# 13 PROCESS MONITORING

INTRODUCTION

Kodak supplies KODAK Control Strips, Process E-6, for monitoring processing of all KODAK EKTACHROME Films in KODAK Chemicals, Process E-6. KODAK Control Strips, Process E-6, are precisely exposed strips of film that contain areas for monitoring D-min, LD, HD, and D-max.

KODAK CONTROL STRIPS, PROCESS E-6 (CAT No. 106 3239)

These 35 mm x 5¼-inch strips are supplied in a box of five foil packages that contain 10 strips each. Each box includes a reference strip. The ends of the strips are perforated for use with standard control-strip racks. Each strip has five steps; a raised dimple is located on the emulsion side at the low-density end. For process monitoring, read and plot the densities of the D-min, LD, HD, and D-max steps.
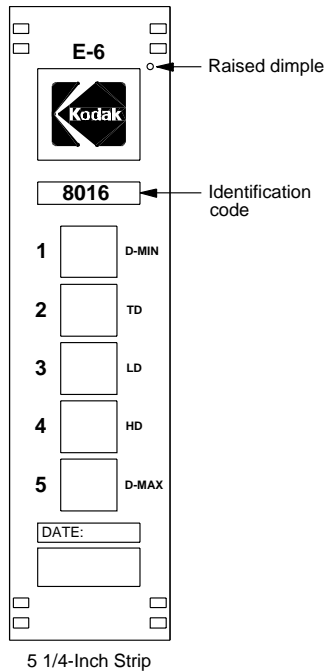
KODAK CONTROL STRIPS, PROCESS E-6 (CAT No. 173 3682)

These 35 mm strips are supplied in 100-foot rolls of approximately 120 strips with cutoff notches at 24.1 cm (9½-inch) intervals. A reference strip is included with each roll. The roll is wound emulsion side in, with the D-min ends of the strips toward the outer end of the roll.

Each strip has 11 steps. For process monitoring, read and plot the densities of the D-min, LD, HD, and D-max steps. You can measure the densities of all 11 steps to plot a full sensitometric curve.

5 1/4-Inch Strip

F009_9005GC

9 1/2-Inch Strip from 100-Foot Roll
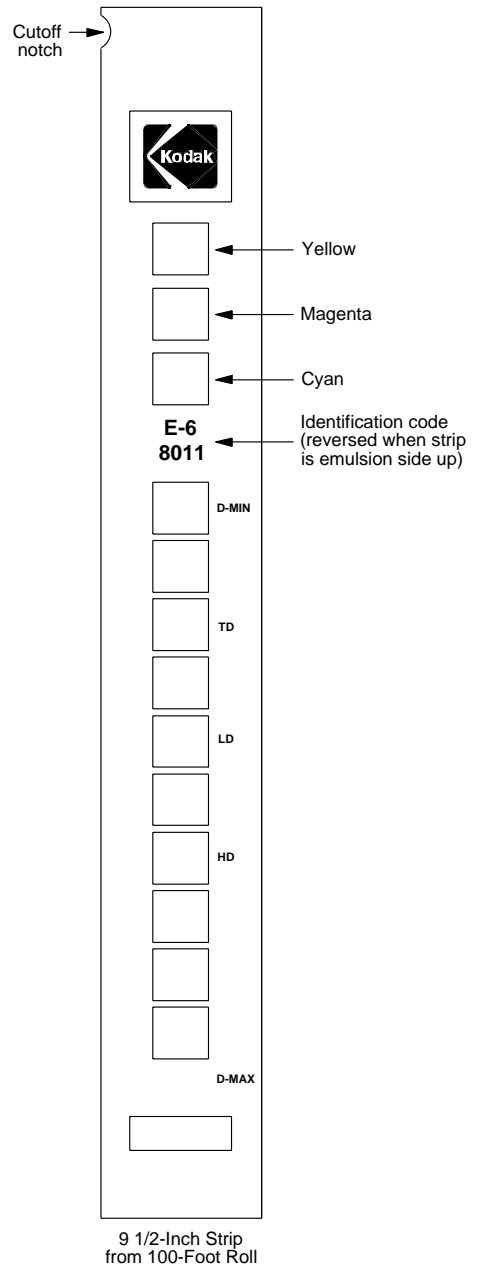
F009_9006CC

Storage and Handling: Store unused control strips at –18°C (0°F) or lower. Handle unprocessed strips in total darkness. Remove only a day's supply at a time from the package, and reseal and return the balance of the package to the freezer as quickly as possible. Store the daily supply in a lighttight container at room temperature. Allow your daily supply of strips to reach room temperature before processing. 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 package to warm up before you open it. However, **do not** keep the package out of the freezer for more than ½ hour per day.

