



KODAK Infrared AEROGRAPHIC Film 2424

KODAK Infrared AEROGRAPHIC Film 2424 is a black-and-white, negative aerial camera film sensitive to infrared radiation as well as to ultraviolet and visible radiation. With a KODAK WRATTEN Filter No. 25, this film requires about one stop more exposure than KODAK PLUS-X AEROGRAPHIC Film 2402 (ESTAR Base) without a filter. Compared with extended red panchromatic-sensitized films, infrared-sensitive films usually provide increased contrast between water and land and greatly improved haze penetration. They may also show more differentiation of vegetation.

Its ESTAR Base provides flexibility, moisture resistance, high tear resistance, and excellent dimensional stability. This film has a thin, highly hardened, and abrasion-resistant emulsion that permits high-temperature rapid processing in modern continuous machines.

This film can be processed in the KODAK VERSAMAT Film Processor, Models 11 and 1140 with KODAK VERSAMAT 885 Chemicals, KODAK VERSAMAT 641 Chemicals, or KODAK VERSAMAT Chemicals, Type A. It can also be processed at normal temperatures in KODAK Developer D-19 or KODAK Developer DK-50 in rewind-processing machines, such as the Morse M-10 Developing Outfit (Military Designator: B-5).

Caution: KODAK Infrared AEROGRAPHIC Film 2424 is susceptible to static markings at low relative humidities. These films are packaged at the optimum relative humidity (45 to 50 percent) and are maintained at this level by the sealed package. In conditions of low relative humidity, these films should be loaded and used immediately after the package is opened, before the film becomes too dry. The camera should be checked to see that all its parts are grounded adequately. Also, these films should be handled carefully during all loading, unloading, and preprocessing operations.

APPLICATIONS

KODAK Infrared AEROGRAPHIC Film 2424 is especially suited for the reduction of haze effects, and for oblique long-distance photography, geological and archaeological studies, agricultural surveys, crop studies, forestry studies, oceanography, multiband aerial photography, hydrology, and other scientific applications where infrared film is needed. It may also be used for camouflage detection.

Note: Thermal photography cannot be done with infrared-sensitive films. These films are not thermal or heat detectors. They are sensitive only to the near-infrared spectral region, up to about 900 nanometers. Thermal recording usually involves obtaining a visible display of longer wavelength radiation, such as on a cathode-ray tube, and then photographing this display.

BASE

3.9-mil (0.10 mm) ESTAR Base with fast-drying backing.

TOTAL FILM THICKNESS

The nominal total thickness (unprocessed) of this film is **4.25 mils** (0.108 mm). This includes emulsion—0.35 mil (0.009 mm), base—3.9 mils (0.10 mm), and fast-drying backing—nil.

WEIGHT

The weight of 2424 Film (unprocessed), conditioned in equilibrium with 50 percent relative humidity, is **0.032 lbs/ft²** (0.0145 kg/ft²).

SPECTRAL SENSITIVITY

Sensitive to ultraviolet, visible, and infrared radiation to approximately 900 nm with maximum sensitivity from 760 to 880 nm.

SAFELIGHT

Total darkness is required.

EXPOSURE

Aerial film speeds (ISO A or EAFS) should not be confused with conventional film speeds which are designed for roll and sheet films used in pictorial photography. The characteristics of aerial scenes differ markedly from those of ordinary pictorial or ground scenes because of the smaller range in subject luminances, atmospheric haze conditions, and other factors. Therefore, different film-speed parameters are used to relate aerial-scene characteristics to practical exposure recommendations. The KODAK Aerial Exposure Computer, KODAK Publication AS-10, has been published based on the aerial film speed criterion.

Nominal speed, daylight (no filter): EAFS or ISO A 400

Other suggested aerial film speeds for processing these films in the KODAK VERSAMAT Film Processor, Models 11 or 1140, using VERSAMAT 885 Chemicals, 641 Chemicals, and Type A Chemicals can be found in the sensitometric data tables.

Aerial film speeds for infrared-sensitive films are not obtainable using radiometric log H values. The ISO A values given in the sensitometric data tables have been determined from empirical data from actual controlled flight tests with aerial cameras. These values correspond to panchromatic film with not appreciable infrared sensitivity.

Note: The aerial film speeds given in this publication were obtained by rounding the calculated values to the nearest cube root of 2 step (equivalent to 1/3 stop).

