NATIONAL MAPPING COUNCIL OF AUSTRALIA

Special Publication 4

STANDARD SPECIFICATIONS FOR BLACK AND WHITE VERTICAL AERIAL PHOTOGRAPHY FOR LINE MAP PRODUCTION

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PREPARED ON BEHALF OF THE
NATIONAL MAPPING COUNCIL OF AUSTRALIA
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1 SCOPE OF SPECIFICATIONS

Conformance to these specifications will give black and white vertical aerial photography suitable for the production of line maps to the accuracy standards set by the National Mapping Council of Australia. These specifications are established as a general technical standard and do not give details of contractural arrangements.

2 AERIAL CAMERA AND ACCESSORIES

2.1 The camera used for standard mapping photography shall be a high precision metric aerial camera with provision to record the following on each exposure:

- exposure number and film registration number
- lens serial number and focal length
- universal time of exposure

2.2 The image format shall be 23 cm x 23 cm.

2.3 The lens used shall have less than 0.015 mm variation between the radial distortion on any diagonal and the mean radial distortion, except in the corners of the format.

2.4 **Fiducial Marks**

2.4.1 The fiducial marks shall produce sharply defined registrations on each frame. The intersection of the limbs of each mark shall be defined by a point or cross, the diameter or line width of which shall not exceed 0.1 mm.

2.4.2 Where a focal plane plate is provided in the camera, the width of the lines defining the fiducial marks, fiducial centre and/or reseau shall preferably be 0.03 mm but shall not exceed 0.05 mm.

2.5 **Camera Calibration**

2.5.1 Each camera used for standard photography shall be calibrated at least once each two years or whenever the camera has been subjected to physical disturbance which could affect its metric properties; or whenever there is reason to believe that the lens system, fiducial marks or focal plane have altered.

2.5.2 A filter shall be regarded as an integral part of the camera system. The camera shall be calibrated with the filter with which it is to be used. Provision shall be made to ensure that a single orientation of the filter on the camera can be easily and reliably maintained and recovered, preferably by mechanical arrangements.

2.5.3 Records of camera calibration shall be kept for each camera used and should include the following information:

- the focal length of the camera
- the mean radial distortion curve for the calibrated focal length and the radial distortion curves for each quadrant of the format, with the fiducial centre as origin

- the co-ordinates of the point of autocollimation with respect to the fiducial centre
- the co-ordinates of the point of symmetry with respect to the fiducial centre
- the co-ordinates of the fiducial marks with respect to the fiducial centre
- an estimate of the standard deviations of the measurements
- the units of measurements and the sign conventions adopted
- the conditions of test including the filter used, the aperture and the laboratory temperature during the test

2.5.4 During calibration the following may also be determined:

- resolving power of the lens, quoted as the area weighted average resolution (AWAR)
- focal plane illumination

2.5.5 In addition to laboratory calibration tests to monitor the metric properties of the optical unit the camera should be calibrated as a whole system over a field test range. This test should simulate the normal conditions of use as closely as possible.

2.6 **Camera Tolerances**

2.6.1 The film shall be held within 0.01 mm of the intended image plane during exposure.

2.6.2 The fiducial axes shall intersect at right angles with a maximum permissible error of 3 minutes of arc.

2.6.3 Neither the autocollimation point nor the point of symmetry shall be further than 0.05 mm from the fiducial centre.

2.6.4 The camera shall have a calibrated focal length within 1 mm of focal length quoted by the manufacturer for that lens.

2.6.5 Resolution of the camera lens shall not be less than 85% of the value specified by the manufacturer.

2.7 **Filters**

2.7.1 Only filters provided by the lens manufacturer or meeting the same optical specifications shall be used.

2.7.2 Graded density (anti-vignetting) filters shall be used for lenses having an angle of view greater than 60°. This is to compensate for light fall-off towards the edges of the image. The coated surface of the filter shall be towards the camera lens.

