



United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VA. 22092REPORT OF CALIBRATION
of Aerial Mapping Camera

March 6, 1985

Camera type: Zeiss RMK A 15/23
Lens type: Zeiss Pleogon A4
Nominal focal length: 153 mmCamera serial no.: 119047
Lens serial no.: 118991
Maximum aperture: f/4
Test aperture: f/4Submitted by: Mark Hurd Aerial Surveys, Inc.
Minneapolis, Minnesota

Reference: Mark Hurd purchase order No. 4271, dated February 19, 1985.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type V-F 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: 153.124 mm

This measurement is considered accurate within 0.005 mm

II. Radial Distortion

Field angle	D_c	D_c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	-1	1	0	-1	-2
15	-3	-2	-4	-4	-2
22.5	-4	-4	-3	-5	-5
30	-2	-3	-2	-1	-2
35	1	1	2	1	2
40	3	5	2	5	2

The radial distortion is measured for each of four radii of the focal plane separated by 90° in azimuth. To minimize plotting error due to distortion, a full least-squares solution is used to determine the calibrated focal length. D_c is the average distortion for a given field angle. Values of distortion D_c based on the calibrated focal length referred to the calibrated principal point (point of symmetry) are listed for azimuths 0°, 90°, 180° and 270°. The radial distortion is given in micrometers and indicates the radial displacement away from the center of the field. These measurements are considered accurate within 5 um.

III. Resolving Power in cycles/mm

Area-weighted average resolution: 68.9

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	159	134	113	95	80	57	48
Tangential lines	159	113	95	80	57	34	40

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 B No. 119085, the D No. 119135, and the C-F No. 125277 filters accompanying this camera are within 10 seconds of being parallel. The B filter was used for the calibration.

V. Shutter Calibration

<u>Indicated shutter speed</u>	<u>Effective shutter speed</u>	<u>Efficiency</u>
1/200	3.75 ms = 1/270 s	70%
1/400	1.88 ms = 1/530 s	70%
1/600	1.16 ms = 1/860 s	70%
1/800	0.88 ms = 1/1140 s	70%
1/1000	0.70 ms = 1/1430 s	70%

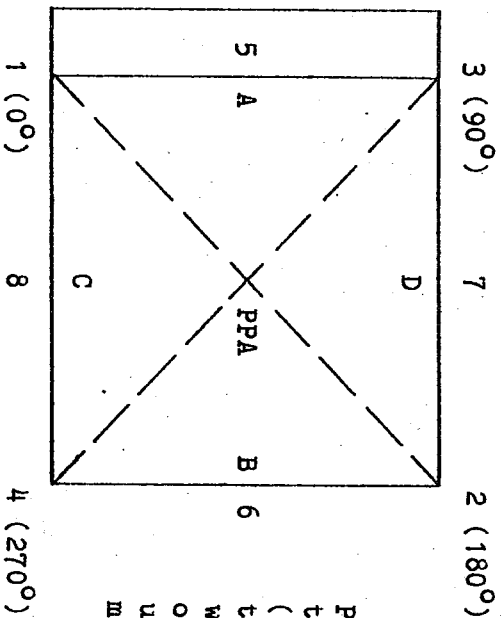
The effective shutter speeds were determined with the lens at aperture $f/4$. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platens mounted in FK 24/120 film magazines No. 36240 and No. 36252 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 "M20" for magazine No. 36240, and "M22" for magazine No. 36252 in the data strip area for each exposure.

VII. Principal Point and Fiducial 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 direction-of-flight fiducial marker or data strip is to the left.

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

	<u>X coordinate</u>	<u>Y coordinate</u>
Indicated principal point, corner fiducials	0.005 mm	-0.007 mm
Indicated principal point, midside fiducials	0.014	-0.010
Principal point of autocollimation	0.0	0.0
Calibrated principal point (point of symmetry)	-0.002	0.002

<u>Fiducial Marks</u>		
1	-103.947 mm	-103.952 mm
2	103.945	103.924
3	-103.937	103.927
4	103.958	-103.952
5	-112.996	-0.005
6	112.990	-0.015
7	0.003	113.001
8	0.026	-112.971

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 293.992 mm 3-4: 293.997 mm

Lines joining these markers intersect at an angle of 90° 00' 17"

Midside fiducials

5-6: 225.986 mm 7-8: 225.972 mm

Lines joining these markers intersect at an angle of 90° 00' 29"

Corner fiducials (perimeter)

