To produce high-quality color prints consistently and with a minimum of waste, you need to match your process to a standard for density, color, and contrast each time you process paper or print and display materials. In addition to monitoring process parameters such as solution times, temperature, replenishment rates, solution concentrations, etc., you should regularly run control strips to ensure best results.

Kodak provides KODAK PROFESSIONAL Pro Strips, CAT 129 8587, for monitoring Process RA-4 in professional labs. These strips are designed specifically for use with KODAK PROFESSIONAL Media. The recommendations for using these strips are essentially the same as those for KODAK Control Strips, Process RA-4.

KODAK PROFESSIONAL Pro Strips, Process RA-4, are designed to detect process conditions that can degrade the quality of your finished prints and materials. They are better able to track the papers and materials that are processed in professional finishing laboratories. When you begin using the PROFESSIONAL Pro Strips, you may find that your process is “out of control”—often in the Blue BP or Blue HD - LD control values. This indicates that you can improve the process to take full advantage of the quality of KODAK PROFESSIONAL Papers and Materials.

This section describes standards and methods for setting up your process and for ongoing process monitoring. The primary “tools” for monitoring your process are the control strips and the reference strip. This section also describes how to use PROFESSIONAL Pro Strips and interpret the results. For the most up-to-date information, you can check the Kodak website, www.kodak.com/go/photochemicals.

**PROCESS-MONITORING TERMS**

The following terms are commonly used in process monitoring:

**Action Limits**—The action limits are the boundaries of the aim operating range of the process. As long as the control-strip 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 process customer work, but you should check for the cause of the shift and correct it. When the density values plot between the upper and lower action limits (i.e., the “aim zone”), your process is in control.

**Aim Values**—You compare your control-strip density readings to these values. To obtain aim values, read the reference-strip densities; then apply the correction factors (supplied with the control strips and reference strip) to those density readings. Enter the aim values in the spaces provided on the left side of your control chart.

**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. Results will be unsatisfactory for color, density, and/or contrast. When any density value plots beyond the control limits, stop processing customer work until you find the cause of the shift and correct it.

**Control Strips**—These are precisely exposed strips used to monitor your process.

**Correction Factors**—Use these numbers 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. Correction factors usually differ for each batch (code number) of control strips.

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

**Tolerances and Limits**—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 KODAK PROFESSIONAL Pro Strips, Process RA-4, are listed in Table 7-1.

**Table 7-1**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Aim-Value Adjustment Tolerance</th>
<th>Action Limits</th>
<th>Control Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-min</td>
<td>—</td>
<td>—</td>
<td>+ 0.02</td>
</tr>
<tr>
<td>LD</td>
<td>± 0.04</td>
<td>± 0.07</td>
<td>± 0.10</td>
</tr>
<tr>
<td>HD – LD</td>
<td>± 0.03</td>
<td>± 0.07</td>
<td>± 0.10</td>
</tr>
<tr>
<td>BP</td>
<td>± 0.05</td>
<td>− 0.10</td>
<td>− 0.15</td>
</tr>
</tbody>
</table>
KODAK PROFESSIONAL PRO STRIPS
PROCESS RA-4

The Basic Control Material
These strips are available in boxes 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 and has the format Y9XX, where Y indicates the year, 9 identifies the code as KODAK PROFESSIONAL Pro Strips, and XX is a sequential number. Each box contains correction factors for that particular code number. Use these correction factors to calculate the aim values for each batch of strips.

Each strip measures $3 \frac{1}{2} \times 12$ inches, and contains three neutral patches, a yellow patch, and an unexposed area. Measure the neutral patches to obtain density values for LD (low density), HD (high density), and BP (black patch). Measure the unexposed patch to obtain the density value for D-min. Use the yellow patch as a visual indicator of retained silver caused by low bleach-fix activity. Low bleach-fix activity will make the yellow patch appear brown and less saturated than normal.

Storing and Handling Control Strips
Store unused control strips at $-18^\circ$C (0°F) or lower. Handle unprocessed strips in total darkness. Remove only a day’s supply from one package at a time; then reseal and return the package to the freezer as quickly as possible. Do not keep the package out of the freezer for more than one hour per day.

Store your daily supply of control strips in a lighttight container at room temperature. Be sure to allow the strips to reach room temperature before you process them. Handle control strips by the edges to prevent fingerprints and surface damage.

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

Figure 7-1

![Control Strip Diagram](image-url)
Starting Out
To begin process monitoring, you will need—
- KODAK PROFESSIONAL Pro Strips, Process RA-4
- An electronic densitometer equipped with Status A filters
- KODAK Process Record Form, KODAK Publication No. Y-55, or similar graph paper. (A blank Y-55 is available at www.kodak.com/go/retailerresources.)
- Red, green, and blue pencils

You can also use the KODALINK Service Software to easily read, plot, and store your results. One of the many advantages of this system is that all calculations around setting the aim and plotting the measurement results are done by the system, including automatic application of control strip correction factors. For more information about this system, contact your Kodak representative or distributor.