2.8 **Optical Flat Glass Port**

2.8.1 Where a camera window is used,the optical flat glass port shall conform to the following specifications:

- the deviation of collimated light at normal incidence shall not be more than 10 seconds of arc or change in deviation more than 2 seconds of arc over the area of the glass

- the glass shall transmit all wave lengths of light from 350 nanometers to the infrared at around 900 nanometers.

BK 17 SCHOTT, or equivalent glass is considered suitable.

2.8.2 The optical flat glass shall be mounted in material eliminating mechanical stress to the window.

2.9 **Camera Installation**

2.9.1 If a camera port glass is used it shall be kept clean and free of scratches. Special provision may have to be made to prevent icing or fogging on the glass inside the aircraft and the prevention of oil, fuel or water stains on the outside of the glass port.

2.9.2 The camera mount shall be of a shockproof, kinematic design so that no undue stress or vibration will be transmitted to the camera body. Provision shall be incorporated for levelling of the camera in flight and for compensating for the drift of the aircraft.

2.10 **Auxiliary Data Recording**

Photographic, manual or computerised records shall be kept of any data provided by the auxiliary instruments synchronised with the aerial camera. Serial numbers of such records shall correspond to those of the camera exposures and shall be correlated at least twice in each flight strip.

3 OPERATIONAL REQUIREMENTS

3.1 Navigation

3.1.1 The mapping area is to be flown with approximately straight parallel continuous flight strips so that the mean bearing of lines joining the principal points in each strip shall be within 3° of the general bearing of the flight line.

3.1.2 The mean bearing of adjacent flight strips shall be parallel within 5°.

3.1.3 The maximum horizontal departure of the plotted photo centre from the straight flight line shall not exceed a distance equal to 20% of the flight altitude.

3.2 Altitude

3.2.1 The mean flight altitude in the area shall not vary by 2% of the indicated flight altitude plus 15 metres.

3.2.2 The altitude at which any photograph in a strip is taken shall not differ from the average indicated altitude by more than 35 metres.

3.3 Photographic Coverage

3.3.1 Each flight strip shall consist of a series of consecutive, correctly overlapping photographs, continuous across the specified area. Break-offs and re-flys of part strips are not normally acceptable.

3.3.2 In the first and last flight strips, a minimum of 12% of each photograph shall laterally overlap the boundaries of the specified mapping area.

3.3.3 At least two 60% stereoscopic pairs shall fall outside the specified mapping area at each end of every flight strip.

3.3.4 Where possible the photography of mapping areas should be taken to include whole units of 1:250 000, 1:100 000, 1:50 000 or 1:25 000 topographic series map sheets.

3.3.5 The lateral overlap of adjacent parallel strips shall normally be at least 15%.

3.3.6 The forward overlap between successive exposures in each flight strip shall normally be at least 60%.

3.3.7 Where a run crosses a shoreline, or other water areas, the overlap shall be increased to a nominal 90%, subject to the constraints imposed by the camera cycling time.

3.3.8 Flight lines parallel to a shoreline may be repositioned to reduce the proportion of water covered provided the coverage extends beyond the limit of any land feature by at least 10% of the format of the photograph.

3.3.9 Flight lines shall be planned such that for near coastal or large water areas the photography is suitable for standard photogrammetric adjustments.

3.3.10 Crab shall not exceed 5° when measured between the baseline and a line parallel to the frame of the negative, nor create gaps in the photography.

3.3.11 Longitudinal tilt shall not exceed 3° for any exposure and the differential tilt between stereoscopic pairs through the flight strip, shall not exceed 2°.

3.4 **Flight Conditions**

3.4.1 For normal Australian conditions no cloud or cloud shadow shall obscure detail on any area being photographed unless that area is fully covered stereoscopically by other photographs and there is no interference with normal photogrammetric joining processes.

3.4.2 Conditions of haze, dust, smoke, cloud, cloud shadow, particularly when in combination with high solar altitude which drastically reduces shadow detail shall be avoided.

3.4.3 Photography shall not normally be attempted when the solar altitude is less than 20° over open flat terrain or less than 30° over steep or timbered country.

