

Calibration Certificate

Lens cone

No.: 265014 A

with lens

No.: 7383190 C

Date of calibration: 13.11.1992

Entries approved by:

A handwritten signature in black ink, consisting of a stylized, cursive script that appears to be a name or initials.

Carl Zeiss JENA GmbH
Department of Photogrammetry

1. General

The data given in this calibration certificate have been determined photographically with the yellow filter belonging to the equipment of the LMK.

Distortion and resolution refer to the respective maximum aperture ratio.

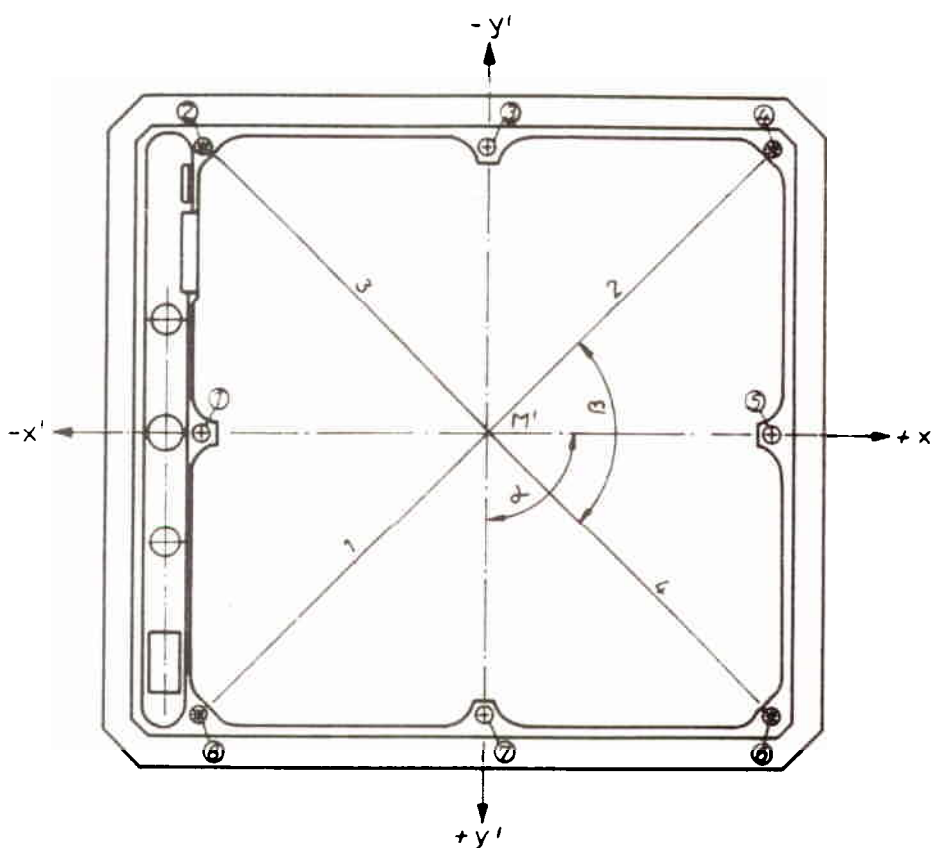
Calibration temperature is $22^{\circ} \text{C} \pm 1.5 \text{ K}$.

The definition of the errors assigned to the measuring data corresponds to the GDR standard, TGL O-1319 (identical to DIN 1319, issue in 1962).

The standard deviation s is related to a level of confidence of $P = 95 \%$ and corresponds to double the value of the mean error usual in surveying, i.e. $P = 68.3 \%$.

All data given without any additional explanations are guaranteed error limits within this standard.

Definition of the measured values (positive image):



$K \triangleq$ Temperature difference $t - t_0$, with $t_0 = 22^{\circ} \text{C}$.

M' = Centre of fiducial mark (intersection point of the fiducial mark connecting lines in the centre of the format sides) = zero point of image coordinate system.