1-3: 207.878 mm 2-3: 207.882 mm

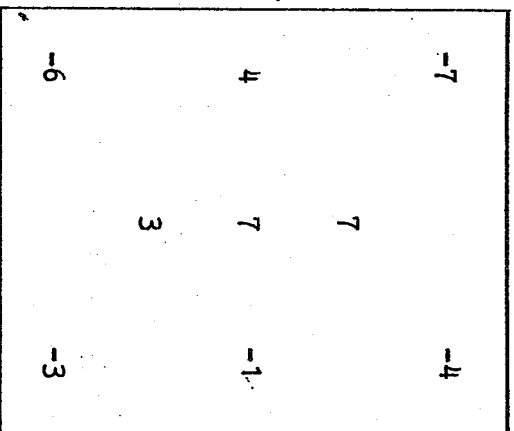
1-4: 207.906 mm 2-4: 207.875 mm

The method of measuring these distances is considered accurate within 0.005 mm

IX. Stereomodel Flatness

Magazine No.: 36240
Platen ID: M20

Base/Height ratio: 0.6
Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

Direction
of flight

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 μ m.

X. Resolving Power in cycles/mm

Area-weighted average resolution: 40.2

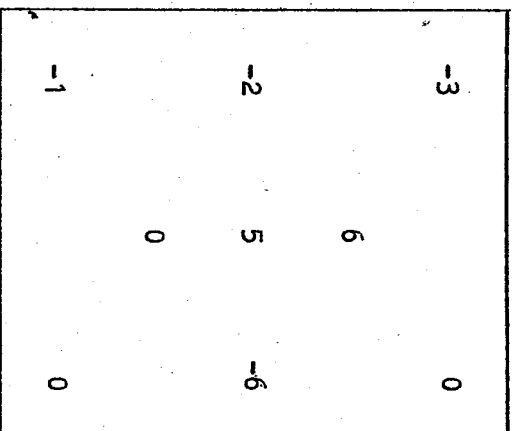
Film: Type 2405

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	80	80	67	48	40	34	34
Tangential lines	80	67	57	40	34	28	24

IX. Stereomodel Flatness

Magazine No. : 36252
 Platen ID: M22

Base/Height ratio: 0.6
 Maximum angle of field tested: 40°



Stereomodel
 Test point array
 (values in micrometers)

Direction
 of flight →

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 μ m.

X. Resolving Power in cycles/mm

Area-weighted average resolution: 40.9

Film: Type 2405

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	80	80	67	57	40	34	34
Tangential lines	80	67	57	40	34	28	24

This report supersedes the previous calibration of this camera contained in USGS Report of Calibration No. RSAS/750, dated November 4, 1981.

Richard F. Schirmacher
 Eberhard G. Schirmacher
 Acting Chief, Optical Science Section
 National Mapping Division

FILM RADIAL DISTORTION, STEREOMODEL FLATNESS AND RESOLUTION

Magazine No.: 36240
 Platea ID: M20

Base/Height ratio: 0.6
 Maximum angle of field tested: 40°

Calibrated Focal Length

Flash plate: 153.124 mm
 Film: 153.150 mm

IX. Radial Distortion

Field angle	D_c	D_c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	1	2	1	1	-1
15	0	1	0	-2	1
22.5	0	2	0	0	-1
30	1	0	2	1	0
35	1	2	1	1	1
40	-1	0	-4	1	-2

X. Stereomodel Flatness

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

-7	-4
4	7
3	-1
-6	-3

→
Direction of flight

Stereomodel test point array
 (values in micrometers)

XI. Resolving Power in cycles/mm

Area-weighted average resolution: 40.2

Film: Type 2405

Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	80	80	67	48	40	34	34
Tangential lines	80	67	57	40	34	28	24

FILM RADIAL DISTORTION, STEREOMODEL FLATNESS AND RESOLUTION

Magazine No.: 36252
 Platen ID: M22

Base/Height ratio: 0.6
 Maximum angle of field tested: 40°

Calibrated Focal Length

flash plate: 153.124 mm
 film: 153.156 mm

IX. Radial Distortion

Field angle	D _c	D _c for azimuth angle			
		0° A-C	90° A-D	180° B-D	270° B-C
degrees	um	um	um	um	um
7.5	0	1	1	0	-1
15	0	0	-2	-3	3
22.5	-2	-3	1	-3	-1
30	-1	-2	0	-2	-2
35	0	-3	1	-1	3
40	2	2	3	1	2

X. Stereomodel Flatness

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereomodels based on comparator measurements on contact glass (Kodak micro flat) diapositives made from Kodak 2405 film exposures. These measurements are considered accurate within 5 um.

-3	0
-2	6
-1	0

Direction of flight →

Stereomodel test point array
 (values in micrometers)

XI. Resolving Power in cycles/um

Area-weighted average resolution:	40.9					Film: Type 2405	
Field angle:	0°	7.5°	15°	22.5°	30°	35°	40°
Radial lines	80	80	67	57	40	34	34
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