Monitoring and Troubleshooting KODAK Black-and-White Film Processes

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WHY SHOULD YOU MONITOR YOUR PROCESS?

Consistently high quality is good business. It means satisfied customers because they get good results from their film, which in turn means new and repeat business.

High-quality photographic processing depends on meeting and maintaining process and product standards. You can meet and maintain these standards by following the manufacturer's processing and printing recommendations, and by monitoring and controlling your process. Process monitoring enables you to ensure that your process is operating consistently within tolerances that yield high-quality negatives. When you monitor your process carefully and your process stays in control, you reduce waste, avoid downtime, and increase customer satisfaction, employee productivity, and profits.

Process control provides the following benefits:

- Process consistency
- Higher overall quality of processed film
- Greater total yield of acceptable film, or processing capacity
- Early detection of process and/or equipment problems
- Less waste of time, chemicals, and film
- Increased printing productivity
- Greater customer satisfaction

The two factors that most affect the quality of black-and-white negatives are exposure and processing. If your process has not been optimized, it is possible that your customers have adjusted their film exposure to compensate. Taking action to correct an out-of-control process may produce unexpected results in your customers' negatives. If you make major process changes after you begin using control strips, encourage your customers to expose and process test rolls to determine if you are still producing quality negatives that suit your printing operation.

If you mix chemicals properly and use the correct settings for the process cycle, the contrast index, speed, and D-min of your processed control strip will plot in control, and your process will produce high-quality negatives. Deviations from normal in the processor, processing solutions, or processing-cycle conditions (e.g., time, temperature, agitation, replenishment, filtration, wash water, drying, etc.) can cause processing problems.

Deviations from normal conditions can cause under- or overdevelopment. Underdevelopment will result in a decrease in density and contrast in your control strips, and a loss of density, contrast, and shadow detail in your customers' negatives. Overdevelopment will produce an increase in density and contrast in your control strips, and an increase in density and contrast with blocked highlights in your customers' negatives.

Although control plots are intended to show a problem before it begins to affect customer negatives, you can usually confirm a problem by visually inspecting customer film when your control plot signals a problem. To analyze and correct a problem, determine the cause by following a logical sequence when you check your control plots and customer negatives.

HOW IS A PROCESS MONITORED?

Process monitoring is a method for regularly checking the condition of your process to ensure that it is operating according to a standard. It helps prevent reduced negative quality by detecting potential problems.

To monitor your process, you will process KODAK Black-and-White Film Process Control Strips; determine the contrast index, speed, and D-min; and then compare those values to aim values. You will plot your process deviations from aim on a control chart. Control charts provide a running record of process quality, and do the following:

- indicate if the process is within acceptable limits
- show trends in the process and signal you to make changes to keep the process in control
- help determine the causes of process problems
- allow you to check adjustments made to the process

The following terms are frequently used in process monitoring:

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

Sensitometric Parameters—The contrast index (CI), speed, and minimum density (D-min) of the control strip are the critical sensitometric parameters in black-and-white film processing. You will use the densities of the control strip to calculate contrast index and speed and to assess the activity of your process.

Contrast Index (CI)—A measure of the degree of development that determines how well the density range of a normally exposed negative will print on a grade 2 (i.e., normal-contrast) paper.

Speed—A value that represents a measure of the ability of your process to develop shadow detail. This value is an arbitrary number that relates only to the control strip; it is not an ISO/ASA speed.

D-min—A measure of the minimum density (base-plus-fog of unexposed film) produced by your process.

Aims—These are the values to which you compare the contrast index, speed, and D-min values of your control strips. The aims for contrast index, speed, and D-min are pre-printed on the *KODAK Plotting Form for Black-and-White Film Processing*, KODAK Publication No. Y-30.

Tolerances—Tolerances are the deviations from aim allowed before you must take corrective action. They include action limits and control limits.

Action Limits—The action limits are the boundaries of the aim operating range of the process. When the variations from aim for contrast index, speed, and D-min plot between the upper and lower action limits (in the acceptable range), your process is in control. Regions exceeding the action limits are shaded light gray on Form Y-30. If the variation from aim for any parameter exceeds the action limit and plots in the light gray area, it is an "early warning." You can still 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. Regions exceeding the control limits are shaded dark gray on Form Y-30. If any variation from aim plots beyond the control limit, results will be unsatisfactory for shadow density and/or contrast. Stop processing customer film until you find the cause and correct it.

Control Chart—A control chart is a plot of your variations from aim over a period of time. Plots on your control chart will confirm the control of your process or provide a clear record of variations in the performance of your process.

GETTING STARTED

To begin monitoring your process, you will need—

- KODAK Black-and-White Film Process Control Strips (CAT No. 180 2990)
- an electronic densitometer with a "visual" mode
- copies of the *KODAK Plotting Form for Black-and-White Film Processing* (KODAK Publication No. Y-30)

KODAK Black-and-White Film Process Control Strips

Kodak supplies KODAK Black-and-White Film Process Control Strips for monitoring the processing of Kodak black-and-white films in KODAK Chemicals. These strips are pre-exposed neutral-density scales on KODAK PROFESSIONAL T-MAX 400 Film / 4053. Each strip has five neutral-density steps; a raised dimple is located on the emulsion side at the low-density end for orientation. You will use the densities of the following steps to calculate the contrast index (CI) and speed of your process:

Step 1 D-min

Step 2 Toe density (TD)

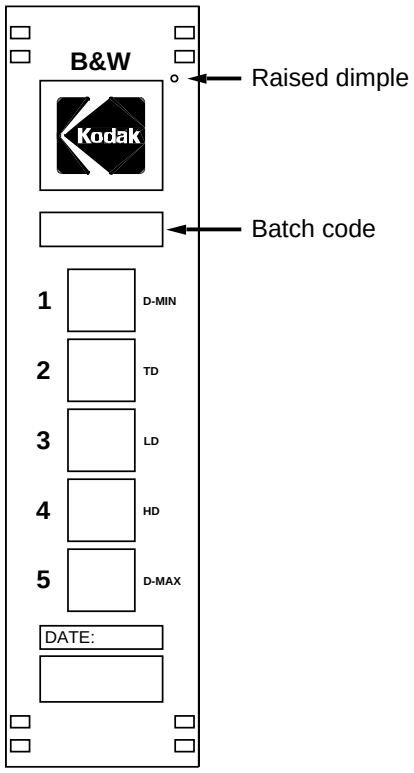
Step 3 Low density (LD)

Step 4 High density (HD)

Step 5 D-max

These strips are supplied in a box of five foil packages that contain 10 strips each. The ends of the strips are perforated for use with standard control-strip racks. **Keep control strips frozen to maintain consistency.** Store and handle control strips according to the instructions packaged with them. Use a densitometer in the visual mode to read the control-strip densities.

You can use these control strips to assist in determining development times when you start up your process, to monitor your process, or to determine starting-point development times for other Kodak black-and-white films.



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Note: Monitor your densitometer to ensure that it is calibrated and operating properly. Drifting and inaccurate readings occur most often in the higher densities. Proper densitometer performance is especially important for accurate monitoring of your process with KODAK Black-and-White Film Process Control Strips. Keep a record of all maintenance (e.g., filter changes, lamp changes, etc.) performed on your densitometer.

Starting Up Your Process

Follow the procedure below when you first start using KODAK Black-and-White Film Process Control Strips. You should also follow these steps whenever you start up a new machine, and if you replace your developer and replenisher with a different type of developer and replenisher.

1. Process a control strip at the time and temperature that you use to process PROFESSIONAL T-MAX 400 Film.* Locate the raised dimple on the control strip; it is located at the low-density end of the strip. The raised side of the dimple is on the emulsion side of the strip. Process the strip with the emulsion facing in the same direction as the emulsion side of the film you process. In continuous processors, process the low-density end of the strip first; in rack-and-tank processors, fasten the strip to a film clip with the low-density end up. Each time you process a strip, position it in the same location in your processor.†

   Note: If your processed control strips show a severe magenta (pink) stain after fixing, your fixer may be near exhaustion, or you may not have used an adequate fixing time. If the stain is slight, it will not affect the density values. If it is severe, refix the strip in fresh fixer; check the fixer in your processor.
2. Measure the densities of the strip in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode.
3. Calculate the contrast index of your strip by using one of the following formulas or Worksheet 1. The first formula has more steps, but it will give you an answer that is more accurate than the second formula will provide.

   Formula 1

   $$CI = 0.128 + (0.267 \times \text{D-min}) - (0.969 \times TD) + (0.454 \times LD) + (0.183 \times HD) + (0.039 \times \text{D-max})$$

   Formula 2

   $$CI = \frac{(HD - TD)}{2.26} + 0.10$$
4. Calculate your variation from aim for contrast index by subtracting 0.58‡ from the number you determined in step 3.
5. Calculate the speed value of your strip by using this formula:

   $$\text{Speed} = 140.9 \times (TD - \text{D-min}) + 335$$
6. Calculate your variation from aim for speed by subtracting 355** from the number you determined in step 5.
7. Calculate your variation from aim for D-min by subtracting 0.06†† from the D-min density reading.

* If you do not process PROFESSIONAL T-MAX 400 Film, follow the procedure described under *Determining an Optimum Development Time for Control Strips*.

† To check the uniformity of your developer tank, you can position control strips to run through several positions in the tank.

‡ 0.58 is the contrast-index aim for printing negatives with a diffusion enlarger; use 0.43 if you will print negatives with a condenser enlarger.

** 355 is the speed-value aim for a replenished process for producing negatives that you will print with a diffusion enlarger; your speed value may be slightly higher when you use fresh developer. The speed-value aim for producing negatives for printing with a condenser enlarger will be between 340 and 350. The speed value is not an ISO/ASA speed.

†† Use 0.09 as your aim for D-min if you process film in KODAK DURAFLO RT Developer Replenisher.

8. Plot your variations from aim for contrast index, speed, and D-min on the *KODAK Plotting Form for Black-and-White Film Processing*, KODAK Publication No. Y-30. (For more information, see *Using Form Y-30*.)
9. Evaluate the control status of your process by looking at the plots on Form Y-30.

   If your variations from aim plot within the action limits (i.e., the white area on each grid on Form Y-30), your process is in good control. Use the development time for this strip for all subsequent strips that you process; proceed to *Process Monitoring*.

   If any of your variations from aim plot on or beyond the action limits (i.e., in the light or dark gray area on each grid on Form Y-30), proceed to *Getting Your Process in Control*.

Determining an Optimum Development Time for Control Strips

In many situations, your variations from aim for the first control strip that you process will plot out of control because the strip was under- or overdeveloped, i.e., your development time was too short or too long. To determine an optimum development time for your control strip, follow the procedure below:

1. Process a control strip at the times given below. Record the development time on each strip.

   For dip-and-dunk processes—
   4 minutes, 6 minutes, 8 minutes, 10 minutes, and 12 minutes

   For roller-transport processors using KODAK DURAFLO RT Developer Replenisher—
   60 seconds, 90 seconds, 120 seconds, and 240 seconds
2. Measure the densities of the strips in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode.
3. Calculate the contrast index of each of the strips; use one of the following formulas or Worksheet 1.

Formula 1

$$CI = 0.128 + (0.267 \times \text{D-min}) - (0.969 \times \text{TD}) + (0.454 \times \text{LD}) + (0.183 \times \text{HD}) + (0.039 \times \text{D-max})$$

Formula 2

$$CI = \frac{(HD - LD)}{2.26} + 0.10$$

4. If one of the contrast-index values you calculated in step 3 is within ±0.02 of your contrast-index aim, record the development time, and use it to process your control strips.

   If none of the values is within ±0.02 of your contrast-index aim, find the strip with the contrast-index value that is closest to your aim. Then increase or decrease the development time to fine-tune it, and process another control strip. Measure the densities of each step of the strip, and calculate the contrast index. If the contrast index is within ±0.02 of your contrast-index aim, record the development time, and use it to process your control strips. If the contrast index is not within ±0.02 of your contrast-index aim, increase or decrease the development time *again* to produce a contrast index that is closer to aim.
5. Return to step 1 under *Starting Up Your Process*. Use the development time that you determined in step 4 (above) to process a control strip instead of using your development time for T-MAX 400 Professional Film.

Note: You can also use the strips processed in the procedure above to determine development times for other Kodak black-and-white films; see *Determining Starting-Point Development Times for Different KODAK Black-and-White Films*.

Getting Your Process in Control

After you process your *first* control strip, if one or more of the variations from aim plot on or beyond the action limits, use the table below to troubleshoot the process.

Condition	Action
Variation from aim for CI plots on or beyond the action limits	Follow the procedure under *Determining an Optimum Development Time for Control Strips*.*
Variations from aim for CI and speed plot on or beyond the action limits	
Variations from aim for CI, speed, and D-min plot on or beyond the action limits	
Variation from aim for speed plots on or beyond the action limits	Follow the procedure under *Detecting and Adjusting an Underreplenished Process*.
Variations from aim for speed and D-min plot on or beyond the action limits†	

* You may have to repeat this procedure if you make adjustments to correct for an underreplenished process.

† If you are using a freshly mixed developer, be sure that it was mixed properly; some fine-grain developers will yield low speed values.

Detecting and Adjusting an Underreplenished Process

If you are just starting to process control strips and you have not recently replaced your developer tank solution, it is possible that your replenishment rate has been too low. You can use one of the following procedures to adjust your process based on where your variation from aim for speed plots.

If your variation from aim for speed plots between the action and control limits **below aim** (i.e., in the light gray area):

1. Replace 25 to 50 percent of your developer tank solution with fresh solution. This will quickly reduce the seasoning of the developer to an acceptable level.
2. Increase your replenishment rate by 10 percent.
3. Return to the procedure described under *Starting Up Your Process*.

