# 4 CONTROL-CHART EXAMPLES

The following charts are examples of how various conditions will affect your control plots. They are intended *only as a guide;* your plot may not look exactly like these examples. Your plot may be different because of processor and control-strip differences, and your processing conditions. More than one problem may also be affecting your process.

These plots are typical for a particular problem; however, if they do not exactly match your plot, find the one that most closely matches the predominant trend. Use these charts to analyze process problems.

| Chart | Solution | Condition |
|---|---|---|
| Process C-41SM | | |
| 1 | Developer | Temperature Too Low/High |
| 2 | Developer | Time Too Short/Long |
| 3 | Developer | Agitation Too Low/High |
| 4 | Developer | Replenishment Rate Error / Part A—Too Low/High |
| 5 | Developer | Replenishment Rate Error / Part B—Too Low/High |
| 6 | Developer | Replenishment Rate Error / Part C—Too Low/High |
| 7 | Developer | Replenishment Rate Error / Water—Too Low/High |
| 8 | Developer | Replenishment Rates Too Low/High |
| 9 | Developer | Oxidation |
| 10 | Developer | Contaminated with Bleach |
| 11 | Developer | Contaminated with Fixer |
| 12 | Bleach | Replenishment Rate Too Low/High |
| 13 | Bleach | Poor Aeration |
| 14 | Fixer | Underreplenished / Dilute |
| Process RA-2SM | | |
| 15 | Developer | Temperature Too Low/High |
| 16 | Developer | Replenishment Rate Error / Water—Too Low/High |
| 17 | Developer | Replenishment Rates Too Low/High |
| 18 | Developer | Contaminated with Bleach-Fix |
| 19 | Developer | Oxidation |

## Process C-41SM

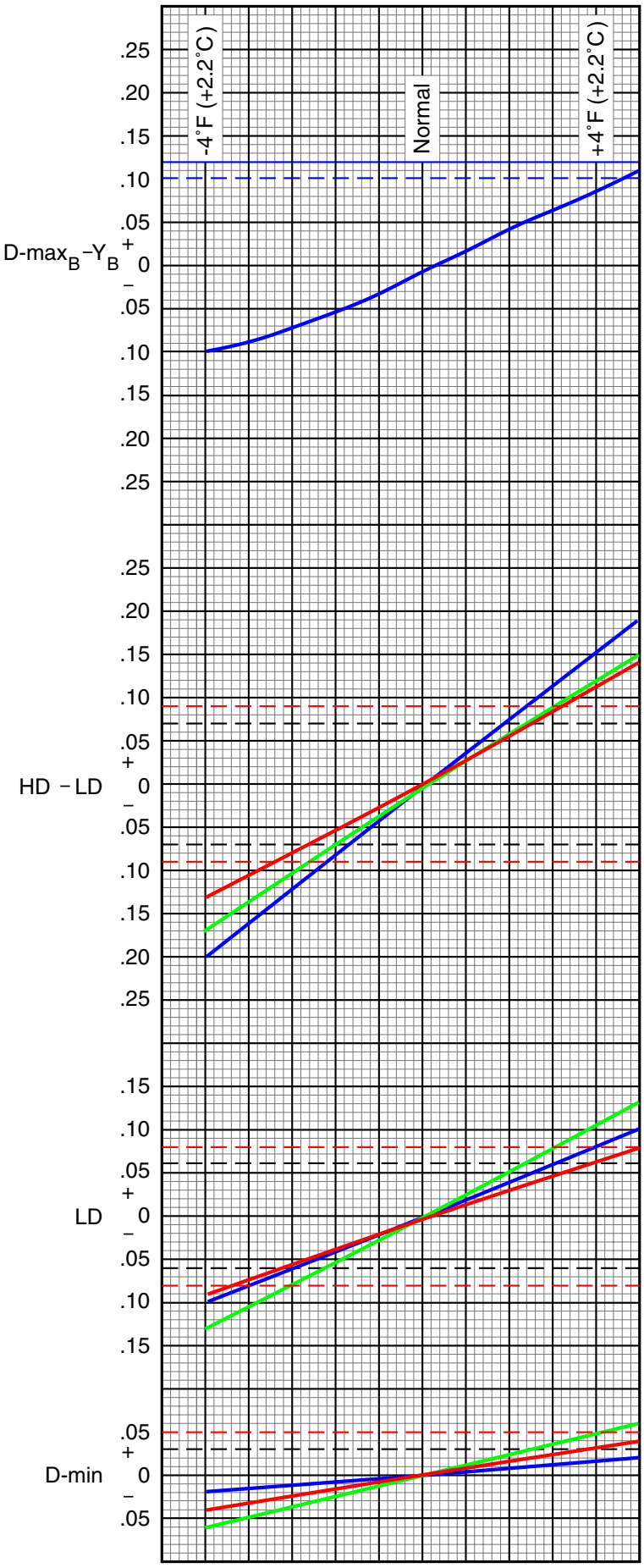
### Developer Temperature Too Low/High

The recommended developer temperature for Process C-41SM is 37.8 ± 0.15°C (100 ± 0.25°F). Developer activity varies directly with temperature. A developer temperature that is too high or too low affects development and the amount of dye formed. If the developer temperature is too high, the density values will plot higher than normal; if the developer temperature it too low, the density values will plot lower than normal.

Out-of-control conditions due to temperature changes are difficult to solve. They can appear and disappear rapidly because they are usually caused by intermittent electrical problems. Poor tank recirculation can also cause temperature problems; check that the developer recirculation filter is not clogged, and replace the filter if needed.

Check the developer temperature with an accurate thermometer frequently, and adjust it as needed.

### Chart 1



## Process C-41SM

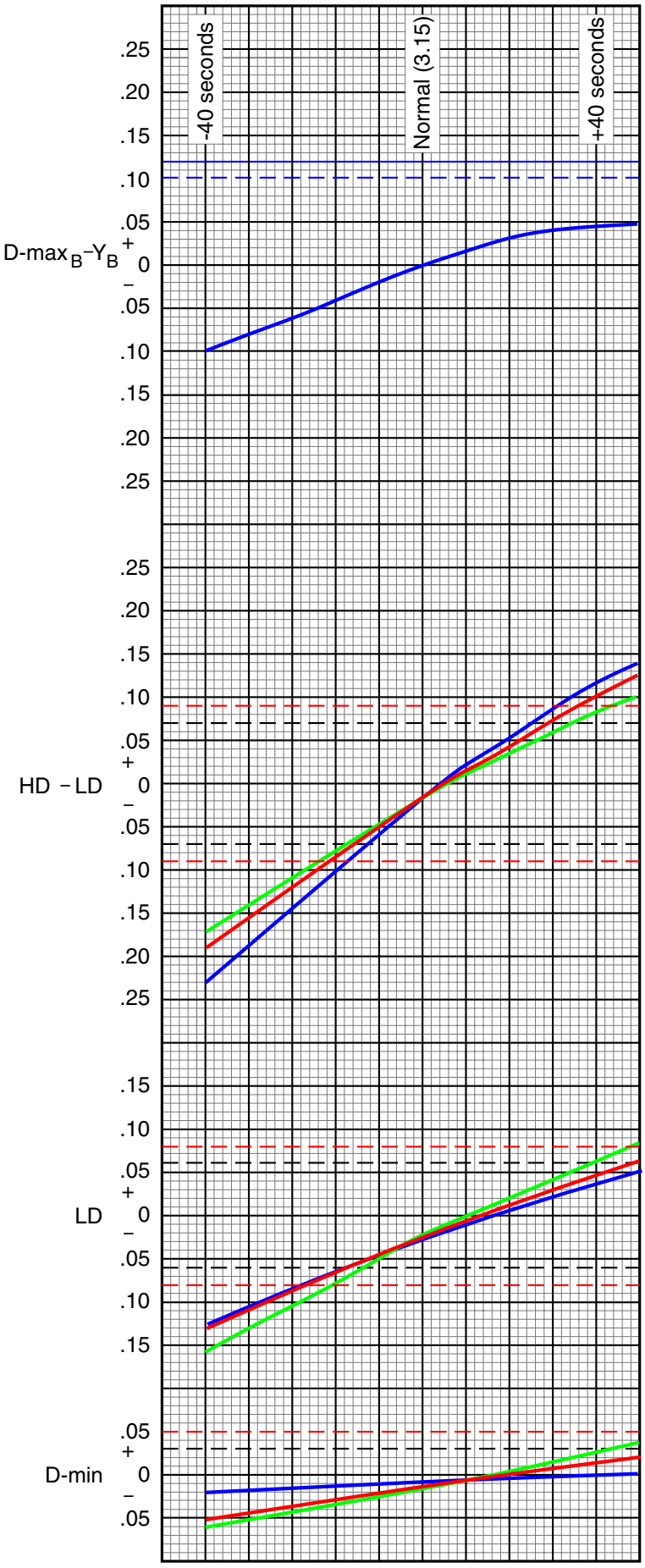
### Developer
### Time Too Short/Long

Developer activity varies directly with time. An increase in developer time produces an increase in the amount of dye formed; a decrease in developer time produces a decrease in the amount of dye formed.

Developer-time variations can occur in processors because of electrical-load variations and motor-temperature differences from a cold start to equilibrium. Electrical-load differences 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 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. Use a stopwatch to measure the developer time, and compare it with the machine setting.