Filters

In general, it is desirable to confine the exposure to the far red and infrared regions of the spectrum. Therefore, the deeper-colored KODAK WRATTEN Filters No. 25 (red) and No. 89B (deep red, visually opaque) are commonly used. The No. 25 filter absorbs all of the blue portion of the visible spectrum and nearly all the green. The No. 89B filter limits the exposing radiation to the infrared region. Differences among object reflectances are often greater with infrared than they are with visible radiation.

In forest survey work there is some evidence that the best differentiation of tree types is obtained by using a yellow filter, such as the KODAK WRATTEN Filter No. 12 (“minus blue”). This filter transmits a minor amount of ultraviolet radiation and absorbs all of the blue portion of the visible spectrum, while transmitting nearly all of the green, red, and infrared portions.

KODAK PROFESSIONAL WRATTEN Gelatin Filter*			
	No. 12	No. 25	No. 89B
Filter Factor	1.5	2	3

*Spectrophotometric absorption curves for these filters can be found in KODAK Publication B-3, “KODAK Photographic Filters Handbook.”

Typical Camera Exposure

A typical exposure for this film is approximately 1/400 second at f/16 through a red filter such as the KODAK WRATTEN Filter No. 25 or 1/250 second at f/16 through a deep red filter such as the KODAK WRATTEN Filter No. 89B. These exposures are based on a solar altitude of 40 degrees, a clear day, an aircraft altitude of 10,000 feet.

When using an aerial camera equipped with an antivignetting filter, or other filter, it is important to increase this typical exposure by the filter factor of the filter used.

Reciprocity Characteristics

No exposure or development time adjustments are required for an exposure time of 1/100 second. At 1/1,000 second, increase the development time by 10 percent; or at 1/10 second, decrease the development time by 10 percent.

IMAGE STRUCTURE

The following data are based on processing in a KODAK VERSAMAT Film Processor using KODAK VERSAMAT Chemicals.

	Resolving Power (line pairs/mm)		rms Granularity*
	TOC 1.6:1	TOC 1000:1	
VERSAMAT Model 11			
885 Chemicals [†]	50	125	27
641 Chemicals [‡]	50	100	28
Type A Chemicals [§]	32	100	28
VERSAMAT Model 1140			
885 Chemicals [¶]	50	125	24

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

[†] 885—2 racks, 15 fpm, 85°F (29.5°C), process gamma 1.45

[‡] 641—2 racks, 7.5 fpm, 85°F (29.5°C), process gamma 1.55

[§] Type A—1 rack, 8.5 fpm, 90°F (32°C), process gamma 1.50

[¶] 885—2 racks, 30 fpm, 104°F (40°C), process gamma 1.45

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 Infrared AEROGRAPHIC Film 2424 can be processed in the KODAK VERSAMAT Film Processor, Model 11 or 1140, with KODAK VERSAMAT 885 Chemicals, KODAK VERSAMAT 641 Chemicals, or KODAK VERSAMAT Chemicals, Type A.

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.

Chemicals

The following KODAK VERSAMAT Chemicals may be used in both the Model 11 and Model 1140 VERSAMAT Processors.

KODAK VERSAMAT 885 Developer Starter

KODAK VERSAMAT 885 Developer Replenisher

KODAK VERSAMAT 885 Fixer and Replenisher

KODAK VERSAMAT 641 Developer Starter

KODAK VERSAMAT 641 Developer Replenisher

KODAK VERSAMAT 641 Fixer and Replenisher

KODAK VERSAMAT Developer Starter, Type A

KODAK VERSAMAT Developer Replenisher, Type A

KODAK VERSAMAT Fixer and Replenisher, Type A

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

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.

Basic Replenishment Rates (mL/in ²) KODAK VERSAMAT Chemicals			
	885	641	Type A
Developer	0.29	0.27	0.30
Fixer	0.45	0.68	0.50

Processing Sequence

KODAK VERSAMAT Processor, Model 11 (all recommended 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)

* Use 90°F (32°C) for KODAK VERSAMAT Chemicals, Type A.

Sensitometric Data

KODAK VERSAMAT 885 Chemicals, Model 11						
Machine Speed (fpm)	1 Developer Rack			2 Developer Racks		
	Average Gamma	ISO A*	D-min	Average Gamma	ISO A*	D-min
85°F (29.5°C)						
5	1.65	500	0.15	2.15	800	0.26
10	1.05	400	0.11	1.95	640	0.15
15	0.85	250	0.09	1.45	500	0.12
20	0.75	200	0.08	1.25	400	0.11
25	0.60	200	0.08	1.00	250	0.10

Fixing: Adequate fixing is obtained at machine speeds up to and including 20 feet per minute.