If your variation from aim for speed plots beyond the control limit **below aim** (i.e., in the dark gray area):

1. Replace your developer tank solution with fresh solution.
2. Increase your replenishment rate by 10 percent.
3. Return to the procedure described under *Starting Up Your Process*.

PROCESS MONITORING

Begin monitoring your process after you have established an optimum development time for your control strip—i.e., a time that yields contrast index, speed, and D-min values that plot within the action limits for your process.

1. Process a control strip at your optimum development time.

   Note: If your processed control strips show a severe magenta (pink) stain after fixing, your fixer may be near exhaustion, or you may not have used an adequate fixing time. If the stain is slight, it will not affect the density values. If it is severe, refix the strip in fresh fixer; check the fixer in your processor.

2. Measure the densities of the strip in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode.

3. Calculate the contrast index of your strip by using one of the following formulas or Worksheet 1. The first formula has more steps, but it will give you an answer that is more accurate than the second formula will provide.

   Formula 1

   $$CI = 0.128 + (0.267 \times \text{D-min}) - (0.969 \times TD) + (0.454 \times LD) + (0.183 \times HD) + (0.039 \times \text{D-max})$$

   Formula 2

   $$CI = \frac{(HD - LD)}{2.26} + 0.10$$

4. Calculate your variation from aim for contrast index by subtracting 0.58* from the number you determined in step 3.

5. Calculate the speed value of your strip by using the formula given below.

   $$\text{Speed} = 140.9 \times (TD - \text{D-min}) + 335$$

6. Calculate your variation from aim for speed by subtracting 355† from the number you determined in step 5.

7. Calculate your variation from aim for D-min by subtracting 0.06‡ from the D-min density reading.

8. Plot your variations from aim for contrast index, speed, and D-min on the *KODAK Plotting Form for Black-and-White Film Processing*, KODAK Publication No. Y-30. (For more information, see *Using Form Y-30*.)

9. Evaluate the control status of your process by looking at the plots on Form Y-30.

   If your variations from aim plot within the action limits (i.e., in the white area on each grid on Form Y-30), your process is in control.

   If your process runs consistently near one of the action limits, you may want to adjust your process; see *Adjusting Your Process to Aim*.

   If any of your variations from aim plot outside the action limits (i.e., in the light or dark gray area on each grid on Form Y-30), proceed to *Diagnosing and Troubleshooting Processing Problems*.

Frequency of Processing Control Strips

After your process is in control, we recommend that you process a control strip—

- at the beginning of the day or shift, before processing customer film
- at regular intervals with customer film
- when you encounter processing problems
- after you have taken corrective action
- when you start up your process with fresh tank solutions
- at the end of the day or shift

Calculate and plot your variations from aim for contrast index, speed value, and D-min for each control strip that you process. Evaluate the control status of your process by looking at the plots on Form Y-30; they will confirm the control of your process or provide a clear record of variations in the performance of your process. For information on troubleshooting your process, see *Diagnosing and Troubleshooting Processing Problems*.

* 0.58 is the contrast-index aim for printing negatives with a diffusion enlarger; use 0.43 if you will print negatives with a condenser enlarger.

† 355 is the speed-value aim for a replenished process for producing negatives that you will print with a diffusion enlarger; your speed value may be slightly higher when you use fresh developer. The speed-value aim for producing negatives for printing with a condenser enlarger will be between 340 and 350. The speed value is *not* an ISO/ASA speed.

‡ Use 0.09 as your aim for D-min if you process film in KODAK DURAFLO RT Developer Replenisher.

KODAK Plotting Form for Black-and-White Film Processing (KODAK Publication No. Y-30)

This form is similar to KODAK Publication No. Y-55, *KODAK Process Record Form*, but it includes areas for plotting only three parameters: contrast index (CI), speed, and D-min. It includes pre-printed aims and action and control limits for these parameters.

Using Form Y-30–Use a separate form for each processor. Record the name of the processor in the blank labeled "Machine." Record the control-strip batch code in the blank at the top of the form.

1. Measure the densities of the strip in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode. Record the date and time on the form.
2. Calculate the contrast index of your strip by using one of the following formulas or Worksheet 1. The first formula has more steps, but it will give you an answer that is more accurate than the second formula will provide.

Formula 1

$$CI = 0.128 + (0.267 \times \text{D-min}) - (0.969 \times TD) + (0.454 \times LD) + (0.183 \times HD) + (0.039 \times \text{D-max})$$

Formula 2

$$CI = \frac{(HD - LD)}{2.26} + 0.10$$

3. Calculate your variation from aim for contrast index by subtracting 0.58* from the number you determined in step 2.
4. Calculate the speed value of your strip by using the formula given below.

$$\text{Speed} = 140.9 \times (TD - \text{D-min}) + 335$$

5. Calculate your variation from aim for speed by subtracting 355† from the number you determined in step 4.
6. Calculate your variation from aim for D-min by subtracting 0.06‡ from the D-min density reading.
7. Plot the differences on Form Y-30. Plot differences that are **larger** than the corresponding aim values (+ values) **above** the aim line, and those that are **smaller** than the aim values (– values) **below** the line.

Tolerances and Limits—Form Y-30 includes the following tolerances and limits for KODAK Black-and-White Film Process Control Strips.

Parameter	Aim	Action Limits—Range Shaded Light Gray on Form Y-30	Control Limits—Range Shaded Dark Gray on Form Y-30
Contrast Index (CI)	0.58*	+ 0.07 to + 0.20 – 0.07 to – 0.12	+ 0.20 or higher – 0.12 or lower
Speed	355†	+ 15 to + 22 – 9 to – 17	+ 22 or higher – 17 or lower
D-min	0.06‡	+ 0.02 to + 0.03 No lower limit	+ 0.03 or higher No lower limit

The light gray regions of the plotting form begin at the action limit and extend to the control limit for each parameter. The dark gray regions begin at the control limit and extend to the edges of each graph.

* 0.58 is the contrast-index aim for printing negatives with a diffusion enlarger; use 0.43 if you will print negatives with a condenser enlarger.

† 355 is the speed-value aim for a replenished process for producing negatives that you will print with a diffusion enlarger; your speed value may be slightly higher when you use fresh developer. The speed-value aim for producing negatives for printing with a condenser enlarger will be between 340 and 350. The speed value is *not* an ISO/ASA speed.

‡ Use 0.09 as your aim for D-min if you process film in KODAK DURAFLO RT Developer Replenisher.

Adjusting Your Process to Aim

After you have monitored your process for a period of time, you may find that your process is not operating close enough to the aims for contrast index and speed. By modifying your development time and/or developer replenishment rate, you can adjust your process to operate at a level closer to aim. The following table lists steps that will help you improve your current process to yield results that are closer to aim.

Condition	Action
Variation from aim for contrast index (CI) consistently plots near the action limit **below aim**	1. Increase the development time for your control strip in increments of 10 percent until your contrast index is close to aim. 2. If your variation from aim for speed plots outside the action limit below aim after you increase the development time, increase the replenishment rate by 10 percent. **Note:** It may take approximately 1 week before you see a significant change in speed.
Variation from aim for contrast index (CI) consistently plots near the action limit **above aim**, and variation from aim for speed consistently plots in the action limit or **below aim**	1. Decrease the development time for your control strip in increments of 10 percent until your contrast index is close to aim. 2. If your variation from aim for speed plots outside the action limit below aim after you decrease the development time, increase the replenishment rate by 10 percent. **Note:** It may take approximately 1 week before you see a significant change in speed.
Variation from aim for contrast index (CI) consistently plots close to aim, and speed value consistently plots near the action limit **below aim**	1. Increase your replenishment rate by 10 percent. **Note:** It may take approximately 1 week before you see a significant change in speed. 2. If your variation from aim for contrast index (CI) plots outside the action limit above aim after you have adjusted your replenishment rate, decrease the development time for your control strip in increments of 10 percent until your contrast index is close to aim.

CONTROL CHARTS

A control chart is probably the simplest and most effective tool for achieving process control. Lines indicating aims and action and control limits provide a standard of evaluation. Measurements plotted on the chart show the distribution of data, and quickly identify an abnormal situation. The chart also tracks the influences of other factors that change the process over time. In black-and-white processing, contrast index (CI), speed, and D-min values of control strips are plotted against pre-determined aims.

Follow these steps when you use control charts:

1. Regularly process control strips, and plot the variation from aim for contrast index, speed, and D-min of each strip.
2. Evaluate the results; look at the control chart for changes or trends causing out-of-control situations.
3. Investigate causes of change.
4. Take corrective action to eliminate the cause.
5. Take steps to prevent recurrence.
6. Keep a log that describes any adjustments that you make to the processing conditions.

Evaluating Control-Chart Plots

Plots can indicate two types of variations in a process: random and non-random. Process variations, both random and non-random, influence the distribution of data points on the control charts and identify the state of control.

Random variations are inherent in the process, and they occur even when the process is running at peak performance. Random variations are caused by chance and are normal; they are often called “process noise.” Random variations plot within the limits. They do not form any particular pattern and they are distributed equally above and below the aim line. A process is in control when the only type of variation is random. No corrective action is required. In fact, it is important to avoid over-controlling a process by reacting to random variations.

Non-random variations indicate changes in the process that usually require investigation and correction. These types of plots indicate non-random data:

- Outliers—Data points that plot on or outside the control limits.
  Important: Whenever a point plots on or outside the control limit, check that your densitometer is properly calibrated and remeasure the control-strip densities. If the first readings were accurate, process another control strip and measure the densities to confirm that the problem still exists.
- Level shifts—Four to eight consecutive data points that fall on one side of the aim line. When data points are not distributed equally above and below the aim line, something in the process is creating the shift. The more consecutive points that plot above or below the aim line, the higher the probability that a process change occurred that requires investigation. If only two or three points plot on one side of the aim line, those points may be random noise. However, if a fourth point plots on the same side, a shift is likely. A fifth point increases the probability, etc.
  Note: To avoid creating a false level shift when you change to a new batch of control strips with a different code number from your current batch, see *Changing to a New Batch of Control Strips*.
- Trends—Four to eight data points that plot in an ascending or descending row. When data points plot in ascending or descending order, the higher the number of points in the row, the more likely that it indicates a trend.

Seasoning Trends for Fresh Solutions—Some developer and replenisher systems are formulated so that a fresh developer solution will produce a higher speed than a highly seasoned and properly replenished developer. For these systems, a declining trend in speed should be considered “normal” as a fresh developer solution gradually seasons. As the developer becomes fully seasoned, the speed level will stop its downward trend. Systems that exhibit this type of trend include processes using KODAK PROFESSIONAL Developer D-76 and Replenisher D-76R and KODAK PROFESSIONAL T-MAX RS Developer and Replenisher working solution mixed without starter. Systems that do not exhibit a trend of this type include processes using KODAK HC-110 Developer with HC-110 Developer Replenisher, KODAK DURAFLO RT Chemicals, and KODAK PROFESSIONAL T-MAX RS Developer Replenisher working solution mixed with an appropriate starter.

Causes of an Out-of-Control Process

Many factors can lead to an out-of-control process:

- Improper solution mixing
- Improper solution storage and keeping
- Solution contamination
- Incorrect processing temperature
- Incorrect processing time
- Improper agitation
- Improper solution replenishment
- Evaporation
- Equipment malfunction

Be sure to prepare each solution according to the instructions packaged with the chemicals. Be especially careful that you mix all constituents well, and that you use the correct amounts of concentrates and water. For personal protection, wear safety goggles, gloves, and an apron when mixing chemicals. Clean mixing tanks and equipment to avoid dirt buildup and solution contamination. Calibrate mixing tanks for the volumes of solutions you are mixing.

Follow the storage and keeping recommendations given in the instruction packaged with your chemicals. To minimize solution storage and keeping problems, mix only the amount of solution that you will use during the recommended keeping time.

Take precautions to minimize the possibility of solution contamination. Contamination is most often caused by—

- mixing equipment that has not been thoroughly cleaned
- dry chemicals that become airborne during mixing and settle in an adjacent solution
- pipes and tanks made of material that reacts chemically with some solutions
- solution splashed or dripped into another solution

You can reduce contamination by using good housekeeping methods, mixing chemicals in a separate mixing room with air exhausted to the outside of the building, checking that tanks and pipes are made of the proper material, and using correct mixing techniques. Avoid splashing by using care when lifting and transferring processing racks and by avoiding overly vigorous agitation. Use separate mixing tanks for developers and fixers.

Temperature variations greater than ±0.5°F (±0.3°C) in your developer will affect process control and image quality. Temperatures that are too low result in a decrease in processing solution activity. To avoid problems, use a consistent temperature for all your processing solutions. Select a temperature that you can maintain consistently.

Agitation is necessary to maintain uniform solution activity by removing exhausted solution from the emulsion surface and replacing it with fresh solution. *Agitation must be uniform throughout the processing tank*. Follow your equipment manufacturer's recommendations for agitation.

Be sure to replenish your solutions properly. Check replenisher pumps and flowmeters regularly to ensure that they are providing the correct amount of replenisher solution.

