



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION of Aerial Mapping Camera

January 05, 2017

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

Camera serial no.: 149977
Lens serial no.: 150021
Maximum aperture: f/4
Test aperture: f/4

Submitted by: FMV Defense Material Administration
Stockholm, Sweden

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:** 153.262 mm

II. **Lens Distortion**

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (μm)	-2	-4	-4	-2	1	4
Decentering tangential (μm)	0	1	2	4	6	8

Symmetric radial distortion	Decentering distortion	Calibrated principal point
$K_0 = 0.1265\text{E-}03$	$P_1 = 0.4901\text{E-}06$	$x_p = -0.001 \text{ mm}$
$K_1 = -0.1528\text{E-}07$	$P_2 = 0.3454\text{E-}07$	$y_p = 0.000 \text{ mm}$
$K_2 = 0.3370\text{E-}12$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

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: 76

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	113	134	134	95	80	80	67
Tangential Lines	113	134	113	80	48	48	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 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

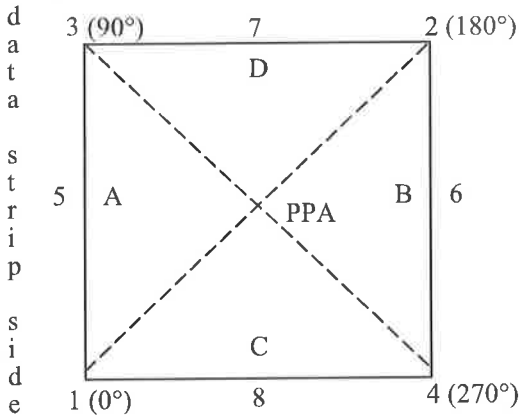
Indicated Time (sec)	Rise Time (μ sec)	Fall Time (μ	½ Width Time (ms)	Nom. Speed (sec)	Efficiency (%)
1/100	3426	3546	11.15	1/110	80
1/200	1969	2098	5.24	1/250	76
1/300	1338	1240	3.61	1/360	78
1/400	938	966	2.65	1/490	78
1/500	747	762	2.11	1/610	78

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 T-MC film magazines Nos. 149875 and 151620 do not depart from a true plane by more than 13 μm (0.0005 in).

The platens for these film magazines are equipped with identification markers that will register "150380" for magazine No. 149875 and "151220" for magazine No. 151620 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.

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

X coordinate (mm) Y coordinate (mm)

0.056 0.011

0.050 0.008

0.000 0.000

-0.001 0.000

Fiducial Marks

1	-112.942	-112.991
2	113.050	113.010
3	-112.941	113.014
4	113.053	-112.991
5	-112.947	0.007
6	113.047	0.010
7	0.049	113.010
8	0.051	-112.996

VIII. Distances Between Fiducial marks

Corner fiducials (diagonals) 1-2: 319.607 mm 3-4: 319.611 mm

Lines joining these markers intersect at an angle of 89° 59' 52"

Midside fiducials 5-6: 225.993 mm 7-8: 226.007 mm

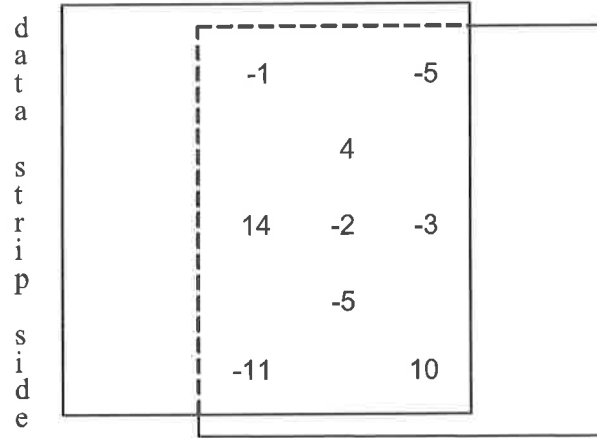
Lines joining these markers intersect at an angle of 89° 59' 59"

Corner fiducials (perimeter) 1-3: 226.005 mm 2-3: 225.991 mm

1-4: 225.995 mm 2-4: 226.001 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.

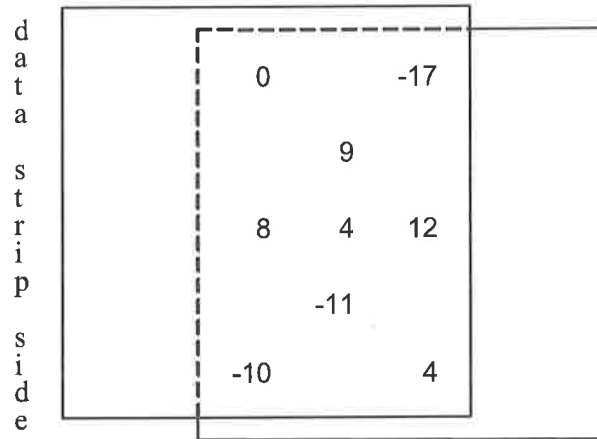
IX. Stereomodel Flatness**FMC Magazine No:** 149875**Base/Height ratio:** 0.6**Platen ID:** 150380**Maximum angle of field tested:** 40 °

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:** 42**Film:** Pan 200

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	57	57	48	48	48	34
Tangential Lines	57	57	57	40	34	34	20

IX. Stereomodel Flatness**Magazine No:** 151620**Base/Height ratio:** 0.6**Platen ID:** 151220**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 Avitane P3p copy film made from Agfa Aviphot Pan 200 film exposures. These measurements are considered accurate to within 5 μ m.

X. System Resolving Power on film in cycles/mm**Area-weighted average resolution:** 42**Film:** Pan 200

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	57	67	57	57	40	48	34
Tangential Lines	57	57	57	48	34	28	20

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