Reciprocity and Special Filter Data for KODAK Films

The reciprocity law states that the *intensity* of light falling on a photographic film multiplied by the exposure *time* equals the total amount of *exposure.*

Intensity x Time = Exposure

This means, for example, that an exposure of *f*/16 at 1/60 second is equivalent to an exposure of *f*/11 at 1/125 second. In either combination of settings, the same amount of light reaches the film.

The reciprocity law applies to most black-and-white and color films at exposure times from approximately ⅕ second to 1/1,000 second. (See the tables in this publication for individual product characteristics.)

However, all photographic emulsions are subject to an effect often called "reciprocity-law failure." At exposure times outside the above range, you will begin to see underexposure (loss of effective film speed) at the normally calculated exposure setting, a change in contrast, a color shift, or a combination of these effects. The word "failure," in this context, does not imply a short coming of the film, but merely that the reciprocity law does not hold for very long or very short exposures times.

We also sometimes refer to these changes in film response to particular illumination levels as "long-exposure effects" and "short-exposure effects."

LONG-EXPOSURE EFFECTS

Under low-light conditions, you may have to extend your exposure times to a point of significant speed loss. With black-and-white films, the effect of this speed loss is partially offset by wide exposure latitude. Most color films require more than the normally calculated exposure when the lighting is unusually low. Also, the sensitivity differences between the many layers of color films can cause a color-balance shift, which means that you will sometimes need to use color-compensating filters to achieve an acceptable color balance.

When you must increase the indicated exposure to compensate for long-exposure effects (see the data in the tables), use a larger lens opening if possible. Extending the exposure time will result in more speed loss, contrast change, and color shift.

SHORT-EXPOSURE EFFECTS

Extremely short exposures produce essentially the same effect as long exposures: speed loss. There is also an increased scattering of exposed silver halide grains, the formation of smaller latent-image centers, and a lower rate of development at the latent-image centers.

The short-exposure effect appears as lower contrast or reduced density in the negative. Exposures of 1/1,000 second or shorter can cause this problem.

KODAK PROFESSIONAL T-MAX Films, KODAK EKTAPAN Film, and most KODAK Color Films have been designed to minimize the short-exposure effect.

ADJUSTMENTS FOR LONG AND SHORT EXPOSURES

Black-and-White Films

Use the exposure and development adjustments in the table below for these black-and-white films:

KODAK EKTAPAN Film*

KODAK PROFESSIONAL PLUS-X 125 Film

KODAK PLUS-X Pan Film

KODAK PLUS-X Pan Professional Film

KODAK PROFESSIONAL TRI-X 400 Film

KODAK TRI-X Pan Film

KODAK PROFESSIONAL TRI-X 320 Film

KODAK TRI-X Pan Professional Film

KODAK VERICHROME Pan Film*

Adjustments for KODAK PROFESSIONAL T-MAX Films, KODAK PROFESSIONAL Technical Pan Film, or KODAK PROFESSIONAL T400 CN Film are listed in Tables 2, 3, and 4.

*To be discontinued in 2002.

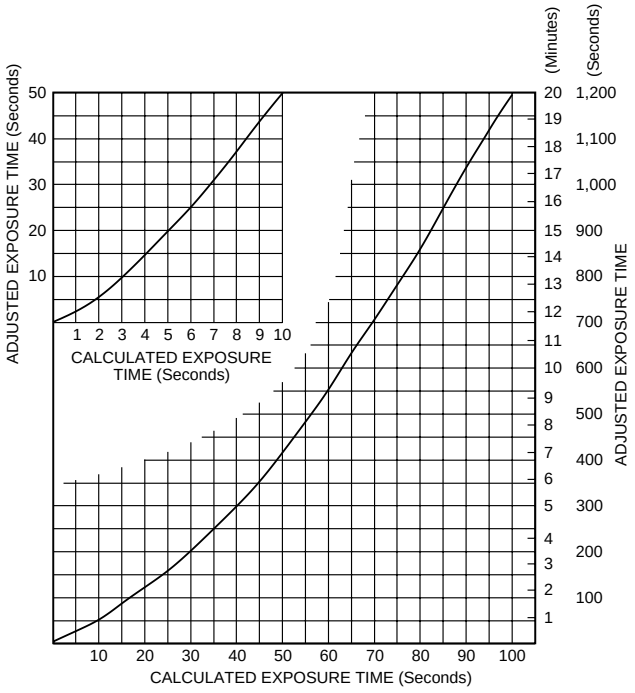
Table 1
Exposure and Development Adjustments for Most Black-and-White Films

