



KODAK AEROGRAPHIC RA Duplicating Film 2416 KODAK AEROGRAPHIC RA Duplicating Film 4416 KODAK Aerial RA Duplicating Film SO-416

These black-and-white negative aerial duplicating films consist of blue-sensitive, extremely high resolution, extremely fine grain emulsion that are coated on a 3.9-mil ESTAR Base, 7-mil ESTAR Thick Base, or 2.5-mil ESTAR Thin Base with fast-drying or dyed-gel backing. The photographic properties of these films are virtually identical; the physical properties differ due to the differences in base thickness and backing.

The ESTAR Base provides flexibility, moisture resistance, high tear resistance, and excellent dimensional stability. Depending on base thickness, the backings provide antihalation protection, curl control, and/or static protection. Because the base-side is significantly darker than the emulsion side, it can be easily identified under the recommended red safelight.

These films can be processed at elevated temperatures in modern continuous-processing machines and in roller-transport processors, such as the KODAK VERSAMAT Film Processor, Model 11 or 1140, with KODAK VERSAMAT 885 Chemicals or KODAK VERSAMAT 641 Chemicals. In addition, these films can be processed in rapid access processors, such as the KODAMATIC 125 Processor, using KODAK RA 2000 Developer and Replenisher. The 2416 and 4416 Films can also be tray processed in such common developers as KODAK Developer D-76 and KODAK Developer DK-50.

APPLICATIONS

This film is designed for duplicating fine- and medium-grain aerial negatives. It is intended for use both as the intermediate positive and as the final negative.

BASE

2416 Film: 3.9-mil (0.10 mm) ESTAR Base with a fast-drying backing

4416 Film: 7-mil (0.18 mm) ESTAR Thick Base with a dyed-gel backing

SO-416 Film: 2.5-mil (0.06 mm) ESTAR Thin Base with a dyed-gel backing

TOTAL FILM THICKNESS

The nominal total thickness (unprocessed) of each film is:

2416 Film: 4.1 mils (0.106 mm)

This includes emulsion—0.2 mils (0.005 mm), base—3.9 mils (0.10 mm) and backing—nil.

4416 Film: 7.3 mils (0.186 mm)

This includes emulsion—0.2 mils (0.005 mm), base—7.0 mils (0.178 mm) and backing—0.1 mil (0.003 mm).

SO-416 Film: 2.8 mils (0.071 mm)

This includes emulsion—0.2 mils (0.005 mm), base—2.5 mils (0.063 mm) and backing—0.1 mil (0.003 mm).

WEIGHT

The weight of each film (unprocessed), conditioned in equilibrium with 50 percent relative humidity, is:

2416 Film: 0.032 lbs/sq ft² (0.0145 kg/ft²)

4416 Film: 0.053 lbs/sq ft² (0.0240 kg/ft²)

SO-416 Film: 0.023 lbs/sq ft² (0.0104 kg/ft²)

SPECTRAL SENSITIVITY

Blue sensitive.

SAFELIGHT

Use a KODAK 1 Safelight Filter (red) in a suitable safelight lamp with a 15-watt bulb at not less than 4 feet (1.2 metres) from the film.

EXPOSURE

These films may be exposed using a variety of printing sources. As in most projection or contact printing operations, the optimum exposure level required for a given processing condition is determined by test exposures.

Reciprocity Characteristics:

Reciprocity data for projection-speed and contact-speed duplicating films are useful when using an on-easel photometer for exposure determination.

No adjustments are required for exposure times of 1/10 second or shorter. At 1 second, adjust the Neutral Density Filters by -0.15 or increase the exposure time to 1.5 second. At 10 seconds, adjust the Neutral Density Filters by -0.30 or increase the exposure time to 20 seconds, and decrease the development time by 40%.

IMAGE STRUCTURE

The following data are based on processing in a KODAK VERSAMAT Film Processor, Model 11, with 1 rack at 15 fpm, using KODAK VERSAMAT 885 Chemicals at 85°F (29.5°C) and a process gamma of 1.5.