### Chart 2



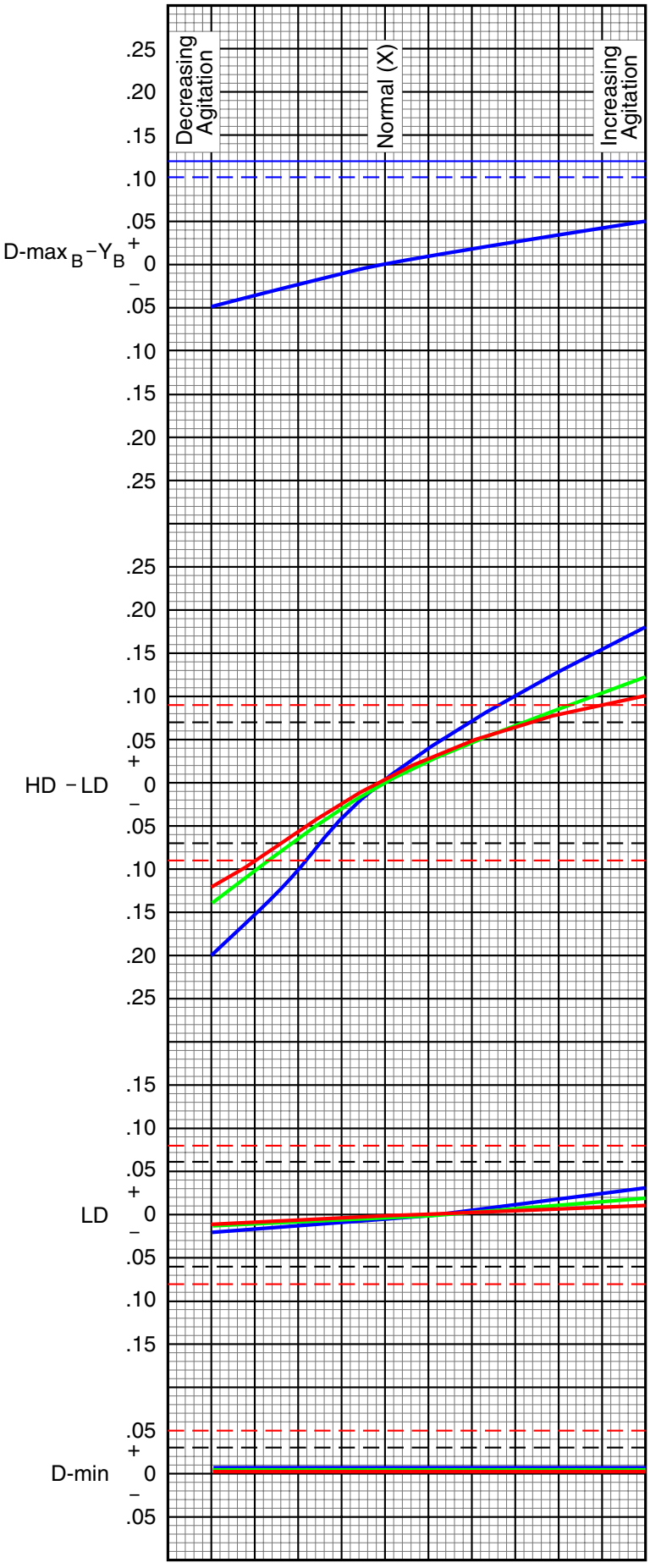
## Process C-41SM

### Developer
### Agitation Too Low/High

Agitation aids in removing developer by-products from the film so that fresh developer can diffuse into the emulsion. An increase in agitation increases the amount of dye formed. Poor agitation does not allow enough development, resulting in low and non-uniform densities. Fluctuations in agitation have the greatest effect on high densities.

Agitation is provided by a recirculation system. A kinked recirculation line or a plugged slot nozzle can hinder agitation causing underdevelopment. Also check the recirculation pumps to be sure they are working within specifications set by the manufacturer.

### Chart 3



## Process C-41SM

### Developer
### Replenishment Rate / Part A
### Too Low/High

Developer activity varies with the delivery of Part A to the developer tank. Overreplenishment results in high activity; underreplenishment results in low activity.

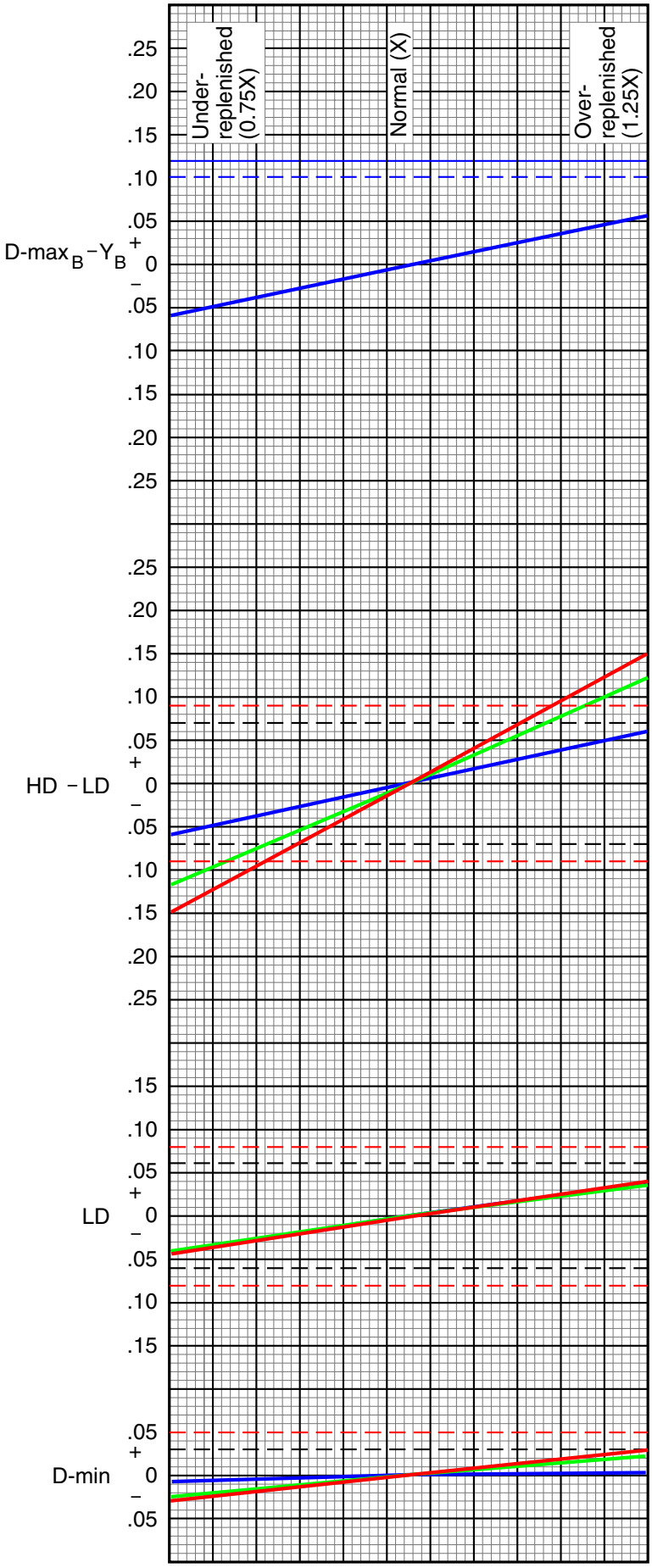
How quickly your control plots change depends on the variation from aim of your replenishment delivery and the amount of film processed.

Check the Part A cube after you replace the F1 Processing Unit; if there is substantial solution remaining in the cube, this indicates that the rate is incorrect.

If the Part A delivery is suspect—

- Check the developer replenishment pump fitting for Part A to be sure it is snug.
- Check the delivery lines for air. This is an indication that the pump valves have failed.
- Check the pump calibration.
- Check the replenishment rate setting.
- Update the pump values in your processor software.

### Chart 4



## Process C-41SM

### Developer
### Replenishment Rate / Part B
### Too Low/High

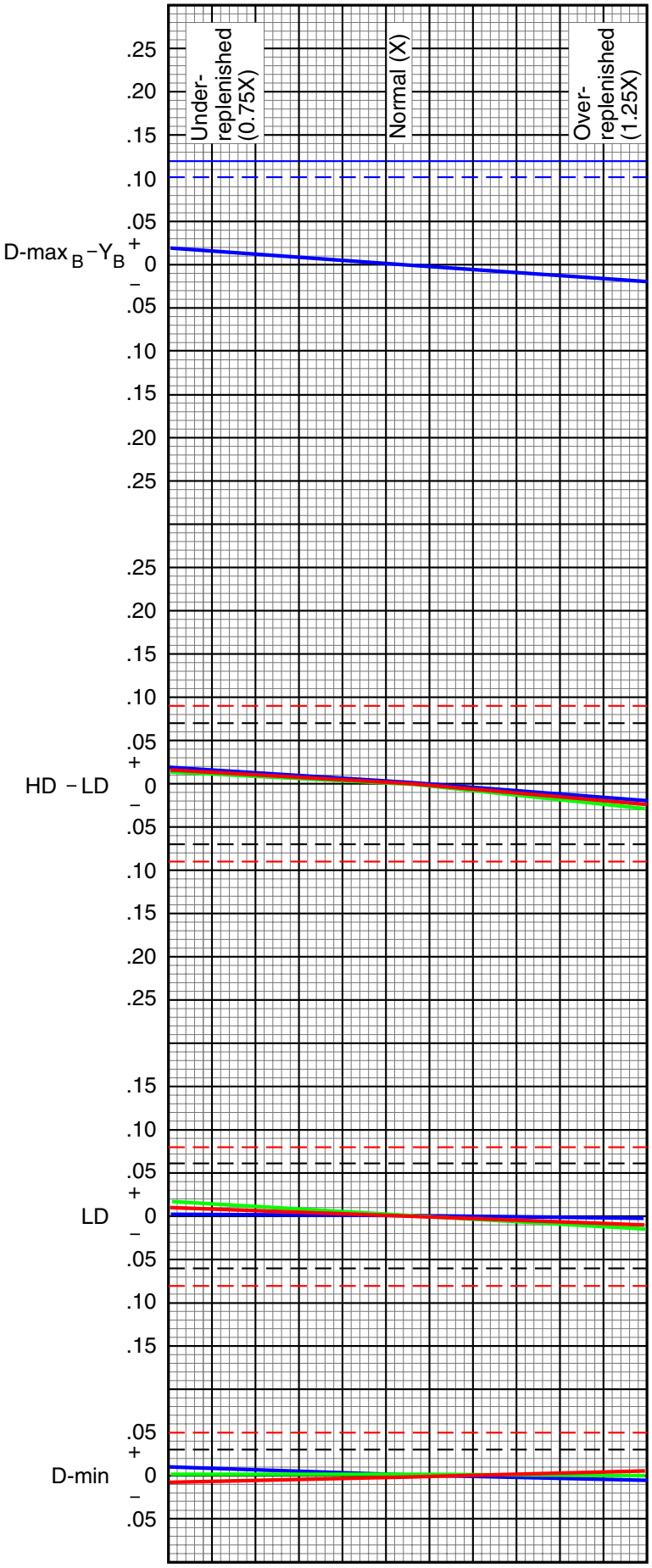
Developer activity varies only slightly with a variation in the delivery of Part B to the developer tank. Over time, however, it will affect the oxidation protection of the developer; see Chart 9.

