



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

June 20, 2013

Camera type:	Zeiss RMK Top 15*	Camera serial no.:	144126
Lens type:	Zeiss Pleogon A3/4	Lens serial no.:	144153
Nominal focal Length:	153 mm	Maximum aperture:	f/4
		Test aperture:	f/4

Submitted by: Richard Crouse & Associates- Maine
Old Town, ME

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: 153.315 mm

II. Lens Distortion

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

<u>Symmetric radial distortion</u>	<u>Decentering distortion</u>	<u>Calibrated principal point</u>
$K_0 = -0.2314E-04$	$P_1 = -0.1745E-06$	$x_p = 0.008$ mm
$K_1 = 0.8992E-08$	$P_2 = 0.5629E-07$	$y_p = 0.000$ mm
$K_2 = -0.5030E-12$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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.

* Equipped with Forward Motion Compensation

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 107

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	159	134	113	113	95	95
Tangential Lines	134	159	134	113	95	95	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 USGS TOP 15 test filter KL-F (60%) No. 142399 are within 10 seconds of being parallel. This filter, in conjunction with the internal "B" 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 (%)
1/100	3501	3670	11.36	1/110	80
1/200	1893	1929	5.10	1/260	77
1/300	1190	1238	3.43	1/370	78
1/400	899	896	2.55	1/500	78
1/500	735	746	2.07	1/620	78

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 platen mounted in Zeiss CC-24 film magazine No. 136377 and Zeiss T-MC film magazine No. 145781 do not depart from a true plane by more than $13 \mu\text{m}$ (0.0005 in).

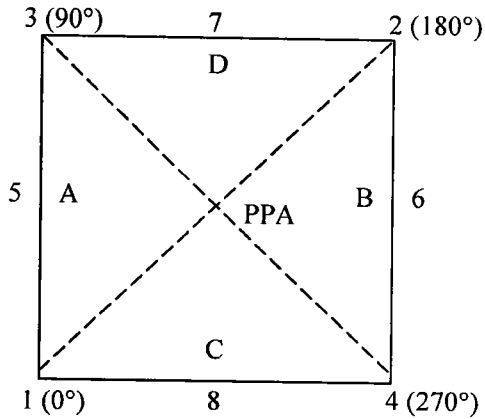
The platens for these film magazines are equipped with identification markers that will register "CZ272" for magazine No. 136377 and "145731" for magazine No. 145781 in the data strip area for each exposure.

VII. Principal Point and Fiducial Mark Coordinates

d
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t
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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.

Indicated principal point, corner fiducials
 Indicated principal point, midside fiducials
 Principal point of autocollimation (PPA)
 Calibrated principal point (point of symmetry)

	<u>X coordinate (mm)</u>	<u>Y coordinate (mm)</u>
Indicated principal point, corner fiducials	0.012	0.009
Indicated principal point, midside fiducials	0.014	0.011
Principal point of autocollimation (PPA)	0.000	0.000
Calibrated principal point (point of symmetry)	0.008	0.000

Fiducial Marks

1	-112.991	-112.991
2	113.016	113.010
3	-112.970	113.003
4	113.000	-112.991
5	-112.982	0.001
6	112.999	0.021
7	0.028	113.011
8	0.000	-112.972

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)	1-2: 319.618 mm	3-4: 319.587 mm
Lines joining these markers intersect at an angle o 89° 59' 52"		
Midside fiducials	5-6: 225.982 mm	7-8: 225.983 mm
Lines joining these markers intersect at an angle o 89° 59' 16"		
Corner fiducials (perimeter)	1-3: 225.994 mm	2-3: 225.987 mm
	1-4: 225.991 mm	2-4: 226.002 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 254mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

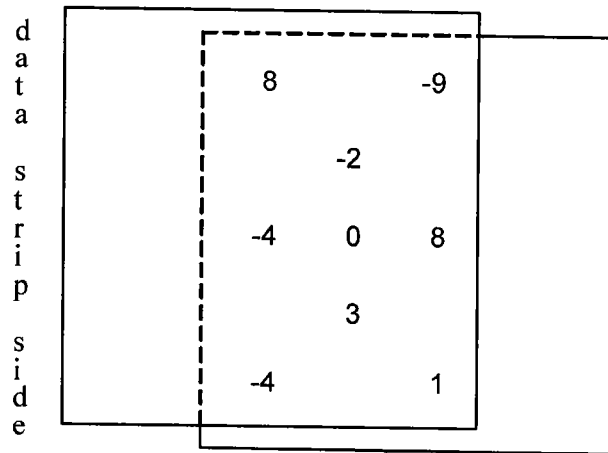
IX. Stereomodel Flatness

FMC Magazine No: 136377

Base/Height ratio: 0.6

Platen ID: CZ272

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 Agfa Avitone P3p copy film made from Agfa Aviphot Pan 200 film exposures. These measurements are considered accurate to within 5 μm.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 48

Film: Pan 200

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

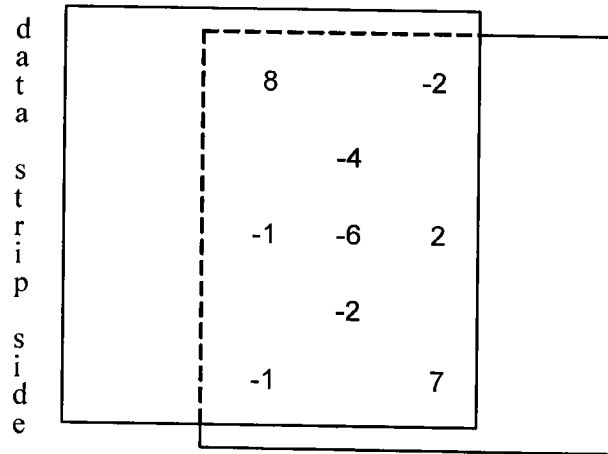
IX. Stereomodel Flatness

FMC Magazine No: 145781

Base/Height ratio: 0.6

Platen ID: 145731

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 Agfa Avitone P3p copy film made from Agfa Aviphot Pan 200 film exposures. These measurements are considered accurate to within 5 μm.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 48

Film: Pan 200

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3530, dated June 25, 2010.

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Climate and Land Use Change