United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

September 28, 2001

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

Camera serial no.: 269155D
Lens serial no.: 7390034D
Maximum aperture: f/4.5
Test aperture: f/4.5

Submitted by: Photo Science, Inc.
Lexington, Kentucky

Reference: Photo Science, Inc. purchase order
No. 95177, dated September 24, 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: 152.649 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	0	1	1	2	1	-2
Decentering (um)	0	1	2	3	5	7

Symmetric radial distortion parameters

$K_0 = -0.8298 \times 10^{-5}$
$K_1 = -0.4362 \times 10^{-8}$
$K_2 = 0.3427 \times 10^{-12}$
$K_3 = 0.0000$
$K_4 = 0.0000$

Decentering distortion parameters

$P_1 = -0.9075 \times 10^{-7}$
$P_2 = 0.4109 \times 10^{-6}$
$P_3 = 0.0000$
$P_4 = 0.0000$

Calibrated principal point

$x_p = -0.002$ mm
$y_p = -0.003$ mm

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

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 94

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	113	95	113	95	95
Tangential lines	113	134	113	80	80	80	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 500 filter No. 51389A accompanying this camera are within 10 seconds of being parallel. This filter was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	½ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/125	2256	2153	7.47	1/80	82
1/175	1555	1540	5.28	1/115	82
1/250	1061	1057	3.68	1/165	82
1/350	741	734	2.58	1/235	82
1/500	551	545	1.86	1/330	82

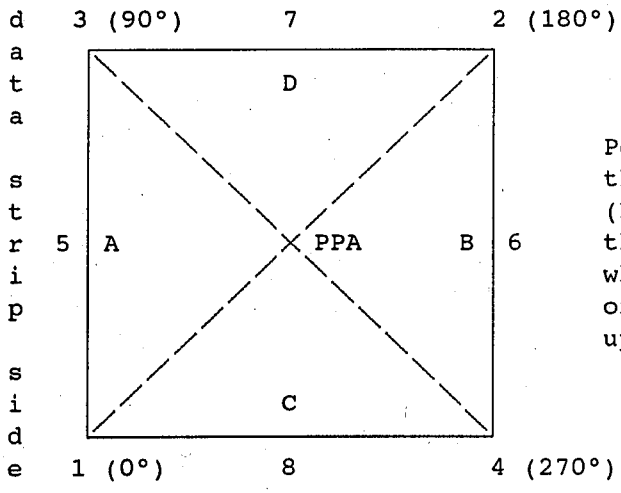
The effective exposure times were determined with the lens at aperture f/4.5. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platens mounted in LMK-K 24/120 film magazines No. 266791B, No. 266799B, and No. 271753B do not depart from a true plane by more than 13 um (0.0005 in).

These film magazines are equipped with identification markers that will register "266791" for magazine No. 266791B, "266799" for magazine No. 266799B, and "271753" for magazine No. 271753B 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.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	-0.005 mm	0.013 mm
Indicated principal point, midside fiducials	-0.007	0.014
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	-0.002	-0.003

Fiducial Marks		
1	-110.009 mm	-109.989 mm
2	109.995	110.010
3	-110.006	110.019
4	109.993	-109.989
5	-112.006	0.018
6	111.991	0.011
7	-0.005	112.015
8	-0.009	-111.991

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)
1-2: 311.129 mm 3-4: 311.131 mm
Lines joining these markers intersect at an angle of 89° 59' 58"

Midside fiducials
5-6: 223.997 mm 7-8: 224.006 mm
Lines joining these markers intersect at an angle of 90° 00' 03"

Corner fiducials (perimeter)
1-3: 220.007 mm 2-3: 220.001 mm
1-4: 220.002 mm 2-4: 219.999 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.