Washing: LE-500 keeping quality may be obtained at a machine speed of 5 feet per minute with 2 developer racks; LE-100 may be obtained at speeds up to and including 15 feet per minute with 2 racks or up to 10 feet per minute with 1 rack. (LE = Life Expectancy)

Drying: Adequate drying is obtained at machine speeds up to and including 20 feet per minute.

KODAK VERSAMAT 641 Chemicals -- Model 11						
Machine Speed (fpm)	1 Developer Rack			2 Developer Racks		
	Average Gamma	ISO A*	D-min	Average Gamma	ISO A*	D-min
85°F (29.5°C)						
5	1.45	250	0.13	1.95	400	0.15
10	0.85	125	0.12	1.30	250	0.12
15	—	—	—	1.05	200	0.10
20	—	—	—	0.85	125	0.09

Fixing: Adequate fixing is obtained at machine speeds up to and including 15 feet per minute.

Washing: With 2 developer racks, LE-500 keeping quality may be obtained at a machine speed of 5 feet per minute and LE-100 up to and including 15 feet per minute. (LE = Life Expectancy)

Drying: Adequate drying is obtained at machine speeds up to and including 20 feet per minute.

KODAK VERSAMAT Chemicals, Type A, Model 11						
Machine Speed (fpm)	1 Developer Rack			2 Developer Racks		
	Average Gamma	ISO A*	D-min	Average Gamma	ISO A*	D-min
90°F (32°C)						
5	2.05	200	0.16	2.60	250	0.21
10	1.40	125	0.11	2.15	200	0.14
15	1.10	100	0.11	1.75	160	0.13
20	0.90	64	0.11	1.45	160	0.12

Fixing: Adequate fixing is obtained at machine speeds up to and including 15 feet per minute.

Washing: LE-100 keeping quality is obtained at all practical machine speeds when using 2 developer racks. (LE = Life Expectancy)

Drying: Adequate drying is obtained at machine speeds up to and including 20 feet per minute.

* *Aerial Film speeds are not obtainable using radiometric log H values. The ISO A values listed have been determined from empirical data in order to give relative exposure values to correspond to panchromatic films with no appreciable infrared sensitivity.*

Processing Sequence

KODAK VERSAMAT Processor, Model 1140 (all recommended chemicals)			
Processing Step	No. of Racks	Path Length	Temperature
Develop	1 or 2	1.2 or 2.4 m (4 or 8 ft)	99 or 104 ± 0.5°F (37 or 40 ± 0.3°C)
Fix	3	3.6 m (12 ft)	99 or 104°F (37 or 40°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)	Up to 149°F (65°C)

Sensitometric Data

KODAK VERSAMAT 885 Chemicals, Model 1140						
Machine Speed (fpm)	1 Developer Rack			2 Developer Racks		
	Average Gamma	ISO A*	D-min	Average Gamma	ISO A*	D-min
99°F (37°C)						
20	1.00	500	0.12	1.80	800	0.25
30	0.75	320	0.10	1.25	640	0.15
40	0.60	200	0.08	1.10	500	0.12
104°F (40°C)						
10	1.70	800	0.33	—	—	—
20	1.10	640	0.16	1.90	800	0.38
30	0.85	400	0.11	1.45	800	0.23
40	0.70	320	0.10	1.20	640	0.17

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

Washing: LE-100 keeping quality is obtained at machine speeds up to and including 20 feet per minute with 2 developer racks or up to and including 30 feet per minute with 1 rack. (LE = Life Expectancy)

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

KODAK VERSAMAT 641 Chemicals, Model 1140						
Machine Speed (fpm)	1 Developer Rack			2 Developer Racks		
	Average Gamma	ISO A*	D-min	Average Gamma	ISO A*	D-min
99°F (37°C)						
10	1.10	320	0.16	1.80	500	0.24
20	0.75	200	0.13	1.15	320	0.15
30	—	—	—	0.95	200	0.19
104°F (40°C)						
10	1.30	400	0.17	1.95	500	0.37
20	0.85	200	0.13	1.40	400	0.19
30	0.60	125	0.16	1.05	250	0.15
40	—	—	—	0.80	200	0.31

* Aerial Film speeds are not obtainable using radiometric log H values. The ISO A values listed were determined from empirical data in order to give relative exposure values that correspond to panchromatic films with no appreciable infrared sensitivity.

