First Developer

The first developer is the most critical step in Process E-6. The solution is essentially a black-and-white film developer, because it forms only a negative silver image in each layer of the film; no dye images are formed.

FUNCTIONS

- The first developer converts exposed silver halide to metallic silver to form a negative silver image in each layer of the film.
- Proper formation of the negative silver image in the first developer is required for correct formation of dye images in the color developer.

COMPONENTS

Developing Agents:

KODAK Developing Agent, DA-1
KODAK DIMEZONE S Developing Agent

These developing agents react with exposed silver halide to form metallic silver. They do not react with the dye couplers in the film. As the silver image is formed, the developing agents are oxidized.

$Ag^{*}X + Dev \rightarrow Ag^{0} + X^{-} + Dev^{ox}$

AG*X	=	exposed silver halide
Dev	=	developing agent
Ag^{0}	=	metallic silver
X^{-}	=	halide ion
Dev^{OX}	=	oxidized developing agent

Replenishment is required to maintain the concentration of the developing agent.

Silver Halide Solvents:

Sodium thiocyanate
Potassium sulfite

These chemicals affect the physical development of the film (they help dissolve “fine” silver halide grains). Thiocyanate is not consumed or oxidized; its concentration is affected only by replenisher concentration and evaporation. Sulfite is oxidized and consumed, but it is a much weaker solvent than thiocyanate; it acts primarily as a preservative.

A change in the concentration of these solvents will have a greater effect on the smaller grains in the emulsion (toe densities) than on the larger grains.

Preservative:

Potassium sulfite

Potassium sulfite acts as a preservative to protect the developing agents from oxidation, and helps to maintain their concentration. It also acts as a mild silver halide solvent.

Restrainers:

Sodium bromide
Potassium iodide

Bromide and iodide ions are released into the first-developer solution as development by-products.

$Ag^{*}Br + Dev \rightarrow Ag^{0} + Br^{-} + Dev^{ox}$
$Ag^{*}I + Dev \rightarrow Ag^{0} + I^{-} + Dev^{ox}$

Ag*Br	=	exposed silver bromide
Ag*I	=	exposed silver iodide
Dev	=	developing agent
Ag^{0}	=	metallic silver
Br^{-}	=	bromide ion
I^{-}	=	iodide ion
Dev^{OX}	=	oxidized developing agent

These ions act as inhibitors to the action of the developer. Replenishment is needed to dilute the concentration of these ions and reduce their restraining effect. If your replenishment rate is too low, developer activity will decrease because the concentration of bromide and iodide ions increases, resulting in higher film densities. If the replenishment rate is too high, developer activity increases because the concentration of bromide and iodide ions decreases, resulting in lower densities.

The KODAK Bromide Test Kit, Process E-6, enables you to measure the concentration of bromide in your Process E-6 first developer and detect changes in the concentration *before* they affect the film you process. Instructions for using this kit are given on page 7-4.

Buffers:

Potassium carbonate
Sodium bicarbonate

Carbonate acts as a buffer. The bicarbonate provides a convenient means of controlling pH.

Sequestering Agents:

KODAK Anti-Calcium, No. 4
KODAK Anti-Calcium, No. 8

These components prevent the precipitation of calcium and magnesium salts to ensure solution cleanliness.

Sensitometric Effects of Solution Component Concentration

The following tables list the effects on processed film of high and low concentrations of first-developer solution components.

HIGH CONCENTRATION

Solution Component	Sensitometric Effect
KODAK Developing Agent, DA-1 KODAK DIMEZONE S Developing Agent	Lower densities
Sodium thiocyanate	Lower densities Higher toe contrast
Potassium sulfite	Lower densities Slightly higher toe contrast
Sodium bromide	Higher densities
Potassium iodide	Higher densities
Potassium carbonate	Little to none
KODAK Anti-Calcium	Little to none

LOW CONCENTRATION

Solution Component	Sensitometric Effect
KODAK Developing Agent, DA-1 KODAK DIMEZONE S Developing Agent	Higher densities
Sodium thiocyanate	Higher densities Lower toe contrast
Potassium sulfite	Higher densities Lower toe contrast
Sodium bromide	Lower densities
Potassium iodide	Lower densities Decrease in blue upper-scale contrast and D-max
Potassium carbonate	Little to none
KODAK Anti-Calcium	Little to none

SPECIFICATIONS

Parameter	Aim	Tolerance	Acceptable Range	Plot Parameter
Time	6 minutes	± 5 seconds	5 to 7 minutes	X
Temperature	100.4°F (38°C)	± 0.3°F (± 0.2°C)	98 to 103°F (36.7 to 39.4°C)	X
Replenishment Rate	200 mL/ft² (2153 mL/m²)	± 20 mL/ft²* (± 215 mL/m²)*	—	X
Specific Gravity				
Seasoned Tank Solution	1.060 at 80°F (27°C) 1.057 at 100.4°F (38°C)	± 0.003	—	X
Fresh Tank Solution†	1.055 at 80°F (27°C) 1.052 at 100.4°F (38°C)	± 0.003	—	
Replenisher	1.057 at 80°F (27°C) 1.054 at 100.4°F (38°C)	± 0.003	—	
Bromide Concentration				
Seasoned Tank Solution	2.5 g/L	± 0.3	—	X
Fresh Tank Solution†	2.57 g/L	± 0.3	—	
Replenisher	1.43 g/L	± 0.3	—	
Agitation	2-second nitrogen burst every 10 seconds (5/8-inch [17 mm] solution rise)‡	—	—	

*For optimum performance, maintain your replenishment rate to within ± 5% of the specified aim (± 10% tolerance allows for measurement “noise”).
†See the mixing instructions at the right. Plot the specific gravity and bromide concentration of the new mix on Form Y-34. Note “NEW FIRST-DEVELOPER TANK MIX” on Form Y-33.
‡For rack-and-tank machines.

PREPARING A FRESH TANK SOLUTION

To prepare a fresh tank solution that will give results similar to those produced by a seasoned tank solution, follow the appropriate mixing instructions given below. (These instructions are different from those provided with the chemicals.) Following either procedure will help you obtain results closer to those produced at optimum process levels. You may need to make slight adjustments to optimize the process; see “Optimizing Your Process,” page 6-7.

Note: These instructions are for mixing solutions from KODAK PROFESSIONAL First Developer Replenisher, Process E-6 and E-6AR (5-gallon flexible container).