DIAGNOSING AND TROUBLESHOOTING PROCESSING PROBLEMS

Correcting a Process That is Out of Control

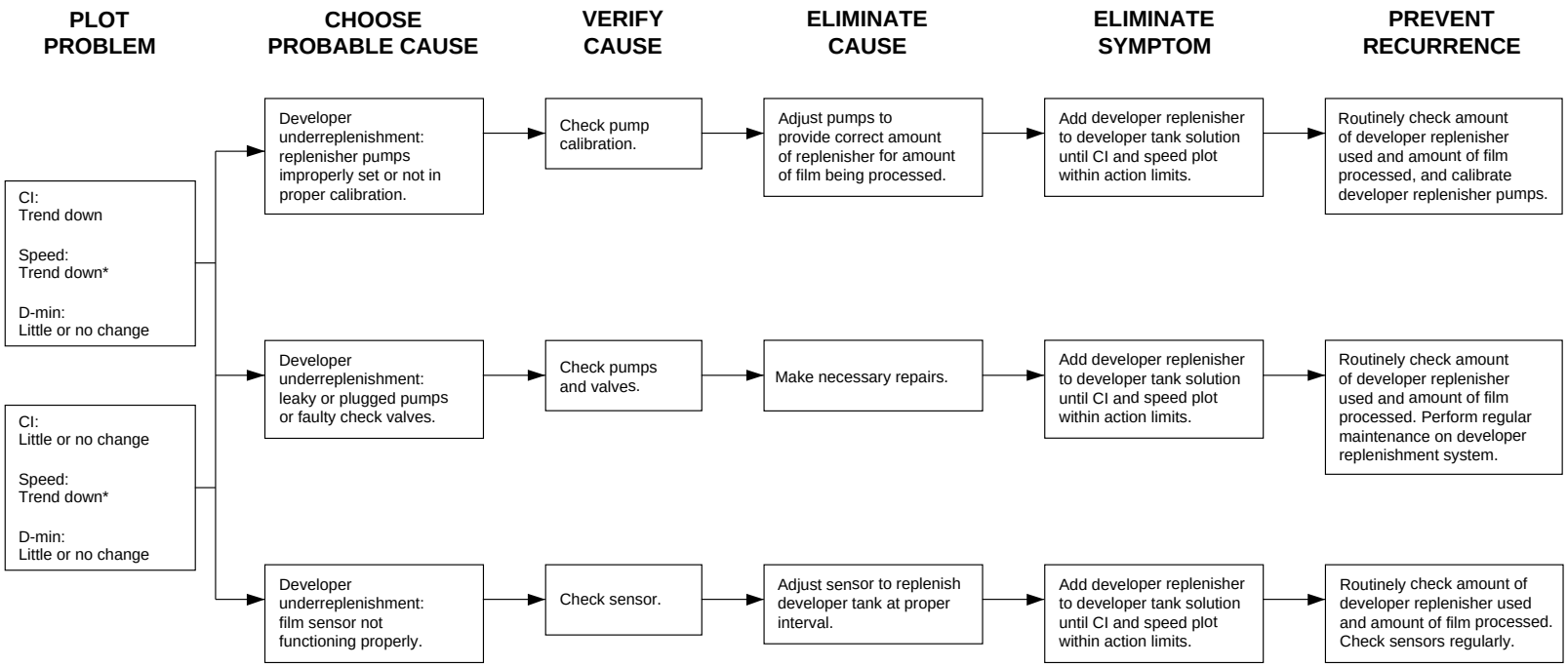
First, verify that the process is out of control:

- Check that your densitometer is operating properly and that your calculations were correct.
- Process another control strip to confirm the out-of-control condition.

If you verify that your process is out of control, determine the cause and correct it. The best indication of the problem will be the plots of the control-strip parameters.

Diagnostic Charts

The diagrams on the following pages provide you with a step-by-step approach to diagnosing process problems; they include the most common causes of problems. They are organized according to the appearance of your control plots. The recommendations in the charts will help you correct outliers, level shifts, and trends. For more information, see *Evaluating Control-Chart Plots*.



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* If you use KODAK PROFESSIONAL T-MAX RS Developer and Replenisher or KODAK PROFESSIONAL Developer D-76, it is normal for speed plots to "trend down" after you start up with fresh solution.

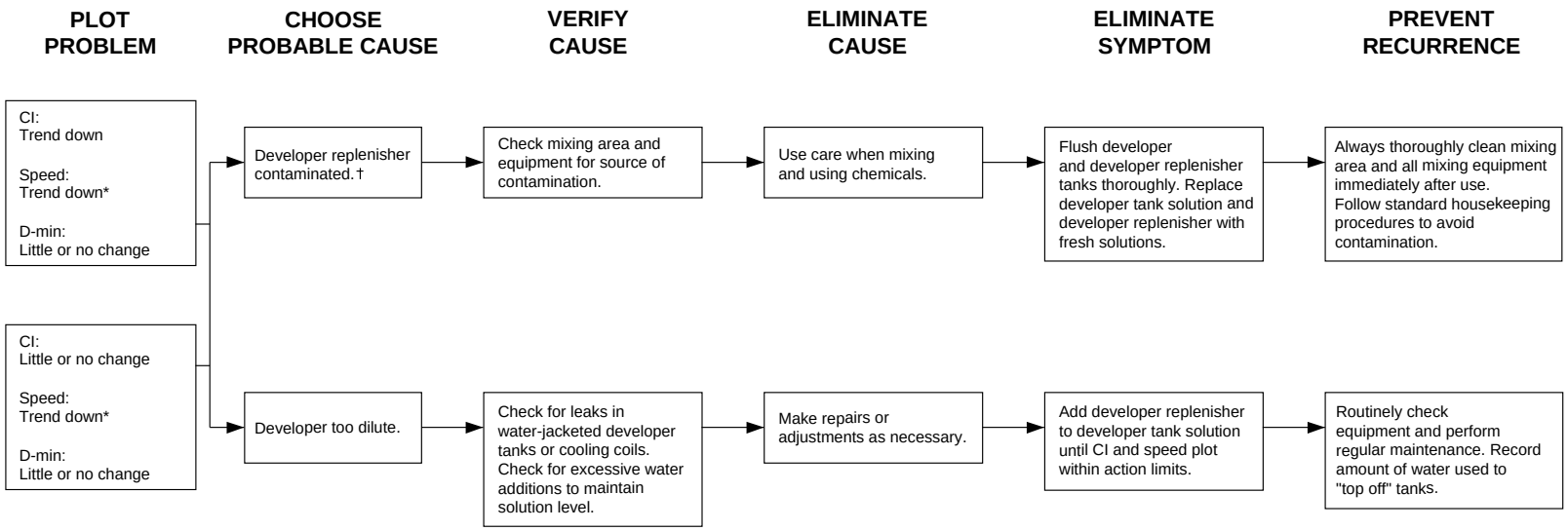
Plot problem (either of the following leads to each of the three probable causes below):

- CI: Trend down; Speed: Trend down*; D-min: Little or no change
- CI: Little or no change; Speed: Trend down*; D-min: Little or no change

CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Developer underreplenishment: replenishment not calculated properly.	Check calculation. Keep record of amount of film processed and amount of replenisher used.	Recalculate developer replenishment rate.	Add developer replenisher to developer tank solution until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Ensure all developer replenishment-rate calculations are done correctly.
Developer underreplenishment: replenisher supply hose pinched.	Check hose.	Make necessary repairs.	Add developer replenisher to developer tank solution until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Check hose regularly.
Developer underreplenishment: replenisher too dilute (mix error).	Closely monitor specific gravity of replenisher mixes. Check mixing records and procedures.	Dump developer replenisher and mix fresh solution; follow mixing instructions carefully.	Add replenisher concentrate to developer tank solution until CI plots within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Verify accuracy of measurement vessels and mix tanks. Ensure correct mixing procedures.

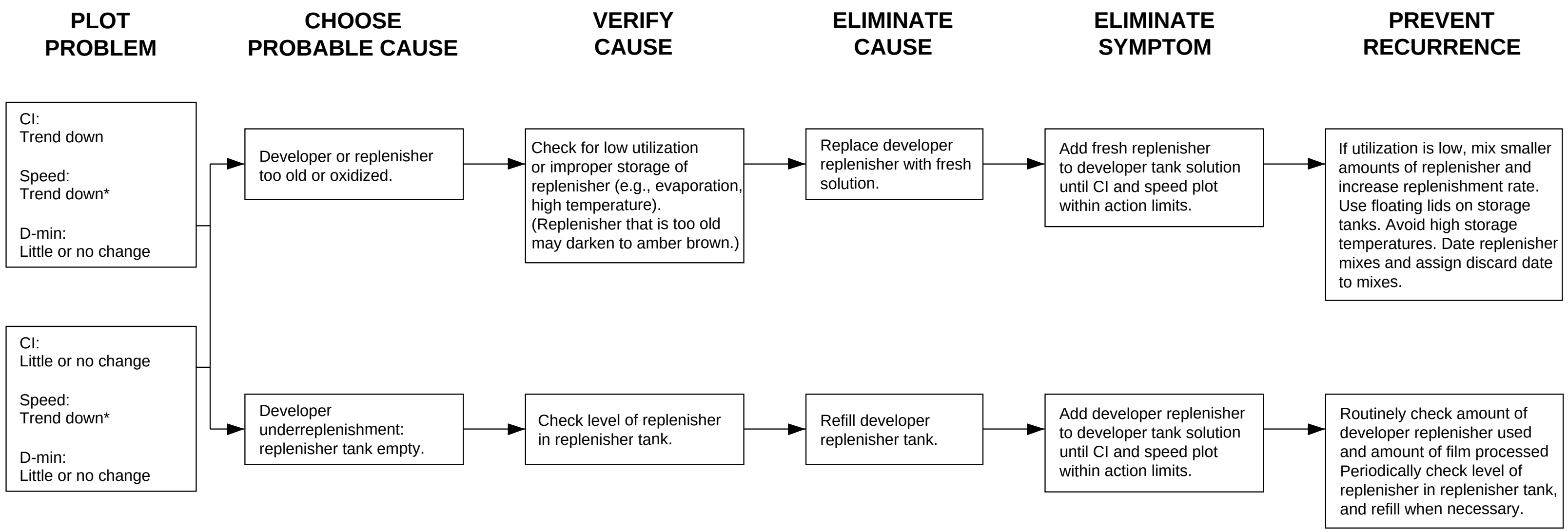
F002_9095EC

* If you use KODAK PROFESSIONAL T-MAX RS Developer and Replenisher or KODAK PROFESSIONAL Developer D-76, it is normal for speed plots to "trend down" after you start up with fresh solution.



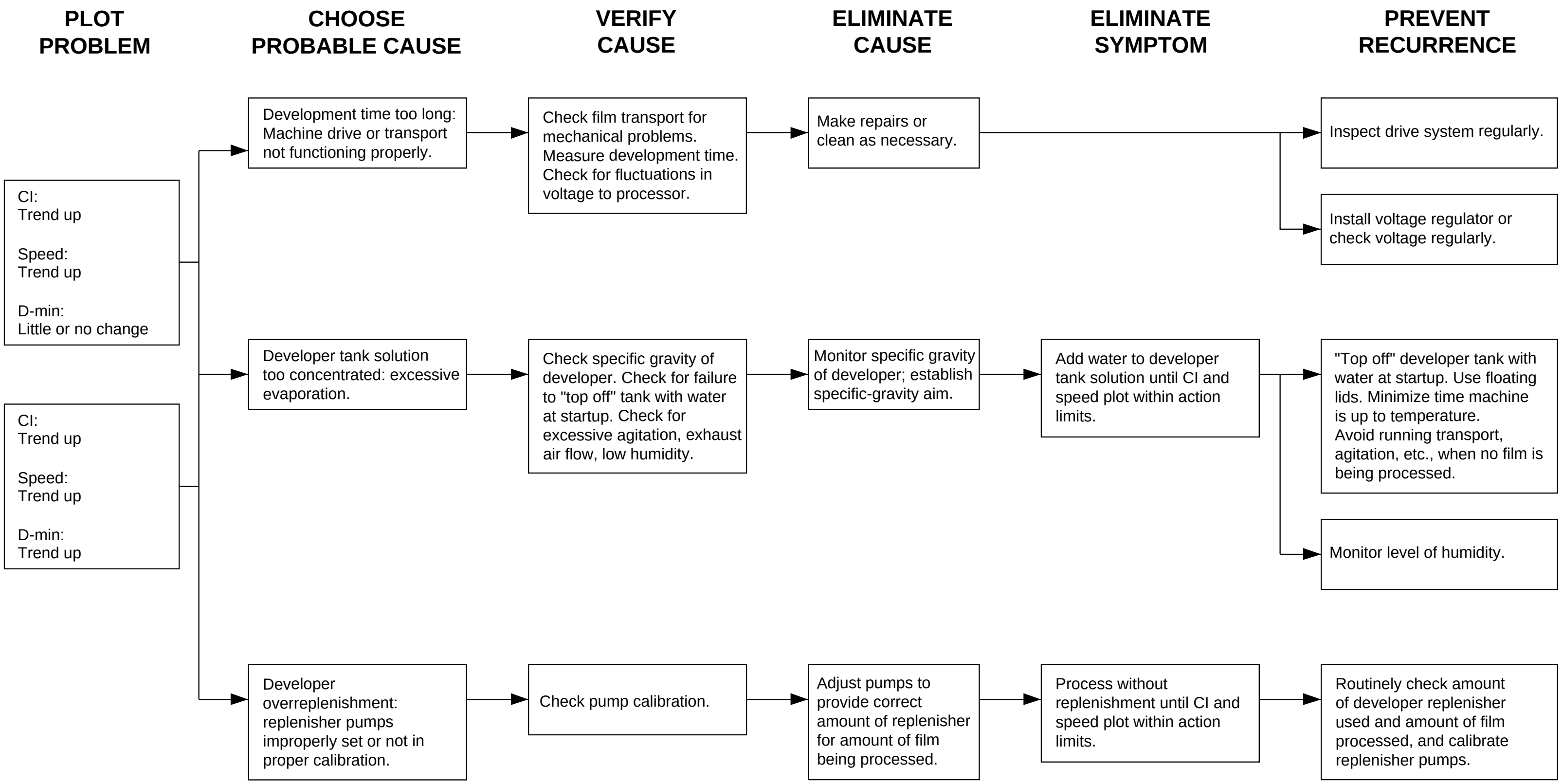
F002_9096EC

* If you use KODAK PROFESSIONAL T-MAX RS Developer and Replenisher or KODAK PROFESSIONAL Developer D-76, it is normal for speed plots to "trend down" after you start up with fresh solution.
† Depending on the contaminant, you may see a significant increase in D-min.



