

JZ69161D-02-7506

USGS Report No. OSL/2818



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

January 17, 2002

Camera type: Jena LMK 1015\*  
Lens type: Jena Lamegon PI/D  
Nominal focal length: 153 mm

Camera serial no.: 269161D  
Lens serial no.: 7390028D  
Maximum aperture: f/4.5  
Test aperture: f/4.5

Submitted by: Aerial Services, Inc.  
Cedar Falls, Iowa

Reference: Aerial Services, Inc. purchase order  
No. 006507, dated January 15, 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: 152.501 mm

II. Lens Distortion

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

Symmetric radial  
distortion parameters

$$\begin{aligned} K_0 &= 0.5238 \times 10^{-4} \\ K_1 &= -0.1128 \times 10^{-7} \\ K_2 &= 0.4855 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

Decentering  
distortion parameters

$$\begin{aligned} P_1 &= 0.7084 \times 10^{-7} \\ P_2 &= 0.1788 \times 10^{-6} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

Calibrated  
principal point

$$\begin{aligned} x_p &= -0.005 \text{ mm} \\ y_p &= 0.005 \text{ mm} \end{aligned}$$

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 ( $\sigma$ ) of  $\pm 3$  microns.

\* Equipped with Forward Motion Compensation

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### 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	67	80

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 filter No. 51991, the 490 filter No. 52016 and the 530 filter No. 52035 accompanying this camera are within 10 seconds of being parallel. The 490 filter was used for the calibration.

### V. Shutter Calibration

Indicated time (sec)	Rise time ( $\mu$ sec)	Fall Time ( $\mu$ sec)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/125	2193	2294	7.42	1/85	81
1/175	1577	1543	5.12	1/120	81
1/250	1101	1067	3.68	1/165	81
1/350	784	758	2.56	1/240	81
1/500	554	557	1.84	1/335	81

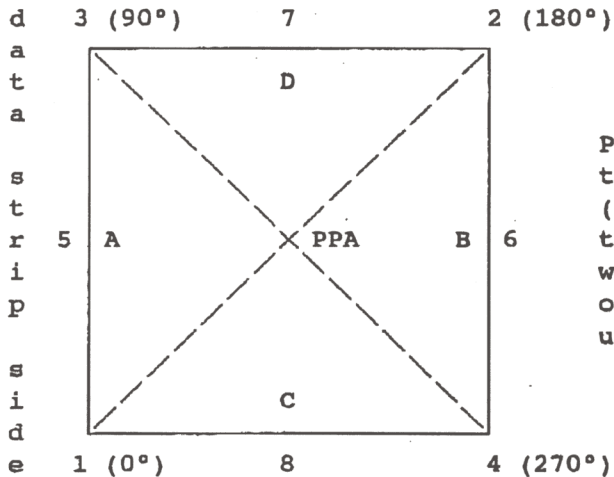
The effective exposure times were determined with the lens at aperture f/4.5. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

### VI. Magazine Platen

The platens mounted in LMK-K 24/120 film magazines No. 269020B and No. 271750B do not depart from a true plane by more than 13  $\mu$ m (0.0005 in).

These film magazines are equipped with identification markers that will register "269020" for magazine No. 269020B, and "271750" for magazine No. 271750B in the film edge for each exposure.

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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.

	<u>X coordinate</u>	<u>Y coordinate</u>
Indicated principal point, corner fiducials	-0.003 mm	0.002 mm
Indicated principal point, midside fiducials	-0.002	0.005
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) $x_p, y_p$	-0.005	0.005

Fiducial Marks

1	-110.000 mm	-109.999 mm
2	109.994	110.003
3	-110.006	110.005
4	109.999	-109.999
5	-111.997	0.005
6	111.980	0.004
7	-0.005	112.018
8	0.002	-112.011

VIII. Distances Between Fiducial Marks

## Corner fiducials (diagonals)

1-2: 311.124 mm 3-4: 311.134 mm

Lines joining these markers intersect at an angle of 89° 59' 56"

## Midside fiducials

5-6: 223.977 mm 7-8: 224.030 mm

Lines joining these markers intersect at an angle of 90° 00' 08"

## Corner fiducials (perimeter)

1-3: 220.004 mm 2-3: 220.000 mm  
1-4: 219.999 mm 2-4: 220.002 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.

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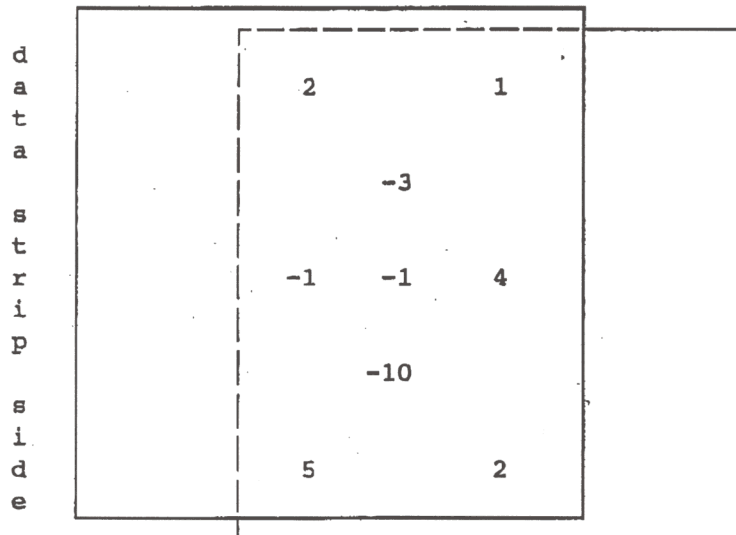
IX. Stereomodel Flatness

FMC Magazine No.: 269020B

Base/Height ratio: 0.6

Platen ID: 269020

Maximum angle of field tested: 40°



Stereomodel  
Test point array  
(values in micrometers)

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: 42

Film: Type 2405

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

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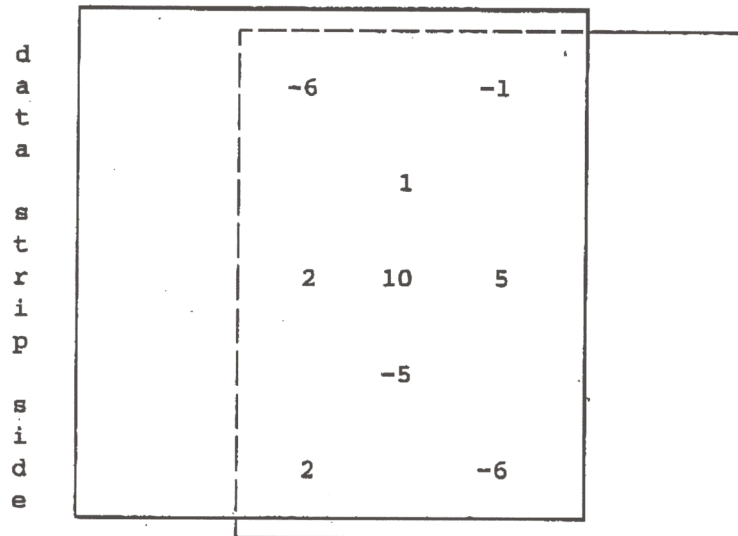
IX. Stereomodel Flatness

FMC Magazine No.: 271750B

Base/Height ratio: 0.6

Platen ID: 271750

Maximum angle of field tested: 40°



Stereomodel  
Test point array  
(values in micrometers)

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. Lens/Film Resolving Power in cycles/mm

Area-weighted average resolution: 44

Film: Type 2405

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2568, dated August 10, 1999.

*Bradish F. Johnson*

for  
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