Check the Part B cube after you replace the F1 Processing Unit; if there is substantial solution remaining in the cube, this indicates that the rate is incorrect.

If the Part B delivery is suspect—

- Check the developer replenishment pump fitting for Part B to be sure it is snug.
- Check the delivery lines for air. This is an indication that the pump valves have failed.
- Check the pump calibration.
- Check the replenishment rate setting.
- Update the pump values in your processor software.

### Chart 5



## Process C-41SM

### Developer
### Replenishment Rate / Part C
### Too Low/High

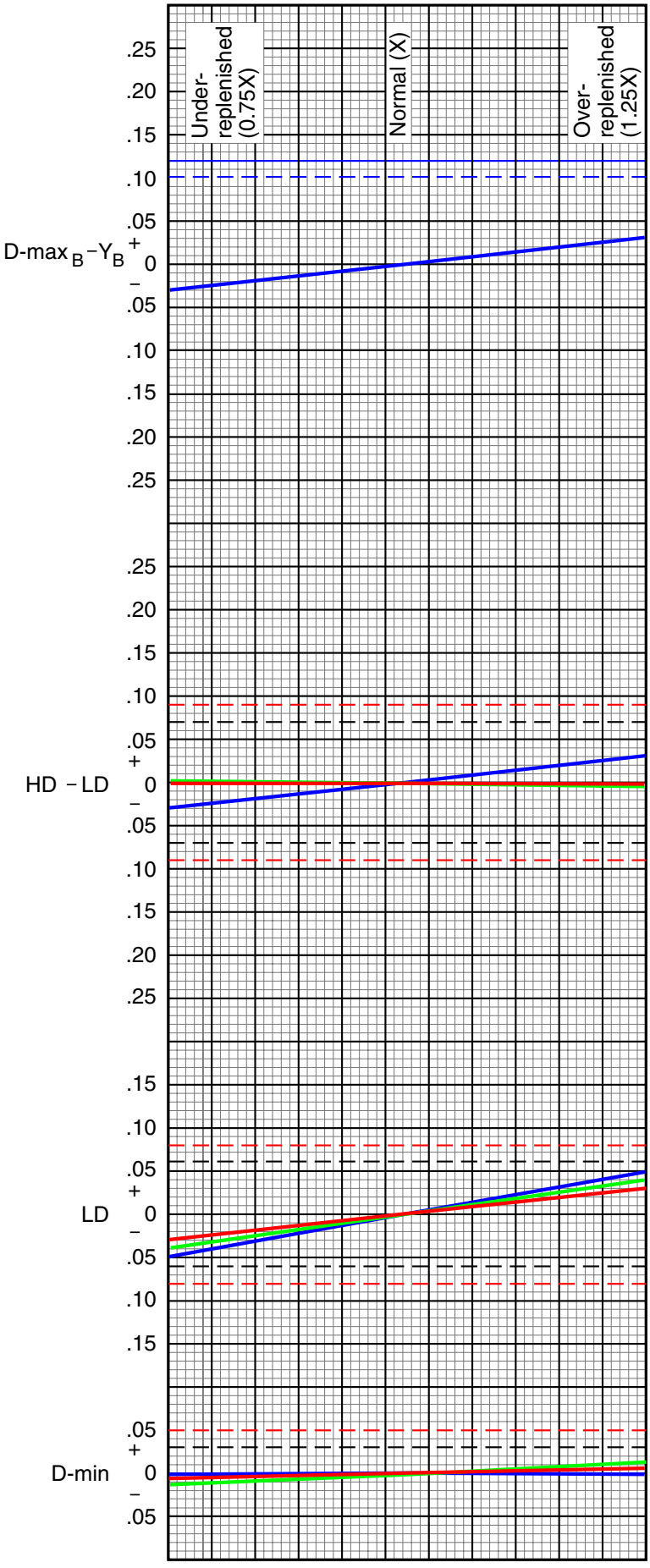
You will notice developer activity variation caused by the delivery of Part C to the developer tank first in the LD parameter; LD will increase with overreplenishment and decrease with underreplenishment.

Check the Part C cube after you replace the F1 Processing Unit; if there is substantial solution remaining in the cube, this indicates that the rate is incorrect.

If the Part C delivery is suspect—

- Check the developer replenishment pump fitting for Part C to be sure it is snug.
- Check the delivery lines for air. This is an indication that the pump valves have failed.
- Check the pump calibration.
- Check the replenishment rate setting.
- Update the pump values in your processor software.

### Chart 6



## Process C-41SM

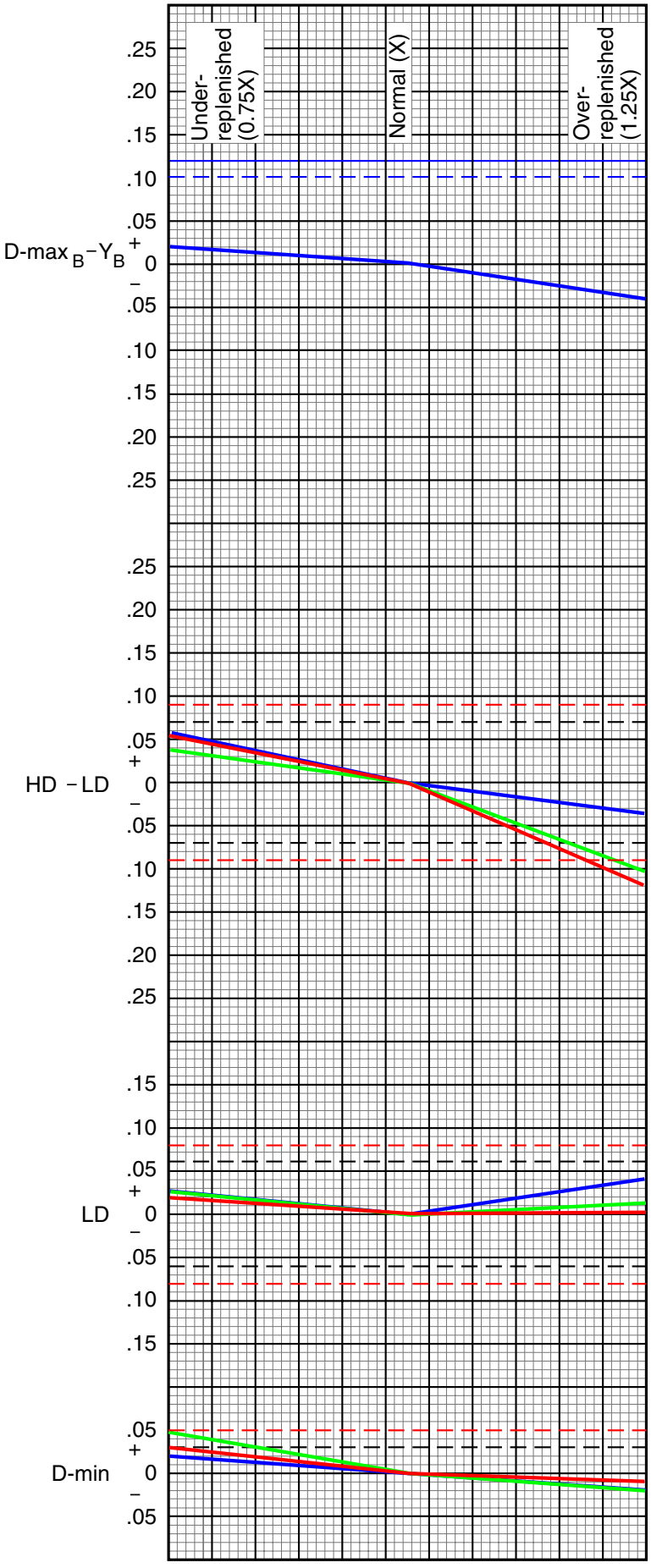
### Developer Replenishment Rate / Water Too Low/High

Developer activity varies with the delivery of water to the developer tank because the working tank solution becomes overconcentrated or diluted. For contrast (the HD – LD parameter), the activity varies inversely with the amount of water, decreasing with too much water and increasing with too little water. However, the speed (or LD parameter) increases with too much or too little water.

If the water delivery is suspect—

- Check the developer replenishment pump fitting for water to be sure it is snug.
- Check the delivery lines for air. This is an indication that the pump valves have failed.
- Check the pump calibration.
- Check the replenishment rate setting.
- Update the pump values in your processor software.

### Chart 7



## Process C-41SM

### Developer Replenishment Rates Too Low/High

Developer replenishment rates (A:B:C:water) directly affect developer activity. An overreplenished developer will produce high dye densities; an underreplenished developer will produce low dye densities. You will see the effects of over- and underreplenishment in all of the control-plot densities. The amount of change that you see in the plot as a result of incorrect replenishment depends on the developer-tank volume, processor speed, and the amount and type of film processed. If incorrect replenishment appears to be the problem, check that the replenishment system is operating properly and is correctly calibrated.

