

United States Department of the Interior



U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

October 20, 2009

Camera type: Zeiss RMK Top 15*
Lens type: Zeiss Pleogon A3/4
Nominal focal Length: 153 mm

Camera serial no.: 144121
Lens serial no.: 144140
Maximum aperture: f/4
Test aperture: f/4

Submitted by: Flight Resource Group
Flagler Beach, FL

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: 153.158 mm

II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (µm)	-3	-5	-6	-4	0	6
Decentering tangential (µm)	0	0	0	1	1	1

<u>Symmetric radial distortion</u>	<u>Decentering distortion</u>	<u>Calibrated principal point</u>
$K_0 = 0.1551E-03$	$P_1 = -0.6344E-07$	$x_p = 0.002 \text{ mm}$
$K_1 = -0.1677E-07$	$P_2 = 0.2721E-07$	$y_p = 0.004 \text{ mm}$
$K_2 = 0.2872E-12$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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: 101

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	134	134	113	113	95	95
Tangential Lines	134	134	113	95	95	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 USGS TOP 15 test filter KL-F (60%) No. 142399 and KL-F (36%) filter No. 144530 are within 10 seconds of being parallel. The USGS Top 15 test 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	2525	2546	12.69	1/90	88
1/200	1271	1274	6.34	1/180	87
1/300	766	761	3.84	1/300	88
1/400	545	551	2.77	1/410	88
1/500	466	470	2.32	1/490	87

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).

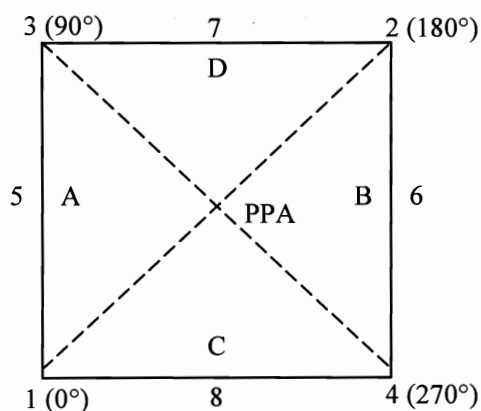
VI. Magazine Platen

The platens mounted in Zeiss T-MC film magazine Nos. 144876 and 145779 do not depart from a true plane by more than 13 μ m (0.0005 in).

The platens for these film magazines are equipped with identification markers that will register "144406" in magazine No. 144876 and "145737" in magazine No. 145779 in the data strip area for each exposure.

VII. Principal Point and Fiducial Mark Coordinates

data strip side



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	0.031	0.029
Indicated principal point, midside fiducials	0.043	0.017
Principal point of autocollimation (PPA)	0.000	0.000
Calibrated principal point (point of symmetry)	0.002	0.004

Fiducial Marks

1	-112.949	-112.985
2	113.001	113.034
3	-112.992	113.013
4	113.085	-112.985
5	-112.964	0.013
6	113.036	0.021
7	0.008	113.011
8	0.078	-113.018

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)	1-2: 319.590 mm	3-4: 319.665 mm
Lines joining these markers intersect at an angle of 90° 00' 04"		
Midside fiducials	5-6: 226.000 mm	7-8: 226.029 mm
Lines joining these markers intersect at an angle of 90° 00' 57"		
Corner fiducials (perimeter)	1-3: 225.998 mm	2-3: 225.993 mm
	1-4: 226.033 mm	2-4: 226.019 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.

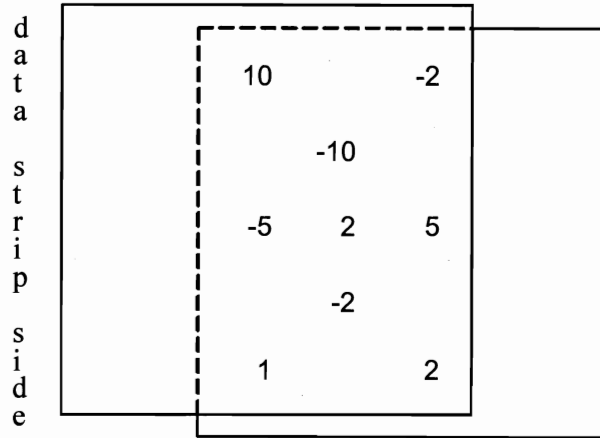
IX. Stereomodel Flatness

FMC Magazine No: 144876

Base/Height ratio: 0.6

Platen ID: 144406

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 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: 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

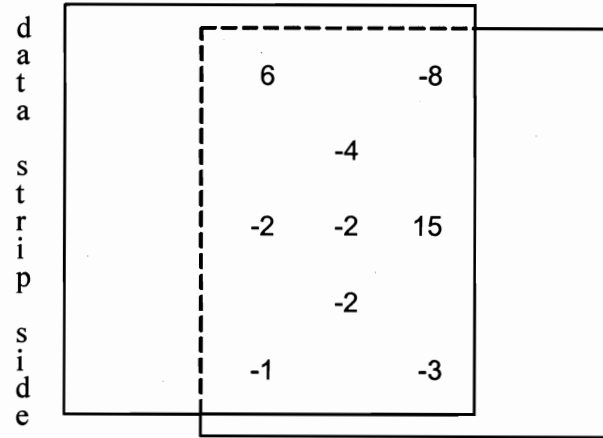
IX. Stereomodel Flatness

FMC Magazine No: 145779

Base/Height ratio: 0.6

Platen ID: 145737

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 Kodak 2405 film exposures. These measurements are considered accurate to within 5 µm.

X. System Resolving Power on film in cycles/mm

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Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	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/3266, dated October 20, 2006.

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Geography Discipline