2. Data of interior orientation

Test emulsion: ORWO - LP 3

2.1. Calibrated focal length $c_k = 152,44 \text{ mm} \pm 0.01 \text{ mm}$

2.2. Position of other reference points in the image coordinate system

2.2.1. Intersection point of the connecting lines of the fiducial marks in the picture corners

$$x' = 0,00 \text{ mm} \pm 0.01 \text{ mm}$$

$$y' = 0,00 \text{ mm} \pm 0.01 \text{ mm}$$

2.2.2. Principal point

$$x' = 0,00 \text{ mm} \pm 0.01 \text{ mm}$$

$$y' = + 0,01 \text{ mm} \pm 0.01 \text{ mm}$$

2.2.3. Symmetry point of distortion

$$x' = - 0,01 \text{ mm}, s = \pm 0.01 \text{ mm}$$

$$y' = 0,00 \text{ mm}, s = \pm 0.01 \text{ mm}$$

2.3. Intersection angle of the fiducial mark connecting lines

2.3.1. Fiducial marks in the centres of the format sides

$$\alpha = 99,996 \text{ gon}^+), s = \pm 0.003 \text{ gon}$$

2.3.2. Fiducial marks in the picture corners

$$\beta = 99,998 \text{ gon}, s = \pm 0.003 \text{ gon}$$

2.4. Radial distortion (μm)

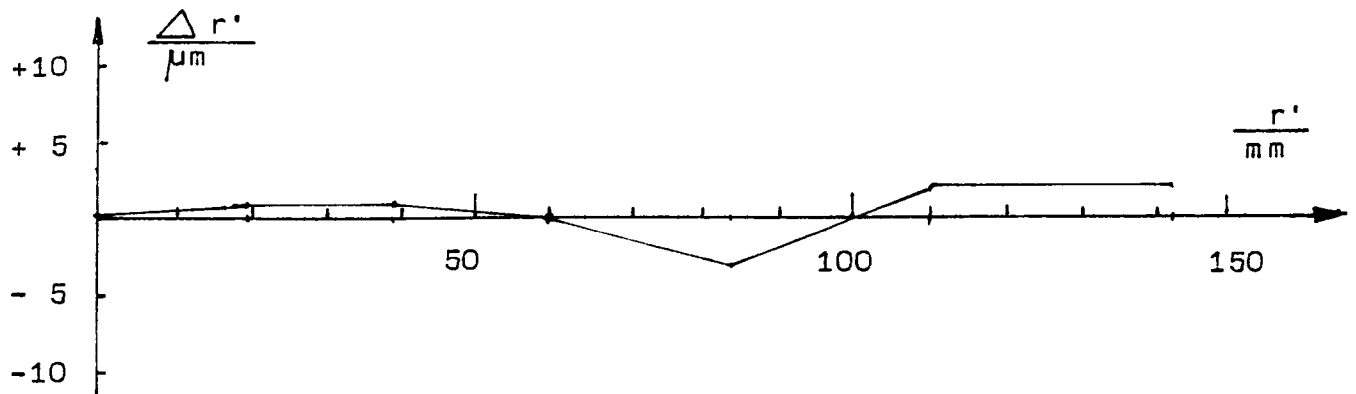
A positive sign corresponds to an enlargement of the image radius.

Reference point	Measuring direction	LMK 9/15	Field angle in gon								
			8	16	24	32	40	48	56	64	
			21	8	16	24	28	32	36		
		30	4	8	12	16	20	24	28		
Zero point of the image coordinate system	1		+ 1	+ 1	0	- 3	- 1	0			
	2		+ 1	+ 1	0	- 3	+ 4	+ 7			
	3		+ 1	+ 1	0	- 6	- 2	- 3			
	4		+ 1	+ 3	+ 1	0	+ 4	+ 5			
Symmetric point of distortion	1		+ 1	+ 1	0	- 2	+ 1	+ 3			
	2		+ 1	+ 2	- 1	- 5	+ 2	+ 3			
	3		+ 1	+ 1	0	- 4	+ 1	+ 1			
	4		+ 1	+ 1	0	- 2	+ 1	0			
Average values											
			+ 1	+ 1	0	- 3	+ 2	+ 2			