Processing Control Strips
Each time you process a control strip, position it in the same location in your processor. Follow this schedule for processing 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 (see the example in Figure 7-2). Then follow the procedure below:

1. Draw in the action and control limits given in Table 7-1. Use black for the action limits and red for the control limits.
2. Remove the reference strip from the box of control strips.
   **IMPORTANT:** Allow the reference strip to warm up to room temperature before you remove it from its envelope (about 15 minutes). Exposing a frozen 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.
3. Use a precision electronic densitometer to measure the Status A red, green, and blue densities in the center of the D-min, LD, HD, and BP patches of the reference strip. **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, the reference strip, and the control strips identifies each batch.
4. To calculate aim values, apply the correction factors supplied in the instruction sheet packaged with the 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.

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 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 DIAGNOSTIC CHARTS and the CONTROL-CHART EXAMPLES will help you troubleshoot process problems.

8. Whenever you take corrective action, process another control strip to confirm that the process is in 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 batches (code numbers) will provide the same information. Be sure that your process is stable and in control before you begin using a new batch of control strips.

Note: When you begin using KODAK PROFESSIONAL Pro Strips for the first time, you should not cross over from the control strips you were using previously.

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 under Plotting Control-Strip Densities.

4. For your current batch of control 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; then divide the result by 2.

7. Add or subtract the results from step 6 from the aim values for the new batch of strips determined in step 3. The amount of the adjustment should not exceed the aim-value adjustment tolerances given in Table 7-1. 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 batch of strips.
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 plot within the control limits.

Corrective Action

When one or more process parameters exceed the control limits, stop processing customer work until you find the cause of the problem and correct it. 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, low activity, and high D-min. Also, you can check your control chart to determine if the process drifted out of control slowly or changed suddenly.

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)
- Mixing error
- 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)
- Mixing error
- Developer tank solution diluted with water
- Developer contamination

High D-min

This condition can be caused by—

- Developer oxidation resulting from low utilization
- Developer contamination
- Weak or oxidized, sulfurized bleach-fix
- Dirty stabilizer, or heavy dirt build up on wash racks/rollers

Trend

A trend shows an out-of-control condition that has occurred slowly over time. It indicates a problem such as—

Improper replenishment—Check that the replenishment rate is correct and that the replenishment system is operating properly. Also check for improperly mixed replenisher.

Evaporation or oxidation—Check for low utilization or air drawn into the processing solutions by a bad pump, a recirculation system leak, or a poorly placed ventilation fan.

Contamination—Check for photographically active materials that are leaching slowly into the solutions. The contaminants may come from anything that is in contact with the solutions, such as filters, plumbing, etc.

Incorrect mixing—Check for mixing errors caused by improper measurement, improper calibration of mixing tanks, etc. If you suspect that the problem was caused by incorrectly mixed replenisher solution, mix a new batch of replenisher to see if a fresh mix gradually corrects the problem.

Sudden Change

This is an out-of-control condition that occurs suddenly. It usually indicates a problem with—

Control strips—Check that you used control strips of the same code number. Remember, if you change code numbers, you need to establish new aim values for the new batch (see Changing to a New Batch of Control Strips). Check that the control-strip code numbers match those of the reference strip. Check that the strips were handled and stored properly.

Densitometer—If your densitometer is not working properly or is out of calibration, the density readings will be wrong. This can falsely signal a process change. Check that you used Status A filters.

Time or temperature—Check that the time and temperature are set correctly, particularly if they are easy to change accidentally.

Contamination—Bleach-fix splashed into the developer during rack cleaning or clearing a paper jam can cause sudden large spreads in your control plots.

Solution 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, check the easiest and most obvious causes first; then check the more difficult and less likely causes.
How Each Processing Solution Affects Your Results

Each solution in Process RA-4 has a specific function. Operational errors involving each solution will affect process performance differently. When you understand the reaction of each solution, you can better diagnose processing problems.

Developer
The developer chemically reduces the exposed silver halide in the paper to form a metallic silver image. At the same time, the color developing agent oxidizes and combines with dye couplers near the silver image to form a color image in each of the dye-forming emulsion layers. Once the dye image has formed, there is no need for the silver image. It will be removed by bleaching and fixing.

The amount of cyan, magenta, and yellow dye formed depends on exposure and developer activity. Temperature, time, replenishment rate, replenisher concentration, agitation, and the rate at which solutions diffuse into the emulsion affect developer activity. Time, temperature, and agitation affect the diffusion rate. With too much developer activity, too much dye forms; with too little activity, not enough dye forms.

Bleach-Fix
The bleach-fix has three primary purposes: to stop the action of the developer; to convert metallic silver into silver halide; and to dissolve the silver halide.

Bleach-fix performance depends on the concentration, the pH and the diffusion rate of the solution into the emulsion. Time, agitation, and temperature affect the diffusion rate. Incorrect bleach-fix conditions or an abnormal bleach-fix can affect the amount of dye formed.

Inadequate bleach-fixing may not convert all of the metallic silver to silver halide. A sign of retained silver is an increase in the black-patch (BP) densities of the control strip and a desaturation of the yellow patch on the control strip. Retained silver degrades image quality by desaturating the colors and is especially apparent when the yellow patch appears brown. It has a greater effect on higher-density areas, which contain more metallic silver. You can remove retained silver by reprocessing the paper or material in a good bleach-fix.

