United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION   December 20, 2011
of Aerial Mapping Camera

Camera type:	Jena LMK 2015*	**Camera serial no.:**	275842
Lens type:	Jena Lamegon PI/E	**Lens serial no.:**	275842E
Nominal focal Length:	153 mm	**Maximum aperture:**	f/4
		Test aperture:	f/4

Submitted by: Aerial Surveys International
                              Watkins, CO

Reference:

These measurements were made on Agfa glass plates, 0.19 inch thick, with spectroscopic emulsion type APX 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: 152.487 mm

II.   Lens Distortion

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

Symmetric radial distortion	Decentering distortion	Calibrated principal point
K_0 = 0.8668E-07	P_1 = 0.8584E-07	x_p = 0.001 mm
K_1 = -0.7619E-08	P_2 = -0.8979E-07	y_p = 0.009 mm
K_2 = 0.5333E-12	P_3 = 0.0000	
K_3 = 0.0000	P_4 = 0.0000	
K_4 = 0.0000		

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.

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* Equipped with Forward Motion Compensation

III.   Lens Resolving Power in cycles/mm

Area-weighted average resolution: 107

Field angle:	0º	7.5º	15º	22.7º	30º	35º	40º
Radial Lines	134	159	134	113	113	95	95
Tangential Lines	134	134	113	95	113	95	95

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. 51993, 490 filter No. 275583 and 530 filter No. 275580 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 (μ sec)	Fall Time (μ sec)	½ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/125	2270	2172	11.14	1/105	88
1/250	1141	1021	5.58	1/205	88
1/500	537	531	2.83	1/400	88
1/1000	295	273	1.41	1/810	87

The effective exposure times were determined with the lens at aperature f/4. The method is considered accurate within 3 percent. The technique used is described in International Standard ISO 516:1999(E).

VI.   Magazine Platen

The platen mounted in Jena LMK-K 24/120 film magazine No. 273505 does not depart from a true plane by more than 13 μm (0.0005 in).
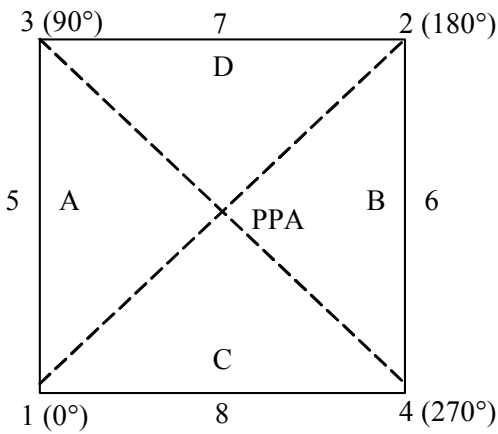
The platen for this film magazine is equipped with an identification marker that will register "273505" in the data strip area for each exposure.

VII. Principal Point and Fiducial Mark Coordinates

```
d
a    3 (90°)        7          2 (180°)
t   ┌─────────────────────────────┐
a   │ ╲           D           ╱   │
    │   ╲                   ╱     │
s   │     ╲               ╱       │
t  5│  A    ╲           ╱    B    │6
r   │         ╲       ╱  PPA      │
i   │           ╲×  ╱             │
p   │         ╱     ╲             │
    │       ╱         ╲           │
s   │     ╱      C      ╲         │
i   │   ╱                 ╲       │
d   └─────────────────────────────┘
e    1 (0°)        8          4 (270°)
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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 (mm)	Y coordinate (mm)
Indicated principal point, corner fiducials	0.008	-0.001
Indicated principal point, midside fiducials	0.005	0.001
Principal point of autocollimation (PPA)	0.000	0.000
Calibrated principal point (point of symmetry)	0.001	0.009

Fiducial Marks

	X	Y
1	-109.997	-109.999
2	110.014	109.997
3	-109.991	109.998
4	110.006	-109.999
5	-111.996	0.001
6	112.019	0.002
7	0.008	111.997
8	0.003	-111.999

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)   1-2: 311.132 mm   3-4: 311.122 mm
Lines joining these markers intersect at an angle o 90° 00' 07"

Midside fiducials   5-6: 224.015 mm   7-8: 223.996 mm
Lines joining these markers intersect at an angle o 89° 59' 55"

Corner fiducials (perimeter)   1-3: 219.997 mm   2-3: 220.004 mm
1-4: 220.003 mm   2-4: 219.996 mm

The Method of measuring these distances is considered accurate within 0.003 mm
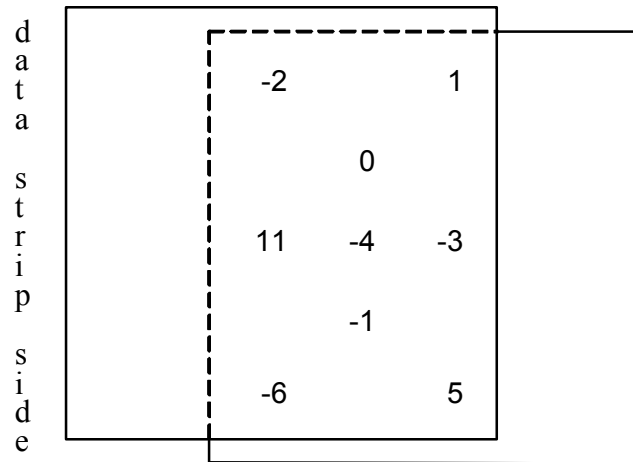
IX. Stereomodel Flatness

FMC Magazine No: 273505   **Base/Height ratio:**   0.6

Platen ID: 273505   **Maximum angle of field tested:**   40°

```
d
a
t      ┌─ ─ ─ ─ ─ ─ ─ ─ ─┐
a      │  -2          1   │
       │                  │
s      │         0        │
t      │                  │
r      │  11   -4    -3   │
i      │                  │
p      │       -1         │
       │                  │
s      │  -6          5   │
i      └── ── ── ── ── ── ─┘
d
e
```

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 Kodak 4425 copy film made from Kodak 2405 flim exposures. These measurements are considered accurate to within 5 μm.

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	48	48	48	48
Tangential Lines	57	57	48	48	48	40	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3365, dated December 20, 2007.

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Climate and Land Use Change