Resolving Power (line pairs/mm)		rms Granularity*
TOC 1.6:1	TOC 1000:1	
160	250	8

*Granularity values read at a net diffuse density of 1.0 with a 48-micrometre aperture.

STORAGE

For consistent results, all aerial films should be stored under fairly constant conditions. Kodak aerial films are “usually” packaged in equilibrium with 40 to 50 percent relative humidity. High temperatures or high humidity may produce undesirable changes in the film.

Unexposed Film

Store unexposed film in a refrigerator at 55°F (13°C) or lower, or freezer at 0 to -10°F (-18 to -23°C), in the original sealed container. If the film is stored in a refrigerator, remove it about 2 hours before opening; if stored in a freezer, remove it about 8 hours before opening. A sufficient warm-up time is necessary to prevent moisture condensation on cold film -- otherwise, moisture spotting, ferrotyping, or sticking may occur.

Exposed Film

Keep exposed film cool and dry. Process the film as soon as possible after exposure to avoid undesirable changes in the latent image. If it is necessary to hold exposed but unprocessed film for several days (such as over a weekend), it should be resealed and refrigerated at 40°F (4°C) or lower. Before unsealing and processing exposed film that has been held in cold storage, follow the warm-up procedures described for unexposed film described above.

Processed Film

For best keeping, store processed film in a dark, dust-free area at 50 to 70°F (10 to 21°C) and 30 to 50 percent relative humidity. Preferably, store negatives on the spool or in individual KODAK Sleeves. High relative humidity promotes the growth of mold and causes ferrotyping. Very low relative humidity causes excessive curl and brittleness. Avoid storage temperatures over 80°F (27°C).

PROCESSING

KODAK AEROGRAPHIC RA Duplicating Films 2416/4416 and KODAK Aerial RA Duplicating Film SO-416 can be processed in KODAK VERSAMAT Film Processors, Model 11 and 1140 with KODAK VERSAMAT 885 Chemicals, KODAK VERSAMAT 641 Chemicals, or KODAK VERSAMAT Chemicals, Type A. (Only data for KODAK VERSAMAT 885 Chemicals are included in this publication.)

Notice: Observe precautionary information on product labels and Material Safety Data Sheets.

Mechanized processing in roller-transport processors offers the advantages of uniform treatment of all portions of the roll, freedom from banding, and absence of significant density variations from ends of the roll to the center. Refer to the operator's manual for the processor set-up information, but in all cases, the fixer replenisher should be introduced into tank No. 5 of the processor with a countercurrent flow to tank No. 3, where it overflows to a collection or recovery system.

General instructions for setting the machine dryer temperature are included in these pages. However, the temperature of the dryer may require some further adjustment, depending upon the ambient temperature conditions in the processing area. Usually it is best to set the temperature approximately 3°F (2°C) above that required to dry unexposed, processed film.

Handling Thin Base Films:

A 7-mil-thick, polyester-base leader tab (at least 9 1/2 inches wide) is recommended when feeding SO-416 Film into KODAK VERSAMAT Film Processors, Model 11 and Model 1140. Follow usual handling and processing procedures for thin-base film products.

Replenishment Rates

Basic developer and fixer replenishment rates, in millilitres per square inch of film processed, vary depending upon the type of chemicals used. The following rates apply to processing in the VERSAMAT Processor, Models 11 and 1140 when using KODAK VERSAMAT 885 Chemicals.