If Indicated Exposure Time Is (Seconds)	Use This Lens-Aperture Adjustment	OR	This Adjusted Exposure Time (Seconds)	AND Use This Development Adjustment
1/1000,000*†	+1 stop		Change aperture	+20%
1/10,000*†	+½ stop		Change aperture	+15%
1/1,000	None		None	+10%‡
1/100	None		None	None
1/10	None		None	None
1	+1 stop		2	-10%
10	+2 stops		50	-20%
100	+3 stops		1200	-30%

* Not applicable to EKTAPAN Film.
† Not recommended for TRI-X Pan Professional Film.
‡ EKTAPAN Film does not require an adjusted development time at 1/1000 second.

It may be difficult to use the previous table to estimate the adjusted exposure times for indicated times between 1 and 100 seconds. The following graphs (Illustration 1) will help you find the adjusted exposure times for times between those given in the table.

Illustration 1
Average Adjustment for Most KODAK Black-and-White Films



F002_0062GC

Table 2
Exposure and Development Adjustments for Long and Short Exposures: KODAK PROFESSIONAL Technical Pan Film (developed in KODAK TECHNIDOL Liquid Developer or KODAK HC-110 Developer [Dil D])

If Indicated Exposure Time Is (Seconds)	Use This Lens-Aperture Adjustment	OR	This Adjusted Exposure Time (Seconds)	AND Use This Development Adjustment
1/10,000	None		None	+30%
1/1,000	None		None	+20%
1/100 to 1/10	None		None	None
1	None		None	-10%
10	+½ stop		15	-10%
100	+1½ stops		Change aperture	None

Table 3
Exposure and Development Adjustments for Long and Short Exposures: KODAK PROFESSIONAL T-MAX 100, 400, and P3200 Films

If Indicated Exposure Time Is (Seconds)	Adjustments for Long and Short Exposures					
	KODAK PROFESSIONAL T-MAX 100 Film		KODAK PROFESSIONAL T-MAX 400 Film		KODAK PROFESSIONAL T-MAX P3200 Film	
	Use This Lens-Aperture Adjustment OR	This Adjusted Exposure Time (Seconds)	Use This Lens-Aperture Adjustment OR	This Adjusted Exposure Time (Seconds)	Use This Lens-Aperture Adjustment OR	This Adjusted Exposure Time (Seconds)
1/10,000	+⅓ stop	Change aperture	None	None	None	None
1/1,000 to 1/10	None	None	None	None	None	None
1	+⅓ stop	Change aperture	+⅓ stop	Change aperture	None	None
10	+½ stop	15	+½ stop	15	+⅔ stop	15
100	+1 stop	200	+1 ½ stop	300	+2 stops	400

Note: KODAK PROFESSIONAL T-MAX Films do not require a development-time adjustment.

Table 4
Exposure and Development Adjustments for Long and Short Exposures: KODAK PROFESSIONAL T400 CN Film and KODAK Black-and-White Film (Process C-41)

If Indicated Exposure Time Is (Seconds)	Use This Lens-Aperture Adjustment	OR	This Adjusted Exposure Time (Seconds)
1/10,000 to 120	None		None

Color Films

Table 5
Exposure Adjustments and Filter Compensation for Color Reversal Films—Daylight