Wash
Washing removes residual chemicals from the paper. If the chemicals are not removed, they can degrade the image and cause the dye to fade. Good washing requires enough circulation to keep fresh water in contact with the emulsion. The water temperature must be warm enough to swell the gelatin so that the water can enter the emulsion to remove the chemicals, but not so warm that it damages the emulsion. For more information on washing, see Section 4, Using KODAK EKTACOLOR Chemicals in Roller-Transport Processors.

Stabilizer or Final Rinse
Washless (non-plumbed) minilabs use a stabilizer instead of a wash step. An optional cycle for roller-transport processors also uses a stabilizer to conserve water. The stabilizer removes residual chemicals from the paper or material.

Checking Prints for Retained Silver
Inadequate bleach-fixing can lead to retained silver in prints and materials. High levels of retained silver affect print quality and can also give false signals to sensors used in automatic print choppers.

Inadequate bleach-fixing is caused by dilute or underreplenished bleach-fix, a short bleach-fix time, a tank pH that is too high, or a low temperature (or a combination of these conditions). The most common cause is dilution of the bleach-fix due to ineffective developer squeegees and excessive developer carryover.

To check prints for retained silver, compare the processed control strip with the reference strip by using an infrared scope in a darkroom. When you view the control strip through the scope, the dye image will appear nearly invisible. If your process does not have a retained-silver problem, the reference strip and your control strip should look the same. If the process does have a retained-silver problem, the silver image in the control strip will be visible as a darker density, most evident in the black patch.

Infrared scopes are available from several sources; check the yellow pages of your telephone directory under Scientific Apparatus and Instruments.
DIAGNOSTIC CHARTS

The diagrams in this section provide you with a step-by-step approach to diagnosing process problems. The preliminary and summary charts show which detailed chart to check for your problem. The charts give probable causes and suggest corrective actions.

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<tr>
<th>Chart</th>
<th>Title</th>
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<td>A</td>
<td>Preliminary</td>
</tr>
<tr>
<td>B</td>
<td>Summary—Control-Chart Plots</td>
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<td>C</td>
<td>Control-Chart Plots—High BP, HD-LD, or LD</td>
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<td>Control-Chart Plots—Low BP, HD-LD, or LD</td>
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<td>E</td>
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<td>G</td>
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<td>H</td>
<td>Control-Chart Plots—Visual Appearance of Paper</td>
</tr>
<tr>
<td>I</td>
<td>Control-Chart Plots—Visual Appearance of Paper</td>
</tr>
</tbody>
</table>
Using KODAK EKTACOLOR Chemicals

Chart A
Preliminary

PLOT PROBLEM

Tolerance limit(s) exceeded on control chart → CHECK THE OBVIOUS

CHECK CONTROL STRIP

CHECK FOR OPERATOR ERROR
- Plots on Y-55 Form done correctly?
- Error in reading control strip?
  (Reread control strip)
  - Area to be read correctly centered and free of defects?
  - Densitometer read correctly?
  - Correct densitometer filters used?
  - Correct step on control strip for parameter plotted?
- Correct control-strip code number plotted?

CHECK FOR PHYSICAL DEFECTS
- Correct handling and storage?
- Control strip damaged when processed?
- Manufacturing deficiency?

CHECK DENSITOMETER
- Correct usage by operator?
  - Instrument warmed up?
  - Correct filters used?
  - Zeroed and calibrated correctly?
- Malfunction of instrument?

Problem Found → Correct → Process

Problem Not Found → Process another control strip and plot variations from aim to confirm problem.

Go to Chart B
Chart B
Summary—Control-Chart Plots

DESCRIPT
PLOT PATTERN

FURTHER IDENTIFY AND
GO TO SPECIFIED CHART

High BP, HD—LD, or LD plots with one or more plots above action limits
See Chart C

Low BP, HD—LD, or LD plots with one or more plots below action limits
See Chart D

High Plots D-min
See Chart E

Visual Appearance of Developer and Bleach-Fix
See Chart F

Visual Appearance of Paper
See Charts G, H, and I

Yellow patch has muddy brown appearance
See Chart G

Find the description in one of the boxes that matches the density plot that is out of control. If tolerance limits are exceeded in more than one parameter, look first at the one that corresponds to the density plot that has the most severe problem.
Using KODAK EKTACOLOR Chemicals

Control-Chart Plots—High BP, HD – LD or LD

Chart C

PROBLEM
PROCESSING SOLUTION
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRANCE

- Long developer time
  See Chart 1
  - Check developer time
  - Adjust developer time to specifications.
  - Maintain routine monitoring schedule.

- High developer temperature
  See Chart 1
  - Check developer temperature
  - Adjust developer temperature to specifications.
  - Maintain routine monitoring procedures.

- High developer replenishment rate
  See Chart 1
  - Check developer replenishment rate
  - Adjust developer replenishment rate to specifications.
  - Maintain routine monitoring procedures.

- Developer replenisher too concentrated
  See Chart 1
  - Developer replenisher mixing errors
    See Chart 1
  - Check mixing procedures and calibration of mix tank
  - Correct mixing procedures.
  - Calibrate mix tank.