From Mixed Replenisher Solution

1. For each litre of tank solution, mix 950 mL of replenisher with 50 mL of water.
2. Add 5 mL of starter per litre of solution.

From Concentrate

1. For each litre of tank solution, mix 190 mL of concentrate with 810 mL of water.
2. Add 5 mL of starter per litre of solution.

Note: When you prepare the solution in either of these ways, the specific gravity and bromide concentration will be within the tolerances for a fresh tank solution.

USING THE *KODAK* BROMIDE TEST KIT, PROCESS E-6

Use this kit to measure the bromide concentration in your Process E-6 first developer. Read these instructions before you run the test so that you are familiar with the procedure. To obtain accurate results, *follow these instructions exactly* and use good laboratory techniques.

Use only distilled water as required in the procedure. (Your results will be unreliable if you use other types of water [e.g., demineralized, deionized, tap, etc].) The silver-nitrate solution in the titration cartridge is light-sensitive. Store the cartridge in a drawer or in the test kit case when you are not using it.

To determine the bromide concentration of your first-developer tank solution, you will use the results of this test in conjunction with an accurate measurement of the tank-solution specific gravity.

Note: To run this test, you will use a procedure called a titration. A titration is a quantitative chemical analysis of a solution.

When you perform a titration, you determine the concentration of a certain chemical component (e.g., bromide) of a solution sample by adding a standardized solution—called a titrant—that causes a chemical reaction. Silver nitrate solution is the titrant used for this test.

The titrant first reacts with the chemical component that you are measuring. When the initial reaction is complete, the titrant then reacts with an indicator or another chemical in the solution to cause the color of the sample to change. The color change marks the end point of the reaction. *It is important to stop adding titrant as soon as the reaction reaches the end point.*

1. Fill the flask to the 30 mL line with distilled water.
2. Add the contents of one Bromide Indicator Powder Pillow to the flask. Swirl the flask until the powder is completely dissolved; this will take approximately 30 to 40 seconds.
3. Remove 1.0 mL of first-developer tank solution with the TenSette Pipet, and add it to the flask. Swirl the flask.
4. Add 5 drops of Polyvinyl Alcohol Solution to the solution in the flask; swirl the flask.
5. Use the digital titrator (with the counter reset to zero) with the Silver Nitrate Titration Cartridge to titrate the solution in the flask. Add titrant and swirl the flask until the color of the solution ***begins*** to change; determine the end point when the solution changes from its original color (yellow-green) to gray or gray-green, and the solution *remains* gray or gray-green after you swirl it continuously for 5 to 10 seconds. ***Be careful that you do not titrate the solution beyond the end point.*** If you titrate beyond the end point, the color of the solution will change to turquoise and then a distinct blue.
6. Read the number from the digital counter.
7. Make a specific-gravity measurement of your first-developer tank solution.
8. To determine the bromide concentration, use the titrator reading (from step 6) and the specific-gravity measurement (from step 7) in the appropriate equation below or with the appropriate table on page 7-5 or 7-6.

Specific gravity measured at ***100.4°F (38°C)***

Bromide concentration =

$$(\text{titrator reading} - 3) \times 0.02902 - \left[\left(\frac{\text{Specific-gravity measurement} - 0.997}{0.060}\right) \times 1.2692\right]$$

Specific gravity measured at ***80°F (27°C)***

Bromide concentration =

$$(\text{titrator reading} - 3) \times 0.02902 - \left[\left(\frac{\text{Specific-gravity measurement} - 1}{0.060}\right) \times 1.2692\right]$$

9. Calculate and plot your variation from aim on Form Y-34; see "Using Forms Y-34, Y-35, and Y-36" on page 4-13 for more information Check the plots of bromide concentration for outliers, shifts, trends, and cycling to determine the state of control. If you detect an out-of-control condition, refer to the diagnostic charts on pages 7-14 and 7-16.
10. Discard the solution from the flask, and rinse the flask thoroughly with distilled water. Remove the tip from the pipet and discard it.

Find your specific-gravity measurement along the top of the table and your titrator reading along the side of the table. The bromide concentration is the number where the vertical column and the horizontal column intersect.