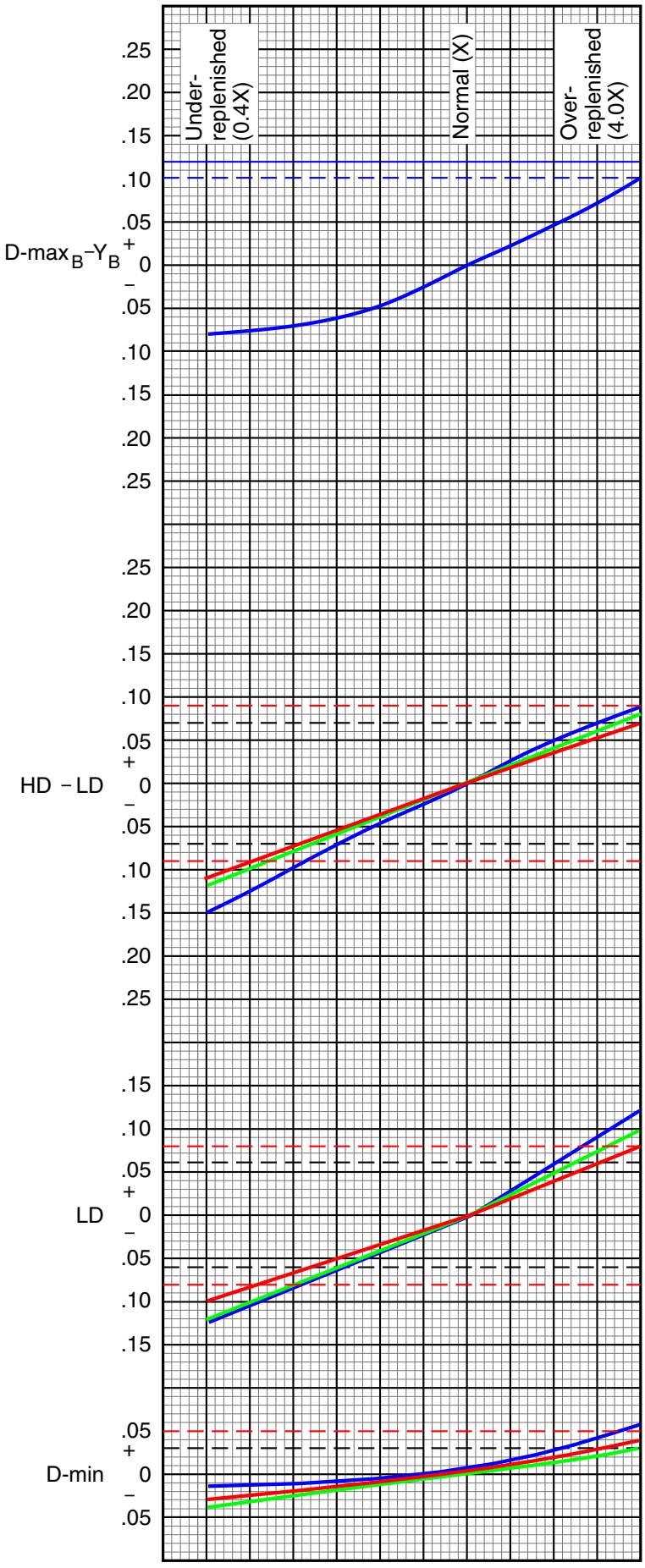
The recommended replenishment rates are *starting points only*. Exact rates depend on the types of film you process, their average densities, and how well you maintain operating conditions, such as development time and temperature. In general, higher speed films (especially ISO 400 and higher) require higher developer replenishment rates. Some private-label films and other manufacturers' films also require slightly higher developer replenishment rates. If you process more of these films, you may need to increase your developer replenishment rates by 10 to 15 percent from the starting point. Determine your exact rates by monitoring the process with control strips and adjusting the rates as needed according to the control plot. However, do not adjust the rates to "chase" small changes in the control plot. **Changing rates should be done proportionately with all developer parts, including water**.

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

If you suspect that replenishment is the problem:

- Check that the replenishment system is set correctly.
- Verify that the replenishment pumps are all operating.
- Verify that the replenishment pumps are producing the correct output.
- If the processor has been idle, verify that the "J" tubes are full of solution.

## Chart 8



## Process C-41SM

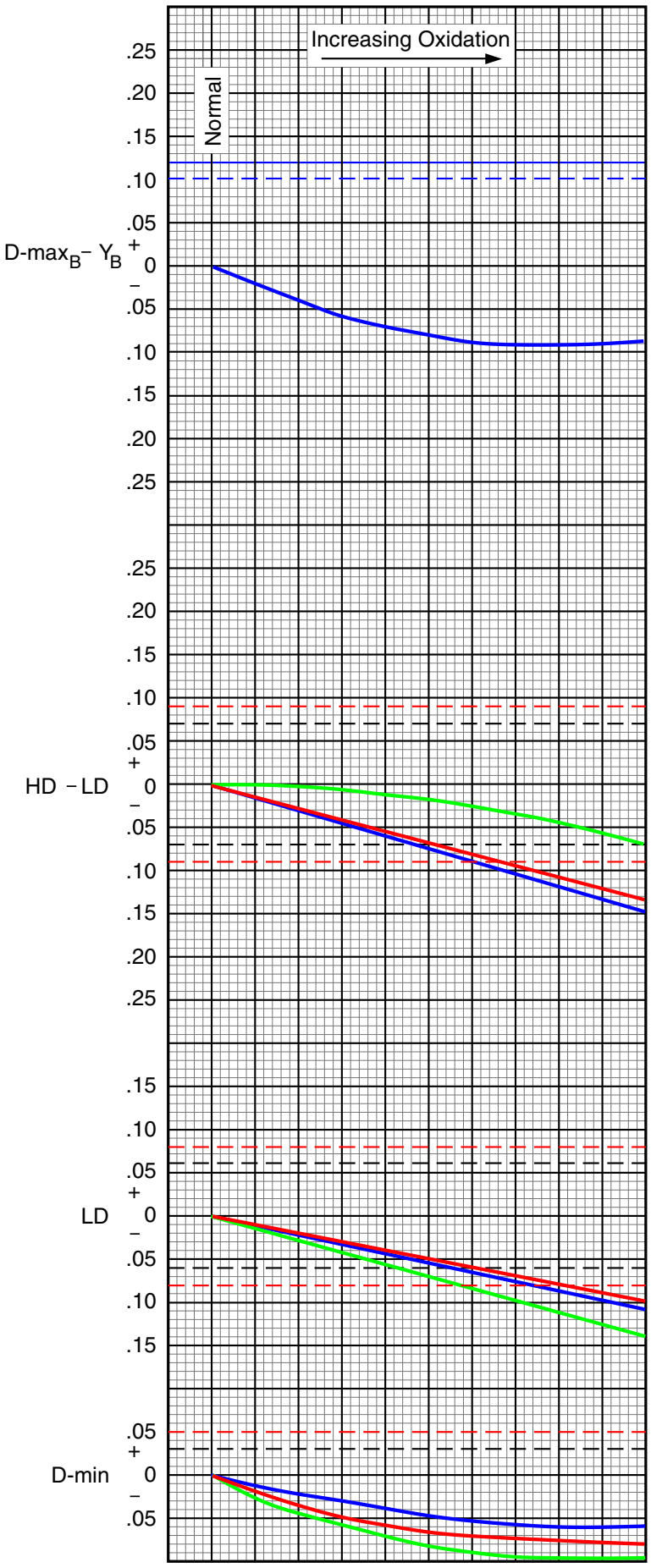
### Developer Oxidation

Developer activity varies inversely with oxidation. Increasing developer oxidation causes less dye to form, lowering density values.

Oxidation can occur during idle periods when the processor is up to temperature, but not processing film. You should be able to avoid severe oxidation problems in most processors by ensuring that at least one developer tank turnover occurs every 4 weeks. If you are operating at low utilization, follow the recommendations in KODAK Publication CIS-190, *Recommendations for the Use of KODAK SM Chemicals in Low-Utilization Operations.*

Leaks in a recirculation line or filter will allow air to bubble into the tank solution, causing oxidation. Check your equipment for leaks if oxidation occurs.

### Chart 9



## Process C-41SM

### Developer
### Contaminated with Bleach

Very small amounts of bleach will contaminate the developer and affect developer activity. The D-min and LD densities will increase because more dye forms due to chemical "fogging." And, HD – LD plots will also increase with more contamination.

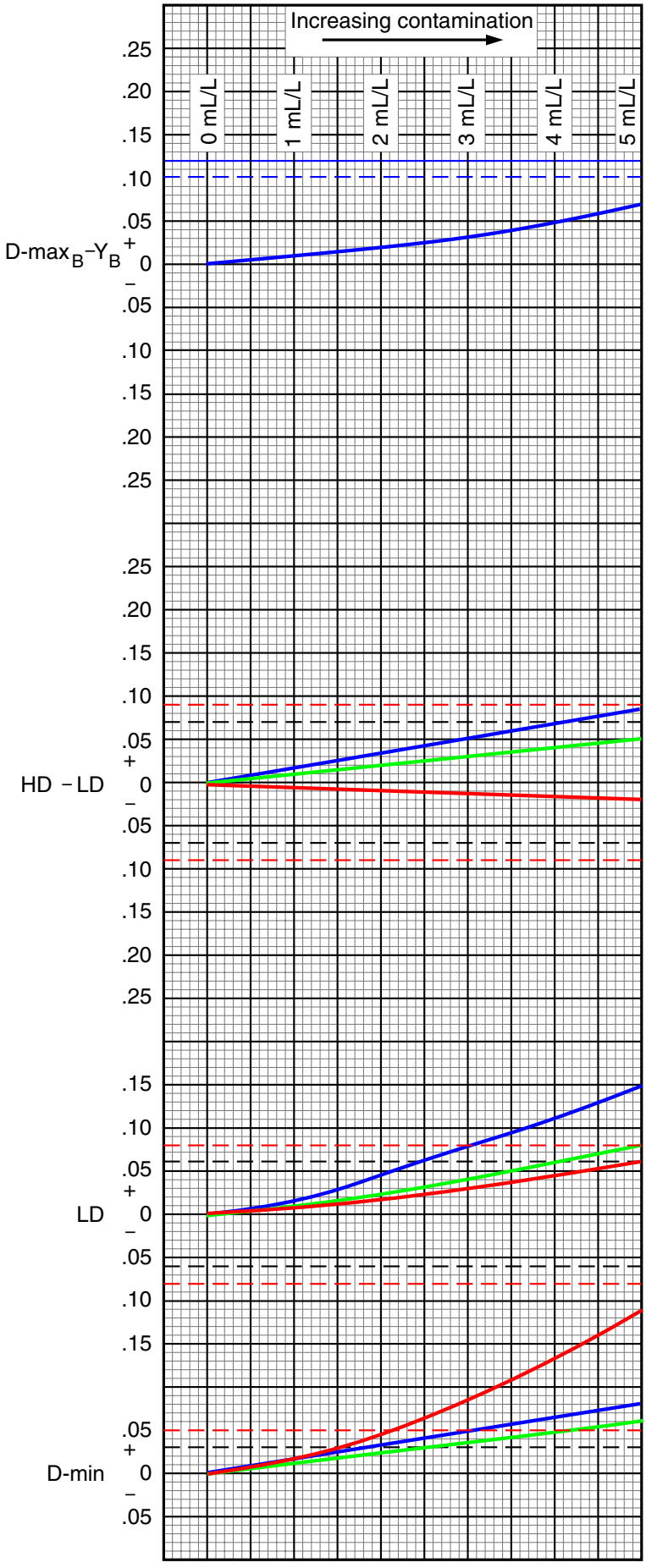
If bleach aeration is excessive, bleach solution can mist or splash and slowly contaminate the developer.