KODAK Film (Film Code)	Calculated Exposure Time (Seconds). Exposure increases include adjustment required for suggested KODAK Color Compensating Filters.					
	1/10,000	**1/1,000 to 1/100**	**1/10**	**1**	**10**	**100**
PROFESSIONAL EKTACHROME E100S	None/No filter					+⅓ stop CC075Y at 120 sec
PROFESSIONAL EKTACHROME E100SW						
PROFESSIONAL EKTACHROME E100VS	None/No filter					NR
PROFESSIONAL EKTACHROME E200						
EKTACHROME 64 Professional (EPR)	None/No filter			+⅓ stop CC05R	NR	
EKTACHROME 100 Professional (EPN)	None/No filter			+⅓ stop CC05M	NR	
EKTACHROME 100 Plus Professional (EPP)	None/No filter			+⅓ stop CC025R	+ 1 stop CC025R	2 stops CC10Y + CC025R
EKTACHROME 200 Professional (EPD)	None/No filter			+½ stop CC05M	NR	
EKTACHROME 400X Professional (EPL)	None/No filter			+⅓ stop CC05R	+½ stop CC10R	NR
EKTACHROME P1600 Professional (EPH)	None/No filter			Make tests for your actual conditions.		
KODACHROME 64 (Daylight) (KR)	None/No filter		+⅓ stop CC05R	NR		
KODACHROME 64 Professional (PKR)						
KODACHROME 200 (Daylight) (KL)	None/No filter			+½ stop CC10Y	NR	
KODACHROME 200 Professional (PKL)						
ELITE Chrome 100 (EB)	None/No filter					+⅓ stop CC075Y
ELITE Chrome Extra Color 100 (EBX)	None/No filter					NR
ELITE Chrome 200 (ED)						
ELITE Chrome 400 (EL)	None/No filter			+⅓ or ½ stop CC05R	+½ stop CC10R	NR

Table 6
Exposure Adjustments and Filter Compensation for Color Reversal Films—Tungsten

KODAK Film (Film Code)	Calculated Exposure Time (Seconds). Exposure increases include adjustment required for suggested KODAK Color Compensating Filters.					
	1/10,000	**1/1,000 to 1/100**	**1/10**	**1**	**10**	**100**
EKTACHROME 64T Professional (EPY)	None/No filter					+⅓ stop CC05R
EKTACHROME 160T Professional (EPT)	None/No filter			+⅓ stop CC10R	NR	
ELITE Chrome 160T (Tungsten) (ET)						
EKTACHROME 320T Professional (EPJ)	None/No filter			+⅓ stop CC05R	+½ stop CC10R	NR

Table 7
Exposure Adjustments and Filter Compensation for Color Negative Films—Daylight

KODAK Film (Film Code)	Calculated Exposure Time (Seconds). Exposure increases include adjustment required for suggested KODAK Color Compensating Filters.					
	1/10,000	1/1,000 to 1/100	1/10	1	10	100
PROFESSIONAL PORTRA 160NC	None/No filter					NR
PROFESSIONAL PORTRA 160VC						
PROFESSIONAL PORTRA 400NC						
PROFESSIONAL PORTRA 400VC						
PROFESSIONAL PORTRA 400UC						
PROFESSIONAL PORTRA 800	None/No filter				NR	
PROFESSIONAL SUPRA 100	None/No filter			NR		
PROFESSIONAL SUPRA 400						
PROFESSIONAL SUPRA 800						
Bright Sun (GA)	None/No filter					NR
Bright Sun & Flash (GB)						
MAX Versatility (400) (GC)	None/No filter				NR	
MAX Versatility Plus (800) (GT)						
ROYAL GOLD 100 (RA)	None/No filter					NR
ROYAL GOLD 200 (RB)						
ROYAL GOLD 400 (RC)						
ROYAL GOLD 1000 (RF)						

Table 8
Exposure Adjustments and Filter Compensation for Color Negative Films—Tungsten

KODAK Film (Film Code)	Calculated Exposure Time (Seconds). Exposure increases include adjustment required for suggested KODAK Color Compensating Filters.					
	1/10,000	1/1,000 to 1/100	1/10	1	10	100
PROFESSIONAL PORTRA 100T	Shorter than 1/1,000 sec—NR 1/1,000 to 5 sec—None/No filter			+⅓ stop at 10 sec +⅔ stop at 30 sec + 1 stop at 60 sec		+1⅓ stops at 120 sec

Table 9
Filters and Exposure Adjustments for KODAK Color Films and Fluorescent Lamps