Specific gravity measured at	Specific-Gravity Measurements												
100.4°F (38°C)	1.051	1.052	1.053	1.054	1.055	1.056	1.057	1.058	1.059	1.060	1.061	1.062	1.063
80°F (27°C)	1.054	1.055	1.056	1.057	1.058	1.059	1.060	1.061	1.062	1.063	1.064	1.065	1.066
Titrator Readings													
90	1.38	1.36	1.34	1.32	1.30	1.28	1.26	1.23	1.21	1.19	1.17	1.15	1.13
91	1.41	1.39	1.37	1.35	1.33	1.31	1.28	1.26	1.24	1.22	1.20	1.18	1.16
92	1.44	1.42	1.40	1.38	1.36	1.33	1.31	1.29	1.27	1.25	1.23	1.21	1.19
93	1.47	1.45	1.43	1.41	1.36	1.36	1.34	1.32	1.30	1.28	1.26	1.24	1.22
94	1.50	1.48	1.46	1.44	1.41	1.39	1.37	1.35	1.33	1.31	1.29	1.27	1.24
95	1.53	1.51	1.49	1.46	1.44	1.42	1.40	1.38	1.36	1.34	1.32	1.29	1.27
96	1.56	1.54	1.51	1.49	1.47	1.45	1.43	1.41	1.39	1.37	1.35	1.32	1.30
97	1.58	1.56	1.54	1.52	1.50	1.48	1.46	1.44	1.42	1.40	1.37	1.35	1.33
98	1.59	1.59	1.57	1.55	1.53	1.51	1.49	1.47	1.45	1.42	1.40	1.38	1.36
99	1.64	1.62	1.60	1.58	1.56	1.54	1.52	1.50	1.47	1.45	1.43	1.41	1.39
100	1.67	1.65	1.63	1.61	1.59	1.57	1.55	1.52	1.50	1.48	1.46	1.44	1.42
101	1.70	1.68	1.66	1.64	1.62	1.60	1.57	1.55	1.53	1.51	1.49	1.47	1.45
102	1.73	1.71	1.69	1.67	1.65	1.62	1.60	1.58	1.56	1.54	1.52	1.50	1.48
103	1.76	1.74	1.72	1.70	1.68	1.65	1.63	1.61	1.59	1.57	1.55	1.53	1.51
104	1.79	1.77	1.75	1.73	1.70	1.68	1.66	1.64	1.62	1.60	1.58	1.56	1.53
105	1.82	1.80	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.61	1.59	1.56
106	1.85	1.83	1.80	1.78	1.76	1.74	1.72	1.70	1.68	1.66	1.64	1.61	1.59
107	1.88	1.85	1.83	1.81	1.79	1.77	1.75	1.73	1.71	1.69	1.66	1.64	1.62
108	1.90	1.88	1.86	1.84	1.82	1.80	1.78	1.76	1.74	1.71	1.69	1.67	1.65
109	1.93	1.91	1.89	1.87	1.85	1.83	1.81	1.79	1.76	1.74	1.72	1.70	1.68
110	1.96	1.94	1.92	1.90	1.88	1.86	1.84	1.81	1.79	1.77	1.75	1.73	1.71
111	1.99	1.97	1.95	1.93	1.91	1.89	1.86	1.84	1.82	1.80	1.78	1.76	1.74
112	2.02	2.00	1.98	1.96	1.94	1.92	1.89	1.87	1.85	1.83	1.81	1.79	1.77
113	2.05	2.03	2.01	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84	1.82	1.80
114	2.08	2.06	2.04	2.02	1.99	1.97	1.95	1.93	1.91	1.89	1.87	1.85	1.83
115	2.11	2.09	2.07	2.04	2.02	2.00	1.98	1.96	1.94	1.92	1.90	1.88	1.85
116	2.14	2.12	2.09	2.07	2.05	2.03	2.01	1.99	1.97	1.95	1.93	1.90	1.88
117	2.17	2.14	2.12	2.10	2.08	2.06	2.04	2.02	2.00	1.98	1.95	1.93	1.91
118	2.20	2.17	2.15	2.13	2.11	2.09	2.07	2.05	2.03	2.00	1.98	1.96	1.94
119	2.22	2.20	2.18	2.16	2.14	2.12	2.10	2.08	2.05	2.03	2.01	1.99	1.97
120	2.25	2.23	2.21	2.19	2.17	2.15	2.13	2.10	2.08	2.06	2.04	2.02	2.00
121	2.28	2.26	2.24	2.22	2.20	2.18	2.16	2.13	2.11	2.09	2.07	2.05	2.03
122	2.31	2.29	2.27	2.25	2.23	2.21	2.18	2.16	2.14	2.12	2.10	2.08	2.06
123	2.34	2.32	2.30	2.28	2.26	2.23	2.21	2.19	2.17	2.15	2.13	2.11	2.09
124	2.37	2.35	2.33	2.31	2.28	2.26	2.24	2.22	2.20	2.18	2.16	2.14	2.12
125	2.40	2.38	2.36	2.33	2.31	2.29	2.27	2.25	2.23	2.21	2.19	2.17	2.14
126	2.43	2.41	2.38	2.36	2.34	2.32	2.30	2.28	2.26	2.24	2.22	2.19	2.17
127	2.46	2.44	2.41	2.39	2.37	2.35	2.33	2.31	2.29	2.27	2.24	2.22	2.20
128	2.49	2.46	2.44	2.42	2.40	2.38	2.36	2.34	2.32	2.30	2.27	2.25	2.23
129	2.51	2.49	2.47	2.45	2.43	2.41	2.39	2.37	2.35	2.32	2.30	2.28	2.26
130	2.54	2.52	2.50	2.48	2.46	2.44	2.42	2.40	2.37	2.35	2.33	2.31	2.29
131	2.57	2.55	2.53	2.51	2.49	2.47	2.45	2.42	2.40	2.38	2.36	2.34	2.32
132	2.60	2.58	2.56	2.54	2.52	2.50	2.47	2.45	2.43	2.41	2.39	2.37	2.35
133	2.63	2.61	2.59	2.57	2.55	2.52	2.50	2.48	2.46	2.44	2.42	2.40	2.38
134	2.66	2.64	2.62	2.60	2.57	2.55	2.53	2.51	2.49	2.47	2.45	2.43	2.41

(Continued on next page)

