



# United States Department of the Interior

U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

December 20, 2007

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

**Submitted by:** Aerial Surveys International, LLC  
Watkins, Colorado

**Reference:** Aerial Surveys International, LLC letter of authorization with purchase order No. 071241E, dated December 12, 2007.

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:** 152.478 mm

## II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (µm)	-3	-5	-4	0	4	4
Decentering tangential (µm)	0	0	1	2	2	3

<u>Symmetric radial distortion</u>		<u>Decentering distortion</u>		<u>Calibrated principal point</u>	
$K_0$	= 0.1613E-03	$P_1$	= 0.3815E-07	$x_p$	= 0.006 mm
$K_1$	= -0.2966E-07	$P_2$	= -0.2088E-06	$y_p$	= 0.008 mm
$K_2$	= 0.1091E-11	$P_3$	= 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 ( $\sigma$ ) of  $\pm 3$  microns.

\* Equipped with Forward Motion Compensation

**III. Lens Resolving Power in cycles/mm**

Area-weighted average resolution: 106

<u>Field angle:</u>	<u>0°</u>	<u>7.5°</u>	<u>15°</u>	<u>22.7°</u>	<u>30°</u>	<u>35°</u>	<u>40°</u>
Radial Lines	113	159	134	113	113	95	113
Tangential Lines	113	134	113	95	95	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, the 490 filter No. 275583 and the 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**

<u>Indicated Time</u> <u>(sec)</u>	<u>Rise Time</u> <u>(μ sec)</u>	<u>Fall Time</u> <u>(μ sec)</u>	<u>½ Width Time</u> <u>(ms)</u>	<u>Nom. Speed</u> <u>(sec)</u>	<u>Efficiency</u> <u>(%)</u>
1/125	2205	2031	11.84	1/95	89
1/250	1043	1014	5.89	1/190	89
1/500	508	498	2.88	1/390	89
1/1000	252	256	1.44	1/780	89

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 described in International Standard ISO 516:1999(E).

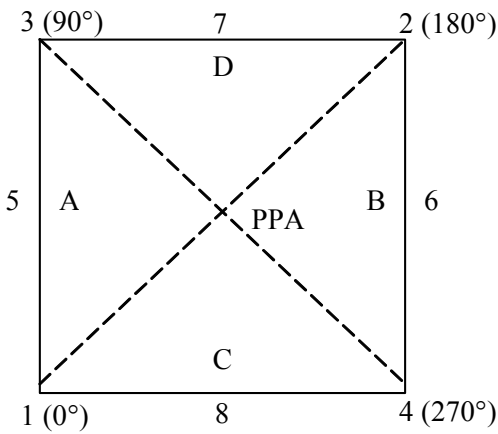
**VI. Magazine Platen**

The platens mounted in Jena LMK-K 24/120 film magazines No. 271821, No. 271902 and No. 273505 do not depart from a true plane by more than 13 μm (0.0005 in).

The platens for these film magazines are equipped with an identification marker that will register "271821" for magazine No. 271821, "271902" for magazine No. 271902 and "273505" for magazine No. 273505, in the data strip area for each exposure.

**VII. Principal Point and Fiducial Mark Coordinates**

d  
a  
t  
a  
  
s  
t  
r  
i  
p  
  
s  
i  
d  
e



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 (mm)</u>	<u>Y coordinate (mm)</u>
Indicated principal point, corner fiducials	.013	-.004
Indicated principal point, midside fiducials	.009	.001
Principal point of autocollimation (PPA)	.000	.000
Calibrated principal point (point of symmetry)	.006	.008
<u>Fiducial Marks</u>		
1	-109.990	-110.000
2	110.020	109.997
3	-109.987	109.995
4	110.010	-110.000
5	-111.994	.001
6	112.019	.000
7	.010	111.995
8	.007	-111.997

**VIII. Distances Between Fiducial marks**

Corner fiducials (diagonals)	1-2: 311.132 mm	3-4: 311.121 mm
Lines joining these markers intersect at an angle o 90° 00' 08"		
Midside fiducials	5-6: 224.013 mm	7-8: 223.992 mm
Lines joining these markers intersect at an angle o 89° 59' 57"		
Corner fiducials (perimeter)	1-3: 219.994 mm	2-3: 220.007 mm
	1-4: 220.000 mm	2-4: 219.997 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.