Developer:	0.08 mL/in ²
Fixer:	0.15 mL/in ²

Processing Sequence

KODAK VERSAMAT Processor, Model 11 or 1140 KODAK VERSAMAT 885 Chemicals			
Processing Step	No. of Racks	Path Length	Temperature
Develop	1 or 2	1.2 or 2.4 m (4 or 8 ft)	85 ± 0.5°F (29.5 ± 0.3°C)
Fix	3	3.6 m (12 ft)	85°F (29.5°C), nominal
Wash	2	2.4 m (8 ft)	2 to 6°F (1 to 3°C) below developer temperature
Dry	—	2.4 m (8 ft)	135 to 145°F (57 to 63°C)

Sensitometric Data

KODAK VERSAMAT 885 Chemicals 85°F (29.5°C), Model 11				
Machine Speed (fpm)	1 Developer Rack		2 Developer Racks	
	Average Gamma	D-min	Average Gamma	D-min
5	1.95	0.21	—	—
10	1.75	0.07	—	—
15	1.45	0.03	1.95	0.13
20	1.45	0.02	1.85	0.09
25	1.40	0.02	1.70	0.05

Fixing: Adequate fixing is obtained at machine speeds up to and including 25 feet per minute.

Washing: LE-500 keeping quality is obtained at process machine speeds up to and including 25 feet per minute with 1 or 2 developer racks. (LE = Life Expectancy)

Drying: Adequate drying is obtained at machine speeds up to and including 25 feet per minute.

Sensitometric Data

KODAK VERSAMAT 885 Chemicals, 85°F (29.5°C), Model 1140				
Machine Speed (fpm)	1 Developer Rack		2 Developer Racks	
	Average Gamma	D-min	Average Gamma	D-min
10	1.75	0.07	—	—
20	1.45	0.02	1.85	0.09
30	1.40	0.02	1.55	0.04
40	1.35	0.01	1.50	0.02

Fixing: Adequate fixing is obtained at machine speeds up to and including 40 feet per minute.

Washing: LE-500 keeping quality is obtained at process machine speeds up to and including 30 feet per minute with 1 developer rack or 25 feet per minute with 2 racks. LE-100 may be obtained at all other practical machine processing speeds with 1 or 2 racks. (LE = Life Expectancy)

Drying: Adequate drying is obtained at machine speeds up to and including 40 feet per minute.

RAPID ACCESS PROCESSING

KODAK AEROGRAPHIC RA Duplicating Films 2416/4416 and KODAK Aerial RA Duplicating Film SO-416 can be processed in most replenishable rapid-access or deep-tank processors accommodating aerial films, such as the KODAMATIC 125 Processor, with KODAK RA 2000 Developer and Replenisher (1:4).

The starting-point recommendation provides a range of acceptable developer times and temperatures. Generally, times and temperatures near the center of the specified ranges provide the best starting point in most processors and will produce optimum results. However, criteria other than development time may dictate the acceptable processing speed for any particular processor.

Fixing efficiency can be improved by raising the temperature of the fixer or by reducing the speed of the processor. Likewise, **Washing** efficiency can be improved by using a higher wash temperature or a lower machine speed.

When making time and/or temperature adjustments, check the recommendations in the table to make sure that the development time does not fall outside the acceptable range.

Chemicals

KODAK RA 2000 Developer and Replenisher / Diluted 1:4

KODAK RA 3000 Fixer and Replenisher (concentrate)—
See Fixer Dilution Options

Note: Observe precautionary information on product labels and on the Material Safety Data Sheets.

Replenishment Rates

The following basic replenishment rates apply to processing in the KODAMATIC 125 Processor using KODAK RA 2000 Developer and Replenisher and KODAK RA 3000 Fixer and Replenisher.

Solution	Average D-max Area	Basic Rates
Developer (1:4)	60 percent	0.45 mL/sq ft
Fixer Options 1 and 2	Any percent	0.12 mL/sq ft

Note: Some large rapid-access machines and small deep-tank machines require different replenishment rates. If a further increase in fixing efficiency is required, the fixer replenishment rate can be increased.

Fixer Dilution Options

KODAK RA 3000 Fixer dilution depends upon the product and processor being used:

Fixer Option No. 1: Normal dilution (1:3 plus part B)

Fixer Option No. 2: 1 part A, 3 parts water, no part B

As a starting point, do not add hardener to the fixer. However, if abrasion or any other transport problems occur in processing, a small amount of KODAK RA 3000 Fixer Part B (hardener) can be added; start with 1 oz of Part B (hardener) per working-strength gallon of fixer and increase as necessary to a maximum of 3.2 oz per gallon. Follow the instructions for adding Part B—slowly and mixing thoroughly.