Bleach can splash back into the developer as the leader card and film emerge from the bleach. The developer can also be contaminated by less soluble bleach complexes that have been deposited on the leader card. Clean all leader cards thoroughly each day at shutdown; you may need to soak them in hot water to remove the bleach. Replace worn or damaged leader cards.

Make sure that bleach does not drip into the developer when you remove the bleach racks for cleaning, maintenance, etc.

If bleach contamination occurs, stop processing customer film. After you locate and eliminate the source of contamination, dump the developer tank solution, rinse the tank thoroughly, and mix a fresh developer tank solution.

### Chart 10



## Process C-41SM

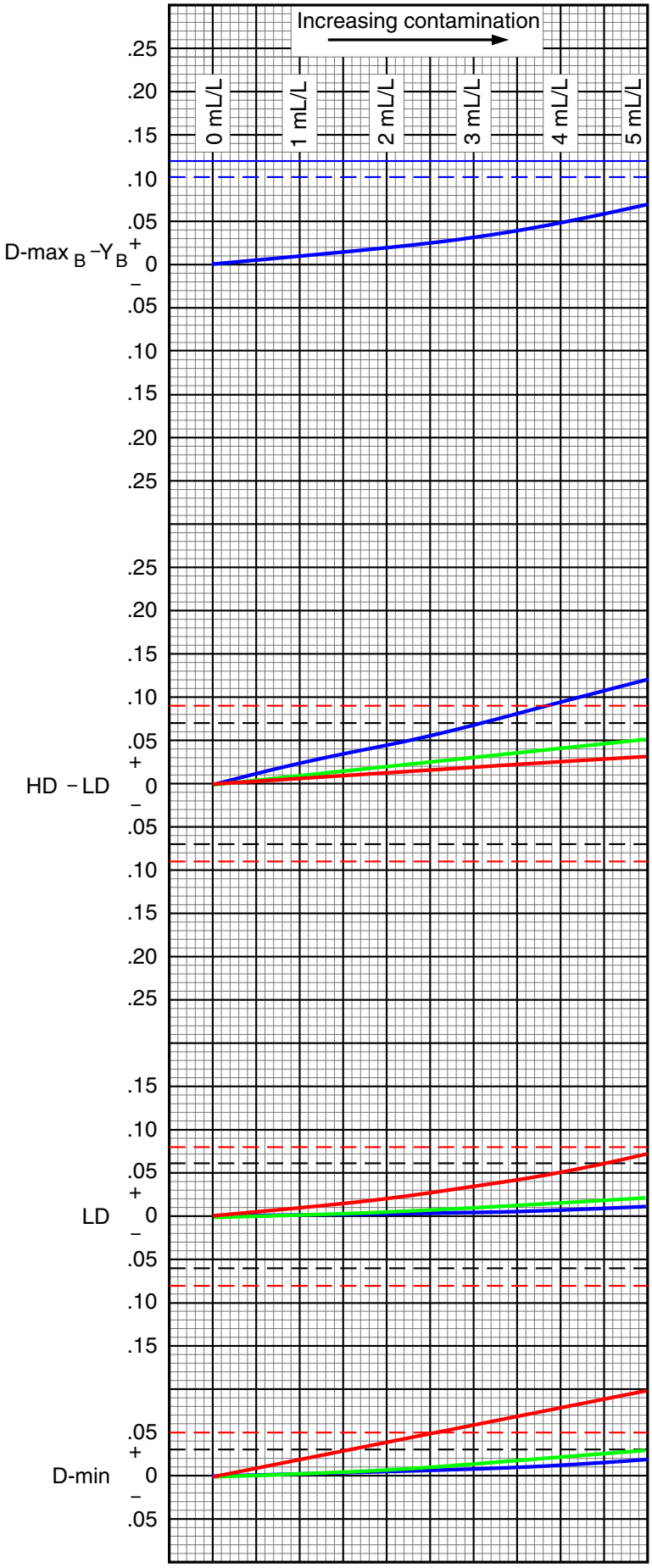
### Developer
### Contaminated with Fixer

Very small amounts of fixer will contaminate the developer and cause chemical “fogging.” As contamination increases, dye density will increase in all of the control-chart plots. Fixer contamination is most noticeable as an increase in the red D-min density.

Fixer contamination of the developer usually occurs from leader cards that are not thoroughly clean. Clean all leader cards thoroughly each day at shutdown in hot water. Replace worn or damaged leader cards.

If fixer contamination occurs, stop processing customer film. After you locate and eliminate the source of contamination, dump the developer tank solution, rinse the tank thoroughly, and mix a fresh developer tank solution.

## Chart 11



## Process C-41SM

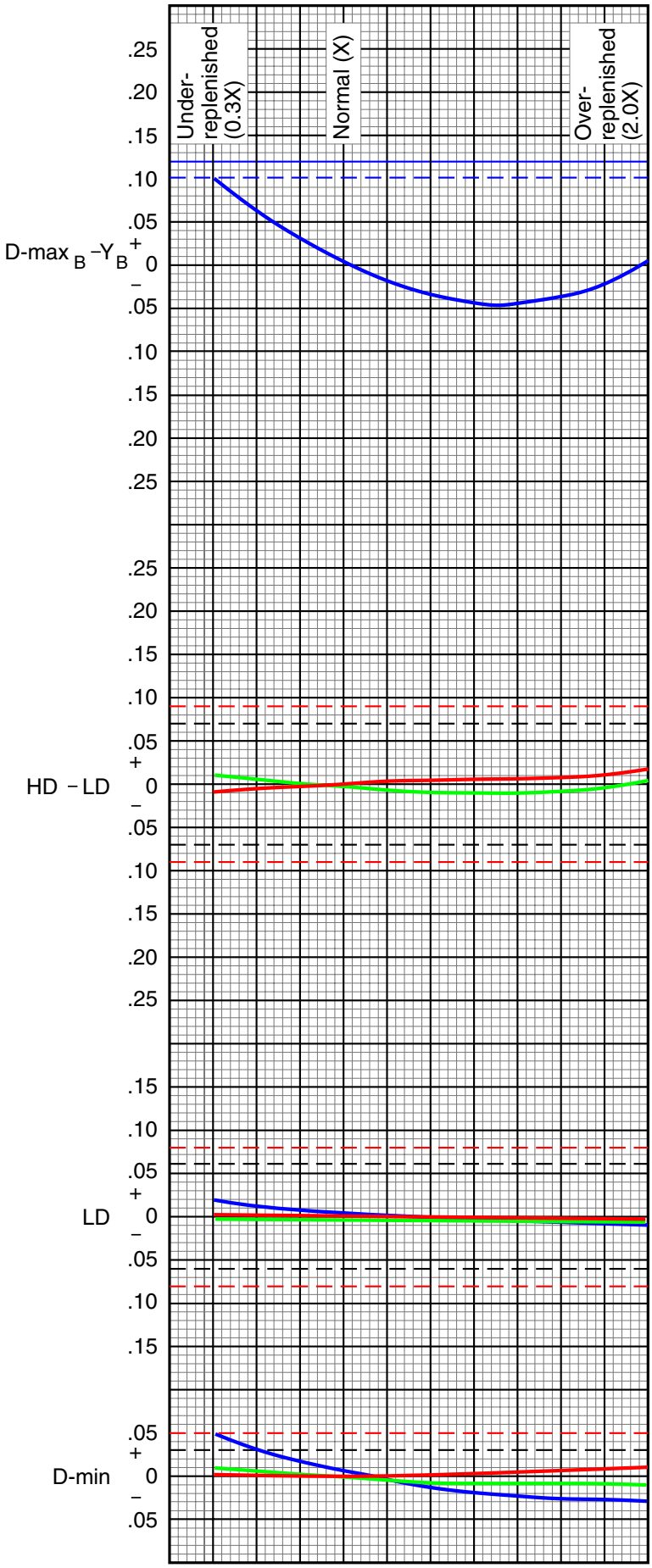
### Bleach
### Replenishment Rate
### Too Low/High

Bleach activity is affected by improper replenishment. An underreplenished bleach solution will not adequately compensate for developer carryover. The pH of the bleach will increase and total iron will decrease causing retained silver.

An underreplenishment problem is most noticeable in the D-max$_B$ – Y$_B$ plot and the blue D-min density. If you think that the problem was caused by incorrect replenishment, check that the replenishment rate and setting are correct; adjust them, if necessary. Check the bleach replenishment rate regularly.

You can correct film that has been improperly bleached by rebleaching it in a known good bleach, and then completing the remaining processing steps. To test for retained silver, follow the procedure described in *Appendix A*. If retained silver is the problem, replace the bleach tank solution and recalibrate the bleach replenisher pump.