- Developer start-up tank
  See Chart 1
  - Developer start-up tank too much replenisher
    See Chart 1
  - Check topping procedure
  - Add water to compensate for developer evaporation losses.

- Developer contaminated with bleach-fix
  See Chart 2
  - Check for bleach-fix contamination of developer tank or replenisher solutions
  - Be sure mixing equipment is clean. Look for bleach-fix leaks or splash-back into developer.

- Developer overconcentrated due to evaporation
  See Chart 1
  - Check topping procedure
  - Add water to compensate for developer evaporation losses.

- Bleach-Fix
  - Retained silver due to high pH or dilution of bleach-fix
  - Verify with:
    - Infrared scope
    - Retbleaching test
  - Replace worn developer squeegees.
  - Correct bleach-fix replenishment rate, time, temperature.

- High BP, HD—LD, or LD plots with one or more plots above action limits
  - Developer
  - Check problem areas regularly.

Depending on severity of problem:
- a. Wait and tolerate.
- b. Dump partially.
- c. Dump completely.

Maintain routine monitoring schedule.

Correct mixing procedures and calibration of mix tank.

Check for bleach-fix contamination of developer tank or replenisher solutions.

Be sure mixing equipment is clean. Look for bleach-fix leaks or splash-back into developer.

Add water to compensate for developer evaporation losses.

Replace worn developer squeegees.

Correct bleach-fix replenishment rate, time, temperature.
Chart E
Control-Chart Plots—High D-min

**SYMPTOM**

- Darkroom fog
- Excessive developer activity
- Developer oxidation
- Bleach-fix tank excessively diluted with developer
- Insufficient washing in bleach-fix
- Deposits from dirty wash racks/rollers
- Stabilizer (in minila)
- Light leaks in darkrooms

**LOCATION OF PROBLEM**

- Darkroom
- Developer
- Bleach-Fix
- Wash
- Stabilizer (in minila)

**PROBABLE CAUSE**

- Low-level white light fog
- Sulfurization of bleach-fix
- Biological growth in bleach-fix
- Developer contaminated with bleach-fix
- See Chart 2

**CHOOSE CAUSE**

- Examine darkroom
- Check developer
- Check bleach-fix
- Check wash
- Check stabilizer

**VERIFY CAUSE**

- Process strip with no safelight
- Check for source of contamination
- Check processor utilization
- Check tank turnover rate
- Examine wash racks/rollers
- Examine stabilizer packs/rollers

**PREVENT RECURRENCE**

- Eliminate cause of developer oxidation
- Adjust wash-water rate to specifications
- Maintain turnover rate
- Increase machine utilization
- Increase stabilizer replenishment rate
- Take steps to prevent problem in future

**PLOT PROBLEM**

- Go to Chart C

**G o t o Chart C**

- High developer activity
- Developer oxidation
- Insufficient washing in bleach-fix
- Deposits from dirty wash racks/rollers
- Stabilizer (in minila)

**SYMPTOM**

- Darkroom fog
- Excessive developer activity
- Developer oxidation
- Bleach-fix tank excessively diluted with developer
- Insufficient washing in bleach-fix
- Deposits from dirty wash racks/rollers
- Stabilizer (in minila)
- Light leaks in darkrooms

**LOCATION OF PROBLEM**

- Darkroom
- Developer
- Bleach-Fix
- Wash
- Stabilizer (in minila)

**PROBABLE CAUSE**

- Low-level white light fog
- Sulfurization of bleach-fix
- Biological growth in bleach-fix
- Developer contaminated with bleach-fix
- See Chart 2

**CHOOSE CAUSE**

- Examine darkroom
- Check developer
- Check bleach-fix
- Check wash
- Check stabilizer

**VERIFY CAUSE**

- Process strip with no safelight
- Check for source of contamination
- Check processor utilization
- Check tank turnover rate
- Examine wash racks/rollers
- Examine stabilizer packs/rollers

**PREVENT RECURRENCE**

- Eliminate cause of developer oxidation
- Adjust wash-water rate to specifications
- Maintain turnover rate
- Increase machine utilization
- Increase stabilizer replenishment rate
- Take steps to prevent problem in future

**PLOT PROBLEM**

- Go to Chart C

**G o t o Chart C**

- High developer activity
- Developer oxidation
- Insufficient washing in bleach-fix
- Deposits from dirty wash racks/rollers
- Stabilizer (in minila)

**SYMPTOM**

- Darkroom fog
- Excessive developer activity
- Developer oxidation
- Bleach-fix tank excessively diluted with developer
- Insufficient washing in bleach-fix
- Deposits from dirty wash racks/rollers
- Stabilizer (in minila)
- Light leaks in darkrooms

**LOCATION OF PROBLEM**

- Darkroom
- Developer
- Bleach-Fix
- Wash
- Stabilizer (in minila)

**PROBABLE CAUSE**

- Low-level white light fog
- Sulfurization of bleach-fix
- Biological growth in bleach-fix
- Developer contaminated with bleach-fix
- See Chart 2

**CHOOSE CAUSE**

- Examine darkroom
- Check developer
- Check bleach-fix
- Check wash
- Check stabilizer

**VERIFY CAUSE**

- Process strip with no safelight
- Check for source of contamination
- Check processor utilization
- Check tank turnover rate
- Examine wash racks/rollers
- Examine stabilizer packs/rollers

