



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192REPORT OF CALIBRATION
of Aerial Mapping Camera

July 16, 2001

Camera type:	Jena LMK 2015*	Camera serial no.:	272302C
Lens type:	Jena Lamegon PI/D	Lens serial no.:	7390600D
Nominal focal length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Photo Science, Inc.
Lexington, KentuckyReference: Photo Science, Inc, purchase order
No. 95141, dated July 9, 2001.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 152.356 mmII. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	-1	-1	0	2	2	-2
Decentering (um)	0	0	1	1	2	3

Symmetric radial distortion parameters	Decentering distortion parameters	Calibrated principal point
K0 = 0.3163 x 10 ⁻⁴	P1 = -0.1262 x 10 ⁻⁶	x _p = 0.004 mm
K1 = -0.1105 x 10 ⁻⁷	P2 = -0.8852 x 10 ⁻⁷	y _p = -0.012 mm
K2 = 0.6089 x 10 ⁻¹²	P3 = 0.0000	
K3 = 0.0000	P4 = 0.0000	
K4 = 0.0000		

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K₀,K₁,K₂,K₃,K₄), Decentering Distortion (P₁,P₂,P₃,P₄), and Calibrated Principal Point [point of symmetry] (x_p,y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ±3 microns.

* Equipped with Forward Motion Compensation

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 98

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	113	113	113	95	95
Tangential lines	113	134	113	95	95	80	67

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the Jena 405 No. 275565, the 500 No. 275564 and the 530 No. 275559 filters accompanying this camera are within 10 seconds of being parallel. The 500 filter was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	$\frac{1}{4}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/125	3618	3668	10.42	1/125	78
1/250	1740	1734	5.12	1/250	78
1/500	916	873	2.55	1/505	78
1/1000	441	442	1.27	1/1010	78

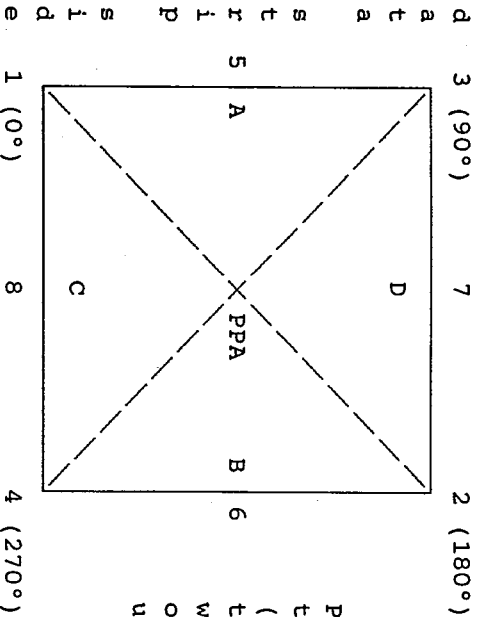
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platens mounted in LMK-K 24/120 film magazines No. 266792B, No. 273395C, and No. 273399C do not depart from a true plane by more than 13 μ m (0.0005 in).

These film magazines are equipped with identification markers that will register "266792" for magazine No. 266792B, "273395" for magazine No. 273395C, and "273399" for magazine No. 273399C in the film edge for each exposure.

VII. Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

Indicated principal point, corner fiducials
 Indicated principal point, midside fiducials
 Principal point of autocollimation (PPA)
 Calibrated principal point (pt. of sym.) x_p, y_p

	X coordinate	Y coordinate
	-0.009 mm	-0.019 mm
	-0.012	-0.012
	0.0	0.0
	0.004	-0.012
1	-110.038 mm	-110.020 mm
2	110.010	109.972
3	-109.987	109.995
4	109.955	-110.020
5	-112.012	-0.011
6	111.977	-0.013
7	0.019	111.995
8	-0.042	-112.032

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 311.155 mm 3-4: 311.096 mm

Lines joining these markers intersect at an angle of 89° 59' 52"

Midside fiducials

5-6: 223.990 mm 7-8: 224.028 mm

Lines joining these markers intersect at an angle of 89° 59' 05"

Corner fiducials (perimeter)

1-3: 220.015 mm 2-3: 219.996 mm

1-4: 219.993 mm 2-4: 219.991 mm

The method of measuring these distances is considered accurate within 0.003 mm

Note: For GPS applications, the nominal entrance pupil distance from the focal plane is 241 mm.

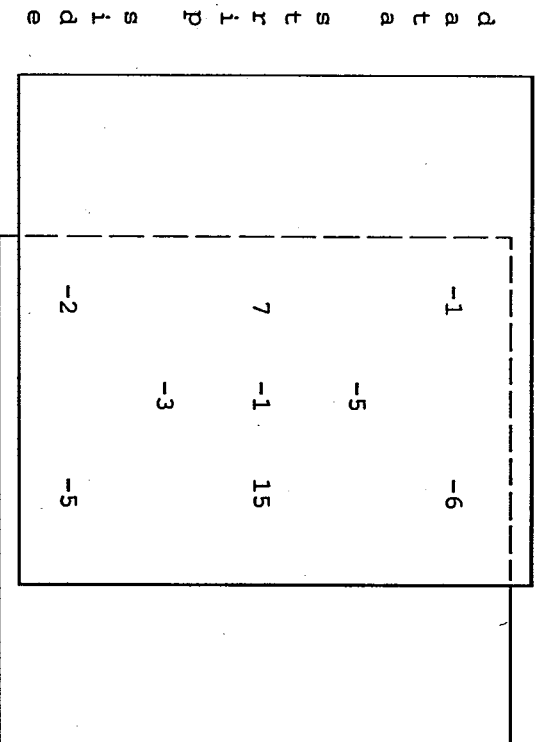
IX. Stereomodel Flatness

FMC Magazine No.: 266792B

Base/Height ratio: 0.6

Platen ID: 266792

Maximum angle of field tested: 40°



The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as $\pm 5 \mu\text{m}$ from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 47