Specific gravity measured at	Specific-Gravity Measurements												
100.4°F (38°C)	**1.051**	**1.052**	**1.053**	**1.054**	**1.055**	**1.056**	**1.057**	**1.058**	**1.059**	**1.060**	**1.061**	**1.062**	**1.063**
80°F (27°C)	**1.054**	**1.055**	**1.056**	**1.057**	**1.058**	**1.059**	**1.060**	**1.061**	**1.062**	**1.063**	**1.064**	**1.065**	**1.066**
Titrator Readings													
135	2.69	2.67	2.65	2.62	2.60	2.58	2.56	2.54	2.52	2.50	2.48	2.46	2.43
136	2.72	2.70	2.68	2.65	2.63	2.61	2.59	2.57	2.55	2.53	2.51	2.48	2.46
137	2.75	2.73	2.70	2.68	2.66	2.64	2.62	2.60	2.58	2.56	2.53	2.51	2.49
138	2.78	2.75	2.73	2.71	2.69	2.67	2.65	2.63	2.61	2.59	2.56	2.54	2.52
139	2.80	2.78	2.76	2.74	2.72	2.70	2.68	2.66	2.64	2.61	2.59	2.57	2.55
140	2.83	2.81	2.79	2.77	2.75	2.73	2.71	2.69	2.66	2.64	2.62	2.60	2.58
141	2.86	2.84	2.82	2.80	2.78	2.76	2.74	2.71	2.69	2.67	2.65	2.63	2.61
142	2.89	2.87	2.85	2.83	2.81	2.79	2.76	2.74	2.72	2.70	2.68	2.66	2.64
143	2.92	2.90	2.88	2.86	2.84	2.81	2.79	2.77	2.75	2.73	2.71	2.69	2.67
144	2.95	2.93	2.91	2.89	2.86	2.84	2.82	2.80	2.78	2.76	2.74	2.72	2.70
145	2.98	2.96	2.94	2.92	2.89	2.87	2.85	2.83	2.81	2.79	2.77	2.75	2.72
146	3.01	2.99	2.97	2.94	2.92	2.90	2.88	2.86	2.84	2.82	2.80	2.77	2.75
147	3.04	3.02	2.99	2.97	2.95	2.93	2.91	2.89	2.87	2.85	2.83	2.80	2.78
148	3.07	3.04	3.02	3.00	2.98	2.96	2.94	2.92	2.90	2.88	2.85	2.83	2.81
149	3.09	3.07	3.05	3.03	3.01	2.99	2.97	2.95	2.93	2.90	2.88	2.86	2.84
150	3.12	3.10	3.08	3.06	3.04	3.02	3.00	2.98	2.95	2.93	2.91	2.89	2.87
151	3.15	3.13	3.11	3.09	3.07	3.05	3.03	3.00	2.98	2.96	2.94	2.92	2.90
152	3.18	3.16	3.14	3.12	3.10	3.08	3.05	3.03	3.01	2.99	2.97	2.95	2.93
153	3.21	3.19	3.17	3.15	3.13	3.10	3.08	3.06	3.04	3.02	3.00	2.98	2.96
154	3.24	3.22	3.20	3.18	3.16	3.13	3.11	3.09	3.07	3.05	3.03	3.01	2.99
155	3.27	3.25	3.23	3.21	3.18	3.16	3.14	3.12	3.10	3.08	3.06	3.04	3.01
156	3.30	3.28	3.26	3.23	3.21	3.19	3.17	3.15	3.13	3.11	3.09	3.07	3.04
157	3.33	3.31	3.28	3.26	3.24	3.22	3.20	3.18	3.16	3.14	3.12	3.09	3.07
158	3.36	3.33	3.31	3.29	3.27	3.25	3.23	3.21	3.19	3.17	3.14	3.12	3.10
159	3.38	3.36	3.34	3.32	3.30	3.28	3.26	3.24	3.22	3.19	3.17	3.15	3.13
160	3.41	3.39	3.37	3.35	3.33	3.31	3.29	3.27	3.24	3.22	3.20	3.18	3.16
161	3.44	3.42	3.40	3.38	3.36	3.34	3.32	3.29	3.27	3.25	3.23	3.21	3.19
162	3.47	3.45	3.43	3.41	3.39	3.37	3.34	3.32	3.30	3.28	3.26	3.24	3.22
163	3.50	3.48	3.46	3.44	3.42	3.40	3.37	3.35	3.33	3.31	3.29	3.27	3.25
164	3.53	3.51	3.49	3.47	3.45	3.42	3.40	3.38	3.36	3.34	3.32	3.30	3.28
165	3.56	3.54	3.52	3.50	3.47	3.45	3.43	3.41	3.39	3.37	3.35	3.33	3.31
166	3.59	3.57	3.55	3.52	3.50	3.48	3.46	3.44	3.42	3.40	3.38	3.36	3.33
167	3.62	3.60	3.57	3.55	3.53	3.51	3.49	3.47	3.45	3.43	3.41	3.38	3.36
168	3.65	3.62	3.60	3.58	3.56	3.54	3.52	3.50	3.48	3.46	3.43	3.41	3.39
169	3.68	3.65	3.63	3.61	3.59	3.57	3.55	3.53	3.51	3.48	3.46	3.44	3.42
170	3.70	3.68	3.66	3.64	3.62	3.60	3.58	3.56	3.53	3.51	3.49	3.47	3.45
171	3.73	3.71	3.69	3.67	3.65	3.63	3.61	3.59	3.56	3.54	3.52	3.50	3.48
172	3.76	3.74	3.72	3.70	3.68	3.66	3.64	3.61	3.59	3.57	3.55	3.53	3.51
173	3.79	3.77	3.75	3.73	3.71	3.69	3.66	3.64	3.62	3.60	3.58	3.56	3.54
174	3.82	3.80	3.78	3.76	3.74	3.71	3.69	3.67	3.65	3.63	3.61	3.59	3.57
175	3.85	3.83	3.81	3.79	3.76	3.74	3.72	3.70	3.68	3.66	3.64	3.62	3.60
176	3.88	3.86	3.84	3.81	3.79	3.77	3.75	3.73	3.71	3.69	3.67	3.65	3.62
177	3.91	3.89	3.86	3.84	3.82	3.80	3.78	3.76	3.74	3.72	3.70	3.67	3.65
178	3.94	3.92	3.89	3.87	3.85	3.83	3.81	3.79	3.77	3.75	3.72	3.70	3.68
179	3.97	3.94	3.92	3.90	3.88	3.86	3.84	3.82	3.80	3.77	3.75	3.73	3.71

ADJUSTING REPLENISHMENT RATES FOR PUSH PROCESSING

You may need to adjust replenishment rates when you push-process KODAK PROFESSIONAL EKTACHROME Films. Push processing consumes more of the chemical components of the first devveloper because it develops more silver than normal processing does. Longer times in the solution will chemically fog, or develop, D-max and shadow areas that normally wouldn't be developed. This consumes more of the developing agents and generates more by-products (bromide and iodide) than normal processing. Because this effect results mainly from development of D-max and shadow areas, scene content of the film is an important factor. Scenes that have a full tonal scale or many high-density areas will cause a greater change in the first-developer chemical balance than scenes with many low-density areas.

Because maintaining the chemical composition of the first developer is critical in operating a quality process, you may have to adjust the replenishment rate for push processing. Consider these two factors when you decide whether or not you need to increase the replenishment rate:

- The amount of film being push-processed
- The scene content of the film being push-processed

If you push-process more than 25 percent of your total film load or push-process a large amount of film at one time, you need to consider increasing the replenishment rate. You can use this simple calculation to determine a "large amount of film":

Film area (square feet) ≥ 1.5 x first-developer tank volume (litres)

For example, if you plan to push-process 150 square feet of film and your first-developer tank volume is 100 litres, 150 square feet equals 1.5 x 100, and is considered to be a "large amount of film." If the tank volume is 20 litres, 30 square feet is a large amount.

If you are push-processing more than 25 percent of your total film load, or square footage that is equal to or more than 1.5 times the first-developer tank volume at one time, you must consider the scene content and the format of the film.

If the scenes have uniform density with very few high-density areas (typical in some product photography with a limited density range), do not change your replenishment rate. This applies especially to sheet film, in which the percentage of unexposed film along the edges is relatively small. These conditions will have little effect on the chemical composition of the solution because little or no additional silver is being developed.

If scenes have a full tonal range with substantial shadows, or high-density areas, you should increase the replenishment rate to maintain the proper chemical balance. The type of scenes that require an increase are those typical of photojournalism, especially when they are on 35 mm film, which includes relatively large unexposed areas along the edges and between frames.

The table below includes recommendations for increasing replenishment rates based on the number of stops the film is being pushed.