KODAK VERSAMAT Chemicals, Type A; Model 1140

This is not a primary processing recommendation, although satisfactory results can be obtained at processor speeds up to 10 feet per minute. Refer to the processing conditions and sensitometric data for the KODAK VERSAMAT Processor, Model 11, above.

REWIND OR SPIRAL REEL PROCESSING

KODAK Infrared AEROGRAPHIC Film 2424 yields optimum results with modern, high-temperature, continuous-processing machines. It can be processed in rewind equipment or on spiral reels, although these methods are not primary processing recommendations. Customers wishing to use spiral reels or rewind equipment such as the Gordon/Morse M-10 Developing Outfit (Military Designator: B-5) may contact Aerial Systems for information on exposure, processing chemicals, process cycles, and general recommendations.

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:	
0.001%	per degree F of change
0.0018%	per degree C of change

Humidity Coefficient of Linear Expansion (Unprocessed):	
0.0018%	per 1% change in relative humidity

Permanent Dimensional Changes

Processing Dimensional Change:	
-0.03% to +0.03%	shrinkage to swell

Aging Shrinkage of Processed Film:	
0.03%	1 week at 120°F (49°C), 20% RH
0.03%	1 year at 78°F (25.5°C), 60% RH

SIZE DATA AND ORDERING INFORMATION

KODAK Infrared AEROGRAPHIC Film 2424 is available in sizes for certain aerial cameras. The following factory-stocked sizes are available without minimum-order requirements:

CAT No.	Spec*	Size
162 0841	Sp 494	70 mm x 150 ft
162 1580	Sp 981	9 1/2 in. x 250 ft

*Kodak specification numbers are assigned to identify film width, spool size and design, type perforations (if required), and other spooling and packaging details.

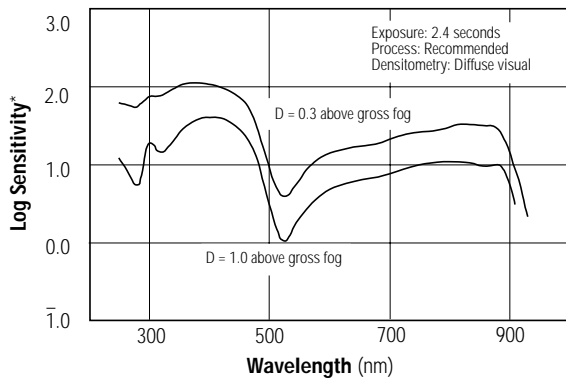
Information on minimum order quantities and other sizes of these films is available by writing or calling:

Aerial Imaging
 Eastman Kodak Company
 Rochester, New York 14653-7128
 (716) 253-1855

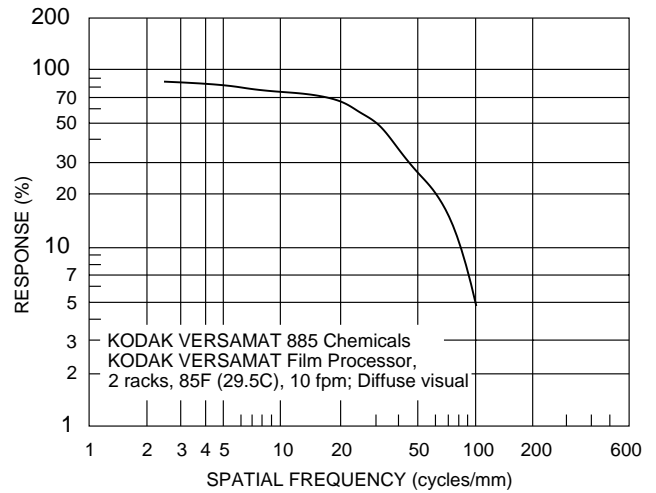
Note: The Kodak materials described in this publication used with KODAK Infrared AEROGRAPHIC Film 2424 are available from those dealers normally supplying Kodak products. Other materials may be used, but equivalent results may not be obtained.