F002_9097EC

* If you use KODAK PROFESSIONAL T-MAX RS Developer and Replenisher or KODAK PROFESSIONAL Developer D-76, it is normal for speed plots to "trend down" after you start up with fresh solution.


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Trend up
Speed: Trend up
D-min: Little or no change
CI: Trend up
Speed: Trend up
D-min: Trend up
Development time too long: Machine drive or transport not functioning properly.
Check film transport for mechanical problems. Measure development time. Check for fluctuations in voltage to processor.
Make repairs or clean as necessary.
Inspect drive system regularly.
Install voltage regulator or check voltage regularly.
Developer tank solution too concentrated: excessive evaporation.
Check specific gravity of developer. Check for failure to "top off" tank with water at startup. Check for excessive agitation, exhaust air flow, low humidity.
Monitor specific gravity of developer; establish specific-gravity aim.
Add water to developer tank solution until CI and speed plot within action limits.
"Top off" developer tank with water at startup. Use floating lids. Minimize time machine is up to temperature. Avoid running transport, agitation, etc., when no film is being processed.
Monitor level of humidity.
Developer overreplenishment: replenisher pumps improperly set or not in proper calibration.
Check pump calibration.
Adjust pumps to provide correct amount of replenisher for amount of film being processed.
Process without replenishment until CI and speed plot within action limits.
Routinely check amount of developer replenisher used and amount of film processed, and calibrate replenisher pumps.

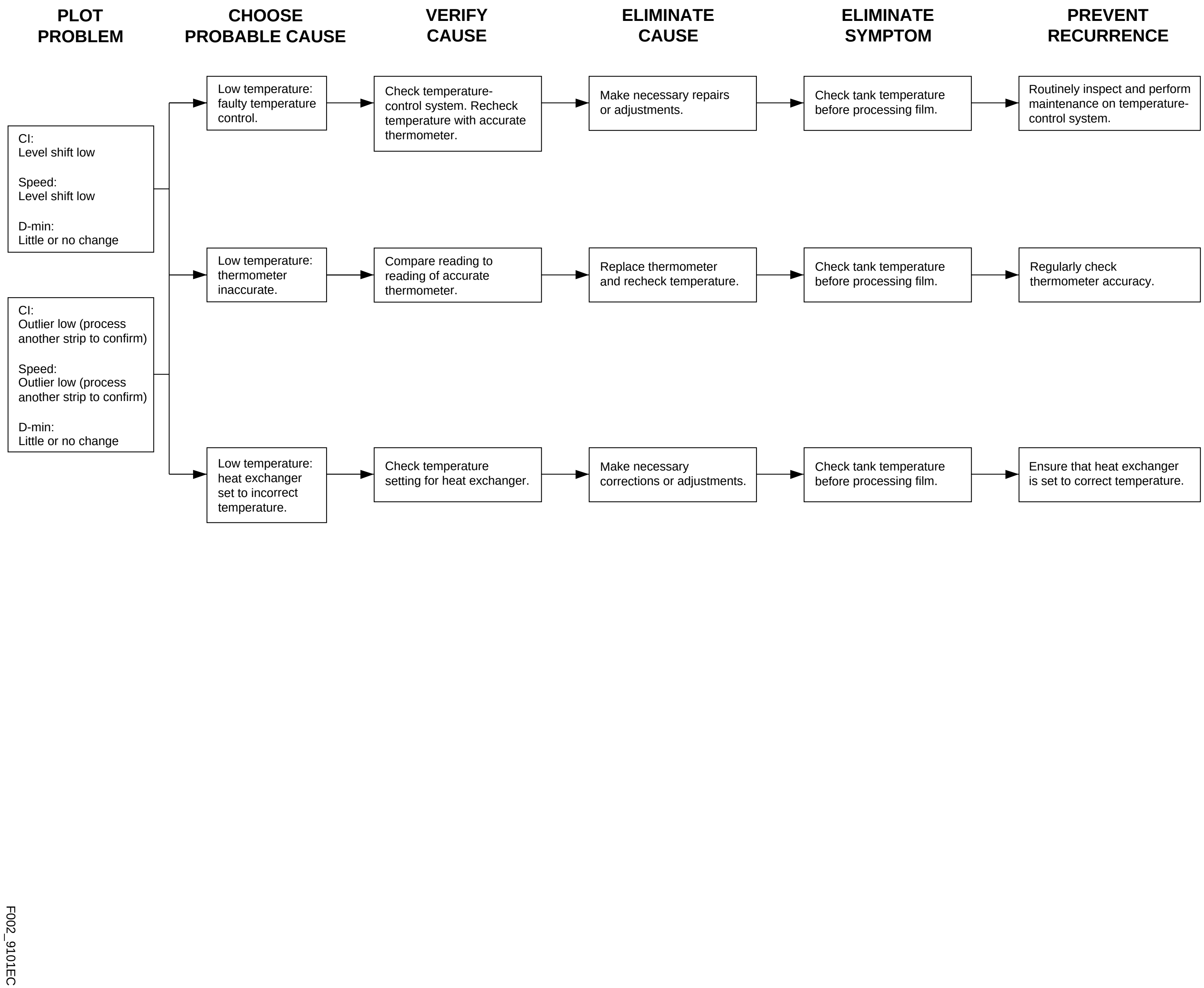
F002_9098EC

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Trend up Speed: Trend up D-min: Little or no change	Developer overreplenishment: faulty metering system.	Check system.	Make necessary repairs.	Process without replenishment until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Perform regular maintenance on replenishment system.
	Developer overreplenishment: film sensor not functioning properly.	Check sensor.	Adjust sensor to replenish developer tank at proper interval.	Process without replenishment until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Check sensors regularly.
	Developer overreplenishment: replenishment rate not calculated properly.	Check calculation. Keep record of amount of film processed and amount of replenisher used.	Recalculate developer replenishment rate.	Process without replenishment until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Ensure all developer replenishment-rate calculations are done correctly.

F002_9099EC

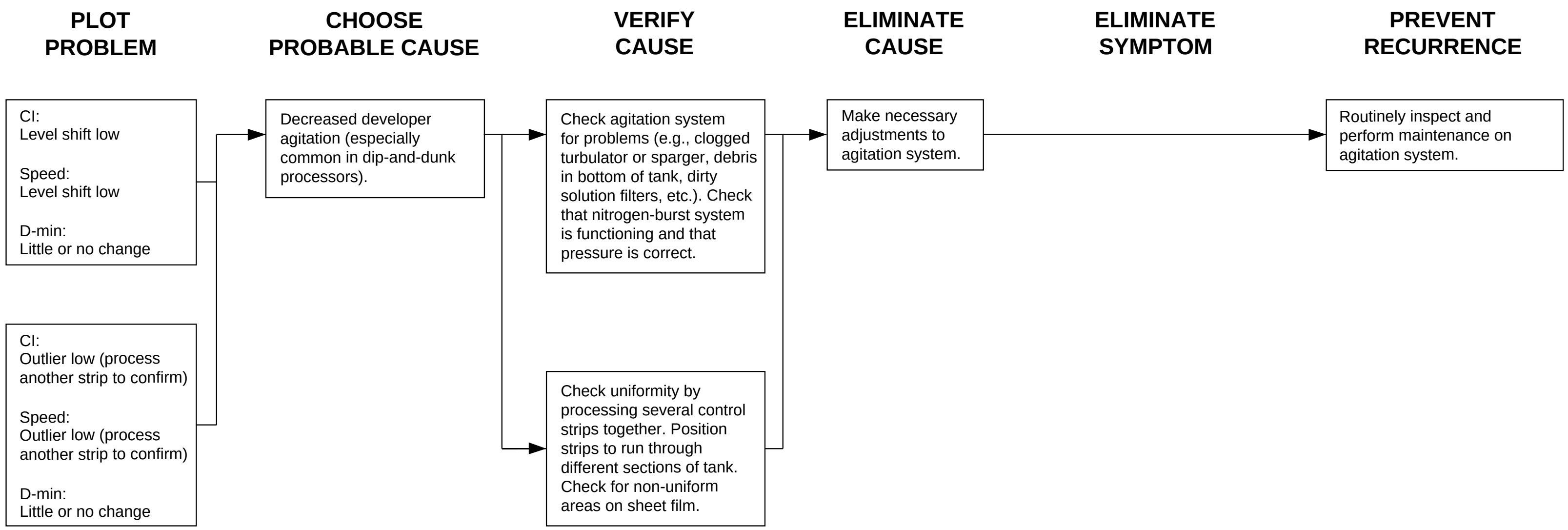
PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Trend up Speed: Trend up D-min: Little or no change	Developer overreplenishment: replenisher too concentrated (mix error).	Check specific gravity of replenisher to detect gross mixing errors. Check mixing records and procedures.	Dump developer replenisher and mix fresh solution; follow mixing instructions carefully.	Add water to developer tank solution until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed. Verify accuracy of measurement vessels and mix tanks. Ensure correct mixing procedures.
	Developer overreplenishment: increase in amount of film processed (i.e., for labs with replenishment rates adjusted for low utilization).	Check amount of developer replenisher used and amount of film processed.	Adjust developer replenishment rate.	Process without replenishment until CI and speed plot within action limits.	Routinely check amount of developer replenisher used and amount of film processed.

F002_9100EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Level shift low
Speed: Level shift low
D-min: Little or no change
CI: Outlier low (process another strip to confirm)
Speed: Outlier low (process another strip to confirm)
D-min: Little or no change
Low temperature: faulty temperature control.
Check temperature-control system. Recheck temperature with accurate thermometer.
Make necessary repairs or adjustments.
Check tank temperature before processing film.
Routinely inspect and perform maintenance on temperature-control system.
Low temperature: thermometer inaccurate.
Compare reading to reading of accurate thermometer.
Replace thermometer and recheck temperature.
Check tank temperature before processing film.
Regularly check thermometer accuracy.
Low temperature: heat exchanger set to incorrect temperature.
Check temperature setting for heat exchanger.
Make necessary corrections or adjustments.
Check tank temperature before processing film.
Ensure that heat exchanger is set to correct temperature.
F002_9101EC

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Level shift low Speed: Level shift low D-min: Little or no change	Development time too short: machine drive or transport not functioning properly.	Check film transport for mechanical problems. Measure time of development. Check for fluctuations in voltage to processor.	Make repairs as necessary.		Inspect drive system regularly. Install voltage regulator or check voltage regularly.
CI: Outlier low (process another strip to confirm) Speed: Outlier low (process another strip to confirm) D-min: Little or no change	Development time too short: machine adjusted for pull processing.	Check time setting.	Adjust machine for normal processing.		Check adjustment of machine before processing film.
	ROLLER-TRANSPORT OR CINE PROCESSOR. Development time too short: loss of developer volume due to leak.	Check developer tank and recirculation system for leaks. Check that drain valves are closed and not leaking.	Make repairs as necessary.	Add working tank solution to developer tank until solution is at normal level.	Regularly inspect and maintain processor. Check solution levels before processing film.

F002_9102EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Level shift low
Speed: Level shift low
D-min: Little or no change
CI: Outlier low (process another strip to confirm)
Speed: Outlier low (process another strip to confirm)
D-min: Little or no change
Decreased developer agitation (especially common in dip-and-dunk processors).
Check agitation system for problems (e.g., clogged turbulator or sparger, debris in bottom of tank, dirty solution filters, etc.). Check that nitrogen-burst system is functioning and that pressure is correct.
Check uniformity by processing several control strips together. Position strips to run through different sections of tank. Check for non-uniform areas on sheet film.
Make necessary adjustments to agitation system.
Routinely inspect and perform maintenance on agitation system.

