly stored or light-fogged can indicate a sudden process change.

Densitometer—if your densitometer is not working properly or is out of calibration, the density readings will be wrong. This can falsely signal that there was a process change.

Time or temperature—check that the time and temperature were set correctly, particularly if it is easy for operators to accidentally change the settings.

Contamination—very small amounts of fixer or bleach-fix can contaminate the developer tank solution and cause a large density and color shift.

Mixing—if the sudden change occurs after you have mixed a fresh tank solution, check that it was mixed correctly.

Aim values—check that you compared the control-strip densities with the correct aim values.

Note: When you troubleshoot a problem, first check the easiest and most obvious causes; then check the more difficult and less likely causes.

Daily Processing Log

Use a daily processing log for your film and paper processors. A processing log will provide you with a convenient means of keeping track of the amount of film and paper you process, and can provide you with valuable information in case of process and/or machine problems.