Fluorescent Lamp	Daylight Film									Tungsten Film (3200 K)
	PROFESSIONAL					ELITE Chrome, Bright Sun, Bright Sun & Flash, MAX Versatility, ROYAL GOLD	PROFESSIONAL EKTACHROME	KODACHROME 64	KODACHROME 200, KODACHROME 200 Professional	EKTACHROME Professional (Tungsten)
	SUPRA 100*	SUPRA 400*	SUPRA 800*, PORTRA 800, MAX Versatility Plus	PORTRA 160 NC/VC 400 NC/VC	PORTRA 400 UC					
Daylight	40R + 1⅓ stops	30R + 5M + 1 ⅓ stops	40R + 1 ⅓ stops	20R + 05M + 1 stop	30R + 5M + 1 ⅓ stops	40R + ⅔ stop	50R + 1 stop†	50R + 10M + 1⅓ stops	30R + ⅔ stop	No. 85B + 40M + 30Y + 1 ⅔ stops
White	30B + 10M + 1 ⅔ stops	30C + 40M + 1 ⅔ stops	30C + 40M + 1 ⅔ stops	40B + 05C + 1 ⅔ stops	30C + 40M + 1 ⅔ stops	20C + 30M + 1 stop	40M + ⅔ stop	05C + 40M + 1 stop	10B + 05M + ⅔ stop	50R + 10M + 1 ⅓ stops
Warm White	50B + 2 stops	60B + 2 ⅓ stops	50B + 5C + 2 stops	40B + 40C + 2 stops	55B + 5C + 2 ⅓ stops	40B + 1 stop	20C + 40M + 1 stop	20B + 20M + 1 stop	40B + 05C + 1 ⅓ stops	50M + 40Y +1 stop
Warm White Deluxe	40B + 40C + 2 stops	55B + 40C + 2 ⅔ stops	40B + 40C + 2 stops	40B + 50C + 2 stops	50B + 40C + 2 ⅓ stops	30B + 30C +1 ⅓ stops	30B + 30C + 1⅓ stops‡	40B + 05C + 1⅓ stops	10B + 50C + 1⅓ stops	10R + ⅓ stop
Cool White	5B + 20M + 1 stop	5C + 30M + 1⅓ stops	30M + 1 stop	30B + 1 stop	30M + 1 stop	30M + ⅔ stop	40M + 10Y + 1 stop	40M + 10Y + 1 stop	20M + ⅓ stop	60R + 1 ⅓ stops
Cool White Deluxe	20B + 20C + 1 stop	20B + 20C + 1⅓ stops	20B + 20C + 1 stop	40C + 10M + 1 stop	20B + 20C + 1 stop	20C + 10M + ⅔ stop	20C + 10M + ⅔ stop	05B + 10M + ⅔ stop	05B + 20C + ⅔ stop	20M + 40Y + ⅔ stop
Average Fluorescent§	—	—	—	—	—	10C + 20M + ⅔ stop	30M + ⅔ stop	05C + 30M + 1 stop	10B + 05C + ⅔ stop	50R + 1 stop
T8 741	30B + 10M + 1 ⅔ stops	30C + 40M + 1 ⅔ stops	20B + 20M + 1⅔ stops	40B + 20C + 1⅔ stops	30C + 40M + 1 ⅔ stops	—	—	—	—	—
T8 830	55B + 20C + 2 ⅓ stops	70B + 20C + 3 stops	55B + 20C + 2 ⅓ stops	50B + 60C + 2 ⅓ stops	70B + 10C + 2 ⅔ stops	—	—	—	—	—
T8 835	40B + 1 ⅓ stops	50C + 40M + 2 stops	40B + 1⅔ stops	40B + 40C + 1 ⅔ stops	50C + 40M + 2 stops	—	—	—	—	—
T8 841	20B + 10M + 1 ⅓ stops	20C + 30M + 1 ⅓ stops	20B + 10C + 1 ⅓ stops	50C + 20M + 1 ⅓ stops	20C + 30M + 1 ⅓ stops	—	—	—	—	—

* To be discontinued by end of 2002.
† Exception: KODAK EKTACHROME 100 Professional Film / EPN, use 1⅓ stops.
‡ With KODAK EKTACHROME 100 Professional Film / EPN, use 2 stops.
§ When the type of fluorescent lamps in unknown, try the filter(s) and exposure adjustments given; color rendition will probably be less than optimum.

