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Analysis of Photographic Image to Evaluate System Performance Mission 1009-2

1 September 1964

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TITLE:

Summary of Microdensitometer Derived Image Quality Data Collected from Mission 1009-2

SECTION I: INTRODUCTION

Microdensitometer tracing of scene edges has been used as an objective technique for evaluating photographic system performance. In this report, the evaluation data is presented as spread function width in microns and resolving power in lines per millimeter. A statistical summary of the edge data is presented in Section II, giving the arithmetic mean, standard deviation, coefficient of dispersion, and number of edges. Section III is a tabulation of the location, description, and image quality data for each edge. Frequency plots of the spread function and resolving power data are presented as Section IV, to show the distribution of values. Summary of all C/M/J Missions traced to date is presented in Section V. Section VI is included to show the sensitometric data for this mission. A diagram of the reference system used in describing the orientation of an edge and a temporary coordinate system used to locate the edges within a frame are presented as Appendix A.

The image quality data was obtained from sharp scene edges in the original negative by scanning with a Kodak Model 5 microdensitometer. A 1 x 80 micron slit was used. The data reduction consisted of the following steps:

(a) hand smoothing of the microdensitometer strip chart recording,

(b) key punching of chart (density) values at sample distance increments of 0.420 microns,

(c) I.B.M. 1620 computer conversion of chart values to relative exposure values, and

(d) computer conversion of exposure data to line spread function and modulation transfer function by numerical methods.

The edge resolving power was predicted graphically as the intersection of the MTF curve and the aerial image modulation curve for 4404 film at a test object contrast of 2:1. The spread function width was calculated from the first differences of relative exposure as the width at which the gradient became 50% of the maximum gradient.

Analysis of Photographic Image to Evaluate System Performance

SECTION II SUMMARY SHEET

Mission 1009-2

Resolution in lines/mm based on the aerial image modulation - 4404 curve from edge trace data reduced by computer techniques.

Arithmetic Mean	83.5
Standard Deviation	26.3
Coefficient of Dispersion	31%
Number of Edges	101

Spread function width at 50% amplitude in microns from edge trace data reduced by computer techniques.

Arithmetic Mean	13.4
Standard Deviation	5.3
Coefficient of Dispersion	40%
Number of Edges	101