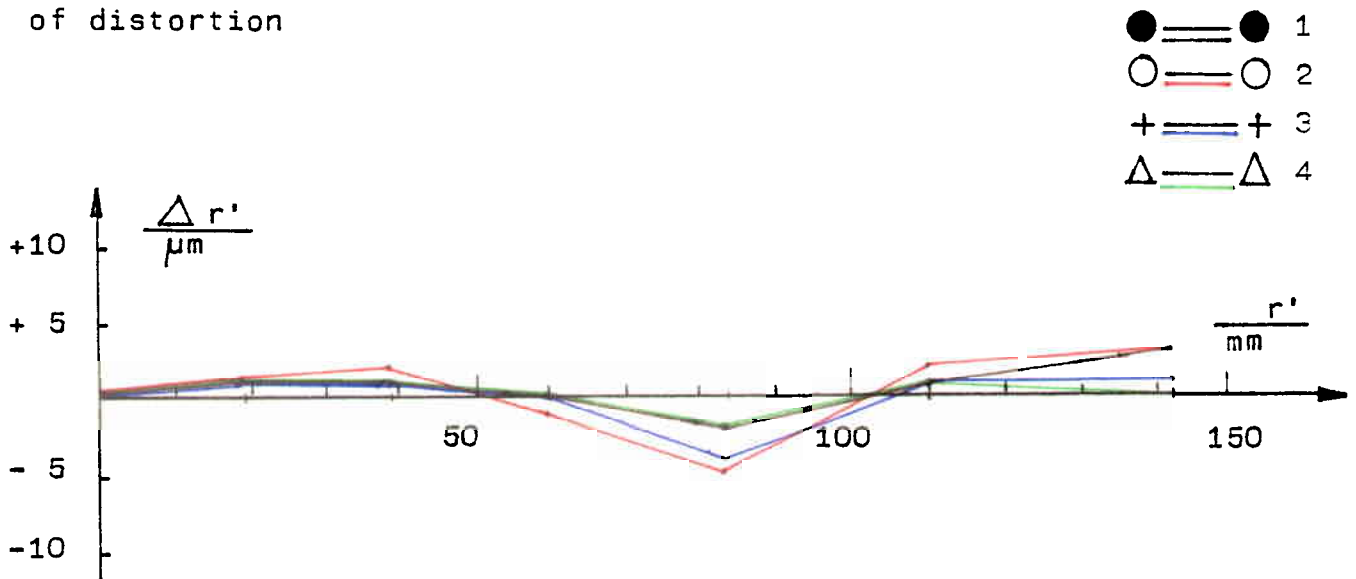
Standard deviation of the distortion values related to the symmetry point of distortion: $s = \pm (3.0 + 1.5 \cdot \tan \tilde{\alpha}) (\mu\text{m})$

$$+) 1 \text{ gon} = \frac{\pi}{200} \text{ rad} = 15.708 \cdot 10^{-3} \text{ rad}$$

Mean distortion



Distortion on the semidiagonals related to the symmetry point of distortion

2.5. Tangential residual errors

Mean value for the largest field angle

Diagonal 1 - 2: $\pm 2 \mu\text{m}$ Diagonal 3 - 4: $\pm 2 \mu\text{m}$ 3. Image coordinates of the fiducial marks (mm)

Point No.	x'	y'
1	- 110,006	- 0,006
2	- 109,993	- 110,000
3	0,000	- 110,003
4	+ 110,002	- 109,995
5	+ 110,003	+ 0,006
6	+ 109,998	+ 110,003
7	0,000	+ 109,995
8	- 110,003	+ 109,993

Standard deviation of the image coordinates: $s = \pm 0.006 \text{ mm}$

4. Fiducial mark spacings

1	-	5	220,009	mm
3	-	7	219,996	mm
2	-	6	311,126	mm
4	-	8	311,122	mm

The distances have been derived from the image coordinates of the fiducial marks.

5. Photographic resolution

The photographic resolution has been determined on the basis of the recommendations of the International Society of Photogrammetry.

Test pattern: Three-line target with high contrast (log k=2.0)

Test emulsion: ORWO - II 15

Developer: ORWO - D 71

Developing time: 4 min

Developing temperature: 20°C

Gradation $\gamma = 1,0$

Mean values of the photographic resolution in lines/mm from the two image diagonals:

Test position	LMK 9/15	Field angles in gon								
		0	8	16	24	32	40	48	56	64
	21	0	8	16	24	32	38			
	30	0	4	8	12	16	20	24	28	
radial		107	91	87	79	76	74	62		
tangential		107	105	95	87	80	59	40		

6. Filter parallelism

The LMK No. comprises the following filters:

350/ /	No.	(clear)
500/ /	No.	(yellow)
550/ /	No.	(orange)

The parallelism of the filter surfaces is $\leq 5''$

7. Flatnes of the film pressure plate

The deviation of the film pressure plate surface from an ideal plane is $\leq \pm 0.008$ mm.

8. Notes:

Lens cone calibrated with filter 500/0,45/15 (yellow)
No. 51391/A