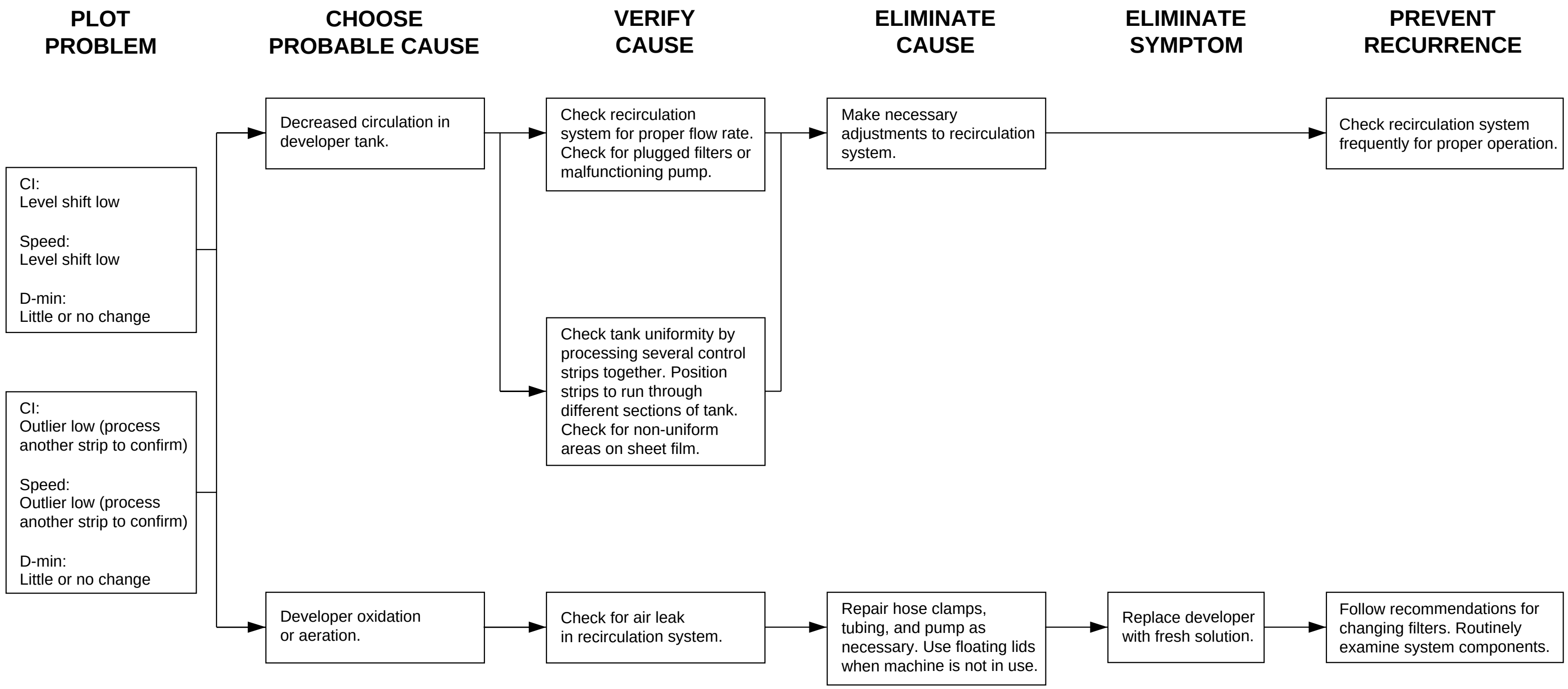
F002_9103EC

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Level shift low Speed: Level shift low D-min: Little or no change	Developer contaminated with fixer.	Check developer and fixer levels. Developer may have strong ammonia odor. Check for proper connection of replenishment lines. Check for splashing of fixer into developer.	Use care when mixing and using chemicals.	Flush developer tank thoroughly. Refill tank with fresh developer solution.	Follow standard housekeeping procedures to avoid contamination. Ensure that machine is properly leveled. Avoid improperly connecting replenishment lines.
CI: Outlier low (process another strip to confirm) Speed: Outlier low (process another strip to confirm) D-min: Little or no change	Developer contaminated with stop bath.	Check developer and stop bath levels. Check for proper connection of replenishment lines. Check for splashing of stop bath into developer.	Use care when mixing and using chemicals.	Flush developer tank thoroughly. Refill tank with fresh developer solution.	Follow standard housekeeping procedures to avoid contamination. Ensure that machine is properly leveled. Avoid improperly connecting replenishment lines.

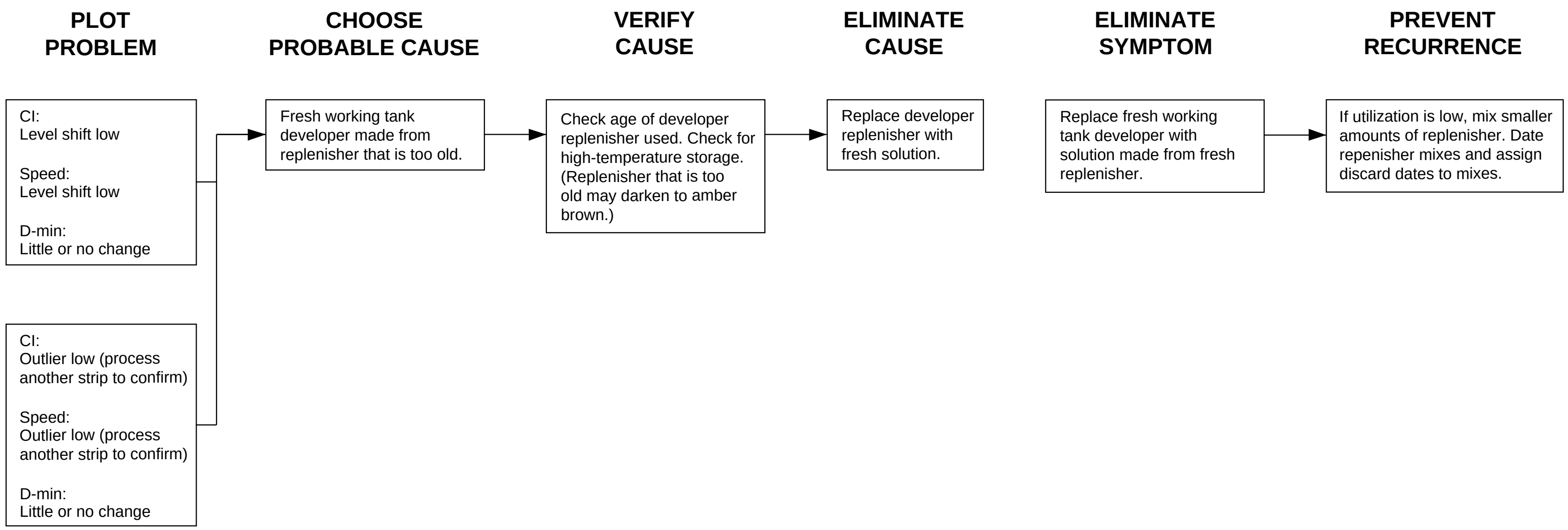
F002_9104EC

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Level shift low Speed: Level shift low D-min: Little or no change	For All Developers Mix error in fresh working tank solution: developer too dilute or too much starter added (in systems that use DURAFLO RT Developer Replenisher). For T-MAX RS Developer and Replenisher Mix error in fresh working tank solution: developer not diluted or too much Part B used.	Check specific gravity of developer tank solution. Check mixing records and procedures.	Follow mixing instructions carefully.	Refill tank with fresh developer solution.	Verify accuracy of measurement vessels and mix tanks. Ensure correct mixing procedures.
CI: Outlier low (process another strip to confirm) Speed: Outlier low (process another strip to confirm) D-min: Little or no change	Developer too dilute.	Check for leaks in water-jacketed developer tanks or cooling coils. Check for excessive water additions to maintain solution level.	Make repairs and adjustments as necessary.	Add developer replenisher to developer tank solution until CI and speed plot within action limits, or replace developer tank solution.	Routinely check equipment and perform regular maintenance. Record amount of water used to "top off" tanks.
	Fresh working tank developer contaminated.	Check mixing area for possible source of contamination.	Use care when mixing and using chemicals.	Flush developer tank thoroughly. Refill tank with fresh developer solution.	Always thoroughly clean mixing area and all mixing equipment immediately after use.

F002_9105EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Level shift low
Speed: Level shift low
D-min: Little or no change
CI: Outlier low (process another strip to confirm)
Speed: Outlier low (process another strip to confirm)
D-min: Little or no change
Decreased circulation in developer tank.
Check recirculation system for proper flow rate. Check for plugged filters or malfunctioning pump.
Check tank uniformity by processing several control strips together. Position strips to run through different sections of tank. Check for non-uniform areas on sheet film.
Make necessary adjustments to recirculation system.
Check recirculation system frequently for proper operation.
Developer oxidation or aeration.
Check for air leak in recirculation system.
Repair hose clamps, tubing, and pump as necessary. Use floating lids when machine is not in use.
Replace developer with fresh solution.
Follow recommendations for changing filters. Routinely examine system components.

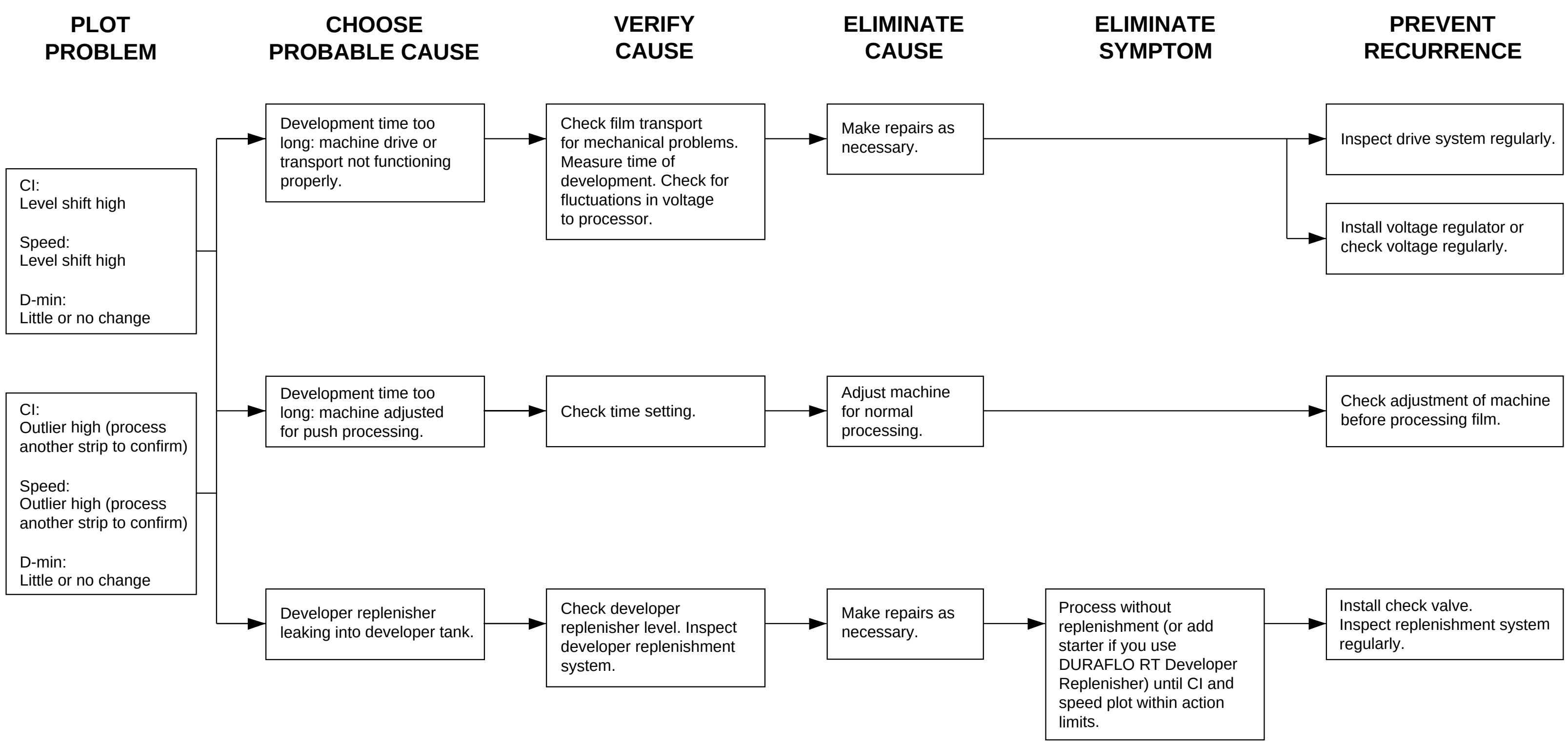
F002_9106EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Level shift low
Speed: Level shift low
D-min: Little or no change
CI: Outlier low (process another strip to confirm)
Speed: Outlier low (process another strip to confirm)
D-min: Little or no change
Fresh working tank developer made from replenisher that is too old.
Check age of developer replenisher used. Check for high-temperature storage. (Replenisher that is too old may darken to amber brown.)
Replace developer replenisher with fresh solution.
Replace fresh working tank developer with solution made from fresh replenisher.
If utilization is low, mix smaller amounts of replenisher. Date repenisher mixes and assign discard dates to mixes.

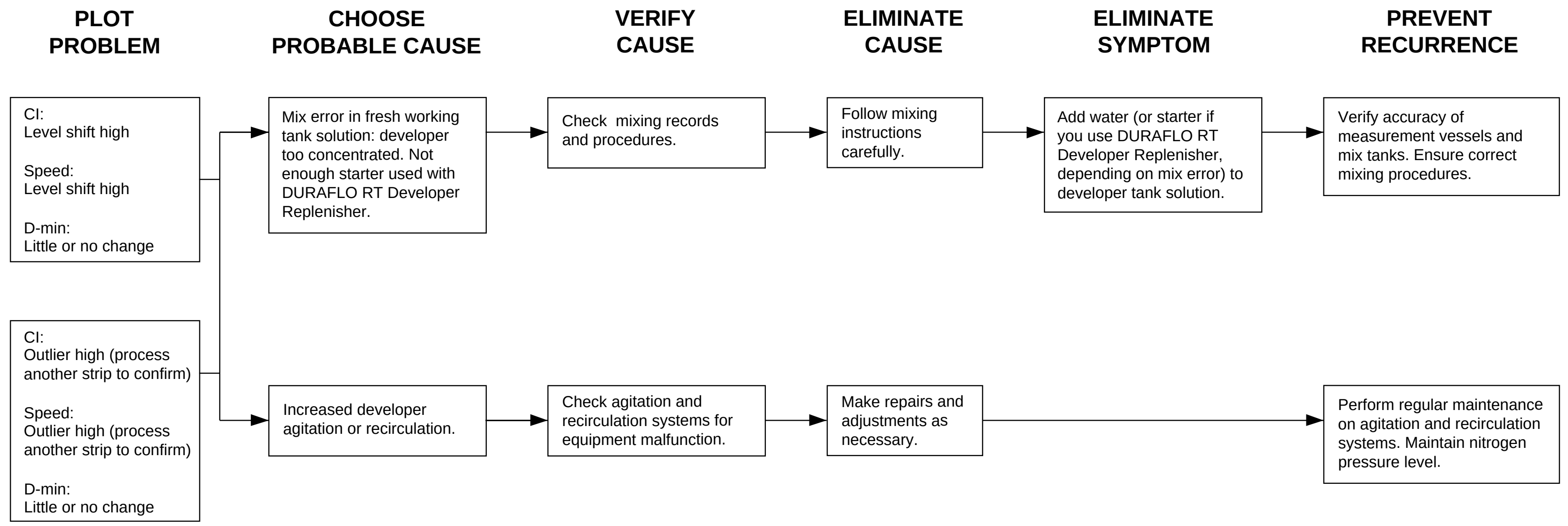
F002_9107EC

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Level shift high Speed: Level shift high D-min: Little or no change	High temperature: faulty temperature control.	Check temperature–control system. Recheck temperature with accurate thermometer.	Make necessary repairs or adjustments.	Check tank temperature before processing film.	Routinely inspect and perform maintenance on temperature-control system.
CI: Outlier high (process another strip to confirm) Speed: Outlier high (process another strip to confirm) D-min: Little or no change	High temperature: thermometer inaccurate.	Compare reading to reading of accurate thermometer.	Replace thermometer and recheck temperature.	Check tank temperature before processing film.	Regularly check thermometer accuracy.
	High temperature: heat exchanger set to incorrect temperature.	Check temperature setting of heat exchanger.	Make necessary corrections or adjustments.	Check tank temperature before processing film.	Ensure that heat exchanger is set to correct temperature.