3.4.4 When water surfaces are extensive in the area being photographed, the solar altitude should be such that the effect of the sun's reflection is minimised and does not obscure detail.

3.4.5 In flat terrain hot spot conditions in the no shadow areas should be minimised by restricting the maximum allowable solar altitude.

3.4.6 It is normally desirable to complete the coverage of each project photography area within six months.

4 AERIAL FILM

4.1 Negative Material

The negative material shall be a dimensionally stable safety base of 0.102 mm (4 mils) thickness. Its dimensional changes under various conditions shall not exceed the following values:

	Dimensional Change Percent Black and White
Relative expansion per one percent relative humidity (R.H.)	0.002
Thermal expansion per degree C.	0.002
Processing shrinkage	–0.03
Processing swell	+0.02
Accelerated aging shrinkage for 7 days at 50° C, 20% R.H.	0.03
One year aging shrinkage at 25° C, 60% R.H.	0.03

4.2 In-Flight Exposure

4.2.1 A shutter speed shall be chosen that meets the combined requirements of minimal image movement and optimum lens aperture for the prevailing illumination conditions.

4.2.2 Forward image movement shall not normally exceed 20 μm for small scale photography but photography at scales 1:5000 and larger, up to 60 μm image movement shall be acceptable.

5 FILM PROCESSING

5.1 Special care shall be exercised to ensure proper development, fixing and washing of film during the processing procedure. All film should be developed as soon as possible after exposure using only recommended procedures.

5.2 The processing of the negative shall produce a gamma between 0.9 and 2.0 depending on the contrast of the scene. A gamma of 1.6 to 1.8 is normally expected for low contrast flat terrain.

5.3 Dimensions obtained from measurements of the fiducial marks in the developed negatives shall not differ from their respective calibration values by more than 0.15% or 0.15 mm (whichever is greater) and the maximum difference of dimensional change between any two measurements on any photograph shall not be greater than 0.1% or 0.10 mm (whichever is greater).

5.4 All processed negatives shall be substantially free of blisters, bubbles, inclusions, coating lines, stress or static marks, bar marks, pin holes, abrasions, streaks, stains, chemical marks, drying marks and scratches.

5.5 **Image Quality of Negatives**

5.5.1 The density and contrast of all processed films shall be such that commercially available grades of paper (covering normal Log H ranges of 0.6 to 1.6) can be used in printing to give detail in significant areas of highlight and shadow.

5.5.2 The base plus fog level (net density) of the processed film shall not exceed D 0.2 measured in an area clear of any exposure to any light except that a net density of fog up to D 0.4 shall be acceptable for fast films having a nominal effective aerial film speed rating in excess of 250 (EAFS).

5.5.3 Useful minimum shadow detail shall not have a density of less than D 0.4 above the base plus fog value.

5.5.4 The maximum density in useful areas of the negative shall not exceed D 1.5, other than in areas of high reflectance where a maximum density of D 2.0 shall be permissible. The average differential density range between low and highlights should approximate 0.8 to 0.9 density units.

5.5.5 All fiducial marks shall be clearly visible and sharp on every frame.

5.5.6 The camera panel of instruments should be clearly legible on all processed frames.

5.5.7 At least three step wedges should be printed on one end of all films. These step wedges should have 17-25 graded steps.

5.5.8 For the purpose of these specifications, density measurements shall be made by a diffuse-density spot digital transmission densitometer such as a MACBETH TD504.

5.6 **Archival Quality Check**

Film for long term archival storage should be tested for residual silver and hypo as follows:

5.6.1 A residual silver test shall be carried out on all films processed, to assure thorough fixation. The test is to be carried out on the emulsion side, in a clear area, of the processed film. A test solution, the equivalent of KODAK RESIDUAL SILVER TEST SOLUTION ST-1, shall be used and shall not cause a milky stain on the film.

The test area is to remain part of the film.