Processing Sequence

KODAMATIC 125 Processor (recommended rapid access chemicals)		
Processing Step	Time	Temperature
Develop	40 sec	95°F (35°C)
Starting Point Range	20 to 50 sec	90 to 100°F (32 to 38°C)
Fix	50 sec	95°F (35°C)
Wash	45 sec	95°F (35°C)
Dry	—	115 to 120°F (46 to 49°C)

Note: Within the specified temperature and time ranges, higher developer temperatures require shorter development times.

Sensitometric Data

RA 2000 Developer and Replenisher, 95°F (35°C) KODAMATIC 125 Processor		
Timer (seconds)	Average Gamma	D-min
20	2.10	0.01
30	2.35	0.01
40	2.50	0.01
50	2.60	0.01

Fixing: Adequate fixing is obtained at all practical development times.

Washing: LE-500 keeping quality is obtained at development times from 20 to 50 seconds. (LE = Life Expectancy)

Drying: Adequate drying is obtained at all practical development times.

Process Control

Process control strips are not required with this developer. Since the developer and replenisher are the same solution, it is not possible to over-replenish from a photographic standpoint.

If a daily trend is noted in the direction of lower D-max with no change in the exposure or exposure conditions, it may indicate under-replenishment. If this occurs, increase the replenishment rate.

If the D-max level is objectionably low, make a partial or full dump of developer and replace with fresh developer. Check the D-max level. If the D-max level is back to normal, increase the replenishment rate.

Solution Life

Drain, clean, and refill the processing tank as per processor manufacturer's recommendations. For rapid-access processors, the recommended interval is every 3 months for 1 shift, 2 months for 2 shifts, or 1 month for 3 shifts.

Mixed developer replenisher should be kept no longer than 3 weeks in a tank with a floating lid and dust cover.

Mixed fixer replenisher should be kept no longer than 4 weeks in a tank with a floating lid and dust cover.

SHEET FILM PROCESSING

Development conditions should be selected to produce diapositives having a density range that permits the formation of a stereo model and accurate plotting. Some users of diapositives have prepared their own standards. As a general rule, a typical density range of 0.7 (from 0.3 minimum to 1.0 maximum) is suitable for diapositives to be used in projection-plotting instruments. For direct-view stereo-plotting instruments, a somewhat more dense diapositive is usable and a density range of 1.2 (from 0.3 to 1.5) is indicated.

Machine Processing

(KODAK VERSAMAT 885 Chemicals)

4416 Film (sheet sizes) may be processed in a roller-transport processor, such as the KODAK VERSAMAT Film Processor, Model 11, using KODAK VERSAMAT 885 Chemicals at 85°F (29.5°C).

For intermittent processing of 4416 Film sheets, use a developer replenishment rate of 0.08 mL/sq in. and a fixer replenishment rate of 0.15 mL/sq in. with 885 Chemicals. Replenishment may be done in a “batch” mode, based on the amount of film processed.

If sheets of 4416 Film are fed into the processor on a continuous basis, the replenishment rates (mL/min) for two strands of 5-inch-wide film may be used at the basic rates (mL/sq in.) noted above.

Tray Processing

KODAK AEROGRAPHIC RA Duplicating Film 4416 in sheet-film sizes can also be tray processed in KODAK Developer D-76, KODAK Developer DK-50, or KODAK DEKTOL Developer (dilution 1:2) depending on the required gamma or the effective density range desired in the diapositive.

1. Develop 4416 Film using the following table as a guide. This table is based on continuous agitation in a tray; for lower levels of agitation, times must be increased.