Analysis of Photographic Image to Evaluate System Performance

Mission 1009-2

Section III

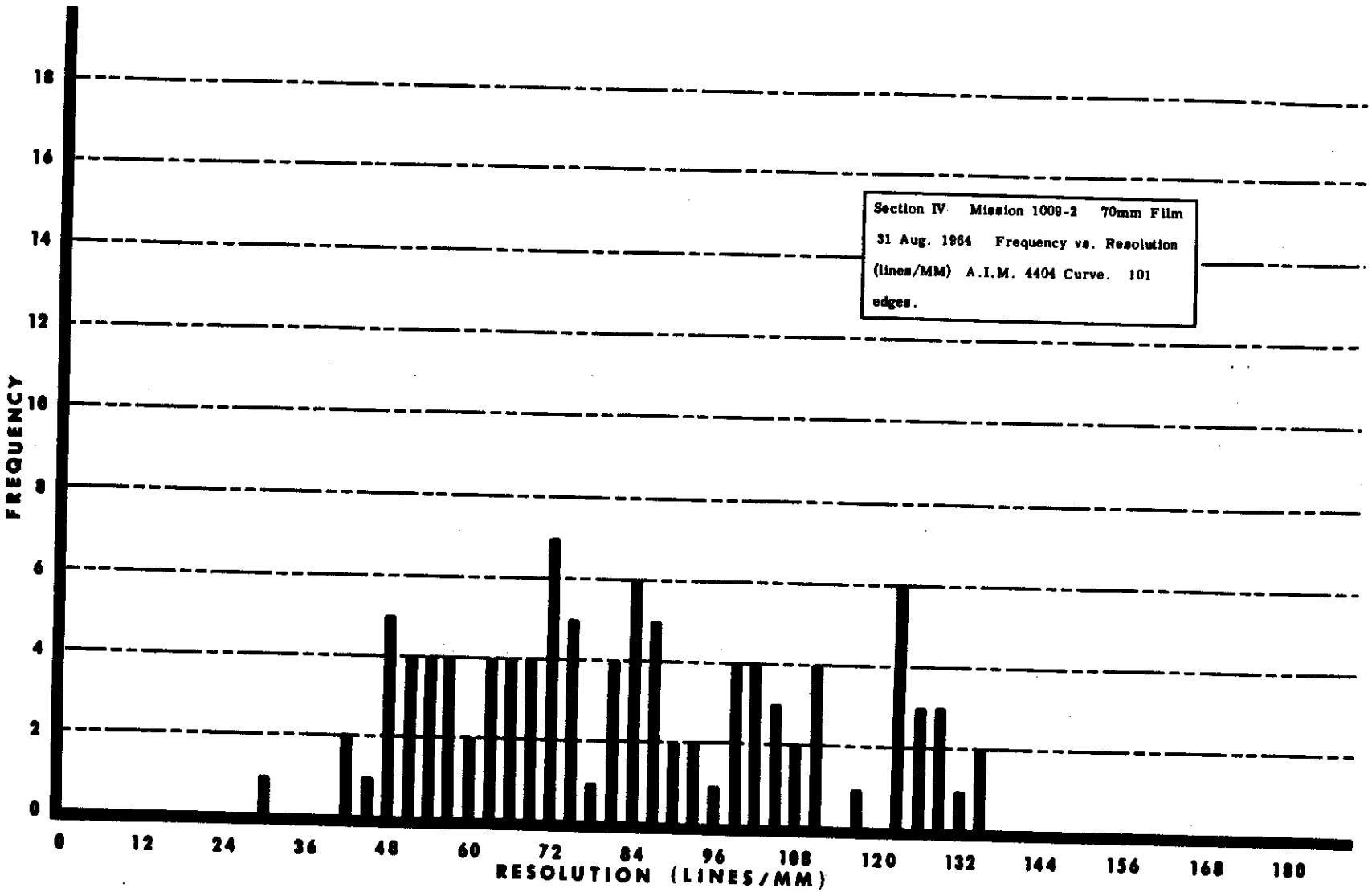
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
1A	Fwd	D-53	133	A-8	115	Airfield	8.7	102
2	Aft	D-53	137	A-6	115	Airfield	16.2	126
3A	Aft	D-53	142	A-8	030	Dam	12.4	69
4	Aft	D-52	144	B-C-11	105	Airfield	14.9	76
4A	Aft	D-52	144	B-C-11	105	Airfield	18.7	65
6	Aft	D-52	154	C-10	170	Buildings	13.9	58
6A	Aft	D-52	154	C-10	170	Buildings	10.4	84
7	Aft	D-52	170	A-7	040	Airfield	12.7	90
7A	Aft	D-52	170	A-7	040	Airfield	9.0	112
8	Aft	D-52	172	B-6	038	Airfield	7.9	104
8A	Aft	D-52	172	B-6	038	Airfield	10.0	106
9	Aft	D-52	180	A-5	175	Airfield	12.3	75
9A	Aft	D-52	180	A-5	175	Airfield	19.6	45
10	Fwd	D-52	139	A-3	095	Airfield	19.2	76
11	Fwd	D-52	122	A-9	130	Airfield	15.6	84
11A	Fwd	D-52	122	A-9	130	Airfield	22.2	57
12	Fwd	D-52	175	A-10	175	Airfield	6.9	126
12A	Fwd	D-52	175	A-10	175	Airfield	10.5	83
14	Aft	D-61	014	B-11	170	Bridge	19.0	72
15	Aft	D-61	015	B-10	130	Dock	10.4	83
16	Aft	D-61	019	C-7-8	030	Airfield & Buildings	11.1	76