Keep the reference strip in its envelope to protect it from light when you're not using it. Avoid glow-in-the-dark tape strips, wrist watches, pagers, and LED radios with glow dials.

Reference Strip: Enclosed in each box of control strips is a reference strip of the same code number; it is processed by Kodak at standard conditions. Use the reference strip to determine aim values for your batch (code number) of control strips.

Correction Factors: Correction factors for each code number are given in the instructions packaged with each box of control strips. Add these correction factors to the reference-strip densities to determine aim values. *Correction factors differ for each code number.*

Aim Values: Aim values are the standard to which you compare your daily control-strip readings. You determine aim values by measuring the densities of the reference strip packaged with each box of control strips, and then adjusting the densities by applying the correction factors supplied with the control strips.

Action Limits: 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 safely process customer film, but you should check for the cause of the shift and correct it.

Control Limits: The control limits define the maximum tolerances that are acceptable for processing customer film. 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 film until you find the cause and correct it.

Color-Balance Spread Limits: A color spread is the density difference between the two most widely separated color plots of the LD and HD steps. If your process exceeds the color-balance spread limit, stop processing customer film and take corrective action. The color-balance spread limits for LD and HD are given in Table 13-1.

Tolerances and Limits: The tolerances and limits are density variations allowed before you must take corrective action; they include an aim-value adjustment tolerance, and action and control limits. The tolerances and limits for Process E-6 are listed in Table 13-1.

Table 13-1
Tolerances and Limits for KODAK Control Strips, Process E-6

Measurement	Aim-Value Adjustment Tolerance	Action Limits	Control Limits	Color-Balance Spread Limit
D-min	±0.02	+0.03	+0.05	—
LD (Speed)	±0.03	±0.08	±0.10	0.07
HD (Color)	±0.05	±0.12	±0.15	0.11
D-max	±0.07	−0.20	−0.25	—

Using Control Strips

We recommend that you process at least three control strips per day or shift. Process a strip at the beginning of the shift (before you process customer film), another strip in the middle of the shift, and another strip at the end of the shift. We also recommend that you process a control strip with customer film at regular intervals. Handle and process control strips according to the instructions packaged with them. Use a densitometer equipped with **Status A** filters to read the control-strip densities.

In rack-and-tank processors and in sink-line processes, process control strips with the D-min end up. In continuous processors, splice control strips so that the D-min end enters the processor first.

1. Create a control chart by using the KODAK Process Record Form Y-55 or similar graph paper.

2. Draw in the action and control limits given in Table 13-1. Use black for the action limits and red for the control limits.

3. 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).

4. Measure the red, green, and blue densities in the center of the D-min, LD, HD, and D-max steps with your densitometer.

   If you have several boxes of strips with the same code number, average the readings of all the reference strips.

5. 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 the batch of control strips.
   Record them in the proper spaces in the left margin of Form Y-55.

Table 13-2
Example of Determining Aim Values

		Red	Green	Blue
D-max	Reference Strip Densities	3.23	3.37	3.69
	Correction Factor	−0.07	−0.03	−0.14
	Aim Value	3.16	3.34	3.55
HD	Reference Strip Densities	2.36	2.35	2.25
	Correction Factor	+0.00	+0.01	+0.00
	Aim Value	2.36	2.36	2.25
LD	Reference Strip Densities	1.03	1.04	1.02
	Correction Factor	+0.00	−0.03	−0.02
	Aim Value	1.03	1.01	1.00
D-min	Reference Strip Densities	0.16	0.18	0.14
	Correction Factor	+0.00	+0.00	+0.01
	Aim Value	0.16	0.18	0.15

6. Process a control strip and measure the same steps that you measured in step 4.

7. 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 aim values (–values) **below** the aim line.