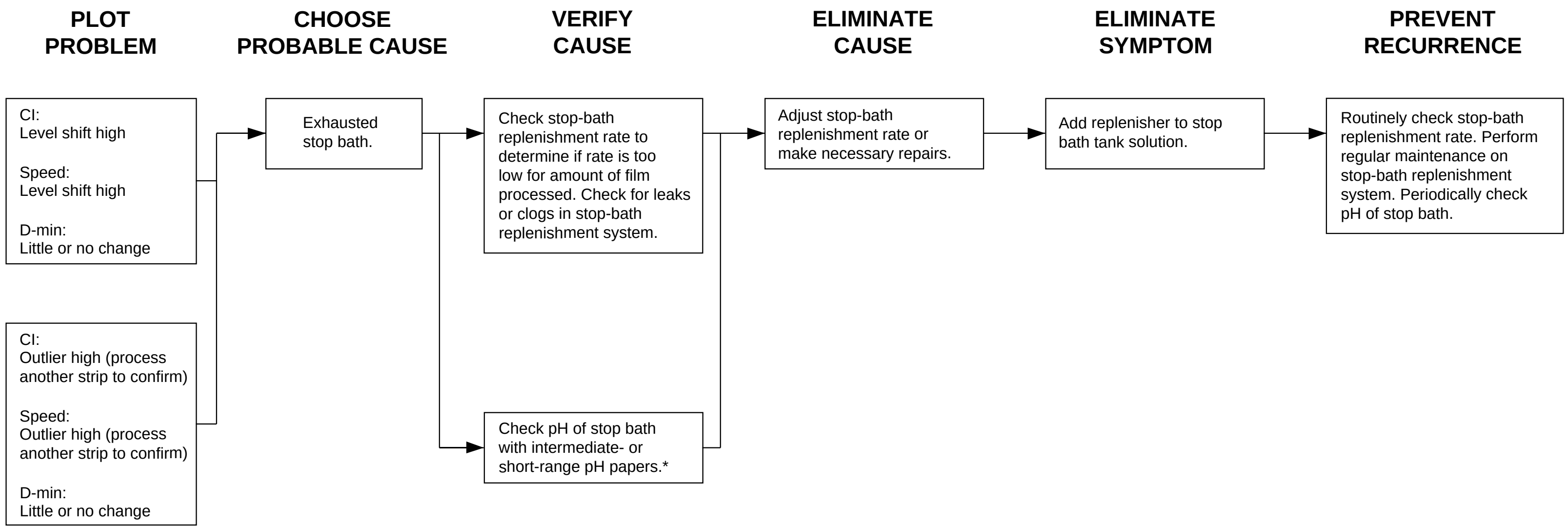
F002_9108EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Level shift high
Speed: Level shift high
D-min: Little or no change
CI: Outlier high (process another strip to confirm)
Speed: Outlier high (process another strip to confirm)
D-min: Little or no change
Development time too long: machine drive or transport not functioning properly.
Check film transport for mechanical problems. Measure time of development. Check for fluctuations in voltage to processor.
Make repairs as necessary.
Inspect drive system regularly.
Install voltage regulator or check voltage regularly.
Development time too long: machine adjusted for push processing.
Check time setting.
Adjust machine for normal processing.
Check adjustment of machine before processing film.
Developer replenisher leaking into developer tank.
Check developer replenisher level. Inspect developer replenishment system.
Make repairs as necessary.
Process without replenishment (or add starter if you use DURAFLO RT Developer Replenisher) until CI and speed plot within action limits.
Install check valve. Inspect replenishment system regularly.

F002_9109EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Level shift high
Speed: Level shift high
D-min: Little or no change
Mix error in fresh working tank solution: developer too concentrated. Not enough starter used with DURAFLO RT Developer Replenisher.
Check mixing records and procedures.
Follow mixing instructions carefully.
Add water (or starter if you use DURAFLO RT Developer Replenisher, depending on mix error) to developer tank solution.
Verify accuracy of measurement vessels and mix tanks. Ensure correct mixing procedures.
CI: Outlier high (process another strip to confirm)
Speed: Outlier high (process another strip to confirm)
D-min: Little or no change
Increased developer agitation or recirculation.
Check agitation and recirculation systems for equipment malfunction.
Make repairs and adjustments as necessary.
Perform regular maintenance on agitation and recirculation systems. Maintain nitrogen pressure level.

F002_9110EC

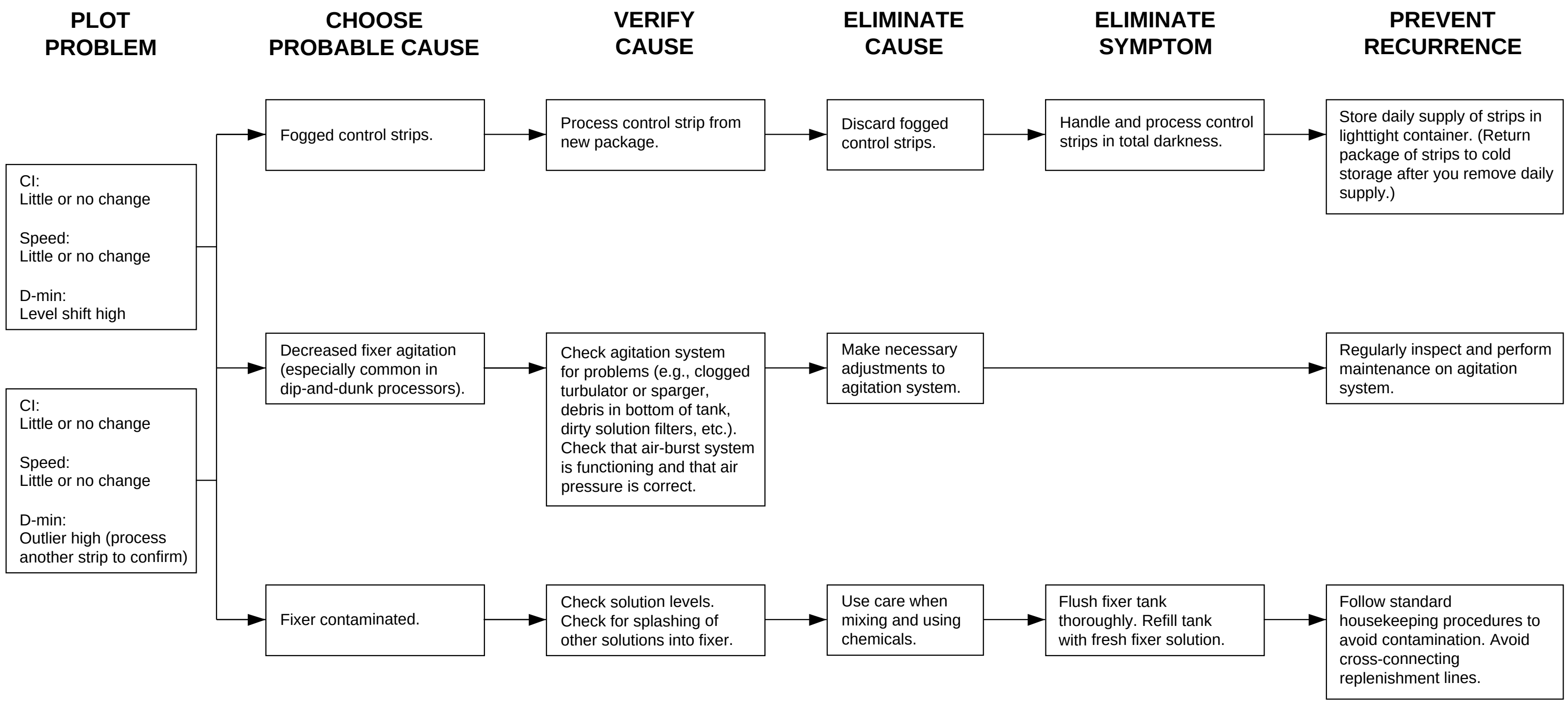


F002_9111EC

* The acceptable range for the pH of stop bath is 4.0 to 5.0. A fresh solution may have a pH of 3.0.

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Level shift low Speed: Level shift high D-min: Level shift high	Fogged control strips.	Process control strip from new package.	Discard fogged control strips.	Handle and process control strips in total darkness.	Store daily supply of strips in lighttight container. (Return package of strips to cold storage after you remove daily supply.)
CI: Outlier low (process another strip to confirm) Speed: Outlier high (process another strip to confirm) D-min: Outlier high (process another strip to confirm)	Developer contaminated.	Check mixing area and equipment for source of contamination.	Flush developer tank thoroughly. Replace developer and replenisher with fresh solution.		Always thoroughly clean mixing area and all mixing equipment immediately after each use.

F002_9112EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Little or no change
Speed: Little or no change
D-min: Level shift high
CI: Little or no change
Speed: Little or no change
D-min: Outlier high (process another strip to confirm)
Fogged control strips.
Process control strip from new package.
Discard fogged control strips.
Handle and process control strips in total darkness.
Store daily supply of strips in lighttight container. (Return package of strips to cold storage after you remove daily supply.)
Decreased fixer agitation (especially common in dip-and-dunk processors).
Check agitation system for problems (e.g., clogged turbulator or sparger, debris in bottom of tank, dirty solution filters, etc.). Check that air-burst system is functioning and that air pressure is correct.
Make necessary adjustments to agitation system.
Regularly inspect and perform maintenance on agitation system.
Fixer contaminated.
Check solution levels. Check for splashing of other solutions into fixer.
Use care when mixing and using chemicals.
Flush fixer tank thoroughly. Refill tank with fresh fixer solution.
Follow standard housekeeping procedures to avoid contamination. Avoid cross-connecting replenishment lines.

F002_9113EC

PLOT PROBLEM

CI:
Little or no change

Speed:
Little or no change

D-min:
Level shift high

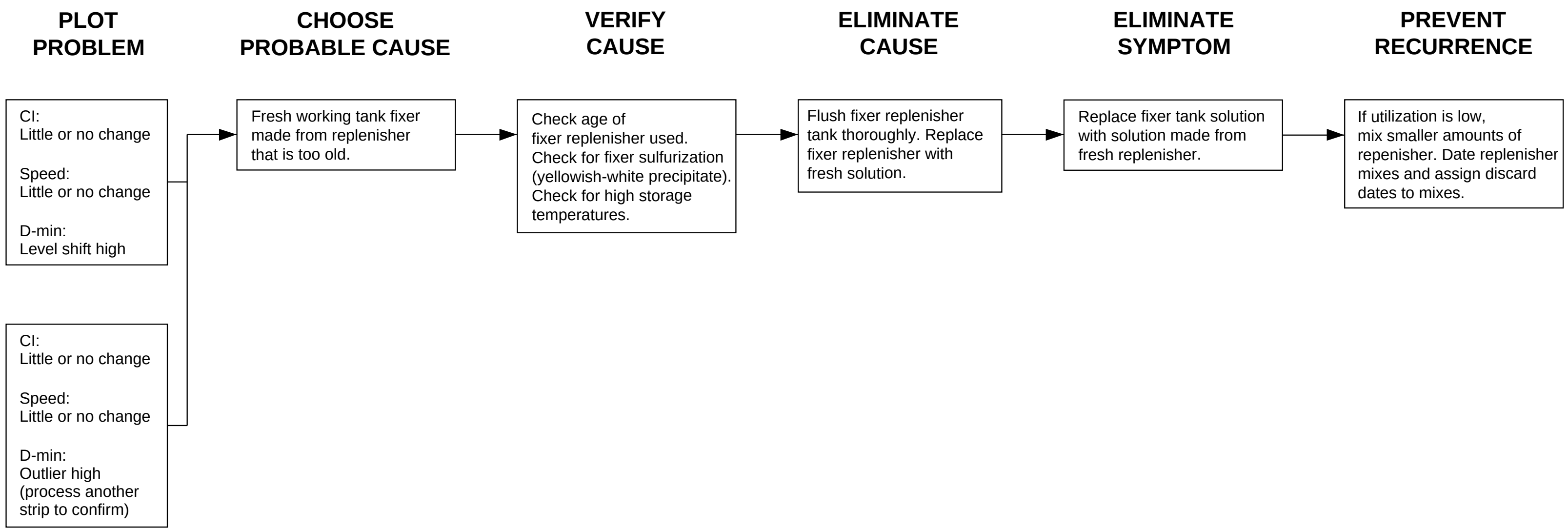
CI:
Little or no change

Speed:
Little or no change

D-min:
Outlier high (process another strip to confirm)

CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Fixer too dilute.	Check for leaks in water-jacketed fixer tanks or cooling coils. Check for excessive water additions to maintain solution level.	Make repairs and adjustments as necessary.	Add fixer replenisher or concentrate to fixer tank solution until D-min plots within action limits.	Routinely check and perform regular maintenance on equipment. Record amount of water used to top off tanks.
Mix error in fresh working tank solution: fixer too dilute.	Check specific gravity of fixer tank solution. Check mixing records and procedures.	Follow mixing instructions carefully.	Add fixer replenisher or concentrate to fixer tank solution until specific gravity is correct.	Verify accuracy of measurement vessels and mix tanks. Ensure corrrect mixing procedures.
Fresh fixer working tank solution contaminated.	Check mixing area for source of contamination.	Use care when mixing and using chemicals.	Flush fixer tank thoroughly. Refill tank with fresh fixer solution.	Always thoroughly clean mixing area and all mixing equipment immediately after use.
Decreased circulation in fixer tank.	Check fixer recirculation for proper flow rate. Check for plugged filters or malfunctioning pump.	Make necessary adjustments or repairs to recirculation system.		Check recirculation system frequently for proper operation.