CURVES

Spectral Sensitivity

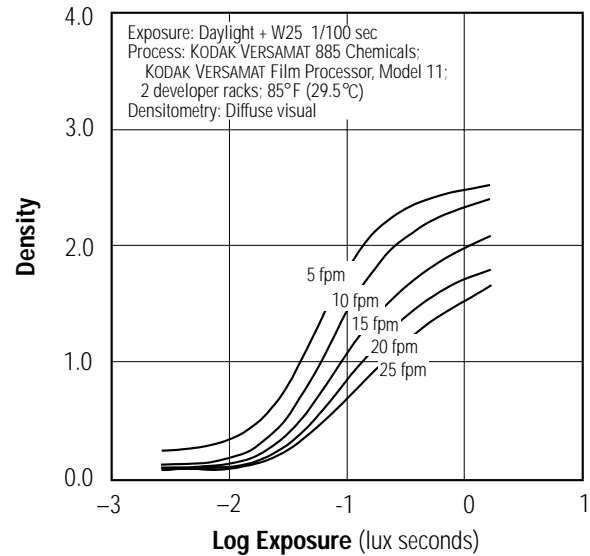


Modulation Transfer Function

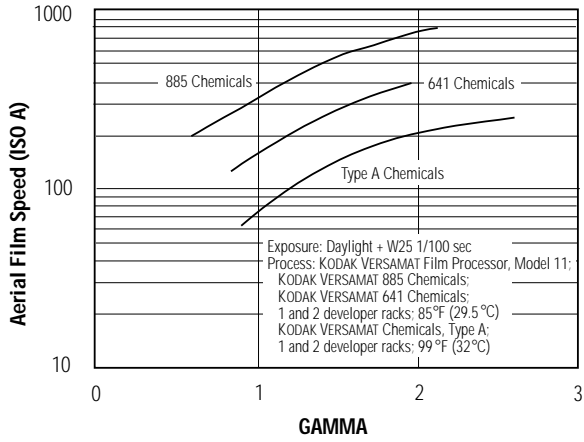


F002_1094AC

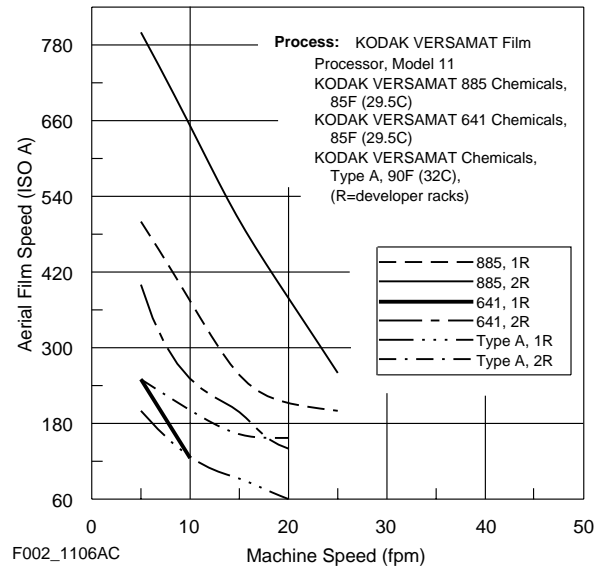
Characteristic Curves



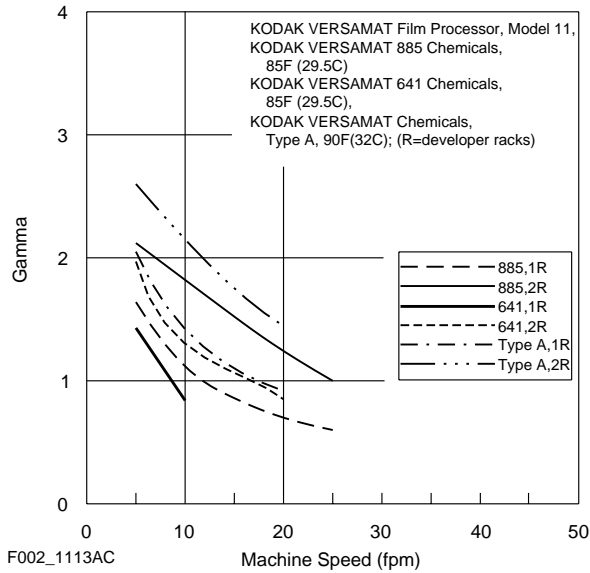
ISO A vs. Gamma



ISO A



Gamma vs. Machine Speed



KODAK Infrared AEROGRAPHIC Film 2424

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
EASTMAN KODAK COMPANY • ROCHESTER, NY 14653-7128