Note: Except for the KODAK WRATTEN Gelatin Filters No. 85 and 85B, all filters are KODAK Color Compensating Filters (CC). Increase exposure by the adjustment given. Cyan, magenta, and yellow filters were used unless equivalent values of red and blue filters could reduce the number of filters or minimize the exposure adjustment. Red filters were substituted for equivalent values or magenta and yellow. Blue filters were substituted for equivalent values of cyan and magenta.

To avoid the brightness and color variations that occur during a single alternating-current cycle, use shutter speeds of 1/60 second or longer with fluorescent lamps.

Table 10
Filters and Exposure Adjustments for KODAK Color Films with High-Intensity Discharge Lamps

Daylight Film										Tungsten Film (3200 K)
High-Intensity Discharge Lamp	PROFESSIONAL					ELITE Chrome, Bright Sun, Bright Sun & Flash, MAX Versatility, ROYAL GOLD	PROFESSIONAL EKTACHROME*	KODACHROME 64	KODACHROME 200, KODACHROME 200 Professional	EKTACHROME Professional (Tungsten)
	SUPRA 100†	SUPRA 400†	SUPRA 800†, PORTRA 800 MAX Versatility Plus	PORTRA 160 NC/VC 400 NC/VC	PORTRA 400 UC					
General Electric Lucalox‡	—	—	—	—	—	70B + 50C + 3 stops	80B + 20C + 2⅓ stops	70B + 30C + 2 ⅔ stops	50B + 30C + 2 ⅔ stops	50M + 20C + 1 stop
General Electric Multi-Vapor	—	—	—	—	—	10R + 20M + ⅔ stop	20R + 20M + ⅔ stop	30R + 10M + 1 stop	20R + 10M +⅔ stop	60R + 20Y + 1⅔ stops
Deluxe White Mercury	—	—	—	—	—	20R + 20M + ⅔ stop	30R + 30M + 1⅓ stops	30R + 30M + 1⅓ stops	10R + 30M + 1⅓ stops	70R + 10Y + 1⅔ stops
Clear Mecury	—	—	—	—	—	80R + 1⅔ stops	70R 1⅓ stops	120R + 20M + 3 stops§	110R + 10M + 2 ⅔ stops	90R + 40Y + 2 stops
High-Pressure Sodium Vapor (2700 K)	55B + 50C + 2 ⅔ stops	55B + 50C + 2 ⅔ stops	60B + 50C + 2 ⅔ stops	50B + 70C + 2 ⅔ stops	55B + 50C + 2 ⅔ stops	—	—	—	—	—
High-Pressure Sodium Vapor (2200 K)	60B + 55C + 3⅓ stops	60B + 55C + 3⅓ stops	120C + 50M + 3⅓ stops	50B + 90C + 3 stops	55B + 60C + 3 stops	—	—	—	—	—
High-Pressure Sodium Vapor (2100 K)	50B + 100C + 3 ⅔ stops	55B + 80C + 4 stops	55B + 100C + 4 stops	200C + 20M + 4 stops	50B + 90C + 3 ⅔ stops	—	—	—	—	—
Metal Halide (4300 K)	5R + 20M + 1 stop	30M + 5Y + 1 ⅓ stops	5R + 20M + 1 stop	5C + 10M + ⅔ stop	20M + 5R + 1 stop	—	—	—	—	—
Metal Halide (3200 K)	50C + 20M + 1 ⅔ stops	30B + 5C + 1 ⅔ stops	20B + 30C + 1 ⅔ stops	80C + 10M + 1 ⅔ stops	20B + 20C + 1 ⅓ stops	—	—	—	—	—
Mercury Vapor (3700 K)	30M + 1 stop	20B + 30M + 1 ⅔ stops	30M + 1 stop	30B + 5C + 1 stop	20B + 20M + 1 ⅔ stops	—	—	—	—	—

* Exception: KODAK EKTACHROME 100 Professional Film / EPN
† To be discontinued by end of 2002.
‡ This is a high-pressure sodium-vapor lamp. The information in the table may not apply to other manufacturers' high-pressure sodium-vapor lamps because of differences in spectral characteristics. Kodak does not recommend sodium-vapor lamps for critical use.
§ To avoid affecting image definition and contrast, we recommend that you use no more than 3 color compensating filters. This combination, which includes 4 filters, is an exception to that recommendation.