Film Pushed by (Stops)	Percent Increase in Replenishment Rate	New Replenishment Rate	
		mL/sq ft*	mL/sq M †
0 (Normal process)	0	200	2153
1/3	8	216	2324
1/2	12	224	2410
2/3	16	232	2496
1 (Push 1)	25	250	2690
1 1/2	35	270	2905
2 (Push 2)	50	300	3228

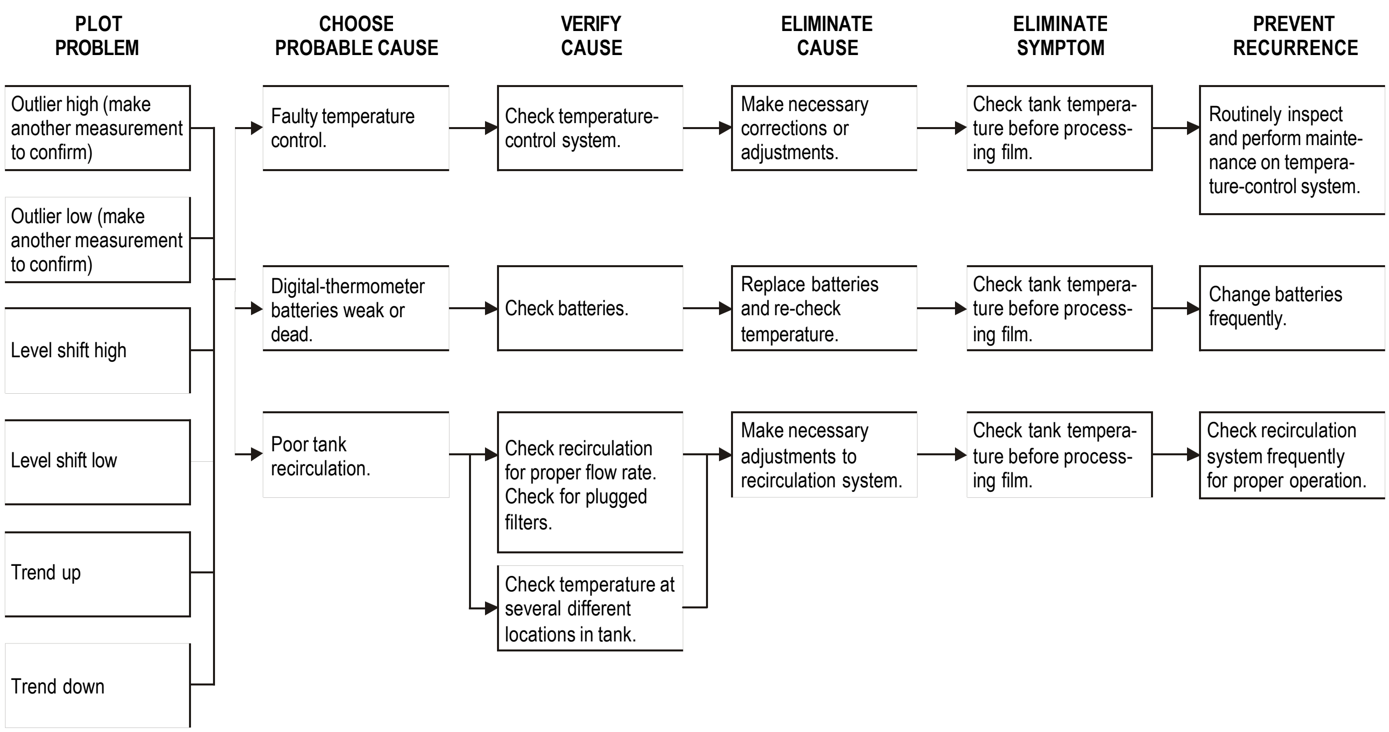
*Based on the specific aim of 200 mL/sq ft. The tolerance remains at ± 20 mL/sq ft.

†Based on the specified aim of 2153 mL/sq M. The tolerance remains ± 215 mL/sq M.