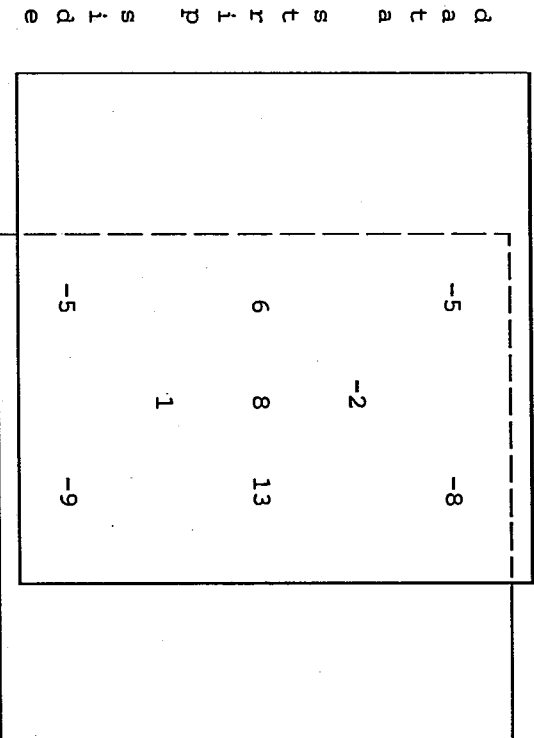
Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	57	48	48	40
Tangential lines	57	48	48	48	48	40	34

IX. Stereomodel Flatness

FMC Magazine No.: 273395C
 Platen ID: 273395

Base/Height ratio: 0.6
 Maximum angle of field tested: 40°



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The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. Lens/Film Resolving Power in cycles/mm

Area-weighted average resolution: 46

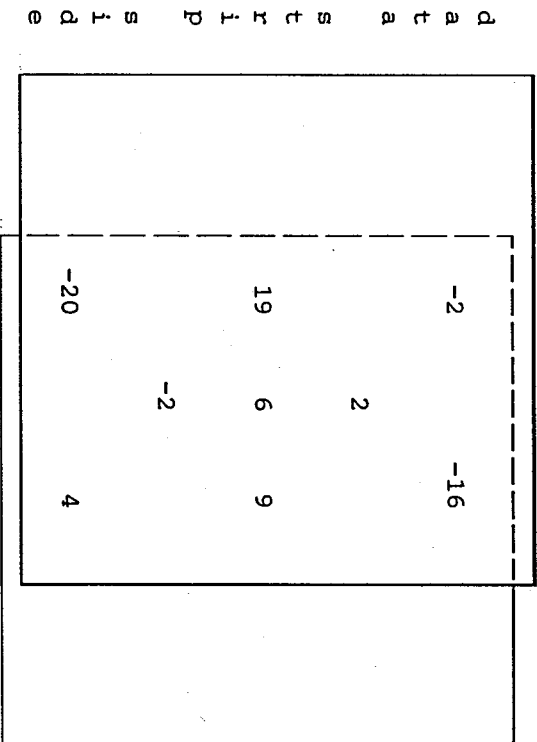
Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	48	48	48	40
Tangential lines	57	48	48	48	48	40	34

IX. Stereomodel Flatness

FMC Magazine No.: 273399C
 Platen ID: 273399

Base/Height ratio: 0.6
 Maximum angle of field tested: 40°



The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

X. Lens/Film Resolving Power in cycles/mm

Area-weighted average resolution: 46

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	48	48	48	40
Tangential lines	57	48	48	48	48	40	34

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2463, dated July 16, 1998.

John J. Lenart
 John J. Lenart
 Chief, Technology Operations Section
 National Mapping Division

LENS/FILM DISTORTION PARAMETERS

FMC Magazine No.: 273995C
Platen ID: 273995C

Base/Height ratio: 0.6
Maximum angle of field tested: 40°

XI. Calibrated Focal Length: 152.356 mm

XII. Lens/Film Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	0	1	2	2	2	-2
Decentering (um)	0	1	2	4	5	8

Symmetric radial distortion parameters		Decentering distortion parameters		Calibrated principal point	
K_0	= -0.1566 x 10^{-4}	P_1	= 0.2594 x 10^{-7}	x_p	= 0.004 mm
K_1	= -0.4295 x 10^{-8}	P_2	= 0.4771 x 10^{-6}	y_p	= -0.012 mm
K_2	= 0.3839 x 10^{-12}	P_3	= 0.0000		
K_3	= 0.0000	P_4	= 0.0000		
K_4	= 0.0000				

The above measurements were computed from Kodak 4425 copy film made from Kodak 2405 film exposed in the magazine.

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0, K_1, K_2, K_3, K_4), Decentering Distortion (P_1, P_2, P_3, P_4), and Calibrated Principal Point [point of symmetry] (x_p, y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ± 3 microns.