### Chart 12



## Process C-41SM

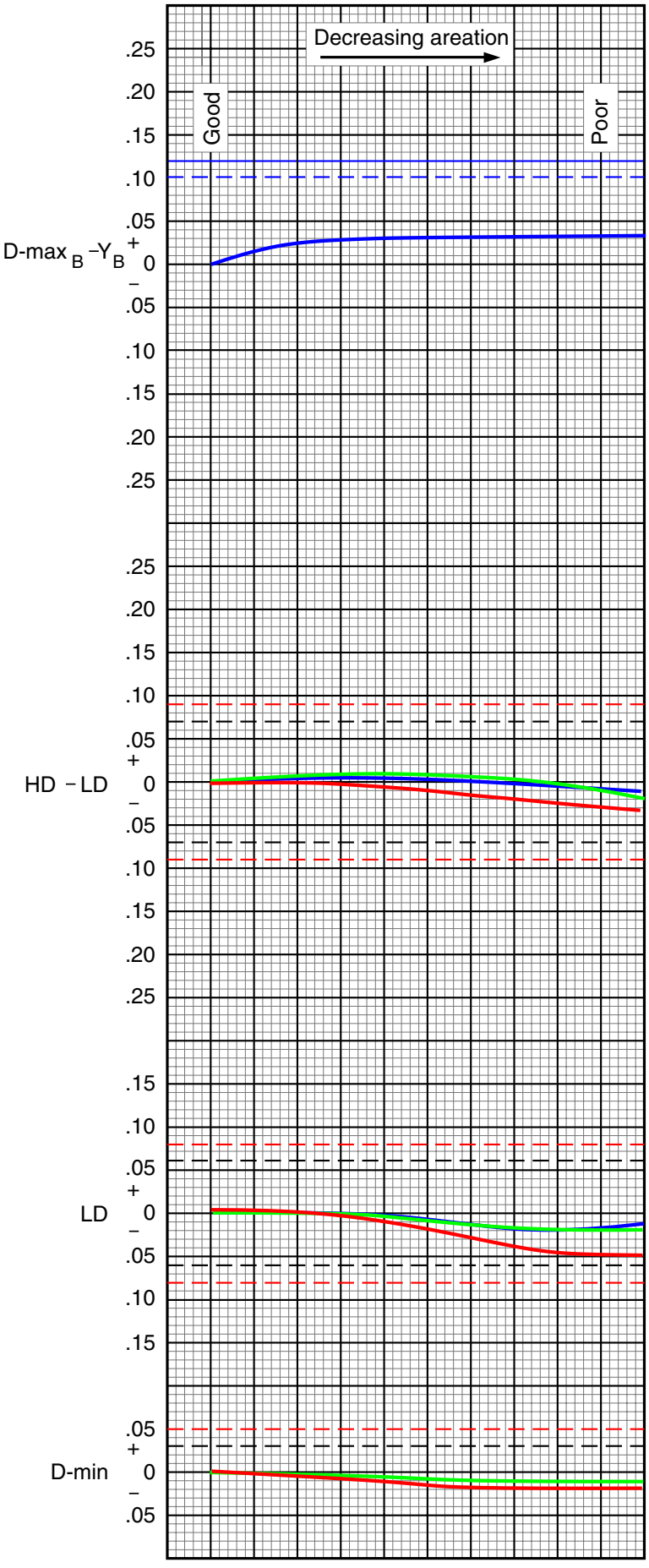
### Bleach
### Poor Aeration

Bleach activity depends on the amount of bleach aeration. Inadequate aeration causes retained silver and leuco-cyan dye.

If you determine that the problem was caused by inadequate aeration, check the air bubbling in the bleach tank. Be sure that the air supply is adequate, the tubing is clear, and the distributor tube is not clogged.

If you think that poor bleach aeration is causing an out-of-control condition, rebleach your control strip, and then complete the remaining processing steps. If rebleaching improves/increases the red HD – LD plot, the problem was caused by the bleach. You can correct film that has been improperly bleached by rebleaching it in a good bleach, and then completing the remaining processing steps. (See *Appendix A* for more information.)

### Chart 13



## Process C-41SM

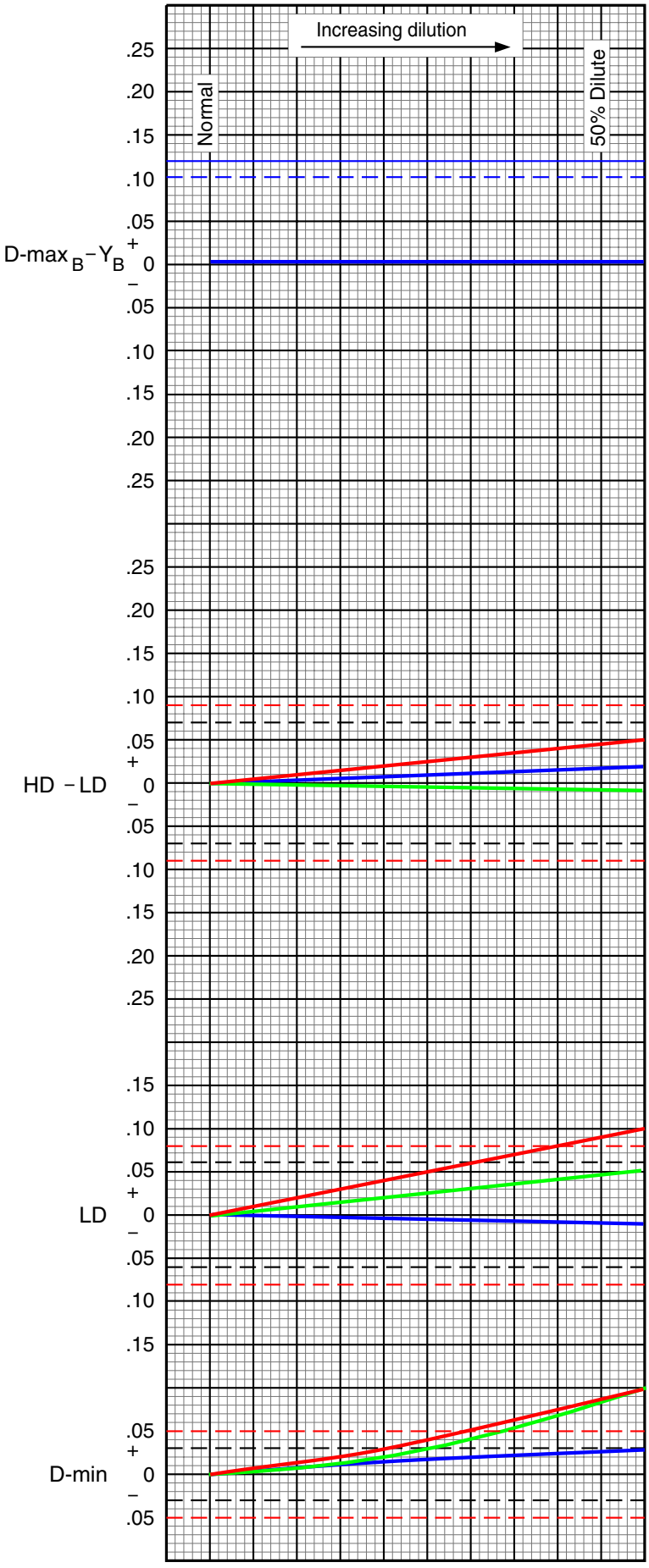
### Fixer
### Underreplenished or Too Dilute

Moderate levels of underreplenishment or fixer dilution can cause an increase in the red and green D-min and LD plot densities. When the fixer is extremely diluted, retained silver halide and sensitizer dye cause increased density in all control plots. When that occurs, the D-min areas of the film will appear cyan to a more opaque milky appearance.

The most probable causes of insufficient fixing are fixer dilution from excessive topping off with water or fixer underreplenishment.

If you think that diluted fixer is causing an out-of-control condition, refix and rewash your control strip according to the procedure in *Appendix B* on page 4-21. If refixing significantly improves the red and green D-min and LD densities, the problem was caused by the fixer. You can correct film that has been incompletely fixed by refixing and rewashing it. Be sure to eliminate the problem that causes dilution, or adjust replenishment as necessary.

### Chart 14



## Process RA-2SM

### Developer
### Temperature Too Low/High

The recommended developer temperature for Process RA-2SM is 40 ± 0.3°C (104 ± 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.

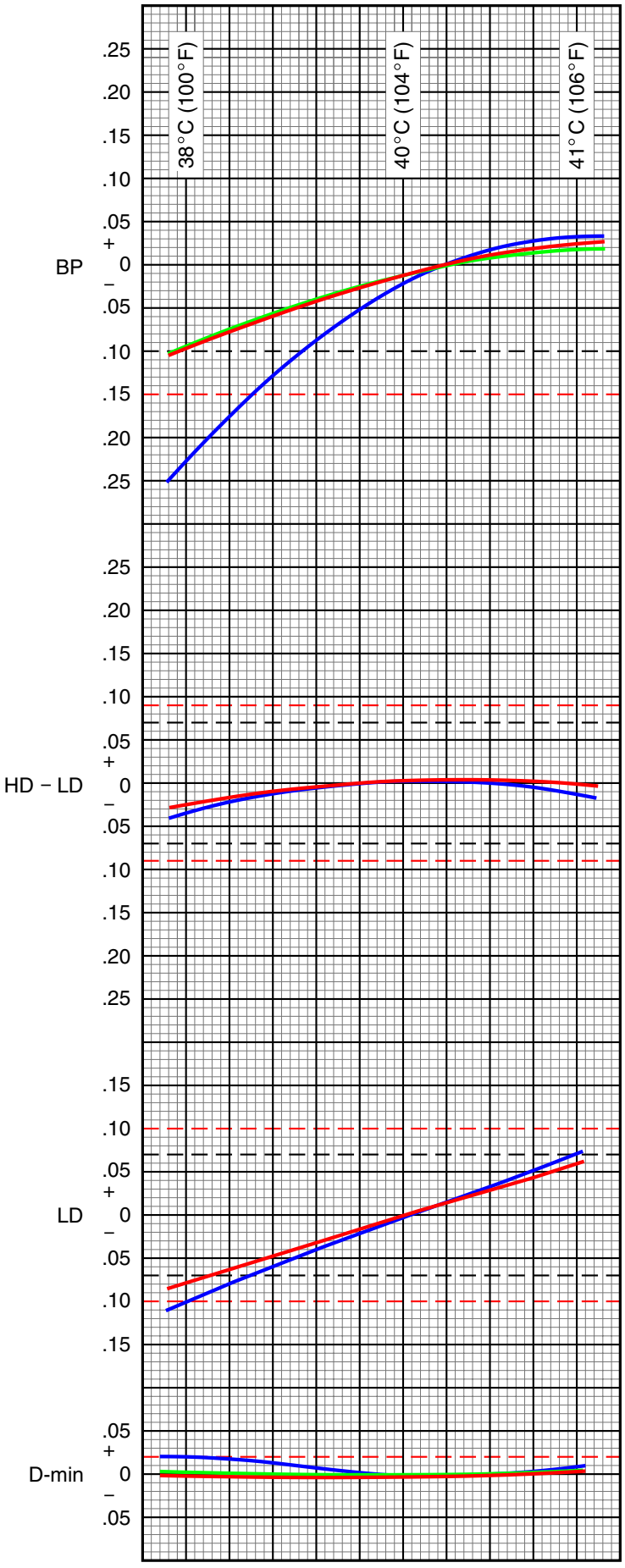
If you suspect that the developer temperature is incorrect:

- Check that the temperature regulator is operating.
- Check that enough time was allowed for the developer to reach operating temperature before processing.
- Check that the developer recirculation filter is not clogged. (A clogged filter can prevent proper heating of the solution.)