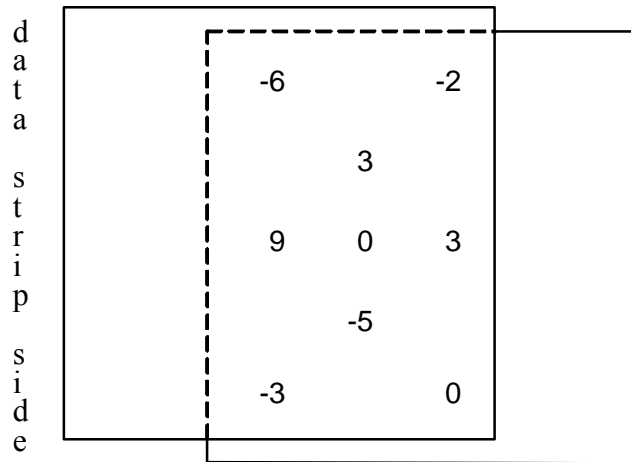
**IX. Stereomodel Flatness**

**FMC Magazine No:** 271821

**Base/Height ratio:** 0.6

**Platen ID:** 271821

**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 Kodak 4425 copy film made from Kodak 2405 film 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	48	48	48	48	48
Tangential Lines	57	48	48	48	48	40	40

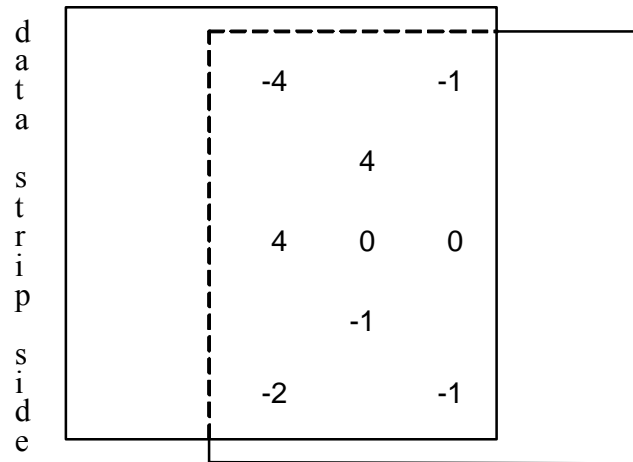
**IX. Stereomodel Flatness**

**FMC Magazine No:** 271902

**Base/Height ratio:** 0.6

**Platen ID:** 271902

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

**X. System Resolving Power on film in cycles/mm**

**Area-weighted average resolution:** 45

**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	48	48	48	40	40

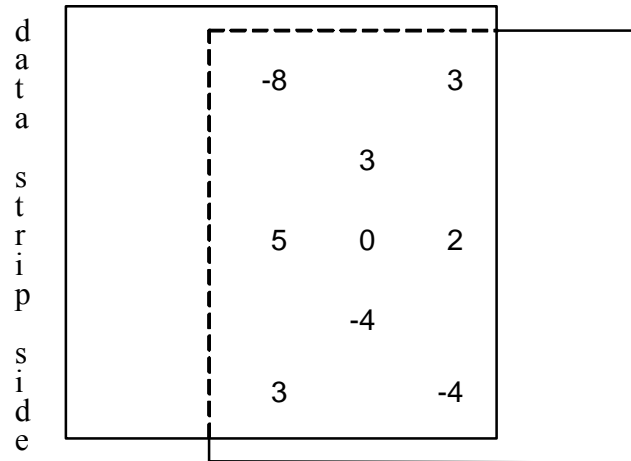
**IX. Stereomodel Flatness**

**FMC Magazine No:** 273505

**Base/Height ratio:** 0.6

**Platen ID:** 273505

**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 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:** 46

**Film:** Type 2405

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3112, dated December 17, 2004.

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