8. 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 and take corrective action.

   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. If you have more than one Process E-6 machine, perform this crossover for each machine. *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 at least 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.

Table 13-3
Example—LD Step Readings

Strip	Current Strips			New Strips		
	Red	**Green**	**Blue**	**Red**	**Green**	**Blue**
1	1.03	0.99	1.00	1.00	1.00	0.97
2	1.00	0.99	0.99	1.01	1.00	0.97
3	1.05	0.98	0.98	1.02	0.99	0.95

3. Determine aim values for the new batch of strips; follow steps 3 through 5 under "Using Control Strips."

4. For your current batch, calculate the variations from aim by subtracting current aim densities from 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 average 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 Table 13-1. If the adjustment is greater than the tolerance, determine the cause. Check your calculations, densitometer, and control stirps.

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. Plot the new control-strip readings against the adjusted aim values.

Making the Crossover Mathematically: You can also use a mathematical procedure to crossover to a new batch of control strips. With this method, you don't need to plot the readings of the two set of processed control strips. Follow the steps shown in the table below.

Calculation	Example	Red	Green	Blue
Current Aim Value	1.00			
New Initial Aim Value	+1.01	+	+	+
Equals	2.01			
Multiply by 3	x 3	x 3	x 3	x 3
Equals	6.03			
+ Density of New Strips	+1.00	+	+	+
	+1.01	+	+	+
	+1.02	+	+	+
– Density of Current Strips	–1.03	–	–	–
	–1.00	–	–	–
	–1.05	–	–	–
Equals	5.98			
Divide by 6	÷ 6	÷ 6	÷ 6	÷ 6
Equals	0.997			
New Adjusted Aim Value (Rounded Up)	1.00			

INTERPRETING YOUR CONTROL PLOT

Your control plot provides a running record of your process. It will show how consistent your process is, and how well it meets your aim. It provides you with helpful information for analyzing and correcting process problems. Your process will produce acceptable results if your control strips always plot within the control limits.

Corrective Action

When a control strip plots outside the control limits, or if the plot shows a gradual drift toward an out-of-control condition, immediately check for the cause and correct it. First, determine if the process drifted out of control slowly over time or if it occurred suddenly.

An out-of-control condition that has occurred slowly over time indicates a problem such as—

- Insufficient replenishment—this may be caused by an incorrect replenishment rate, an incorrectly mixed replenisher, or a defective replenisher pump.

- Evaporation or oxidation—evaporation or oxidation can be caused by low utilization or by too much air flow around the processing solutions.

An out-of-control condition that occurs suddenly can indicate a problem with your—

- Control strip—did you use a control strip from the correct code number? Remember, if you change code numbers, you need to establish new aim values for that code number (see "Changing to a New Batch of Control Strips" on page 13-4). Do the control-strip code numbers match those of the reference strip? Were the strips handled and stored properly?

- Densitometer—is your densitometer working properly? Did you use Status A filters?

- Time or temperature—check that they are set properly. Check your temperature regulator.

- First or color developer—was the tank or replenisher solution contaminated with another processing solution (e.g., fixer)? Contamination can cause a large density and color shift.

- Solution mixing—was the tank solution mixed properly? If the problem occurred with a fresh mix, check for improper mixing.

When you troubleshoot a problem, check the easiest and most obvious causes first; then check the more difficult and less likely causes. With process monitoring, first check the following—

- Did you use control strips with the same code number?
- Did you plot the density values against the correct aim values?
- Is the densitometer operating properly?
- Were the time and temperature set correctly?
- Is the replenishment rate set correctly?

Checking for contamination or for correct mixing requires more time and effort. Unless you have a good reason to suspect one of these causes, check them after you have checked the causes that are easier to check and verify. To help you determine the cause of an out of-control condition, use the information in section 14, "Diagnostic Charts," and the sample plots in section 15, "Control-Chart Examples."

Daily Processing Log

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