**PREVENT RECURRENCE**

- Eliminate cause of developer oxidation
- Adjust wash-water rate to specifications
- Maintain turnover rate
- Increase machine utilization
- Increase stabilizer replenishment rate
- Take steps to prevent problem in future

**PLOT PROBLEM**

- Go to Chart C

**G o t o Chart C**

- High developer activity
- Developer oxidation
- Insufficient washing in bleach-fix
- Deposits from dirty wash racks/rollers
- Stabilizer (in minila)
Chart G
Control-Chart Plots—Visual Appearance of Paper

1. **Product Problem**
   - Yellow patch has muddy brown appearance
   - Fingerprints (black marks)
   - Black deposits on prints

2. **Choose Probable Cause**
   - Retained silver in print (condition of bleach-fix)
   - Sulfurization in developer tank
   - Biological growth in developer tank
   - White light leak
   - Black deposits on prints
   - Yellow or brownish appearance

3. **Verify Cause**
   - Check handling procedures
   - Developer tar
   - Biological growth in developer tank
   - White light leak
   - Black deposits on prints
   - Yellow or brownish appearance

4. **Eliminate Cause**
   - Replacement developers
   - Correct handling procedures
   - Check for light leaks in darkroom
   - Do not use safelight

5. **Prevent Recurrence**
   - Check problem areas regularly

6. **Symptom**
   - Fog
   - Purple fog
   - Light fog

7. **Solution**
   - Check solution storage conditions.
   - Fog
   - Purple fog
   - Light fog

8. **Verify with**
   - Infrared scope
   - Rebleaching test

9. **Eliminate**
   - Dump solution (or each wash)
   - Dump completely

10. **Choose Probable Cause**
    - Fingerprints (or wash water)
    - Retained silver in print due to a normal condition of bleaching procedures
    - Fingerprints

11. **Verify**
    - Wait and tolerate.
    - Dump partially.
    - Dump completely.

12. **Prevent Recurrence**
    - Check problem areas regularly.

13. **Solution**
    - Yellow or brownish appearance
    - Fingerprints (black marks)
    - Black deposits on prints

14. **Verify with**
    - Infrared scope
    - Rebleaching test

15. **Eliminate**
    - Dump solution (or each wash)
    - Dump completely

16. **Prevent Recurrence**
    - Check problem areas regularly.

17. **Solution**
    - Yellow or brownish appearance
    - Fingerprints (black marks)
    - Black deposits on prints

18. **Verify with**
    - Infrared scope
    - Rebleaching test

19. **Eliminate**
    - Dump solution (or each wash)
    - Dump completely

20. **Prevent Recurrence**
    - Check problem areas regularly.
Chart H
Control-Chart Plots—Visual Appearance of Paper

- **PRODUCT PROBLEM**
  - Light-density spots
  - Cyan or blue spots
  - White, yellow, or red spots (spots look like comet tails)
  - Magenta and spots and streaks from splashing
  - Dull spots or streaks
  - Scratches or emulsion damage

- **PROBABLE CAUSE**
  - Splashing of water prior to processing
  - Chemical dust in or near printing area
  - Splashing of bleach before processing
  - Splashing of bleach during processing
  - Splashing of water after processing or uneven drying
  - Physical abrasion

- **VERIFY CAUSE**
  - Check handling procedures
  - Check mixing procedure
  - Check processor for dirty or stuck rollers
  - Check processor rollers for dirty or stuck rollers

- **PREVENT RECURRENT**
  - Check problem areas regularly
  - Correct handling procedures
  - Correct mixing procedure
  - Eliminate splashing procedures
  - Clean or replace rollers. Adjust strategies.

- **CAUSE**
  - ELIMINATE CAUSE
  - Correct handling procedures
  - Correct mixing procedure
  - Eliminate splashing procedures
  - Correct drying conditions.

**PROBLEM AREAS**
- PREVENT RECURRENT
- ELIMINATE CAUSE
- VERIFY CAUSE
- CHOOSE PROBABLE CAUSE
- PRODUCT PROBLEM
Chart I
Control-Chart Plots—Visual Appearance of Paper

PROBLEM

PRODUCT

Magenta streaking or mottle

Nonuniform areas or mottle

Fine plus density lines

Static marks

PREVENT RECURRENT

ELIMINATE CAUSE

Verify Cause

Choose Probable Cause

Adjust agitation

Adjust or replace squeegees

Allow paper to warm up before removing from package

Adjust paper processor

Use a humidifier

Check agitation of first bleach & tank

Check developer exit squeegees

Check handling procedure

Check paper processor for sources of scratches

Check humidity

Inadequate agitation in first bleach & tank result from non-uniform stirring of developer

Excessive developer carryover

Moisture collecting on cold unexposed paper

Abrasion during development

Low humidity in lab area

Check agitation of bleach & tank

Check exit squeegees

Check handling procedure

Check paper processor

Check humidity

PROBABLE CAUSE

Check problem areas regularly

VERIFY CAUSE

Check control charts

Chart I
CONTROL-CHART EXAMPLES

Generally, the control-plot patterns you can detect when you use KODAK PROFESSIONAL Pro Strips, Process RA-4, result from processing problems that can be summarized in the following three charts. The charts are intended only as guides; your plots may not look exactly like these examples.