5.6.2 The thoroughness of film washing shall be checked using a hypo patch test equivalent to KODAK HYPO ESTIMATOR and KODAK TEST SOLUTION HT-2. The test is to be carried out on the emulsion side of the processed film, in a clear area. A negative test indicates that the film is outside specification and should be rewashed. The test area is to remain part of the film.

6 FILM ANNOTATION

6.1 Numbering and annotation of negatives shall be carried out using heat foil or permanent ink in neat legible type. The height of type shall be approximately 3 mm.

6.2 Each roll of film shall be identified by a film registration number.

6.3 On each film at least one metre immediately before the first and immediately after the last exposure shall be left unused.

6.4 On the leading clear section of film or on a sheet always accompanying the film the following information shall be printed in permanent, black lettering:

- the film registration
- the serial numbers of the first and last exposures on the roll
- the project identification, if applicable
- a list of all flight-strips on the roll, together with the numbers of the first and last exposures and the direction of flight of each strip
- the type and serial numbers of the lens/camera/magazine combination used in making the exposures
- the calibrated focal length of the camera lens
- the type of film
- the type of filter used
- the altitude (above mean sea level) from which the exposures were acquired
- where applicable, a reference to any auxiliary instruments used with the vertical aerial camera
- the date of exposure

6.5 Each accepted exposure shall be identified by a frame number, such numbers to be consecutive in the direction of flight throughout each film.

6.6 When photographically recorded information is not suitable for reproduction the following shall be permanently and legibly printed in the margin of each frame of the negative:

- the film registration number
- the exposure number

6.7 Any negative which does not meet the standard required by these Specifications shall not be removed from the roll but shall be stamped "NOT USED" just inside the frame.

6.8 A "NOT USED" negative may carry but need not carry a consecutive photo number. A "NOT USED" photo number shall not be used for any other photograph.

6.9 Any duplication of photo numbers in the project area should be avoided.

6.10 Paper prints or diapositives from the negative should clearly show identification information from the negative annotation or by use of title strips. The information should include:

- area or project identification
- flight strip identification

- date of exposure
- calibrated focal length and serial number of the camera lens
- altitude in metres above mean sea level
- an arrow indicating approximate true north

7 FLIGHT DIAGRAMS AND DOCUMENTATION

7.1 A flight diagram showing all accepted photography, for the mapping area and other relevant data shall be produced.

7.1.1 The most accurate suitable topographic series map available is to be used as the reference base map preferably at a scale of 1:100 000 or 1:250 000.

7.1.2 Data may be annotated directly onto the base map or onto a transparent medium, suitably marked to recover correct registration with the base map.

7.1.3 The annotated map or composite must be suitable for reduction and reproduction. Clarity to enable subsequent reduction to A4 size is desirable.

7.1.4 The photo centre position (plotted by topographic detail) of selected photographs from each flight strip shall be shown by symbols. Those selected will usually be the first and last photographs plus all those whose frame numbers end with the digit 0 or 5.

7.1.5 The first and last frames of each flight strip will show the complete number and those between, only the last two digits. To avoid clutter, where the first/last photo centre is within three frames of the one next plotted, it is not necessary to symbolise or annotate these next plotted photo centres, eg, 7, 15, 20, 25-55, 60, 66.

7.1.6 In densely populated areas, space permitting, every photo centre should be shown, but not necessarily annotated.

7.1.7 Plotted flight strips shall be annotated with the relevant flight line and film registration number.

7.1.8 Additional information which will usually be shown outside the map area is:

- film registration number
- flight strip numbers
- date of exposure for each strip
- camera type and lens focal length
- film type
- height of aircraft above mean sea level in metres
- nominal photography scale
- nominal longitudinal overlap
- to scale diagram showing area covered by nominal photograph
- index to adjoining map sheets

7.2 A sample of a typical flight diagram for 1:80 000 scale photography is given in Annex A.

7.3 A report giving the following information shall accompany each film:

- photography flown by
- area
- producer's identification
- film number
- camera type, lens type