Note: All filters are KODAK Color Compensating Filters (CC). Increase exposure by the adjustment given. Cyan, magenta, and yellow filters were used unless equivalent values of red and blue filters could reduce the number of filters or minimize the exposure adjustment. Red filters were substituted for equivalent values of magenta and yellow. Blue filters were substituted for equivalent values of cyan and magenta.

To avoid the brightness and color variations that occur during a single alternating-current cycle, use shutter speeds of 1/125 second or longer with high-intensity discharge lamps.

Note: The reciprocity data in this publication represent products tested under the condition of exposure and processing specified. They are representative of production coatings and, therefore, do not apply directly to a particular box or roll of film. They do not represent standards or specifications that must be met by Eastman Kodak Company.The company reserves the right to change and improve product characteristics at any time.

For critical use, make test with film of the same emulsion number that you will use for the final exposure. The emulsion number is stamped on each box of film.

MORE INFORMATION

Kodak has many publications to assist you with information on Kodak products, equipment, and materials.

Additional information is available on the Kodak website.

The following publications are available from Kodak Customer Service, from dealers who sell Kodak products, or you can contact Kodak in your country for more information.

E-8	*KODAK EKTACHROME 64 Professional Film*
E-27	*KODAK EKTACHROME 100 Professional Film (EPN)*
E-28	*KODAK PROFESSIONAL EKTACHROME Film E200*
E-30	*Storage and Care* of KODAK Photographic Materials—Before and After Processing
E-41	*KODAK ROYAL GOLD 100 Film*
E-42	*KODAK ROYAL GOLD 200 Film*
E-43	*KODAK ROYAL GOLD 400 Film*
E-73	*Why a Color May Not Reproduce Correctly*
E-88	*KODACHROME 25, 64, and 200 Films*
E-126	*KODAK ELITE Chrome Extra Color 100 Film*
E-130	*KODAK EKTACHROME 64T Professional Film*
E-134	*KODAK ELITE Chrome 100 Film*
E-144	*KODAK EKTACHROME 160T Professional Film*
E-145	*KODAK EKTACHROME 320T Professional Film*
E-147	*KODAK EKTACHROME P1600 Professional Film*
E-148	*KODAK ELITE Chrome 200 Film*
E-149	*KODAK ELITE Chrome 400 Film*
E-154	*KODAK ELITE Chrome 160T Film*
E-160	*KODAK PROFESSIONAL EKTACHROME Film E100VS*
E-161	*KODAK EKTACHROME 400X Professional Film*
E-163	*KODAK PROFESSIONAL EKTACHROME Film E100VS*
E-164	*KODAK PROFESSIONAL EKTACHROME Films E100S and E100SW*
E-190	*KODAK PROFESSIONAL PORTRA Films*
E-2328	*KODAK Bright Sun Film*
E-2329	*KODAK Bright Sun & Flash Film*
E-2330	*KODAK MAX Versatility Film*
E-2452	*KODAK MAX Versatility Plus Film*
E-2468	*KODAK PROFESSIONAL PORTRA 100T Film / Tungsten*
E-2519	*KODAK PROFESSIONAL SUPRA Films*
F-32	*KODAK T-MAX Professional Films*
F-7	*KODAK VERICHROME Pan Film*
F-8	*KODAK PLUS-X Pan and KODAK PLUS-X Pan Professional Films*
F-9	*KODAK TRI-X Pan and KODAK TRI-X Pan Professional Films*
F-10	*KODAK EKTAPAN Film*
F-2350	*KODAK PROFESSIONAL T400 CN Film*
F-4016	*KODAK PROFESSIONAL T-MAX Films*
F-4017	*KODAK PROFESSIONAL TRI-X 320 and 400 Films* (available late 2002)
F-4018	*KODAK PROFESSIONAL Plus-X 125 Film*
J-24	*KODAK PROFESSIONAL HC-110 Developer*
J-78	*KODAK PROFESSIONAL Developer D-76*
J-86	*KODAK T-MAX Developers*
P-255	*KODAK PROFESSIONAL Technical Pan Film*

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