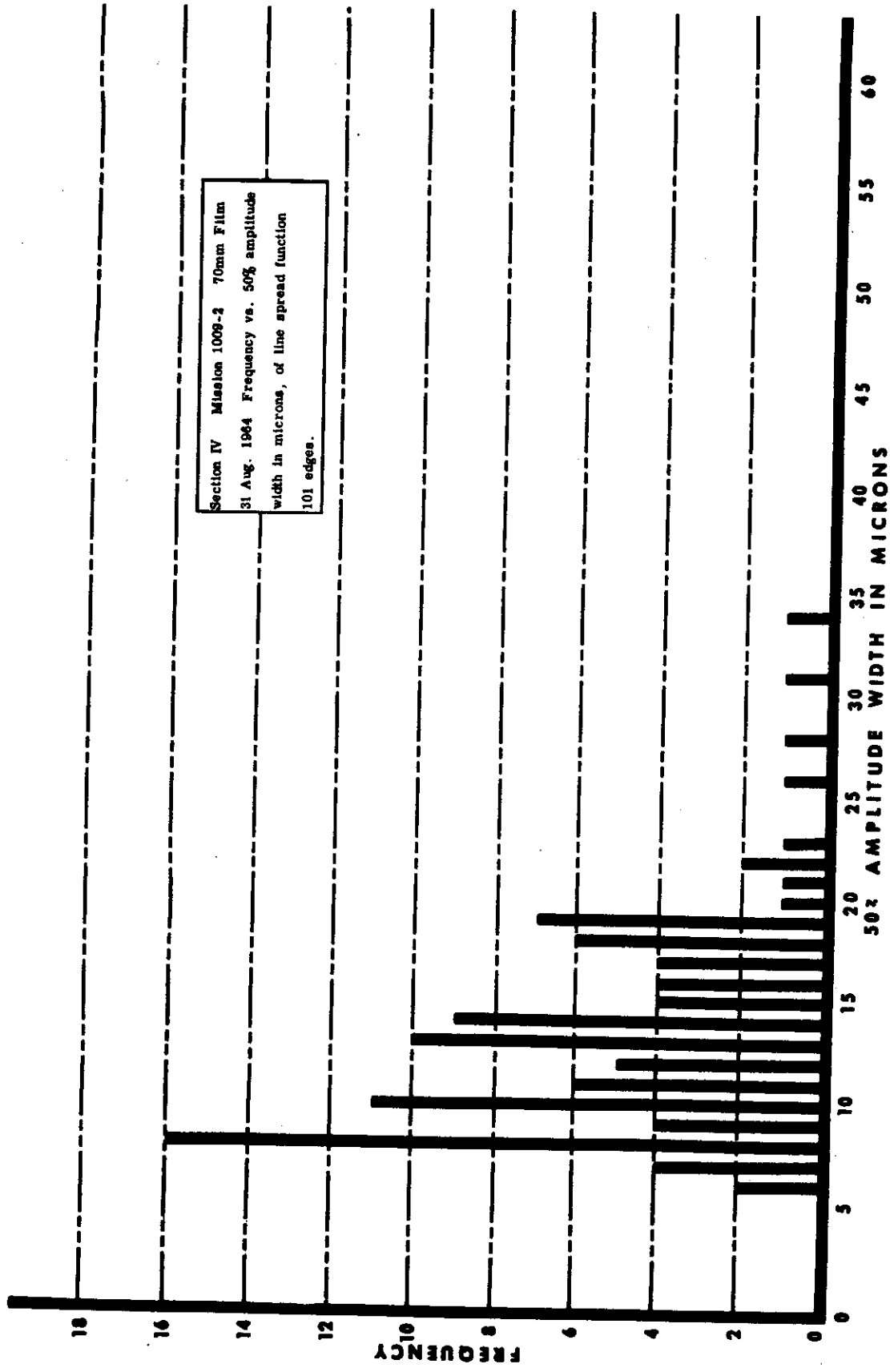
Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
16A	Aft	D-61	019	C-7-8	030	Airfield & Buildings	14.7	88
17	Aft	D-61	022	B-7	090	Airfield	8.4	110
17A	Aft	D-61	022	B-7	090	Airfield	6.4	135
18	Aft	D-61	016	C-10	010	Bridge	22.7	54
19	Fwd	D-61	007	C-2	095	Airfield	12.6	111
19A	Fwd	D-61	007	C-2	095	Airfield	7.2	124
21	Fwd	D-61	010	B-4	010	Bridge	10.6	86
21A	Fwd	D-61	010	B-4	010	Bridge	8.4	123
22	Fwd	D-61	013	B-7	175	Building near Airfield	18.8	49
22A	Fwd	D-61	013	B-7	175	Building near Airfield	9.7	107
23	Fwd	D-61	014	B-12	160	Bridge	11.5	72
23A	Fwd	D-61	014	B-12	160	Bridge	25.8	55
24	Fwd	D-61	016	C-10	130	Airfield	8.3	103
24A	Fwd	D-61	016	C-10	130	Airfield	6.4	134
25	Fwd	D-56	081	A-7	080	Airfield	10.7	77
25A	Fwd	D-56	081	A-7	080	Airfield	33.6	48
26	Fwd	D-56	099	B-2	020	Airfield	7.9	100
26A	Fwd	D-56	099	B-2	020	Airfield	17.1	51
27	Fwd	D-56	112	C-8	018	Airfield	19.2	65
27A	Fwd	D-56	112	C-8	018	Airfield	27.7	30