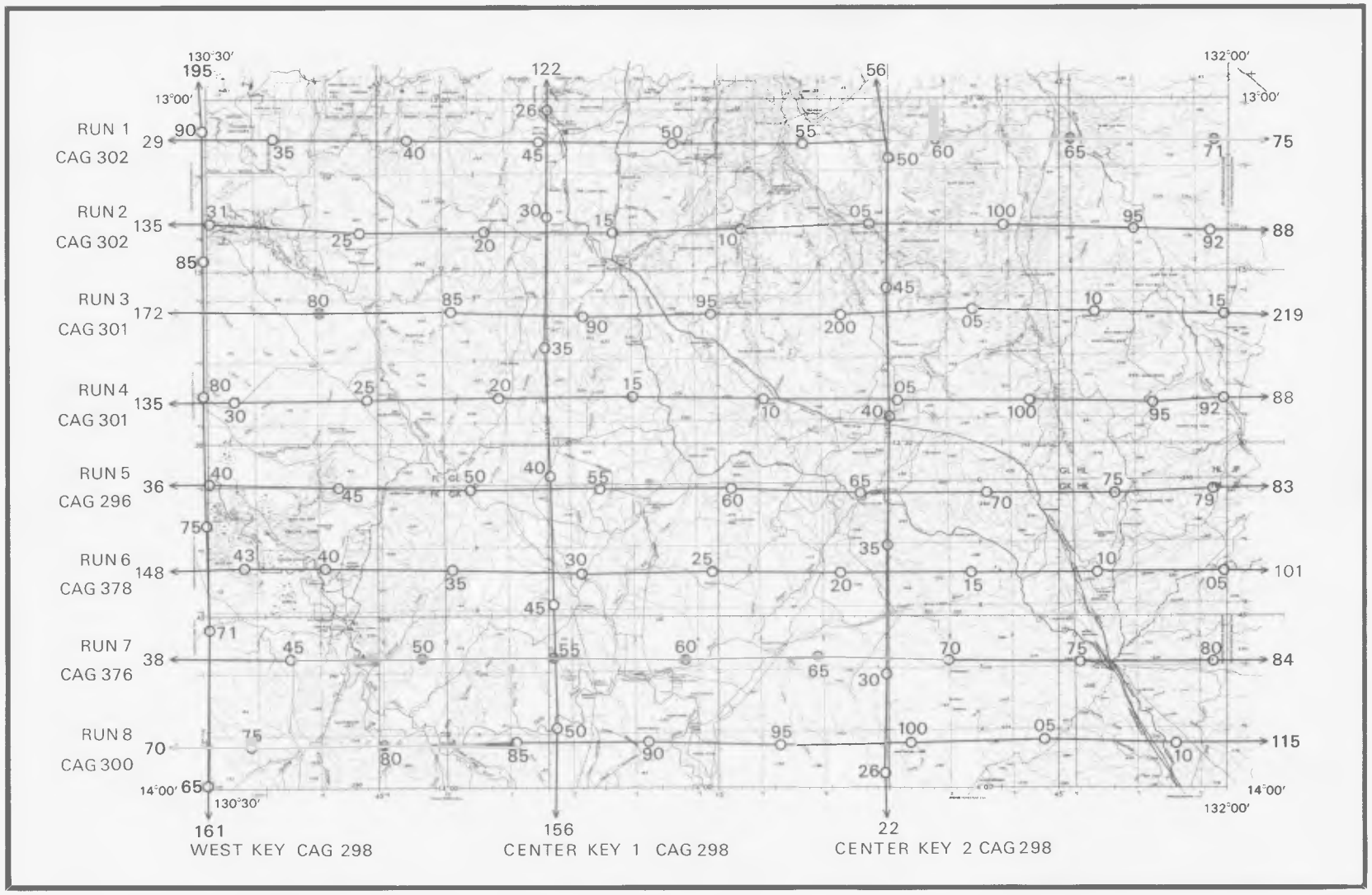
- filter type and factor
- film type
- effective aerial film speed
- lens aperture and shutter speed (range)
- time of day (U.T.) or solar altitude
- date of photography
- flight altitude above mean sea level
- nominal scale of photography
- forward image motion
- weather conditions—outside air temperature, degree of haze, dust, smoke or fog
- terrain contrast
- method of development— chemistry, temperature, racks, speed
- average processed gamma (G gradient)
- density of base plus fog plus sampled minimum and maximum densities through film
- fogging
- blemishes
- general comment on quality