The exact appearance of the control plot depends on the specific mechanical design of the processor and the condition of the chemical concentrations in the processor tank. You may also have more than one problem affecting your process. Beside each chart is a description of potential causes and remedies for problems.

Use these charts with the DIAGNOSTIC CHARTS and the descriptions under INTERPRETING YOUR CONTROL PLOT to analyze process problems.

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Although we have not included a control plot pattern for the effects of developer oxidation, a discussion of the results you can expect and the possible remedies follows the control chart examples.
Developer Activity

Developer—High or Low Activity

When the developer activity is too high relative to the process aim, the density of the processed materials will be too high, and the materials will be dark. If the developer activity is too low, the materials will be too light.

High and low developer activity have several potential causes. They all produce control-plot patterns very similar to that shown in Chart 1. The process problems that would cause the large shifts shown in Chart 1 would result from gross errors in operation. For example, a low-temperature shift of –11°F or a high-temperature shift of +11°F would cause shifts of the magnitude plotted here.

If your problem is caused by high or low developer activity, you should consider each of the potential causes. Also, be aware that the condition may have more than one cause, or one problem may be partially compensating for another. When you detect a developer-activity problem, it is good practice to verify all the operational conditions for the processor.

Chart 1
**Developer—Time Too Short or Too Long**

The recommended developer time for Processes RA-4 is 45 seconds. If the developer time is too short or too long, it will affect development and the amount of dye formed.

Developer times that are too long will produce higher-than-normal LD, HD – LD, and BP density values. Developer times that are too short will produce lower-than-normal LD, HD – LD, and BP density values.

Developer-time variations can occur in processors because of variations in electrical load and differences in motor temperature from a cold start to equilibrium. Electrical-load variations can be caused by other equipment (e.g., a heater) on the same power line. In some cases, you may need a voltage regulator on the processor drive motor to compensate for external voltage variations.

Mechanical problems, such as misaligned moving parts, can cause developer-time problems. Be sure that the transport is functioning properly. Extended developer times can also result from intermittent paper slippage in the developer tank. Use a stopwatch to measure the developer time, and compare it with the machine setting.

**Developer—Temperature Too Low or Too High**

The recommended developer temperature for Process RA-4 is 35 ±0.3°C (95.0 ±0.5°F) for KODAK EKTACOLOR RA Developer Replenisher or KODAK EKTACOLOR RA Developer Replenisher RT. For EKTACOLOR Developer Replenisher 12 (EKTACOLOR Developer Replenisher 161 in Europe) and EKTACOLOR PRIME Developer Replenishers, the recommended temperature is 37.8 ±0.3°C (100.0 ±0.5°F).

A developer temperature that is too low or too high affects development and the amount of dye formed. If the developer temperature is too high, the density values for LD, HD – LD, BP, and perhaps D-min will plot higher than normal. If the developer temperature is too low, the density values for LD, HD – LD, and BP will plot lower than normal.

If you suspect that the developer temperature is incorrect:

- Check that the temperature regulator is operating.
- Check that the developer had enough time to reach operating temperature before processing.
- Check that the temperature of the replenisher solution was not too low or too high.
- If your processor has more than one developer tank, check that the temperature is the same in all tanks. Check that the temperature within each tank is uniform from top to bottom and side to side.
- Check that the developer recirculation filter is not clogged. A clogged filter can prevent proper heating of the solution. Check for constricted circulation lines.

The temperature controller and the recirculation system—individually or in combination—can cause temperature problems. Replace the recirculation filters if they are clogged.

If the temperature of the developer replenisher is too low or too high, it may be affecting the temperature of the tank solution. If this occurs, you may need to provide more heat in the replenisher storage area or heat the replenisher before using it.

Check the developer temperature frequently, and adjust it as necessary. Also, check the developer temperature periodically while the processor is operating under full load. The heater may not be able to maintain the temperature as fresh replenisher and a maximum load of paper are entering the developer.
Developer—
Replenishment Rate Too Low or Too High
Developer activity varies directly with the replenishment rate. If the rate is too low, the LD, BP, and HD – LD density values will plot lower than normal. If the rate is too high, the density values for LD and BP will plot higher than normal. The amount of change that you see in control-strip plots due to incorrect replenishment depends on the developer-tank volume, processor speed, and the amount of paper processed.

The recommended replenishment rates are starting points only. The exact rate depends on the type of processor and replenisher mixing and storage conditions. It can also depend on how well you maintain operating conditions, such as development time and temperature. Determine your exact rate by monitoring the process with control strips and adjusting the rate as needed according to the control plots. Do not adjust the rate to “chase” small changes in the control plots. Once the process is in control, continue to use the rate you established; don’t change it unless processor utilization changes. Be aware that the rate of change after a replenishment-rate adjustment may be relatively slow; you may not see the full impact of a developer replenishment-rate change for several weeks.

To avoid replenishment problems, check the replenisher settings regularly to be sure that the correct rates and tank volumes are maintained.