KODAK Developer	Development Time (minutes)
DEKTOL (1:2), 20°C (68°F)	1 1/2 to 8
DEKTOL (1:2), 24°C (75°F)	1 1/2 to 4
D-76, 20°C (68°C)	3 1/2 to 10
DK-50, 20°C (68°F)	1 1/2 to 10

2. After development, rinse with continuous agitation in KODAK Indicator Stop Bath or in running water at 65 to 70°F (18 to 21°C) for approximately 30 seconds. (A suitable stop bath can also be made from using 125 mL/L of KODAK 28% Acetic Acid.)
3. Fix at 65 to 70°F (18 to 21°C) in KODAK Fixer for 5 to 10 minutes with continuous agitation.
4. Wash in running water at 65 to 70°F (18 to 21°C) for at least 30 minutes. To reduce time and conserve water, use KODAK Hypo Clearing Agent. After washing, treat the film in KODAK PHOTO-FLO Solution (prepared as directed on the bottle label) to minimize drying marks.
5. Dry the film in a dust-free area. It is important that both sides of the processed 4416 Film sheets be dried thoroughly.

DIMENSIONAL STABILITY

The dimensional stability of aerial films is of particular interest and importance in accurate mapping and in the reproduction of maps.

Dimensional stability is an all-inclusive term. In photography, it applies to size changes caused by changes in humidity and in temperature, and by processing and aging. The absence of solvent in ESTAR Base is one of the reasons why ESTAR Base films show excellent dimensional stability. The dimensional properties of ESTAR Base may vary slightly in different directions within a sheet; the differences that may exist, however, are not always between the length and width directions.

Temporary Dimensional Changes

Thermal Coefficient of Linear Expansion:			
2416	4416	SO-416	
0.001%	0.001%	0.001%	per degree F of change
0.0018%	0.0018%	0.0018%	per degree C of change

Humidity Coefficient of Linear Expansion (Unprocessed):			
2416	4416	SO-416	
0.0018%	0.0015%	0.0029%	per 1% change in relative humidity

Permanent Dimensional Changes

Processing Dimensional Change (percent shrinkage to swell):		
2416	4416	SO-416
-0.02% to +0.02%	-0.01% to +0.02%	-0.02% to +0.01%

Aging Shrinkage of Processed Film:			
2416	4416	SO-416	
0.02%	0.02%	0.02%	1 week at 120°F (49°C), 20% RH
0.02%	0.02%	0.02%	1 year at 78°F (25.5°C), 60% RH

SIZE DATA AND ORDERING INFORMATION

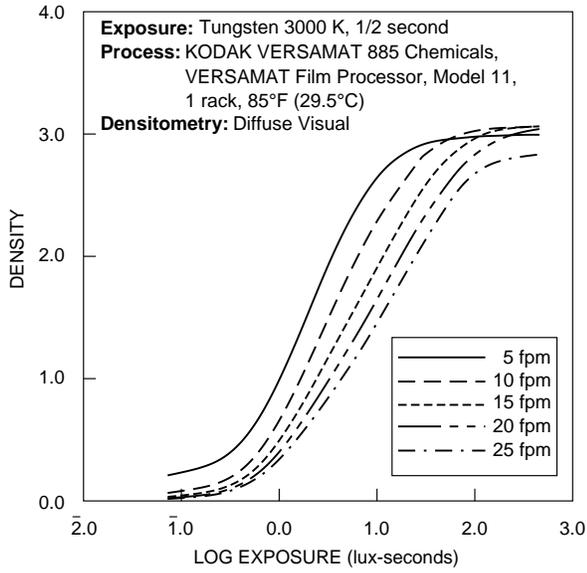
Information on available sizes and minimum order quantities of this film is available on the web at www.kodak.com/go/aerial. You can also write or call:

Aerial Imaging
 Eastman Kodak Company
 343 State Street
 Rochester, New York 14650-0505
 (585) 724-4688
 Toll-free in the US: (877) 909-4280