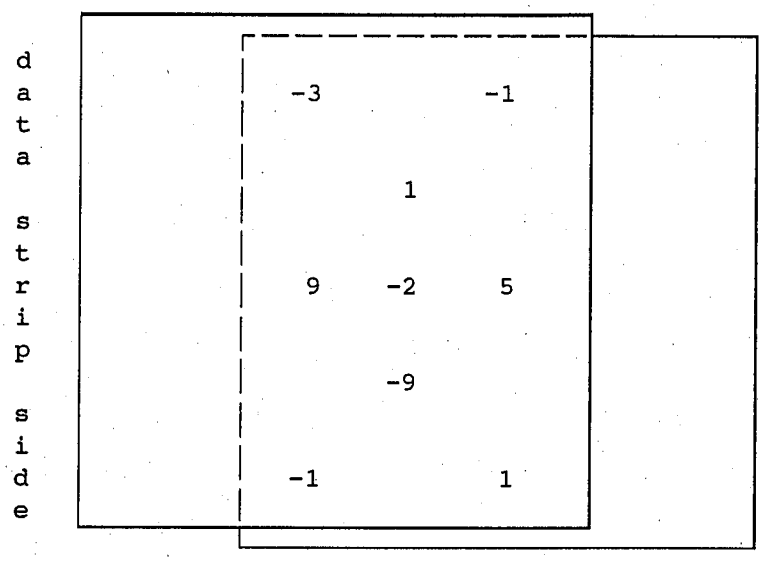
IX. Stereomodel Flatness

FMC Magazine No.: 266791B

Platen ID: 266791

Base/Height ratio: 0.6

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 ± 5 μm from model to model.

X. System Resolving Power on film 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	48	48	48	48	40
Tangential lines	57	48	48	48	48	40	40

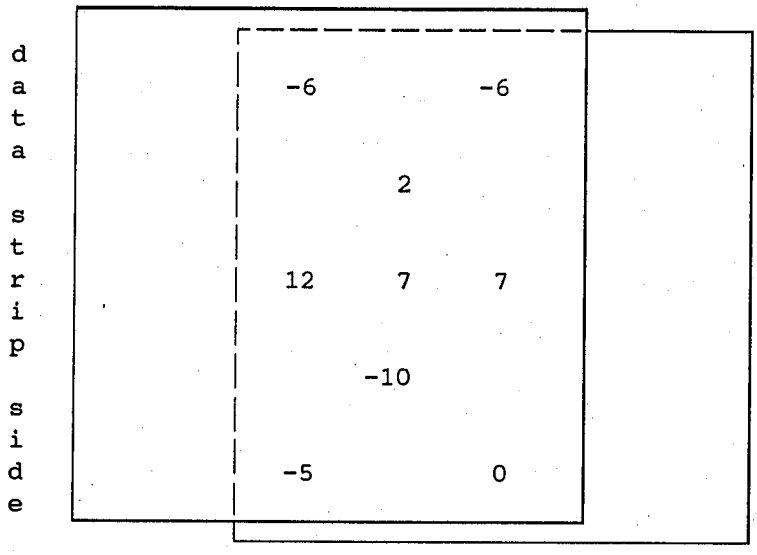
IX. Stereomodel Flatness

FMC Magazine No.: 266799B

Platen ID: 266799

Base/Height ratio: 0.6

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 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	48	48	48	48	48	48
Tangential lines	57	48	57	48	40	40	40

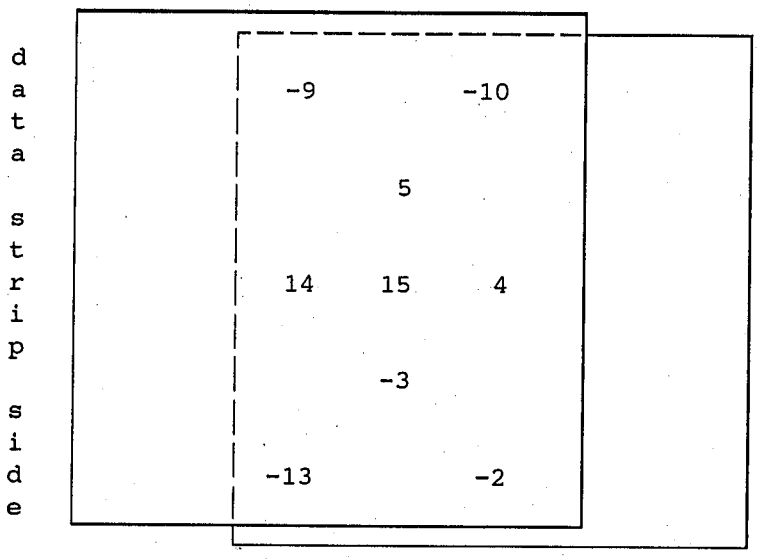
IX. Stereomodel Flatness

FMC Magazine No.: 271753B

Platen ID: 271753

Base/Height ratio: 0.6

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 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

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Radial Lines	57	48	57	48	48	48	40
Tangential lines	57	48	57	48	40	40	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2494, dated October 15, 1998.

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for

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