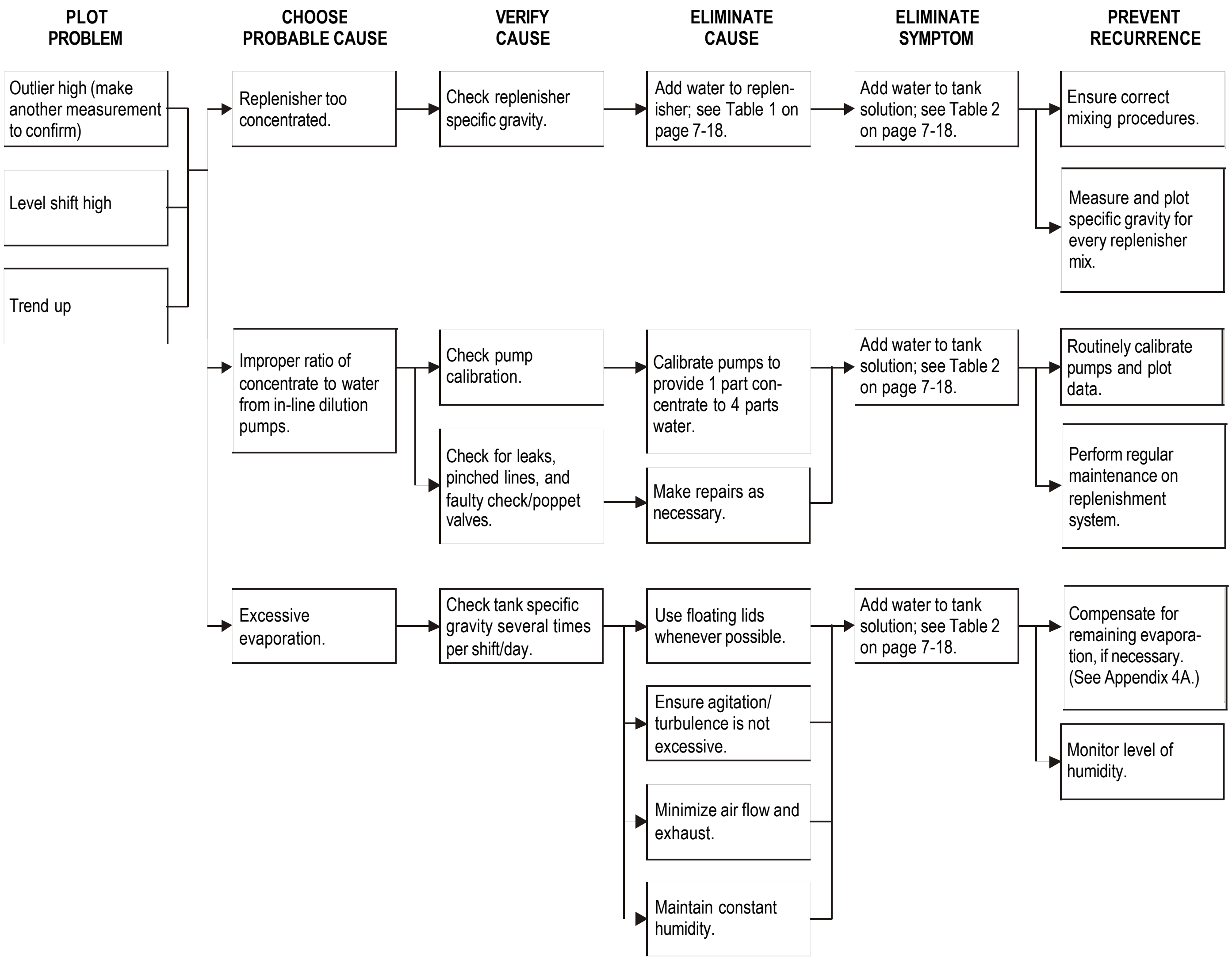
DIAGNOSTIC CHARTS

The diagrams on pages 7-8 to 7-16 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 for the key parameters for first developer. The recommendations in the charts will help you correct outliers (data on or outside the tolerance lines), level shifts, trends, and cycling. For more information on evaluating control-chart plots, see *Process Control—A Better Way*, Section 1.

FIRST DEVELOPER—TEMPERATURE—
Outlier High or Low, Level Shift High or Low, Trend Up or Down



FIRST DEVELOPER—SPECIFIC GRAVITY—
Outlier High, Level Shift High, Trend Up



FIRST DEVELOPER— SPECIFIC GRAVITY— Outlier Low, Level Shift Low, Trend Down

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Outlier low (make another measurement to confirm)	Replenisher too dilute.	Check replenisher specific gravity.	Add concentrate to replenisher; see Table 3 on page 7-18.	Add concentrate to tank solution; see Table 4 on page 7-18.	Ensure correct mixing procedures.
Level shift low					Measure and plot specific gravity for every replenisher mix.
Trend down	Improper ratio of concentrate to water from in-line dilution pumps.	Check pump calibration.	Calibrate pumps to provide 1 part concentrate to 4 parts water.	Add concentrate to tank solution; see Table 4 on page 7-18.	Routinely calibrate pumps and plot data.
		Check for leaks, pinched lines, and faulty check/poppet valves.	Make repairs as necessary.		Perform regular maintenance on replenishment system.
	Overcompensation for evaporation.	Check tank specific gravity several times per shift/day.	Reduce amount of water added to tank or replenisher.	Add concentrate to tank solution; see Table 4 on page 7-18. If necessary, add concentrate to replenisher (premixed solutions) or adjust amount of water added by pump (in-line dilution/ blender systems).	Determine proper compensation for evaporation; see Appendix 4A.
					Monitor level of humidity.

FIRST DEVELOPER—TIME—
Outlier High or Low, Level Shift High or Low

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Outlier high (make another measure-ment to confirm) or Level shift high	Machine adjusted for push processing.	Check time setting.	Readjust machine for normal processing.		Check adjustment of machine before processing.
Outlier high or Outlier low	Machine drive or transport not func-tioning properly.	Check film transport for mechanical problems. Check for dirty racks and rollers. Check for fluctuations in voltage to processor.	Make repairs or clean as necessary.		Inspect drive system regularly. Check voltage regularly.
Outlier low (make another measure-ment to confirm) or Level shift low	Machine adjusted for pull processing.	Check time setting.	Readjust machine for normal processing.		Check adjustment of machine before processing.

FIRST DEVELOPER—TIME—
Trend Up or Down

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Trend up or down	Machine drive or transport not func-tioning properly.	Check film transport for mechanical problems. Check for dirty racks and rollers. Check for fluctuations in voltage to processor.	Make repairs or clean as necessary.		Inspect drive system regularly. Check voltage regularly.

FIRST DEVELOPER—REPLENISHMENT RATE—
Outlier High or Low, Level Shift High or Low

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Outlier high (make another measurement to confirm) or Level shift high	In-line dilution pumps not in proper calibration.	Check pump calibration.	Adjust pumps to provide 200 mL/sq ft (1 part concentrate to 4 parts water).	Add replenisher or starter to tank solution. Base adjustment on bromide concentration; see Table 5 or Table 7 on page 7-19.	Routinely calibrate pumps and plot data.
Outlier low (make another measurement to confirm) or Level shift low	Film sensor not functioning properly.	Check sensor.	Adjust sensor to replenish tank at proper interval.	Add replenisher or starter to tank solution. Base adjustment on bromide concentration; see Table 5 or Table 7 on page 7-19.	Check sensors regularly.
	Pump leaks or faulty check valves.	Check pumps and valves.	Make necessary repairs.	Add replenisher or starter to tank solution. Base adjustment on bromide concentration; see Table 5 or Table 7 on page 7-19.	Perform regular maintenance on replenishment system.
	Replenishment not calculated properly.	Check calculation; see procedure in Section 4.	Recalculate replenishment rate.		Ensure all replenishment-rate calculations are done correctly.

FIRST DEVELOPER—REPLENISHMENT RATE—Trend Up or Down

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Trend up or down	In-line dilution pumps not in proper calibration.	Check pump calibration.	Adjust pumps to provide 200 mL/sq ft (1 part concentrate to 4 parts water).	Add replenisher or starter to tank solution. Base adjustment on bromide concentration; see Table 5 or Table 7 on page 7-19.	Routinely calibrate pumps and plot data.
	Film sensor not functioning properly.	Check sensor.	Adjust sensor to replenish tank at proper interval.	Add replenisher or starter to tank solution. Base adjustment on bromide concentration; see Table 5 or Table 7 on page 7-19.	Check sensors regularly.
	Pump leaks or faulty check valves.	Check pumps and valves.	Make necessary repairs.	Add replenisher or starter to tank solution. Base adjustment on bromide concentration; see Table 5 or Table 7 on page 7-19.	Perform regular maintenance on replenishment system.