If you suspect that replenishment is the problem:
• Check that the replenishment system is set correctly.
• Check that your calculations are correct if you set your replenishment rate for the average paper width being processed. Does the paper width vary seasonally? Check your replenishment rate by using this calculation.

\[
\text{Flow Processor Paper Replenishment Rate} = \text{Speed} \times \text{Width} \times \text{Rate} \\
\text{Rate} = \text{(mL/min)} \times \text{(m/min or ft/min)} \times \text{(m or ft)} \times \text{(mL/m² or ft²)}
\]

• Check that the processor was receiving replenishment when you detected the problem.
• Check for a possible mechanical problem with the replenishment system. Is the system replenishing at a constant and repeatable rate?

If underreplenishment is the cause of the problem, adjust the replenishment rate to the correct rate. To correct the underreplenished processor tank condition, remove enough developer tank solution so that you can add replenisher in 5- to 10-percent increments of tank volume. Repeat if needed to correct the tank condition. After each addition, recirculate the developer for approximately 10 minutes before you process another control strip.

If overreplenishment is the cause of the problem, adjust the replenishment rate to the correct rate. To correct the overreplenished processor tank condition, remove enough developer tank solution so that you can add water and starter to bring the process back into control. Add one part starter to 11 parts water. If the process is not far out of control, add the water and starter in 5-percent increments of tank volume. If the process is grossly out of control, add water and starter in 10-percent increments. After each addition, recirculate the developer for approximately 10 minutes before you process another control strip. If the process is still out of control after you have added water and starter equivalent to 20 percent of the tank volume, replace the tank solution with a fresh mix.
Developer—Fresh-Tank Mixing Error—Too Little or Much Starter
Using too little starter in a fresh developer mix will increase developer activity. You will see this in the control plots as an increase in the LD and HD – LD density values. Using too much starter for a fresh developer tank solution decreases developer activity. You will see this in the control plots as a decrease in the LD, HD – LD, and BP density values.

To avoid these fresh-tank mixing errors, carefully follow the directions provided with the developer.

If you know the amount of starter that was left out, you can add the missing amount. If you added too much starter or do not know the amount of the error, it will be difficult to correct the problem without a chemical analysis. Replace the tank solution with a fresh mix.

Developer—Mixing Error—Incorrect Water/Replenisher Ratio
Developer activity is affected by a mix that is prepared with too little replenisher and topped with water, or with too little water and topped with replenisher.

Using too much water and too little replenisher has the greater effect. You will see this as lower-than-normal LD, HD – LD, and BP values in the control plots. If you use too much replenisher and too little water, the effect in the control charts will be slight.

Review your mixing procedures and verify the mix-tank calibration. Follow the mixing order in the instructions provided with the chemicals.

Because it is very difficult to determine the exact cause or amount of this type of mixing error without chemical analysis, replace the solution with a fresh mix.

Developer—Replenisher Mixing Error—Too Little or Too Much Part B
Using the wrong amount of any of the developer components affects developer activity. Too little Part B causes low activity; too much Part B causes high activity.

Omitting Part B entirely usually results from human error. However, the chance of leaving out just a portion increases if you split the packaged developer to mix a smaller volume. Errors of 5 to 10 percent will affect the control plots. Be sure that your measuring device is accurate and that you use it correctly. Check that you have calculated the amounts correctly, and that you added the correct amount.

To reduce errors, always use accurate measuring equipment. Graduated cylinders calibrated in millilitres, not ounces, are the most accurate. If you use an automatic mixer, be sure it is properly calibrated for the volumes being mixed. Review mixing procedures for sources of possible error.

Because it is very difficult to determine the exact cause or amount of this type of mixing error without chemical analysis, replace the solution with a fresh mix.

Developer Replenisher Mixing Error—Too Little or Too Much Part C
Using the wrong amount of any of the developer components affects developer activity. Too little Part C causes high activity; too much Part C causes low activity.

Omitting Part C entirely usually results from human error. However, the chance of leaving out just a portion increases if you split the packaged developer to mix a smaller volume. Errors of 5 to 10 percent will affect the control plots. Be sure that your measuring device is accurate and that you use it correctly. Check that you have calculated the amounts correctly, and that you added the correct amount.

To reduce errors, always use accurate measuring equipment. Graduated cylinders calibrated in millilitres, not ounces, are the most accurate. If you use an automatic mixer, be sure it is properly calibrated for the volumes being mixed. Review mixing procedures for sources of possible error.

Because it is very difficult to determine the exact cause or amount of this type of mixing error without chemical analysis, replace the solution with a fresh mix.

Developer—Replenisher Mixing Error—Too Little or Too Much Part A
Using the wrong amount of any of the developer components affects developer activity. Too little Part A causes high activity; too much Part A causes low activity.

Omitting Part A entirely usually results from human error. However, the chance of leaving out just a portion increases if you split the packaged developer to mix a smaller volume. Errors of 5 to 10 percent will affect the control plots. Be sure that your measuring device is accurate and that you use it correctly. Check that you have calculated the amounts correctly, and that you added the correct amount.

To reduce errors, always use accurate measuring equipment. Graduated cylinders calibrated in millilitres, not ounces, are the most accurate. If you use an automatic mixer, be sure it is properly calibrated for the volumes being mixed. Review mixing procedures for possible sources of error.