Check the temperature controller or the recirculation system; one or both can cause the problem. Replace the recirculation filters if they are clogged.

Check the developer temperature frequently, and adjust it as necessary.

### Chart 15



## Process RA-2SM

### Developer
### Replenishment Rate Error / Water Too Low/High

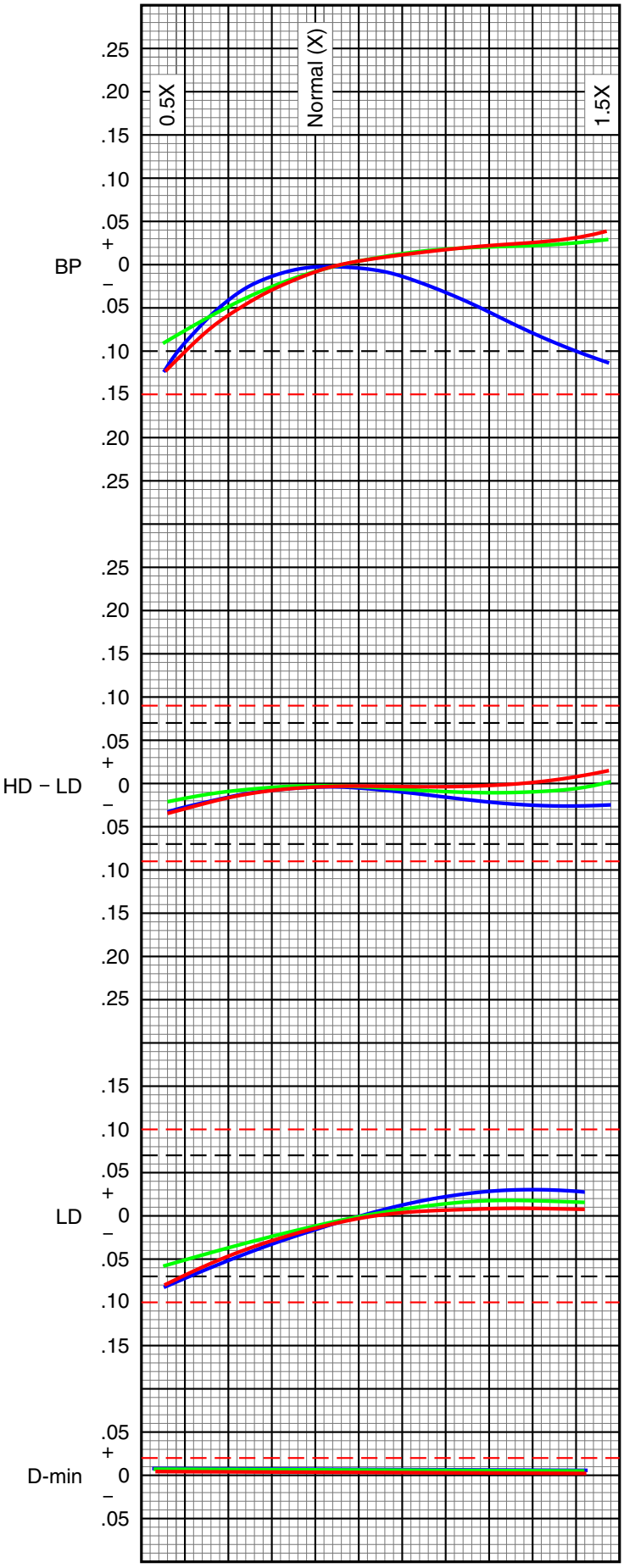
Developer activity varies with the delivery of water to your developer tank. Underreplenishment results in low activity in all three colors of BP; overreplenishment results in low activity of the blue BP.

How quickly your control plots change depends on the variation from aim of your replenishment delivery and the amount of paper processed.

If the water delivery is suspect:

- Check the developer replenishment pump fitting for water to be sure it is snug.
- Check the delivery lines for air. This is an indication that the pump valves have failed.
- Check the pump calibration.
- Check the replenishment rate setting.
- Update the pump values in your processor software.

### Chart 16



## Process RA-2SM

### Developer Replenishment Rates Too Low/High

Developer replenishment rates (A:B:C:water) directly affect developer activity. If the rates are too high, the density values for LD and BP will plot higher than normal. If the rates are too low, LD, BP, and HD – LD will plot lower than normal. The amount of change that you see in the plot as a result of incorrect replenishment depends on the developer-tank volume, processor speed, and amount of paper processed. If incorrect replenishment appears to be the problem, check that the replenishment system is operating properly and is correctly calibrated.

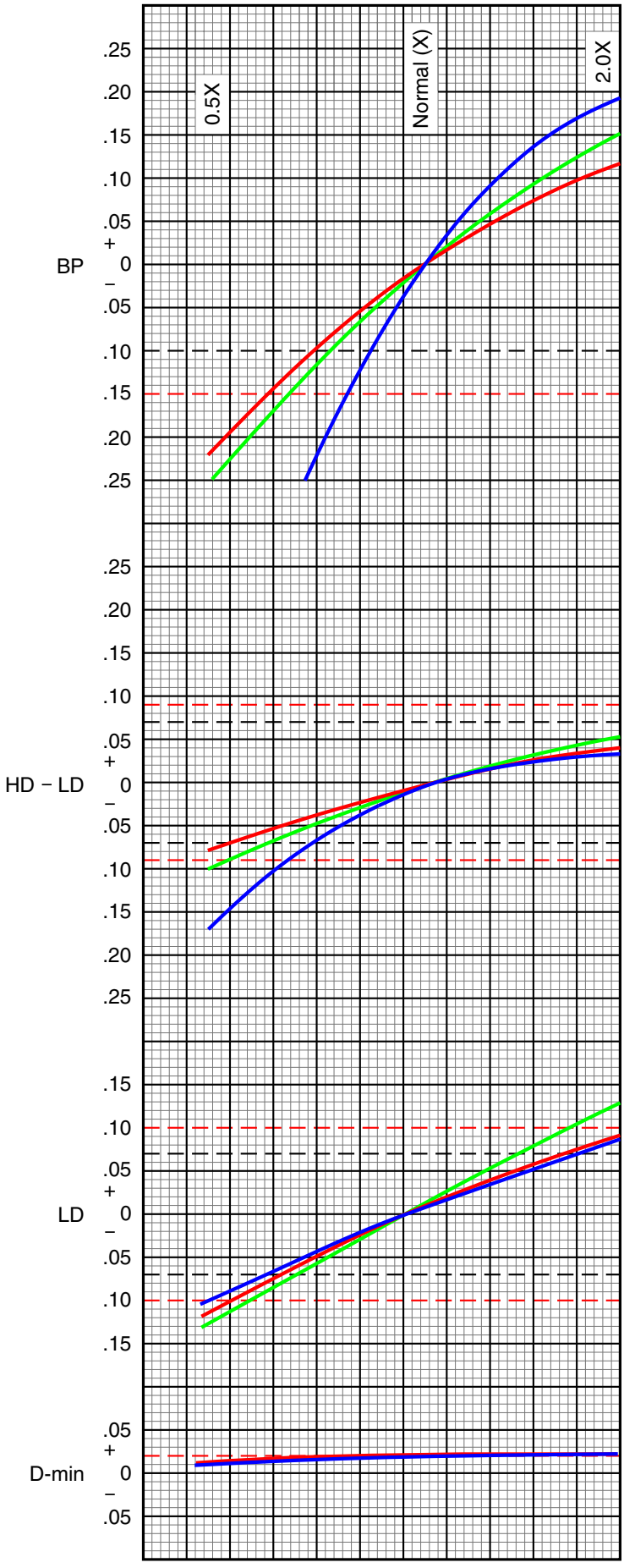
The recommended replenishment rates are *starting points only.* Exact rates depend on the type of paper you process, and how well you maintain operating conditions, such as development time and temperature. Determine your exact rates by monitoring the process with control strips and adjusting the rate as needed according to the control plot. However, do not adjust the rates to "chase" small changes in the control plot. Once your process is in control, continue to use the rates that you established; don't change them unless processor utilization changes. **Changing rates should be done proportionately with all developer parts, including water**.

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

If you suspect that replenishment is the problem:

- Check that the replenishment system is set correctly.
- Verify that the replenishment pumps are all operating.
- Verify that the replenishment pumps are producing the correct output.
- If the processor has been idle, verify that the "J" tubes are full of solution.