F002_9114EC


PLOT PROBLEM
CHOOSE PROBABLE CAUSE
VERIFY CAUSE
ELIMINATE CAUSE
ELIMINATE SYMPTOM
PREVENT RECURRENCE
CI: Little or no change
Speed: Little or no change
D-min: Level shift high
CI: Little or no change
Speed: Little or no change
D-min: Outlier high (process another strip to confirm)
Fresh working tank fixer made from replenisher that is too old.
Check age of fixer replenisher used. Check for fixer sulfurization (yellowish-white precipitate). Check for high storage temperatures.
Flush fixer replenisher tank thoroughly. Replace fixer replenisher with fresh solution.
Replace fixer tank solution with solution made from fresh replenisher.
If utilization is low, mix smaller amounts of repenisher. Date replenisher mixes and assign discard dates to mixes.

F002_9115EC

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Little or no change Speed: Little or no change D-min: Trend up	Developer tank solution too concentrated: excessive evaporation.	Check specific gravity of developer. Check for failure to "top off" tank with water at startup. Check for excessive agitation, exhaust air flow, low humidity.	Monitor specific gravity of developer; establish specific-gravity aim.	Add water to developer tank solution until CI and speed plot with action limits.	"Top off" developer tank with water at startup. Use floating lids. Minimize time machine is up to temperature. Avoid running transport, agitation, etc., when no film is being processed. Monitor level of humidity.
	Fixer underreplenishment: replenisher pumps improperly set or not in proper calibration.	Check pump calibration. Refix strip in fresh fixer.*	Adjust pumps to provide correct amount of replenisher for amount of film being processed.	Add fixer replenisher to fixer tank solution until D-min plots within action limits.	Routinely check amount of fixer replenisher used and amount of film processed. Periodically calibrate replenisher pumps.
	Fixer underreplenishment: leaky or plugged pumps or faulty check valves.	Check pumps and valves. Refix strip in fresh fixer.*	Make necessary repairs.	Add fixer replenisher to fixer tank solution until D-min plots within action limits.	Routinely check amount of fixer replenisher used and amount of film processed. Perform regular maintenance on fixer replenishment system.

F002_9116EC

* If D-min goes down after refixing, proceed with corrective action indicated; if D-min stays the same, check control strips for fog.

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Little or no change Speed: Little or no change D-min: Trend up	Fixer underreplenishment: film sensor not functioning properly.	Check sensor. Refix strip in fresh fixer.*	Repair sensor.	Add fixer replenisher to fixer tank solution until D-min plots within action limits.	Routinely check amount of fixer replenisher used and amount of film processed. Check sensors regularly.
	Fixer underreplenishment: replenishment rate not calculated properly.	Check calculation. Keep record of amount of film processed and amount of replenisher used. Refix strip in fresh fixer.*	Recalculate fixer replenishment rate.	Add fixer replenisher to fixer tank solution until D-min plots within action limits.	Routinely check amount of fixer replenisher used and amount of film processed. Ensure all fixer replenishment-rate calculations are done correctly.
	Fixer underreplenishment: replenisher supply hose pinched.	Check hose. Refix strip in fresh fixer.*	Make necessary repairs.	Add fixer replenisher to fixer tank solution until D-min plots within action limits.	Routinely check amount of fixer replenisher used and amount of film processed. Check hose regularly.
	Fixer replenisher contaminated.	Check mixing area and equipment for source of contamination.	Use care when mixing and using chemicals.	Flush fixer and fixer replenisher tanks thoroughly. Replace fixer and fixer replenisher with fresh solutions.	Always thoroughly clean mixing area and all mixing equipment immediately after use. Follow standard housekeeping procedures to avoid contamination.

F002_9117EC

* If D-min goes down after refixing, proceed with corrective action indicated; if D-min stays the same, check control strips for fog.

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Little or no change Speed: Little or no change D-min: Trend up	Fixer underreplenishment: replenisher too dilute (mix error).	Check specific gravity of fixer tank solution and replenisher. Check mixing records and procedures. Refix strip in fresh fixer.*	Replace fixer replenisher with fresh solution. Follow mixing instructions carefully.	Add concentrate to fixer tank solution until specific gravity is correct.	Routinely check amount of fixer replenisher used and amount of film processed. Verify accuracy of measurement vessels and mix tanks. Ensure correct mixing procedures. Monitor specific gravity of fixer tank solution.
	Fixer too dilute.	Check for leaks in water-jacketed fixer tanks or cooling coils. Check for excessive water additions to maintain solution level.	Make repairs and adjustments as necessary.	Add fixer replenisher to fixer tank solution until CI and speed plot within action limits.	Routinely check and perform regular maintenance on equipment. Record amount of water used to top off tanks.
	ROLLER-TRANSPORT OR CINE PROCESSORS Short fixing time: loss of fixer volume due to leak.	Check fixer tank and recirculation system for leaks. Check that drain valves are closed and do not leak.	Make repairs and adjustments as necessary.	Add working tank solution to fixer tank until solution is at normal level.	Regularly inspect and maintain recirculation system. Check solution levels before processing film.

F002_9118EC

* If D-min goes down after refixing, proceed with corrective action indicated; if D-min stays the same, check control strips for fog.

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
CI: Little or no change Speed: Little or no change D-min: Trend up	Fixer replenisher too old.	Check for low utilization or poor storage of fixer replenisher (i.e., high temperature, no floating lids).	Replace fixer replenisher with fresh solution.	Add fresh fixer replenisher to fixer tank solution until D-min plots within action limits.	If utilization is low, mix smaller amounts of replenisher. Date replenisher mixes and assign discard dates to mixes.
	Fixer underreplenishment: replenisher tank empty.	Check level of fixer replenisher in replenisher tank.	Refill fixer replenisher tank.	Add fixer replenisher to fixer tank solution until D-min plots within action limits.	Routinely check amount of fixer replenisher used and amount of film processed. Periodically check solution level in replenisher tank and refill when necessary.

F002_9119EC

Troubleshooting from the Appearance of Processed Film

The following table will help you use the appearance of processed film to diagnose process problems. Whenever you take corrective action, process another control strip to confirm that the change has returned the process to control before you resume normal processing.

Problem with Film Appearance	Possible Cause	Corrective Action
Milkiness (most apparent in low-density areas)— pale, white translucence	Retained silver halide due to inadequate fixing	Check fixer dilution, time, and temperature.
Graininess or mottle— white, grainy particles	Sulfurized fixer	Check fixer for sources of oxidation (e.g., excessive aeration or agitation). Replace fixer.
Surface dirt	Dirt in solutions or water	Filter solutions and change filters regularly. Dump and clean wash and PHOTO-FLO Solution tanks regularly.
	Dirt particles from air, dirty work area, or processing/drying equipment	Clean processor and dryer regularly. Follow good housekeeping habits.
Scum— very fine dissolved material that dries and makes surface cloudy	Dirty PHOTO-FLO Solution	Dump and replace solution routinely.
	Dirt or dust from dryer	Change filters in dryer routinely.
	Dirt in solutions	Use floating covers on processor and replenisher tanks. Change filters in recirculating system weekly.
	Sulfurized fixer	Replace fixer.
Severe magenta (pink) stain	Retained sensitizing dye due to inadequate fixing and/or washing	Check fixer dilution, time, and temperature. Check wash time and flow rate. Check for fixer exhaustion or underreplenishment.
Streaks of non-uniform density	Excessive or uneven developer agitation	Check and adjust agitation if needed. With gaseous-burst agitation, check that initial burst is adequate and uniformly distributed throughout tank.
Mottle— areas of non-uniform density	Inadequate developer agitation	Check and adjust agitation if needed. With gaseous-burst agitation, check that initial burst is adequate and uniformly distributed throughout tank.
Chemical splash marks— irregular or random density differences	Excessively high Solution level	Check and correct solution levels; wash level should be higher than that of other solutions.
	Excessive agitation	Check and correct agitation.

Problem with Film Appearance	Possible Cause	Corrective Action
Scratches and/or abrasions— marks on emulsion or base side	Dirt or chemical buildup on rollers, squeegees, or racks of continuous or roller-transport processors	Check and clean these parts routinely. Follow good housekeeping habits.
	Stuck, misaligned, or dirty rollers	Check alignment with test film or leader. Replace worn bearings or rollers.
	Processor mechanical problems	Check processor for mechanical problems. Follow routine maintenance schedule.
	Cinch marks due to excessive tension, improper handling or loading	Check processor for mechanical problems. Train operators in correct handling methods.
	Dirt in camera	Notify customer.
Water marks— marks caused by excess water that causes differential drying	Water collecting in perforations	Check that PHOTO-FLO Solution is diluted correctly.
	Water rundown from clips (rack-and-tank processors)	Check that wash and PHOTO-FLO Solution levels do not cover clips.
	Water splashed on film	Check and eliminate source of splashing.
	Inadequate drying	Check that drying temperature is adequate.
	Film drying too quickly	Reduce drying temperature.
Skivings— thin pieces of emulsion	Rollers not aligned (roller-transport or continuous processors)	Adjust equipment.
Pressure marks— plus-density areas (e.g., half-moons, crescents, etc.)	Poor film handling	Train operators in correct handling methods.
	Excessive tension (continuous processors)	Check processor for mechanical problems.
	Camera malfunction	Notify customer.
Static marks— branch-like marks, circular spots with dark centers, row of spots (often surrounded by fogged areas)	Static electricity discharges before development	Maintain moderate levels of humidity and temperature in splicing and processing areas. Handle film carefully. Separate rolls and sheets slowly and carefully.

Problem with Film Appearance	Possible Cause	Corrective Action
Light fog— plus density (especially noticeable in low-density areas)	Incorrect use of safelight	Check safelight and follow recommendations.
	Inspection during development	*Do not* develop by inspection.
	Light leaks in darkroom or processor; luminescent tape, timers, indicators; fluorescent lamp afterglow	Find and eliminate light leaks and light sources.
	Improper film loading or handling by customer; camera malfunction	Notify customer.
Dark film— abnormally high density	Overdevelopment or extreme overexposure	Check developer time, temperature, mixing; check camera exposure.
	Light fog	See “Light fog.”
Light film— abnormally low density	Underdevelopment or extreme underexposure	Check developer time, temperature, mixing; check camera exposure.
	Liquid concentrate developer overconcentrated or underconcentrated	Mix developer in proper ratio of concentrate to water.
	Developer contaminated with fixer or stop bath	Replace contaminated developer. Wash mixing equipment thoroughly before use.
Surface spots that appear dark by transmitted light	Dirt from PHOTO-FLO Solution	Replace PHOTO-FLO Solution.
	Water spotting	Check dilution of PHOTO-FLO Solution.
	Dirt from dryer	Check cleanliness and dryer filters.
	Sulfurized fixer	Replace fixer.

MORE INFORMATION ON USING CONTROL STRIPS

Note: If you convert a processor from one black-and-white film developer and replenisher to another, follow the procedure for using control strips described under *Starting Up Your Process*.

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. Calculate the contrast index and speed of each of the six strips (use Formula 1 or 2 under *Starting Up Your Process* or Worksheet 1).
4. Average the contrast index, speed, and D-min of the three strips from the new batch. Average the contrast index, speed, and D-min of the three strips from the current batch.
5. To determine the differences between the two batches of strips, subtract the average values for contrast index, speed, and D-min of your current strips from the average values for contrast index, speed, and D-min of the new strips.
6. Apply the differences between the two batches of strips to your current aims for contrast index, speed, and D-min, and write the values on Form Y-30. Indicate the code number of the new batch of strips on your control chart.

Determining Starting-Point Development Times for Different KODAK Black-and-White Films

To determine starting-point development times for Kodak black-and-white films you haven't processed before, follow the procedure below. The values in the table correlate the contrast-index value of control strips with the development level required for a variety of Kodak films.

Note: You can also use the values in the table to confirm that your existing development times for black-and-white films are producing an optimum development level. See *Confirming Existing Development Times*.

1. Process a control strip at the times given below.* Record the development time on each strip.

   For dip-and-dunk processes—
   4 minutes, 6 minutes, 8 minutes, 10 minutes, and 12 minutes

   For roller-transport processors using KODAK DURAFLO RT Developer Replenisher—
   60 seconds, 90 seconds, 120 seconds, and 240 seconds
2. Measure the densities of the strip in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode.
3. Calculate the contrast index of each of the strips; use Formula 1 or 2 under *Starting Up Your Process* or Worksheet 1.
4. Refer to the table of contrast-index values. Find your developer, film type, and type of processing you will do (i.e., normal or push 2). *The value in the table is the contrast index that you need to obtain with your control strip*.

