



United States Department of the Interior

USGS Report No. OSL/2785

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

September 19, 2001

Camera type: Jena LMK 1015*
Lens type: Jena Lamagon PI/C
Nominal focal length: 153 mm

Camera serial no.: 266617B
Lens serial no.: 7384529C
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. 006340, dated September 5, 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: 152.589 mm

II. Lens Distortion

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

Symmetric radial distortion parameters

$$\begin{aligned} K_0 &= -0.4871 \times 10^{-4} \\ K_1 &= 0.1366 \times 10^{-7} \\ K_2 &= -0.7076 \times 10^{-12} \\ K_3 &= 0.0000 \\ K_4 &= 0.0000 \end{aligned}$$

Decentering distortion parameters

$$\begin{aligned} P_1 &= 0.8889 \times 10^{-7} \\ P_2 &= 0.1908 \times 10^{-6} \\ P_3 &= 0.0000 \\ P_4 &= 0.0000 \end{aligned}$$

Calibrated principal point

$$\begin{aligned} x_p &= -0.001 \text{ mm} \\ y_p &= 0.000 \text{ mm} \end{aligned}$$

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 (σ) of ± 3 microns.

* Equipped with Forward Motion Compensation

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III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 80

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	113	113	95	95	67	57
Tangential lines	134	113	95	80	95	57	40

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 350 filter No. 51145A, the 500 filter No. 51163A and the 550 filter No. 51190A 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)	$\frac{1}{2}$ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/125	2199	2477	7.27	1/85	81
1/175	1493	1657	5.18	1/120	81
1/250	1060	1175	3.66	1/170	81
1/350	755	823	2.52	1/245	81
1/500	550	583	1.83	1/340	81

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. 266787B and No. 266804B 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 "266787" for magazine No. 266787B, and "266804" for magazine No. 266804B in the film edge for each exposure.

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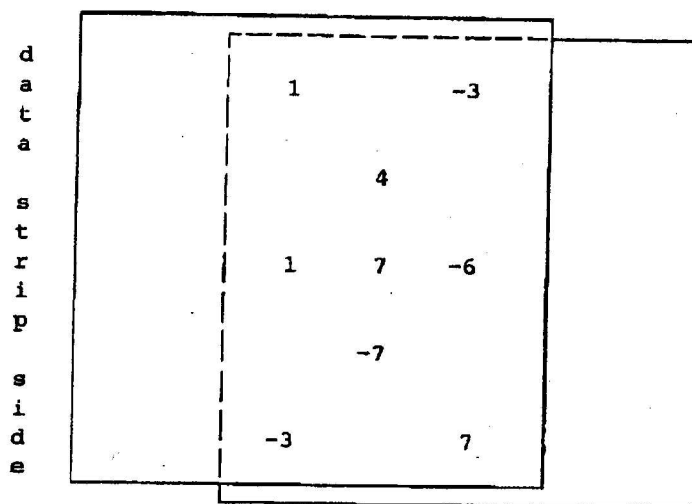
IX. Stereomodel Flatness

FMC Magazine No.: 266787B

Base/Height ratio: 0.6

Platen ID: 266787

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.

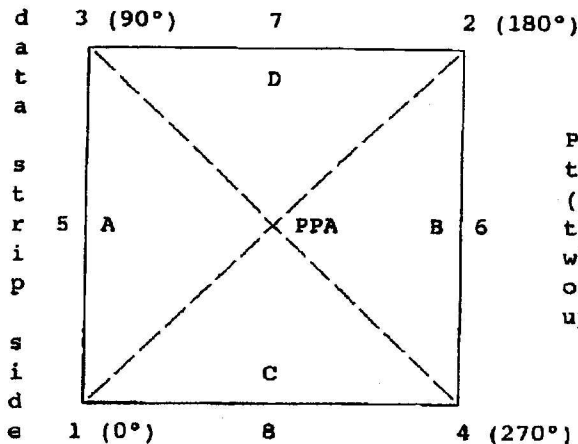
X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 41

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	48	48	48	48	40	34
Tangential lines	57	48	48	40	40	34	28

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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	0.013 mm	-0.002 mm
Indicated principal point, midside fiducials	0.015	-0.004
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	-0.001	0.000

Fiducial Marks

1	-109.991 mm	-110.007 mm
2	110.005	109.991
3	-109.987	110.002
4	110.014	-110.007
5	-111.987	0.000
6	111.996	-0.008
7	0.015	111.979
8	0.015	-111.999

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 311.123 mm 3-4: 311.134 mm

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

Midside fiducials

5-6: 223.983 mm 7-8: 223.978 mm

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

Corner fiducials (perimeter)

1-3: 220.009 mm 2-3: 219.992 mm
1-4: 220.006 mm 2-4: 219.998 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 251 mm.

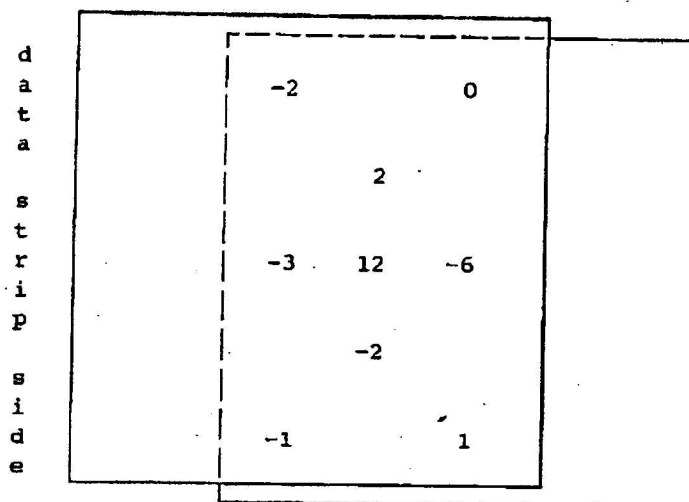
IX. Stereomodel Flatness

FMC Magazine No.: 266804B

Base/Height ratio: 0.6

Platen ID: 266804

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: 42

Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	48	48	48	48	40	40
Tangential lines	57	48	40	40	48	34	28

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for

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