

# United States Department of the Interior



U.S. GEOLOGICAL SURVEY  
Reston, Virginia 20192

## REPORT OF CALIBRATION of Aerial Mapping Camera

November 16, 2007

<b>Camera type:</b>	Zeiss RMK Top 15*	<b>Camera serial no.:</b>	145844
<b>Lens type:</b>	Zeiss Pleogon A3/4	<b>Lens serial no.:</b>	145891
<b>Nominal focal Length:</b>	153 mm	<b>Maximum aperture:</b>	f/4
		<b>Test aperture:</b>	f/4

**Submitted by:** Midwest Aerial Photography  
Hilliard, Ohio

**Reference:** Midwest Aerial Photography letter of authorization, dated November 9, 2007.  
Signed by Ms. Jeannie Radford.

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:** 152.987 mm

## II. Lens Distortion

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial ( $\mu\text{m}$ )	-1	-1	-1	-1	0	1
Decentering tangential ( $\mu\text{m}$ )	0	0	1	2	3	4

<u>Symmetric radial distortion</u>		<u>Decentering distortion</u>		<u>Calibrated principal point</u>	
$K_0$	= 0.3946E-04	$P_1$	= -0.2004E-06	$x_p$	= 0.009 mm
$K_1$	= -0.4903E-08	$P_2$	= -0.1252E-06	$y_p$	= 0.012 mm
$K_2$	= 0.1130E-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 ( $\sigma$ ) of  $\pm 3$  microns.

\* Equipped with Forward Motion Compensation

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

Area-weighted average resolution: 103

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	134	134	134	113	113	95	95
Tangential Lines	134	113	95	95	113	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 Zeiss KL-F (36%) filter No. 150025 accompanying this camera, and the USGS TOP 15 test filter KL-F (60%) No. 142399 are within 10 seconds of being parallel.

The USGS test filter, in conjunction with the internal "B" filter, was used for the calibration.

**V. Shutter Calibration**

Indicated Time (sec)	Rise Time ( $\mu$ sec)	Fall Time ( $\mu$ sec)	$\frac{1}{2}$ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	3926	4005	10.75	1/120	77
1/200	1887	1934	5.20	1/250	77
1/300	1267	1263	3.46	1/370	77
1/400	900	880	2.52	1/510	78
1/500	741	738	2.01	1/650	77

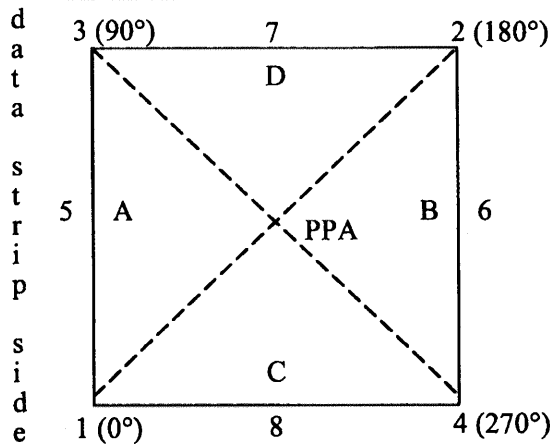
The effective exposure times were determined with the lens at aperture f/4. The method is considered accurate within 3 percent. The technique used is described in International Standard ISO 516:1999(E).

**VI. Magazine Platen**

The platen mounted in Zeiss T-MC film magazine No. 145759 does not depart from a true plane by more than 13  $\mu$ m (0.0005 in).

The platen for this film magazine is equipped with an identification marker that will register "144862" in the data strip area for each exposure.

**VII. Principal Point and Fiducial Mark 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.

	<u>X coordinate (mm)</u>	<u>Y coordinate (mm)</u>
Indicated principal point, corner fiducials	.022	.004
Indicated principal point, midside fiducials	.027	.002
Principal point of autocollimation (PPA)	.000	.000
Calibrated principal point (point of symmetry)	.009	.012

Fiducial Marks

1	-112.975	-112.986
2	113.021	112.995
3	-112.975	113.004
4	113.010	-112.986
5	-112.983	.010
6	113.016	-.005
7	.021	113.001
8	.032	-112.964

**VIII. Distances Between Fiducial marks**

Corner fiducials (diagonals)	1-2: 319.595 mm	3-4: 319.594 mm
Lines joining these markers intersect at an angle of	90° 00' 04"	
Midside fiducials	5-6: 225.999 mm	7-8: 225.966 mm
Lines joining these markers intersect at an angle of	90° 00' 24"	
Corner fiducials (perimeter)	1-3: 225.990 mm	2-3: 225.995 mm
	1-4: 225.985 mm	2-4: 225.981 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 254 mm with a 10 mm filter thickness. Additional filter thickness will increase entrance pupil distance by 0.34 X added thickness.

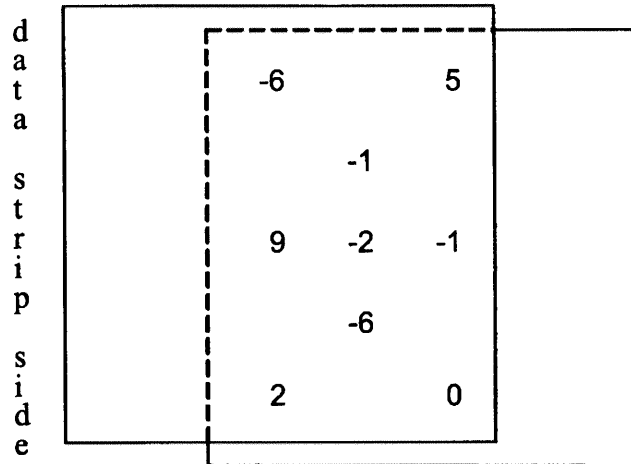
**IX. Stereomodel Flatness**

**FMC Magazine No:** 145759

**Base/Height ratio:** 0.6

**Platen ID:** 144862

**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:** 50

**Film:** Type 2405

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

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3043, dated May 27, 2004.

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