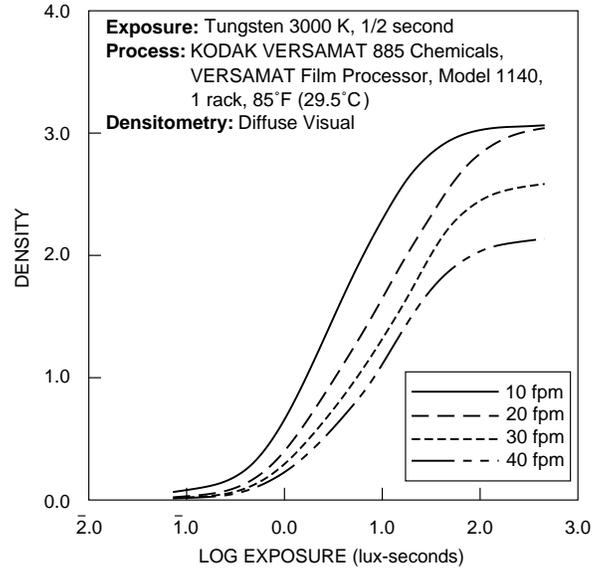
Note: The Kodak materials described in this publication used with KODAK AEROGRAPHIC RA Duplicating Films 2416 and 4416 and KODAK Aerial RA Duplicating Film SO-416 are available from those dealers normally supplying Kodak products. Other materials may be used, but equivalent results may not be obtained.

CURVES

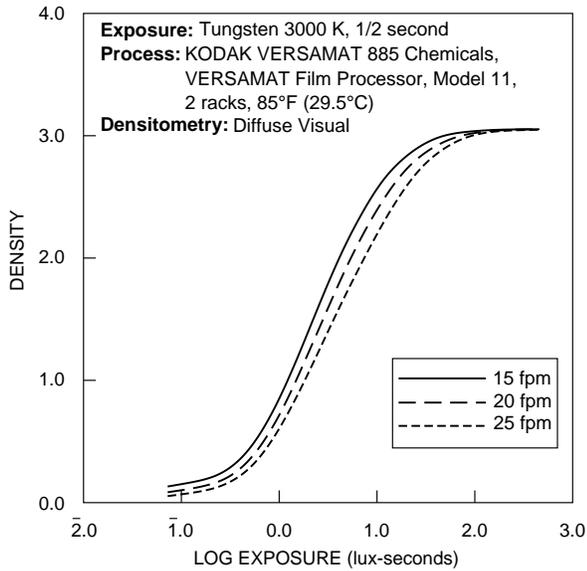
**Characteristic Curves: VERSAMAT Model 11,
885 Chemicals; 1 rack**



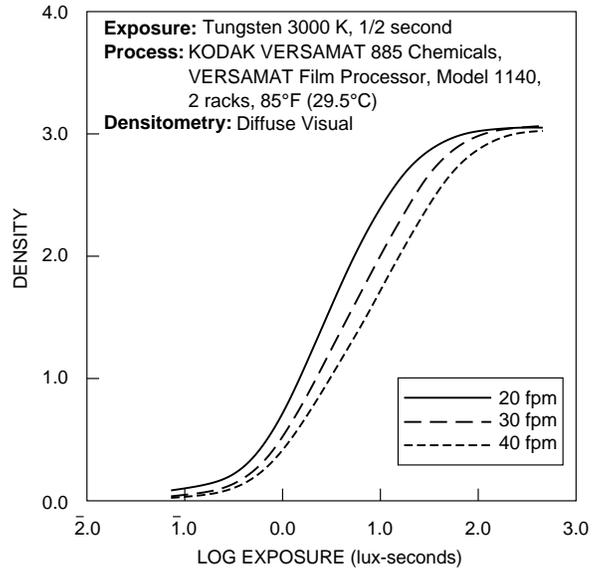
**Characteristic Curves: VERSAMAT Model 1140,
885 Chemicals; 1 rack**



