United States Department of the Interior

U.S. **GEOLOGICAL SURVEY**
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

July 21, 2011

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

Submitted by: Midwest Aerial Photography
Galloway, OH

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: 152.991 mm

II. Lens Distortion

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

Symmetric radial distortion		Decentering distortion		Calibrated principal point	
K_0	= -0.8075E-04	P_1	= -0.2527E-06	x_p	= -0.003 mm
K_1	= 0.7228E-08	P_2	= -0.5938E-07	y_p	= 0.007mm
K_2	= -0.5339E-13	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 (a) of ±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	159	134	134	113	113	95	95
Tangential Lines	159	113	95	113	113	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. 150025 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)	½ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	3457	3568	11.36	1/110	81
1/200	1829	1930	5.54	1/230	79
1/300	1263	1235	3.64	1/350	79
1/400	894	876	2.66	1/470	79
1/500	730	727	2.12	1/600	78

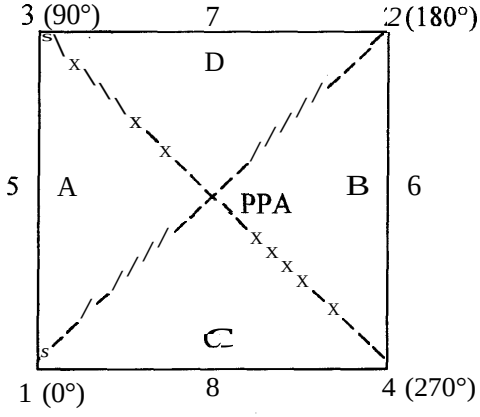
The effective exposure times were determined with the lens at aperature f/4. The method is considered accurate within 3 percent. The technique used is described in International Standard ISO 516:1999(E).

VI. Magazine Platen

The platen mounted in Zeiss T-MC film magazine No. 145759 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 "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.

	X coordinate (mm)	Y coordinate (mm)
Indicated principal point, corner fiducials	0.008	0.008
Indicated principal point, midside fiducials	0.012	0.009
Principal point of autocollimation (PPA)	0.000	0.000
Calibrated principal point (point of symmetry)	-0.003	0.007
Fiducial Marks		
1	-112.988	-112.986
2	113.003	113.002
3	-112.993	113.011
4	113.002	-112.986
5	-112.996	0.017
6	113.001	0.001
7	0.007	113.008
8	0.018	-112.963

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals)	1-2:	319.598 mm	3-4:	319.606 mm
Lines joining these markers intersect at an angle o 90° 00' 00"				
Midside fiducials	5-6:	225.998 mm	7-8:	225.971 mm
Lines joining these markers intersect at an angle o 90° 00' 26"				
Corner fiducials (perimeter)	1-3:	225.997 mm	2-3:	225.996 mm
	1-4:	225.990 mm	2-4:	225.989 mm

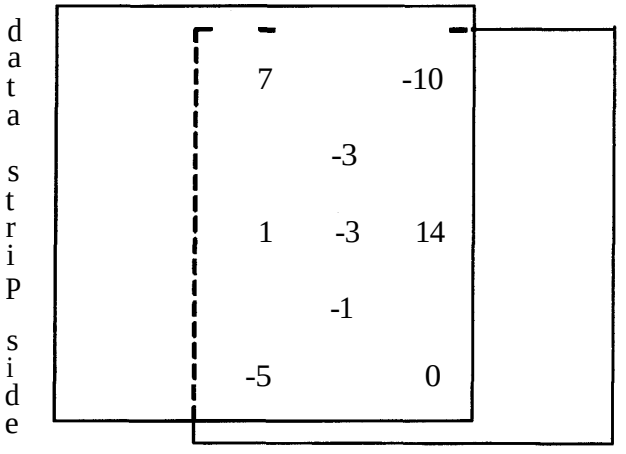
The Method of measuring these distances is considered accurate within 0.003 mm

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: 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 flim 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	57	48	48
Tangential Lines	57	57	48	48	48	48	40

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/3460, dated May 1, 2009.

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Climate and Land Use Change