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
28	Aft	D-56	118	C-7	020	Airfield	13.6	69
28A	Aft	D-56	118	C-7	020	Airfield	20.9	41
29	Aft	D-56	104	A-12	020	Airfield	18.5	47
29A	Aft	D-56	104	A-12	020	Airfield	16.5	51
30	Aft	D-56	086	B-8	080	Airfield	7.9	105
30A	Aft	D-56	086	B-8	080	Airfield	6.6	130
31	Aft	D-56	086	A-9	170	Dam	8.5	118
31A	Aft	D-56	086	A-9	170	Dam	19.4	62
32	Aft	D-56	085	C-6	035	Airfield	9.8	98
32A	Aft	D-56	085	C-6	035	Airfield	13.8	86
33	Fwd	D-72	029	A-10	170	Airfield	8.0	128
33A	Fwd	D-72	029	A-10	170	Airfield	9.6	111
34A	Fwd	D-72	041	A-5	155	Airfield	12.5	101
35	Fwd	D-72	048	B-3	065	Airfield	17.0	70
35A	Fwd	D-72	048	B-3	065	Airfield	18.3	83
36	Fwd	D-72	050	B-12	070	Airfield	10.6	102
36A	Fwd	D-72	050	B-12	070	Airfield	13.1	62
37	Fwd	D-72	060	C-5	170	Airfield	14.6	71
37A	Fwd	D-72	060	C-5	170	Airfield	18.4	75
38	Aft	D-55	141	A-9	170	Airfield	13.4	71
38A	Aft	D-55	141	A-9	170	Airfield	13.3	82
39	Fwd	D-115	041	B-1	170	Airfield	12.6	87
39A	Fwd	D-115	041	B-1	170	Airfield	21.7	58

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
40	Aft	D-69	190	A-4	090	Airfield	6.8	124
40A	Aft	D-69	190	A-4	090	Airfield	7.7	122
41	Aft	D-72	066	B-9	016	Airfield	9.6	109
41A	Aft	D-72	066	B-9	016	Airfield	10.3	92
42	Aft	D-72	060	B-9	050	Dam	13.6	71
42A	Aft	D-72	060	B-9	050	Dam	17.8	50
43	Aft	D-72	056	B-2	065	Airfield	7.7	129
43A	Aft	D-72	056	B-2	065	Airfield	9.7	100
44	Aft	D-72	054	C-11	085	Airfield	15.2	54
44A	Aft	D-72	054	C-11	085	Airfield	16.8	50
45	Aft	D-72	052	B-4	100	Airfield	8.3	93
45A	Aft	D-72	052	B-4	100	Airfield	17.1	48
46	Fwd	D-56	080	A-8	120	Airfield	11.7	71
47	Fwd	D-56	079	B-8	040	Airfield	7.7	99
47A	Fwd	D-56	079	B-8	040	Airfield	13.8	80
48	Fwd	D-72	084	A-3	055	Airfield	8.4	132
48A	Fwd	D-72	084	A-3	055	Airfield	19.0	47
49	Fwd	D-72	083	C-5	025	Airfield	14.0	57
49A	Fwd	D-72	083	C-5	025	Airfield	13.2	59
50	Fwd	D-88	033	B-C-7	110	Airfield	12.7	70
50A	Fwd	D-88	033	B-C-7	110	Airfield	11.9	80
51	Fwd	D-99	042	B-11	060	Airfield	13.6	67
51A	Fwd	D-99	042	B-11	060	Airfield	15.8	62