**Characteristic Curves: VERSAMAT Model 11,
885 Chemicals; 2 racks**



**Characteristic Curves: VERSAMAT Model 1140,
885 Chemicals; 2 racks**

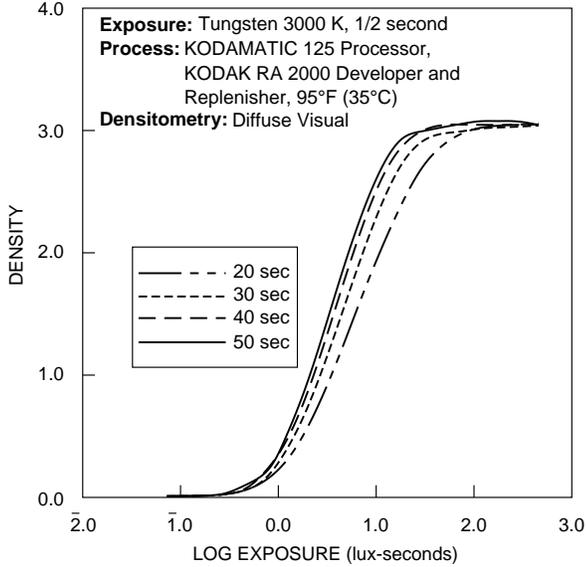


KODAK AEROGRAPHIC RA Duplicating Film 2416

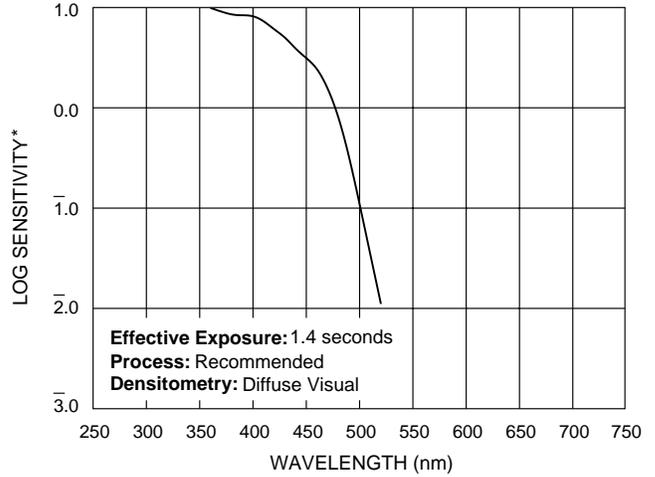
KODAK AEROGRAPHIC RA Duplicating Film 4416

KODAK Aerial RA Duplicating Film SO-416

**Characteristic Curves: KODAMATIC 125 Processor,
RA 2000 Chemicals**

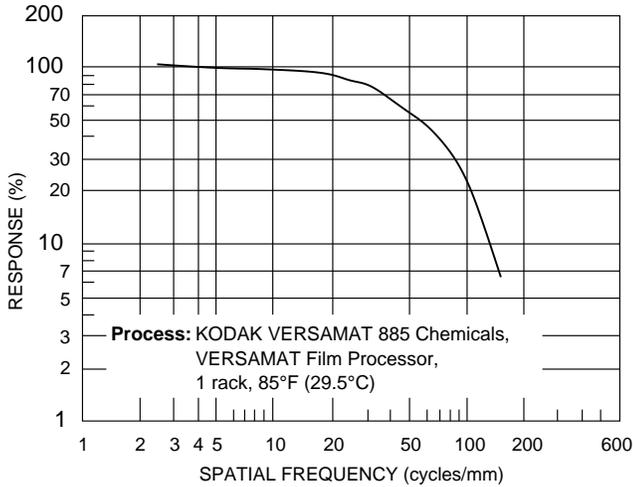


Spectral Sensitivity



*Sensitivity = reciprocal of exposure (erg/cm²) required to produce specified density

Modulation Transfer Function



NOTICE: While the sensitometric data in this publication are typical of production coatings, they do not represent standards which must be met by Kodak. Varying storage, exposure, and processing conditions will affect results. The company reserves the right to change and improve product characteristics at any time.

Aerial Imaging

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