7.4 A sample of a typical report is given in Annex B.

8 ANNEXES

8.1 Annex A: Example of Flight Diagram

PINE CREEK



FILM NO.	RUN	DATE	CAMERA & F.L.	Ht(m)ASL	SCALE	FILM TYPE
CAG 302	1 & 2	22-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 301	3 & 4	21-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 296	5	7-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 378	6	6-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 376	7	6-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 300	8	20-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 298	CENTER KEY 1	18-4-69	RC9 88.35mm	7620	1:84 000	B&W

FILM NO.	RUN	DATE	CAMERA & F.L.	Ht(m)ASL	SCALE	FILM TYPE
CAG 298	CENTER KEY 2	18-4-69	RC9 88.35mm	7620	1:84 000	B&W
CAG 298	WEST KEY	18-4-69	RC9 88.35mm	7620	1:84 000	B&W

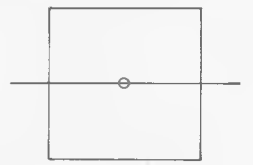
SHEET D52-8

AERIAL PHOTOGRAPHY FLIGHT DIAGRAM

STANDARD MAPPING PHOTOGRAPHY

80 % Forward Lap

APPROXIMATE AREA COVERED BY ONE PHOTOGRAPH



INDEX TO ADJOINING 1:250 000 SHEETS

FOG BAY SD52-3	DARWIN SD52-4	ALLIGATOR RIVER SD53-1
CAPE SCOTT SD52-7	PINE CREEK SD52-8	MOUNT EVELYN SD53-5
PORT KEATS SD52-11	FERGUSSON RIVER SD52-12	KATHERINE SD53-9

NATMAP

APPROXIMATE SCALE 1 : 1 000 000

0 5 10 15 20 25 30 35 40 Km

PINE CREEK D52-8

8.2 **Annex B: Example of Film Report**

DIVISION OF NATIONAL MAPPING

AERIAL PHOTOGRAPH—QUALITY CHECK

FILM TYPE 2402/2412/ _____ **FILM NUMBER** _____/_____

EAFS _____ **AREA** _____

FLIGHT ALTITUDE _____ **PHOTO SCALE** _____

TERRAIN CONTRAST low/medium/high **DATE FLOWN** _____/_____/_____

AERIAL CAMERA **CREW** _____

Type of camera RC10/ _____

Type of lens SAG/UAG/ _____

Type of filter none/yellow/ _____

A.V.x Filter Factor = _____

EXPOSURE DETAILS

Time of the day/solar altitude_____

Range of exposure settings f_____1/_____to f_____1/_____

Image motion (if critical—refer table opposite)_____

WEATHER

(according to in-flight records)

Haze Nil/light/medium/heavy

Dust, smoke, fog, _____

OAT_____°C

PROCESSING

Chemistry 885-Temperature 85° F/_____

Suggested Speed_____Racks 1/2 from field

Actual Speed_____Racks 1/2 after test

Average gradient (G) Suggested_____Measured_____

Base+Fog start_____middle_____end_____

Film min_____min_____min_____

Densities max_____max_____max_____

Any fogging evident?_____

BLEMISHES_____

RECOMMENDATION

Paper Prints_____

Diapositives_____

SIGNED_____ **DATE**_____

For maximum forward image motion of 15 μm at the altitudes listed below the minimum shutter speed is given.

Lens	25,000 ft min-speed
SAG	1/75
UAG	1/120
	15,000 ft.
SAG	1/125
UAG	1/180
	10,000 ft.
SAG	1/180
UAG	1/300