FIRST DEVELOPER—BROMIDE CONCENTRATION—
Outlier High, Level Shift High, Trend Up

PLOT PROBLEM

- Outlier high (make another measurement to confirm)
- Level shift high
- Trend up

CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Too much first-developer starter added.	Check mixing records/procedures.	Follow mixing instructions closely.	Add replenisher to tank solution until bromide concentration is correct; see Table 5 on page 7-19.	Ensure correct mixing procedures.
Underreplenishment.	Check volume of replenisher used vs amount of film processed.	Adjust replenishment rate.	Add replenisher to tank solution until bromide concentration is correct; see Table 5 on page 7-19.	Routinely calibrate pumps and plot data.
Replenisher too concentrated.	Check specific gravity and bromide concentration of replenisher.	Adjust concentration of replenisher until specific gravity and bromide concentration are correct; see Table 1 on page 7-18.	Add water to tank solution until specific gravity and bromide concentration are correct; see Table 2 on page 7-18.	Ensure correct mixing procedures. Measure and plot specific gravity and bromide concentration for each replenisher mix.
Improper ratio of concentrate to water from in-line dilution pumps.	Check pump calibration.	Adjust pumps to provide 200 mL/sq ft (1 part concentrate to 4 parts water).	Add water to tank solution until specific gravity and bromide concentration are correct; see Table 2 on page 7-18.	Routinely calibrate pumps and plot data. Perform regular maintenance on replenishment system.
	Check for leaks, pinched lines, and faulty check/poppet valves.	Make repairs as necessary.		
Excessive evaporation.	Monitor specific gravity of tank solution closely.	Use floating lids whenever possible. Ensure agitation/turbulence is not excessive. Minimize air flow and exhaust. Maintain constant humidity.	Add water to tank solution until specific gravity and bromide concentration are correct; see Table 2 on page 7-18.	Compensate for remaining evaporation, if necessary. (See Appendix 4A.) Monitor level of humidity.

(Continued on next page)

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Outlier high (make another measurement to confirm)	Average density of processed film lower than normal.	Check for high percentage of low-density scenes.	Increase replenishment rate to compensate for change in average density of processed film; see Table 6 on page 7-19.	Add replenisher to tank solution to adjust bromide concentration to aim; see Table 5 on page 7-19.	Closely monitor tank bromide concentration and average density of processed film.
Level shift high					
Trend up					

FIRST DEVELOPER—BROMIDE CONCENTRATION— Outlier Low, Level Shift Low, Trend Down

PLOT PROBLEM	CHOOSE PROBABLE CAUSE	VERIFY CAUSE	ELIMINATE CAUSE	ELIMINATE SYMPTOM	PREVENT RECURRENCE
Outlier low (make another measurement to confirm) Level shift low Trend down	Overreplenishment.	Check volume of replenisher used vs amount of film processed.	Adjust pumps to provide 200 mL/sq ft (1 part concentrate to 4 parts water).	Add starter to tank solution to adjust bromide concentration to aim; see Table 7 on page 7-19.	Routinely calibrate pumps and plot data.
	Replenisher too dilute.	Check specific gravity and bromide concentration of replenisher.	Adjust concentration of replenisher until specific gravity and bromide concentration are correct; see Table 3 on page 7-18.	Add concentrate to tank solution until specific gravity and bromide concentration are correct; see Table 4 on page 7-18.	Ensure correct mixing procedures. Measure and plot specific gravity and bromide concentration for each replenisher mix.
	Improper ratio of concentrate to water from in-line dilution pumps.	Check pump calibration.	Adjust pumps to provide 200 mL/sq ft (1 part concentrate to 4 parts water).	Add concentrate to tank solution until specific gravity and bromide concentration are correct; see Table 4 on page 7-18.	Routinely calibrate pumps and plot data. Perform regular maintenance on replenishment system.
		Check for leaks, pinched lines, and faulty check/poppet valves.	Make repairs as necessary.		
	Average density of processed film higher than normal.	Check for high percentage of high-density scenes.	Adjust replenishment rate to compensate for change in average density of processed film; see Table 6 on page 7-19.	Add starter to tank solution to adjust bromide concentration to aim; see Table 7 on page 7-19.	Closely monitor tank bromide concentration and average density of porcessed film.

FIRST DEVELOPER—Cycling

TEMPERATURE

Look for a relationship between cycling and events that occur regularly:

- Start-up on Monday mornings
- Power-supply fluctuations in the lab during the day/week
- Large replenisher additions before the temperature is measured

Make corrections or adjustments to eliminate the cause of cycling.

SPECIFIC GRAVITY

Look for a relationship between cycling and events that occur regularly:

- Start-up on Monday mornings
- Shift/operator changes
- Use of new replenisher mixes (check mixing procedures)
- Intermittent use of air conditioning

Check that you are compensating for evaporation correctly (see the procedure given in Appendix 4A, "Compensating for Evaporation"). Make specific-gravity measurements every 2 to 4 hours for 2 or 3 days to determine the cause of cycling.

Make corrections or adjustments to eliminate the cause of cycling.

TIME

Look for a relationship between cycling and events that occur regularly:

- Measurements made by different operators
- Power-supply fluctuations in the lab during the day/week

Make corrections or adjustments to eliminate the cause of cycling.

REPLENISHMENT RATE

Look for a relationship between cycling and events that occur regularly:

- Shift/operator changes
- Power-supply fluctuations in the lab during the day/week
- Fluctuations in machine utilization

Make corrections or adjustments to eliminate the cause of cycling.

BROMIDE CONCENTRATION

Cycling in bromide concentration is frequently caused by a combination of a probable cause that raises the concentration followed by a probable cause that lowers the concentration. Cycling can also be linked to fluctuations in the average density of processed film (lower or higher than normal). The amount of bromide released into the first developer depends on film exposure, so large runs of one scene type will cause more or less bromide to be released.

Look for a relationship between cycling and events that occur regularly:

- Start-up on Monday mornings
- Shift/operator changes
- Use of new replenisher mixes (check mixing procedures)

Check that you are compensating for evaporation correctly (see the procedure given in Appendix 4A, "Compensating for Evaporation"). Make bromide measurements every 2 to 4 hours for 2 or 3 days to determine the cause of cycling.

Make corrections or adjustments to eliminate the cause of cycling.