## Chart 17



## Process RA-2SM

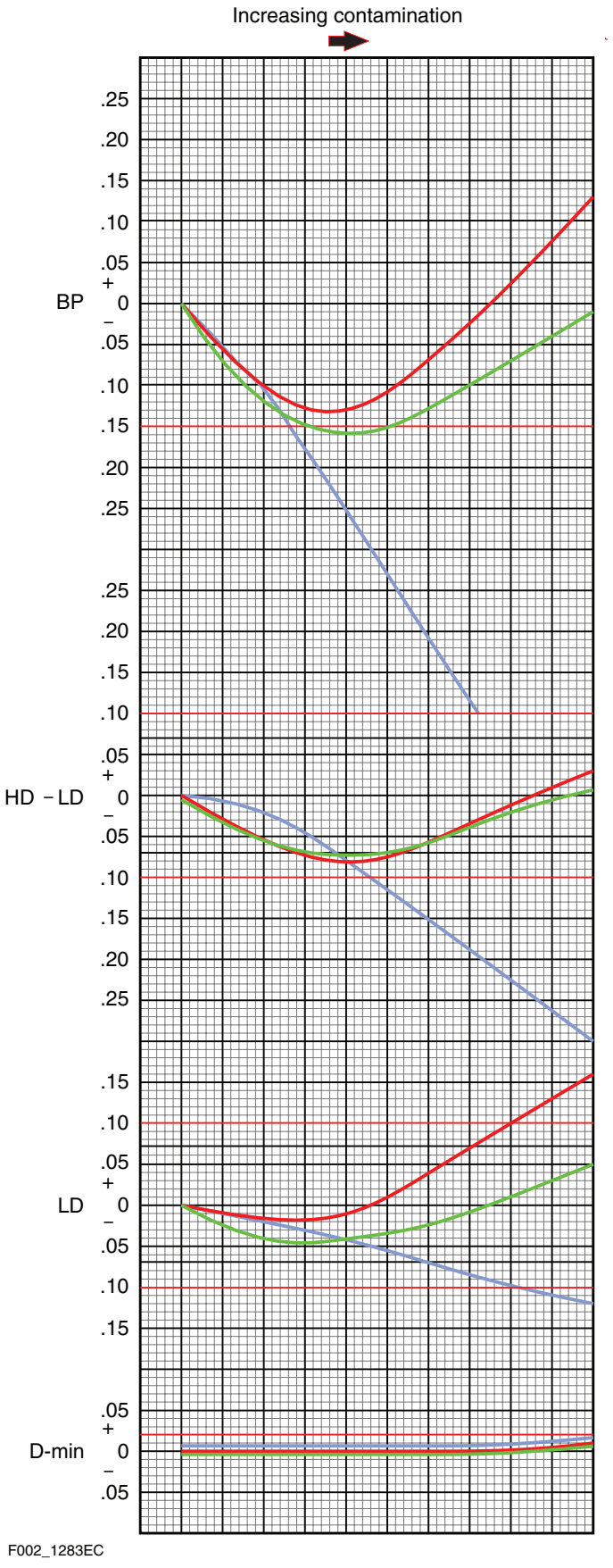
### Developer
### Contaminated with Bleach-Fix

A very small amount of bleach-fix will contaminate the developer. As little as 0.1 mL/L of bleach-fix in the developer can cause an out-of-control process. 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.

Possible sources of contamination are bleach-fix splashed into the developer when racks are raised or when developer is mixed with equipment that contains a small amount of bleach-fix from the last time it was used. Use a separate mixing bottle to mix developer working-tank solution, and wash it thoroughly. **Don't** mix a bleach-fix working-tank solution in a developer mixing bottle.

Stop production until you find the source of contamination. Check for any procedures that might cause splashing during processing. A developer contaminated with bleach-fix cannot be salvaged; replace it with a fresh mix.

### Chart 18

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## Process RA-2SM

### Developer Oxidation

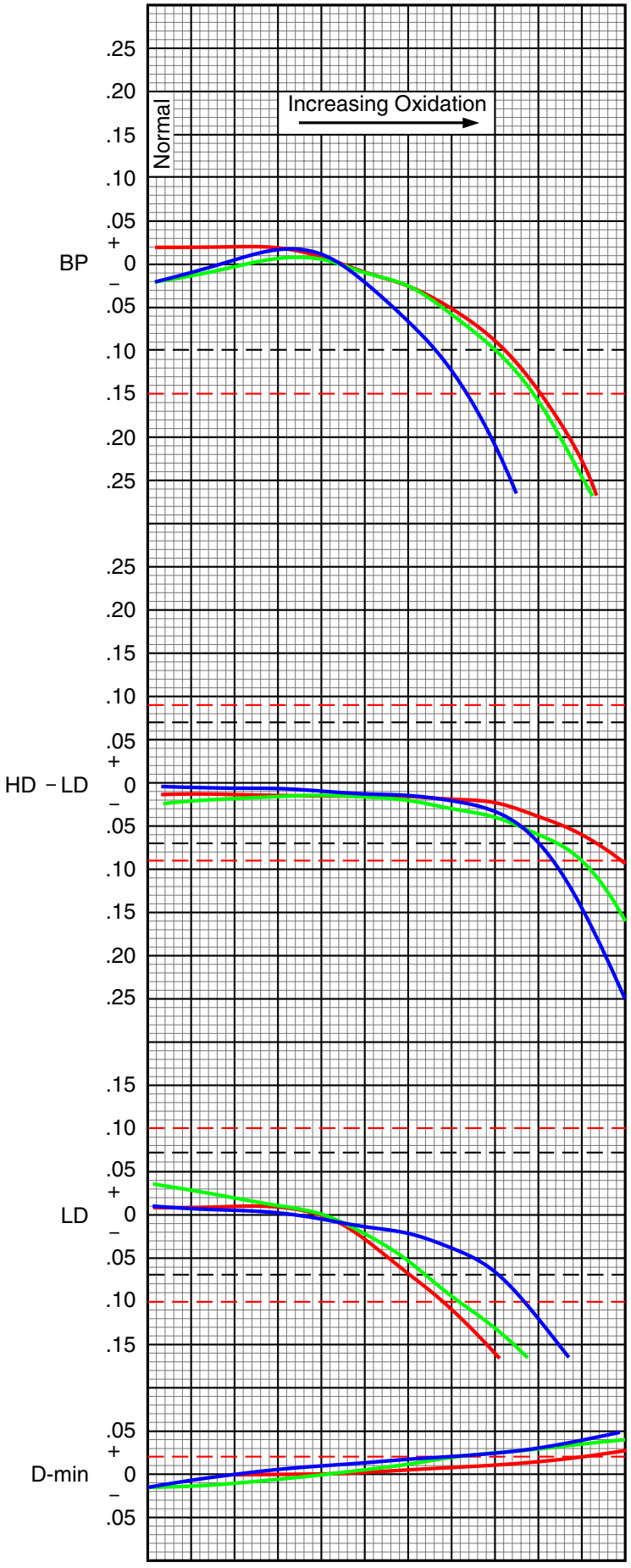
Developer, exposed to air, reacts with oxygen. To protect the developing agent, developers contain preservatives that react with oxygen. However, prolonged exposure to air will eventually deplete the preservative and cause the developing agents to oxidize. Oxidation of the developing agent causes decreased developer activity and the formation of a precipitate. You will see an increase in D-min, HD – LD, and a decrease in LD and BP in the control plots.

The most common causes of oxidation are excessive agitation or low processor utilization. Excessive agitation forces air into the solution, depleting the preservative more rapidly. This can occur when you mix a fresh working-tank solution by mixing it excessively or too vigorously, or it can occur inside the processor tank. A faulty processor recirculation pump can also cause oxidation by sucking air into the solution. Foaming may indicate that the recirculation pump is leaky and is pumping air.

Oxidation is a more common problem in roller-transport processors than in other types of processors 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, leading to developer overconcentration. Overconcentration can offset some of the effects of oxidation and mask the condition.

Minimize oxidation by turning the processor off when it is not in use. Check for excessive air flow over the processor developer working tank, and reduce or minimize it.

### Chart 19



# Appendix A

## Rebleaching Test for Determining Retained Silver, Process C-41SM

Use the following procedure to verify retained-silver problems.

1. Zero your densitometer. Measure and record the blue densities of the D-max and yellow steps of your control strip.
2. Rebleach the control strip for 5 minutes in a *known good bleach* (i.e., a properly constituted Process C-41 bleach).
3. Refix the control strip for 5 minutes in a *known good fixer* (i.e., a properly constituted Process C-41 fixer).
4. Wash the control strip for several minutes, and allow it to dry.
5. Rezero your densitometer. Read the blue densities of the D-max and yellow steps of the rebleached and refixed control strip.
6. Calculate the **change** in density readings of the control strip by subtracting the readings from step 1 from the readings from step 5. We will refer to these numbers as $\Delta$ D-max$_B$ and $\Delta$ Y$_B$.
7. Subtract $\Delta$ D-max$_B$ from $\Delta$ Y$_B$ to determine the amount of retained silver. If the difference is greater than +0.08, a retained-silver problem exists. If the difference is less than +0.08, retained silver is most likely not the problem.

**Note:** You can remove retained silver from processed film by following the steps given below.

8. Rebleach the film in a *known good bleach*.
9. Refix the film in a *known good fixer*.
10. Wash, restabilize, and dry the film.

You can also use an infrared scope to detect retained silver.

# Appendix B

## Testing for Retained Silver Halide, Process C-41SM

Use this test to determine if processed film has retained silver halide.

1. Zero your densitometer. Read and record the red Status M density of the D-min step of a control strip that you have recently processed.
2. Refix the control strip for 5 minutes in a *known good fixer* or a solution made from KODAK Farmer's Reducer, Part B.
3. Wash the control strip for 2 to 3 minutes, and allow it to dry.
4. Rezero your densitometer. Read and record the red density of the D-min step of the refixed control strip.
5. Calculate the **change** in density readings by subtracting the reading from step 4 from the reading from step 1.

Any significant change in density readings after refixing indicates a fixer problem. If a *loss* in red density is greater than 0.05 for D-min or LD, a retained silver-halide problem probably exists due to low activity of the fixer tank solution. This problem may be accompanied by retained sensitizing dye. If the *loss* in red density is less than 0.04, the activity of the fixer tank solution is probably acceptable.