Because it is very difficult to determine the exact cause or amount of this type of mixing error without chemical analysis, replace the solution with a fresh mix.
Developer—Contamination With Bleach-Fix

Chart 2 demonstrates that very small amounts of thiosulfate (also called hypo) from the bleach-fix will contaminate the developer. As little as 0.1 mL of bleach-fix per litre of developer can put a process out of control. If the developer is contaminated with bleach-fix, you will see a severe color change in the prints and large shifts in the control plots. You will also see an increase in D-min.

The chart shows the typical plot pattern that results from bleach-fix contamination of a developer tank. The degree of contamination is severe in this example; the most severe contamination shown is at 2.4 mL of EKTACOLOR RA Bleach-Fix NR Replenisher per litre of developer.

Possible causes of bleach-fix contamination are bleach-fix splashed into the developer when the racks are raised or mixing developer with equipment that contains a small amount of bleach-fix. Check for any procedures that might cause splashing during mixing or processing. If possible, use separate mixing tanks for developers, and wash all mixing equipment thoroughly before reusing it.

Stop production until you find the source of the contamination. A developer contaminated with bleach-fix or fixer cannot be salvaged; replace it with a fresh mix.

Chart 2
**Bleach-Fix—Leuco-Cyan Dye**

Chart 3 demonstrates controls plots that can result from a problem in the bleach-fix. Leuco-cyan dye is a colorless form of the cyan dye caused by poor bleach-fix performance. Prints with leuco-cyan dye will appear to have a reddish cast in the higher neutral-density regions of the images.

The most common cause of a leuco-cyan dye condition is low bleach-fix pH. This can result from overreplenishment of the bleach-fix tank or from incorrect pH adjustment if you make any manual pH adjustments. You may also observe leuco-cyan dye when you start up with a fresh mix.

If your process control plots indicate low cyan densities, verify the bleach-fix replenishment rates and avoid overreplenishment. Following the test procedure on the following page can verify the presence and significance of a leuco-cyan dye problem.

**Chart 3**
Rebleaching Test for Leuco-Cyan Dye

Leuco-cyan dye is a colorless form of cyan dye. You can recover the dye by rebleaching the control strip. The degree of recovery is a measure of the amount of leuco-cyan dye. To test for leuco-cyan dye, follow these steps.

1. Zero your densitometer. Measure and record the BP density of your control strip.
2. Rebleach the control strip for 2 minutes in a known good bleach (i.e., a properly constituted Process C-41 bleach or a solution made from KODAK Farmer’s Reducer, Part A).
3. Wash the control strip for several minutes and allow it to dry.
4. Rezero your densitometer. Read the BP density of the control strip again.
5. To calculate the change in density readings, subtract the reading in step 1 from the reading in step 4. If the difference is greater than + 0.06, a leuco-cyan dye problem exists.
6. Check the pH of the bleach-fix. Use ammonium hydroxide to adjust the pH to 6.25 ± 0.25. Verify replenishment rates and mixing methods.

Caution

AMMONIUM HYDROXIDE IS CORROSIVE. Ammonium hydroxide requires careful handling; it is strongly corrosive and can cause serious harm to the skin and eyes; it will damage clothing. For your safety, see the Material Safety Data Sheet for handling and precautionary information. Observe all CAUTION statements. Avoid contact with skin or clothing by solution or vapors. Use a ventilation hood to avoid exposure to vapors. Do not weigh this chemical in an aluminum container.

Developer—Oxidation

When developer is exposed to air, it reacts with oxygen. To protect the developing agent, developers contain preservatives that react with oxygen. However, prolonged exposure to air will eventually deplete the preservatives and cause the developing agent to oxidize. Oxidation of the developing agent causes decreased developer activity and precipitate formation.

It is difficult to produce a representative plot pattern for the effects of developer oxidation, because it depends on the degree of aeration of the tank. Also, if you adjust your developer replenishment rate in an attempt to reduce the process control bias, you may be masking the impact of the oxidation. Generally, you will see an increase in BP, HD – LD, and D-min in the control plots.

The most common causes of oxidation are excessive agitation and low processor utilization. Excessive agitation—e.g., from long or too rapid mixing or too much agitation in the processor—forces air into the solution. A faulty processor recirculation pump can also suck air into the solution. Foaming may indicate that the recirculation system is leaky and is sucking air.

Oxidation is a more common problem in roller-transport processors than in other type of processor, because the rollers constantly expose large areas of solution to the air. Oxidation is also more likely in roller-transport processors because they often have low utilization, which means that the solution is exposed to air for long periods without replenishment. Without replenishment, preservatives in the developer are not replaced as they would be with normal utilization. Evaporation is also higher in low-utilization processors, and leads to overconcentration of the developer. Overconcentration may offset some of the effects of the oxidation and mask the condition.

Minimize oxidation by turning off the processor when it is not in use. In roller-transport processors, use solutions that contain extra protection against oxidation, such as KODAK EKTACOLOR RA Developer Replenisher RT.

Check for excessive air flow over the processor developer tanks and developer replenisher storage tanks. Use floating lids on storage tanks. Avoid overmixing and excessive agitation.