TABLE 1

Addition of Water to Correct for *Overconcentration* of First Developer Replenisher Solution

Specific Gravity Measured at 80°F (27°C)	mL of Water per Litre of Replenisher Solution	Specific Gravity Measured at 100.4°F (38°C)	mL of Water per Litre of Replenisher Solution
1.057	0	1.054	0
1.058	16	1.055	16
1.059	32	1.056	32
1.060	48	1.057	48
1.061	63	1.058	63
1.062	77	1.059	77
1.063	91	1.060	91
1.064	104	1.061	104
1.065	118	1.062	118
1.066	130	1.063	130
1.067	143	1.064	143

TABLE 2

Addition of Water to Correct for *Overconcentration* of Seasoned Tank Solution

Specific Gravity Measured at 80°F (27°C)	mL of Water per Litre of Tank Solution	Specific Gravity Measured at 100.4°F (38°C)	mL of Water per Litre of Tank Solution
1.060	0	1.057	0
1.061	16	1.058	16
1.062	31	1.059	31
1.063	45	1.060	45
1.064	60	1.061	60
1.065	74	1.062	74
1.066	87	1.063	87
1.067	100	1.064	100
1.068	113	1.065	113
1.069	125	1.066	125
1.070	137	1.067	137
1.071	149	1.068	149
1.072	160	1.069	160
1.073	171	1.070	171
1.074	182	1.071	182
1.075	192	1.072	192
1.076	203	1.073	203
1.077	212	1.074	212

TABLE 3

Addition of First-Developer Concentrate to Correct for *Underconcentration* of Replenisher Solution

Specific Gravity Measured at 80°F (27°C)	mL of Concentrate per Litre of Replenisher Solution	Specific Gravity Measured at 100.4°F (38°C)	mL of Concentrate per Litre of Replenisher Solution
1.057	0	1.054	0
1.056	5	1.053	5
1.055	9	1.052	9
1.054	14	1.051	14
1.053	18	1.050	18
1.052	23	1.049	23
1.051	27	1.048	27
1.050	32	1.047	32
1.049	36	1.046	36
1.048	40	1.045	40
1.047	45	1.044	45

TABLE 4

Addition of First-Developer Concentrate to Correct for *Underconcentration* of Seasoned Tank Solution

Specific Gravity Measured at 80°F (27°C)	mL of Concentrate per Litre of Tank Solution	Specific Gravity Measured at 100.4°F (38°C)	mL of Concentrate per Litre of Tank Solution
1.060	0	1.057	0
1.059	5	1.056	5
1.058	9	1.055	9
1.057	14	1.054	14
1.056	19	1.053	19
1.055	23	1.052	23
1.054	28	1.051	28
1.053	32	1.050	32
1.052	36	1.049	36
1.051	41	1.048	41
1.050	45	1.047	45
1.049	49	1.046	49
1.048	54	1.045	54
1.047	58	1.044	58
1.046	62	1.043	62
1.045	66	1.042	66
1.044	70	1.041	70
1.043	74	1.040	74
1.042	78	1.039	78
1.041	82	1.038	82

For each 40 mL of KODAK First Developer Replenisher, Process E-6AR, add 1 mL of KODAK First Developer Starter, Process E-6

TABLE 5

Addition of Replenisher to Correct for High Bromide Concentration

Bromide Concentration (g/L)*	mL of Replenisher per Litre of Tank Solution
3.6	494
3.4	442
3.2	379
3.0	300
2.8	198
2.6	61

*If the bromide concentration is higher than 3.6 g/L, discard the solution and prepare a new first developer according to the mixing instructions on page 7-3.

TABLE 7

Addition of Starter to Correct for Low Bromide Concentration

Bromide Concentration (g/L)	mL of Starter per Litre of Tank Solution
1.4	5
1.6	4
1.8	3
2.0	2
2.2	1
2.4	0.5

TABLE 6

Adjusted Replenishment Rates to Compensate for High or Low Bromide Concentration Due to Changes in Average Density of Processed Film

Bromide Concentration (g/L)	Replenishment Rate	
	mL/sq ft	mL/sq M
3.0	286	3077
2.9	268	2881
2.8	249	2685
2.7	231	2489
2.6	200	2153
2.5	200	2153
2.4	200	2153
2.3	159	1707
2.2	140	1511
2.1	122	1315
2.0	104	1119

COMPENSATING FOR LOW UTILIZATION

You can compensate for low utilization by following the procedure described below; the procedure is based on the theory that you must complete one first-developer tank turnover every three weeks for efficient process operation.

This procedure establishes a *minimum daily square footage requirement* for the amount of film processed. You can follow the procedure for any processor type that uses replenishment.

1. To determine the minimum daily square footage requirement, multiply the first-developer tank volume (in litres) by 5; then divide by the number of days the processor is operated during a three-week period.

   For example, a processor with a first-developer tank volume of 70 litres operated for 15 days over a three week period would have a minimum daily square footage requirement of 23 ([70 x 5] ÷ 15 = 23).

2. Throughout the day, record the amount of film you process.

3. At the end of each day, record the amount of film you processed (in square feet) to the minimum daily square footage requirement.

- If the amount of film processed meets or exceeds the minimum daily square footage requirement, no additional replenishment if required.

- If the amount of film processed is less than the minimum requirement, replenish all of your tank solutions for the difference in square footage. You will also need to add 1mL of first developer starter to your first-developer tank solution for every square foot of film processed below the minimum daily requirement. Do not add color developer starter to the color-developer tank; additional starter will lower color-developer activity.

  The first time you use this procedure, you may have to re-optimize your process by following the procedure for "Optimizing Your Process" in section 6.

Example—Your minimum daily square footage requirement is 23 ft^2, but you processed only 18 ft^2 of film. The difference between the minimum requirement and the amount of film processed is 5 ft^2. Based on a replenishment rate of 200mL/ft^2, you need to add an additional 1,000mL (5 x 200mL) of first developer replenisher to your first-developer tank solution and 1,000 mL of color developer replenisher to your color-developer tank solution. For processors that have a 1 ft^2 replenishment cycle, you need an additional 5 replenishment cycles. You also need to add 1mL/ft^2 (1mL/cycle) or 5mL of first developer starter to the first-developer tank solution. Replenish all other solutions for the difference between the minimum requirement and the amount of film processed.

Note: If your processor has very low utilization, you may want to divide your minimum daily square footage requirement in half, and compare the amount of film processed with the minimum requirement twice during the day (i.e., at midday and at shutdown), and make any adjustments required.