   Compare the contrast-index values of the control strips that you processed in step 1 with the value in the table.

* If you performed a development-time series to determine an optimum development time for control strips, you can use those control strips instead of processing additional strips; proceed to step 4.

Select the control strip that has the contrast-index value that is closest to the value in the table.

- If the contrast-index value is within ±0.02 of the value in the table, use the time for the strip you selected to process your film.
- If the contrast-index value is more than 0.02 below the value in the table, process control strips at development times that are 5 percent, 10 percent, and 20 percent longer than that of the strip you selected. Then, repeat steps 2 through 4.
- If the contrast-index value is more than 0.02 above the value in the table, process control strips at development times that are 5 percent, 10 percent, and 20 percent shorter than that of the strip you selected. Then, repeat steps 2 through 4.

Confirming Existing Development Times—To confirm that your existing development times for specific black-and-white films are providing an optimum development level, follow the procedure below:

1. Process a control strip at the development time that you currently use for a particular film and type of processing (i.e., normal or push 2).
2. Measure the densities of the strip in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode.
3. Calculate the contrast index of the strip; use Formula 1 or 2 under *Starting Up Your Process* or Worksheet 1.
4. Refer to the table at the right. Find your developer, film type, and type of processing. Compare the contrast-index value that you calculated in step 3 with the value and the range in the table.
   - If the contrast-index value is within the range in the table, record the contrast-index value and continue using your current development time for this film. Routinely process a control strip with customer film to confirm process consistency; you may find that the contrast index changes slightly as your process seasons.
   - If the contrast-index value is *not* within the range in the table, we strongly recommend additional testing to determine if you will produce negatives of higher quality by changing your development time to obtain a control-strip contrast index that is within the range in the table.

Important

The contrast-index values in the table are starting-point recommendations. Fine-tune your process as required to maximize the quality of your negatives.

The contrast-index values in the table are for printing with a diffusion enlarger. If you print with a condenser enlarger, subtract 0.15 from the values in the table.

KODAK Developer or Developer and Replenisher	KODAK PROFESSIONAL Film	Contrast Index of Control Strip	
		Normal	Push 2
PROFESSIONAL T-MAX RS	TRI-X 400	0.61 ±0.06	0.76 ±0.08
	PLUS-X 125	0.55 ±0.08	0.79 ±0.11
	T-MAX 100	0.71 ±0.04	0.92 ±0.06
	T-MAX 400	0.58 ±0.03	0.72 ±0.03
	T-MAX P3200	**EI 1600** 0.86 ±0.06	**EI 3200** 0.97 ±0.07
D-76	TRI-X 400	0.59 ±0.03	0.76 ±0.05
	PLUS-X 125	0.49 ±0.04	0.67 ±0.05
	T-MAX 100	0.62 ±0.03	0.84 ±0.05
	T-MAX 400	0.58 ±0.03	0.72 ±0.03
	T-MAX P3200	**EI 1600** 0.86 ±0.03	**EI 3200** 1.00 ±0.06
DURAFLO RT	TRI-X 400	0.68 ±0.03	0.94 ±0.06
	PLUS-X 125	0.50 ±0.06	0.69 ±0.07
	T-MAX 100	0.64 ±0.03	0.78 ±0.03
	T-MAX 400	0.58 ±0.03	0.72 ±0.03
	T-MAX P3200	**EI 1600** 0.94 ±0.03	**EI 3200** 1.09 ±0.03
XTOL	TRI-X Pan	0.53 ±0.03	0.70 ±0.05
	PLUS-X 125	0.46 ±0.04	0.70 ±0.05
	T-MAX 100	0.62 ±0.03	0.80 ±0.03
	T-MAX 400	0.57 ±0.03	0.72 ±0.03
	T-MAX P3200	**EI 1600** 0.74 ±0.03	**EI 3200** 0.83 ±0.06

SAFE HANDLING OF PHOTOGRAPHIC CHEMICALS

- Handle photographic chemicals and processing solutions with care. See KODAK Publication No. J-98A, *Safe Handling of Photographic Processing Chemicals*.
- Packages of Kodak photographic chemicals have precautionary labels when necessary. Always read the labels and follow the instructions carefully. Also read the Material Safety Data Sheets (MSDSs) for the chemicals for precautionary information.*
- Keep the darkroom, processing area, and mixing room clean. Clean up spilled chemicals promptly.
- Use personal protective equipment, such as a waterproof apron and impervious gloves made of a material such as Neoprene or nitrile, when you handle solutions. Always wear goggles or safety glasses when you mix solutions from concentrates.
- Avoid skin contact with chemicals. Some photographic solutions, especially developers, can cause allergic skin reactions. See KODAK Publication No. J-98A, *Safe Handling of Photographic Processing Chemicals*.
- Keep chemical solutions out of your mouth. Never start a siphoning action with your mouth. Do not eat or drink in a room where chemicals are mixed or used.
- Maintain proper ventilation in the mixing room and processing area.
- Store chemicals and processing solutions safely. Keep them out of the reach of children.
- Dispose of solutions safely. See KODAK Publication No. J-411, *Dealing with Hazardous Waste and Processing Effluents at Photographic Processing Facilities.*

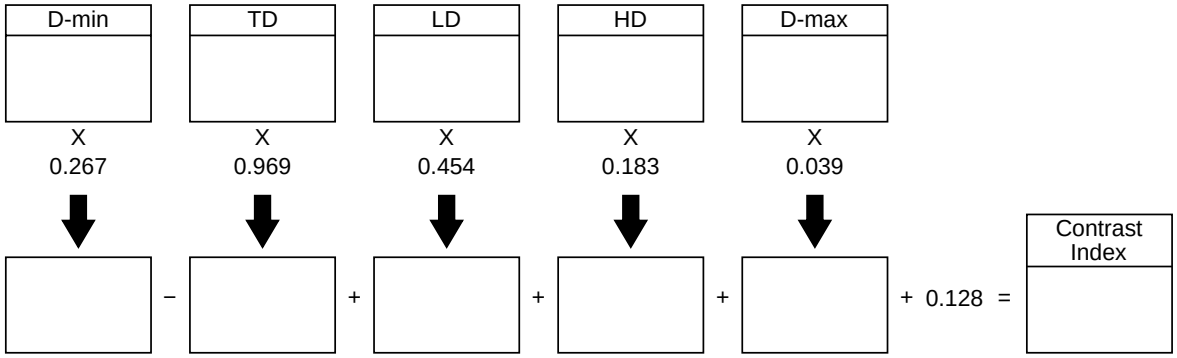
* You can obtain MSDSs for Kodak chemicals from the Kodak website at **www.kodak.com/go/MSDS**. You will need to know the catalog (CAT) numbers for the chemicals when you request MSDSs.

WORKSHEET 1

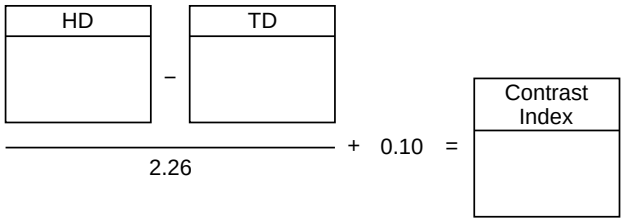
CALCULATION OF CONTRAST INDEX

1. Measure the densities of your control strip in the center of the D-min, TD, LD, HD, and D-max steps with a densitometer in the visual mode.
2. Calculate the contrast index of your control strip by using one of the following formulas. The first formula has more steps, but it will give you an answer that is more accurate than the second formula will provide. Record the densities of each step in the appropriate boxes, and then perform the calculations.

FORMULA 1

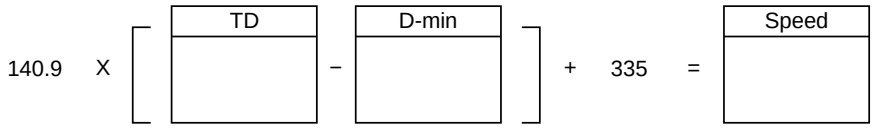


FORMULA 2



CALCULATION OF SPEED

To calculate the speed value of your control strip, record the densities of TD and D-min in the boxes below, and then perform the calculations.



Calculate Your Variations from Aim

Contrast Index				Variation from Aim (CI)
	−	0.58*	=	

Speed				Variation from Aim (Speed)
	−	355†	=	

D-min				Variation from Aim (D-min)
	−	0.06‡	=	

Plot Your Variations from Aim: Plot differences that are **larger** than the corresponding aim values (+ values) **above** the aim line, and those that are **smaller** than the aim values (– values) **below** the line.

* 0.58 is the contrast-index aim for printing negatives with a diffusion enlarger; use 0.43 if you will print negatives with a condenser enlarger.

† 355 is the speed-value aim for a replenished process for producing negatives that you will print with a diffusion enlarger; your speed value may be slightly higher when you use fresh developer. The speed-value aim for producing negatives for printing with a condenser enlarger will be between 340 and 350. The speed value is *not* an ISO/ASA speed.

‡ Use 0.09 as your aim for D-min if you process film in KODAK DURAFLO RT Developer Replenisher.

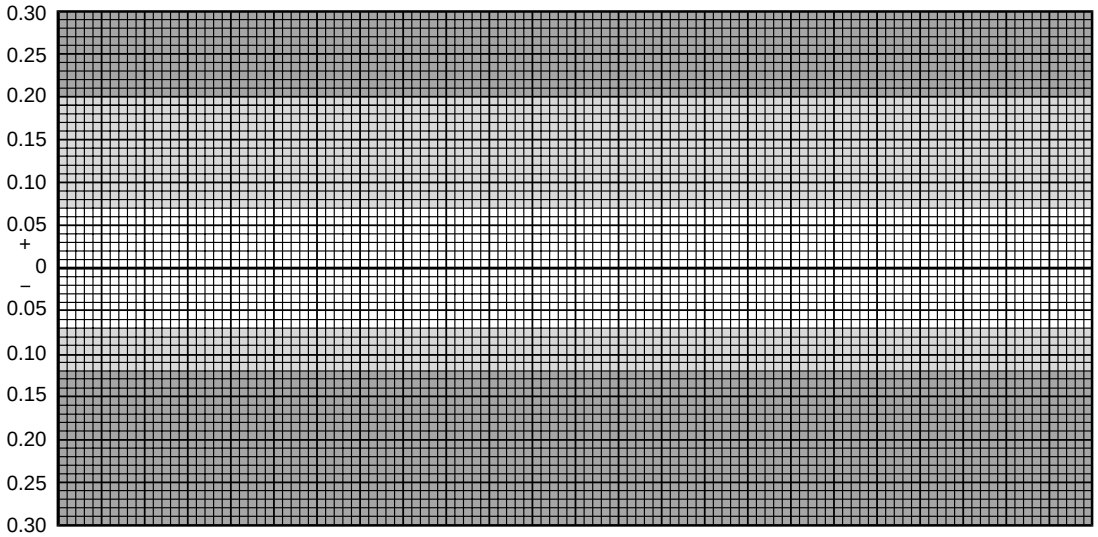
FORM Y-30

KODAK PLOTTING FORM FOR BLACK-AND-WHITE FILM PROCESSING

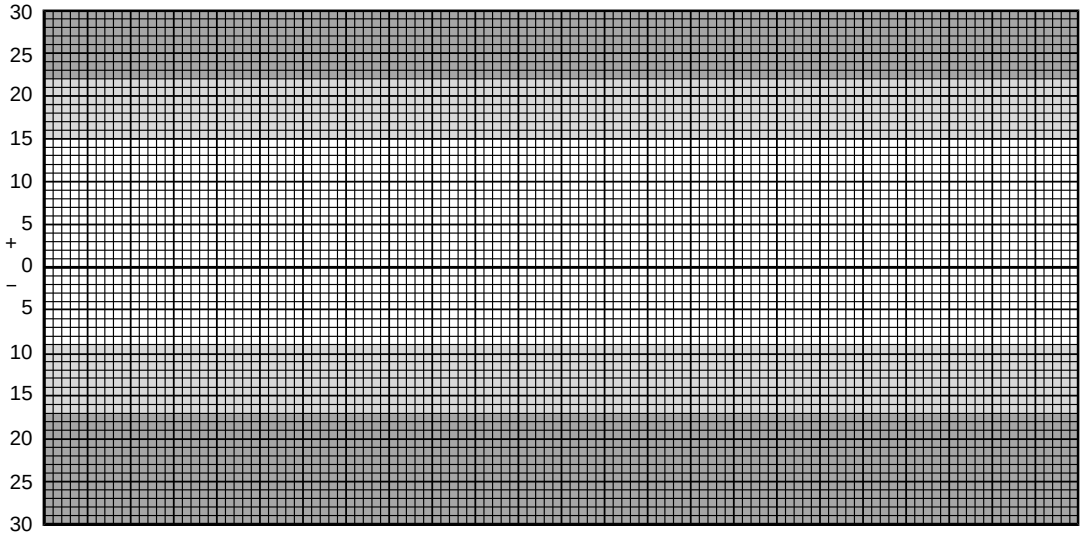
Y-30

CODE NO. _____

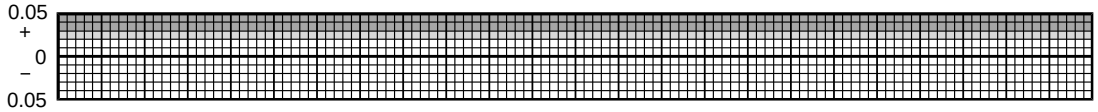
CONTRAST INDEX
Aim = 0.58



SPEED VALUE
Aim = 355



D-MIN
Aim = 0.06*



*Use 0.09 if you use KODAK DURAFLO RT Developer Replenisher

DATE

MACHINE _____

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