Edge No.	Camera	Pass	Frame	Location	Orientation	Subject	50% Amplitude Spread Function Width (Microns)	A.I.M. Resolution
52	Fwd	D-99	029	B-2	050	Airfield	14.4	64
52A	Fwd	D-99	029	B-2	050	Airfield	9.1	91
53	Fwd	D-99	028	B-1	070	Airfield	30.6	43
53A	Fwd	D-99	028	B-1	070	Airfield	17.5	71
54	Fwd	D-116	069	C-10	115	Airfield	7.9	125
54A	Fwd	D-116	069	C-10	115	Airfield	9.5	88
55	Fwd	D-100	076	C-7	045	Airfield	7.8	122
55A	Fwd	D-100	076	C-7	045	Airfield	8.4	122
56	Aft	D-99	048	B-3	045	Airfield	18.2	55
56A	Aft	D-99	048	B-3	045	Airfield	8.5	95
57	Aft	D-99	035	B-13	090	Airfield	11.9	80
57A	Aft	D-99	035	B-13	090	Airfield	12.8	65
58	Aft	D-99	034	B-13	085	Airfield	13.7	60
58A	Aft	D-99	034	B-13	085	Airfield	9.8	85


Section IV Mission 1009-2 70mm Film
31 Aug. 1964 Frequency vs. Resolution
(lines/MM) A.I.M. 4404 Curve. 101
edges.
FREQUENCY
0
2
4
6
8
10
12
14
16
18
0
12
24
36
48
60
72
84
96
108
120
132
144
156
168
180
RESOLUTION (LINES/MM)


Section IV Mission 1009-2 70mm Film
31 Aug. 1964 Frequency vs. 50% amplitude
width in microns, of line spread function
101 edges.
FREQUENCY
50% AMPLITUDE WIDTH IN MICRONS
0
2
4
6
8
10
12
14
16
18
0
5
10
15
20
25
30
35
40
45
50
55
60

SECTION V
Summary of all C/M/J Missions Traced to Date

Mission Number	Number of Edges	Spread Function Width at 50% Amplitude in Microns, Computer Calculations			Resolution in lines/mm from A.I.M. 4404 Curve, Computer Calculations		
		Arithmetic Mean	Standard Deviation	Coefficient of Dispersion	Arithmetic Mean	Standard Deviation	Coefficient of Dispersion
9054	12	14.3	4.6	32%	81.7	27.9	34%
9057	35	12.0	4.1	34%	81.3	30.2	37%
9062	69	12.0	4.5	37%	89.4	30.3	34%
1001	117	25.6	11.3	44%	45.9	16.8	37%
1004-1	60	10.1	5.6	56%	115.7	38.8	34%
1004-2	69	12.6	4.9	39%	84.6	31.3	37%
1006-1	93	12.0	4.3	36%	85.3	26.4	31%
1006-2	109	11.4	3.3	29%	85.5	22.1	26%
1007-1	107	11.9	3.6	30%	89.7	22.2	25%
1007-2	106	12.3	3.9	31%	85.8	25.1	29%
1008-1	95	10.8	3.1	29%	96.3	25.4	26%
1008-2	114	10.5	3.8	36%	97.7	24.8	25%
1009-1*	74	11.5	3.5	30%	92.2	25.2	27%
1009-2*	101	13.4	5.3	40%	83.5	26.3	31%

* A 1 x 80 micron slit was used.

Sensitometric Data

Mission 1009-2

Film Manufacturer: Eastman Kodak Company

Exposure Date: May 26, 1964

Emulsion No.: 4404-42

Lamp No.: 1903

Exposure Time: 1/25 second

Wedge No.: 711-15

Filter: Daylight

Development Conditions:

Primary: P-693, 2' 15", 74°F

Intermediate: Primary Development Plus 12DX90, 25", 67°F

Full: Primary Development Plus 12DX90, 1' 41", 67°F

Absolute Log E 11th Step: 1.30 M.C.S.

Sensitometric Data

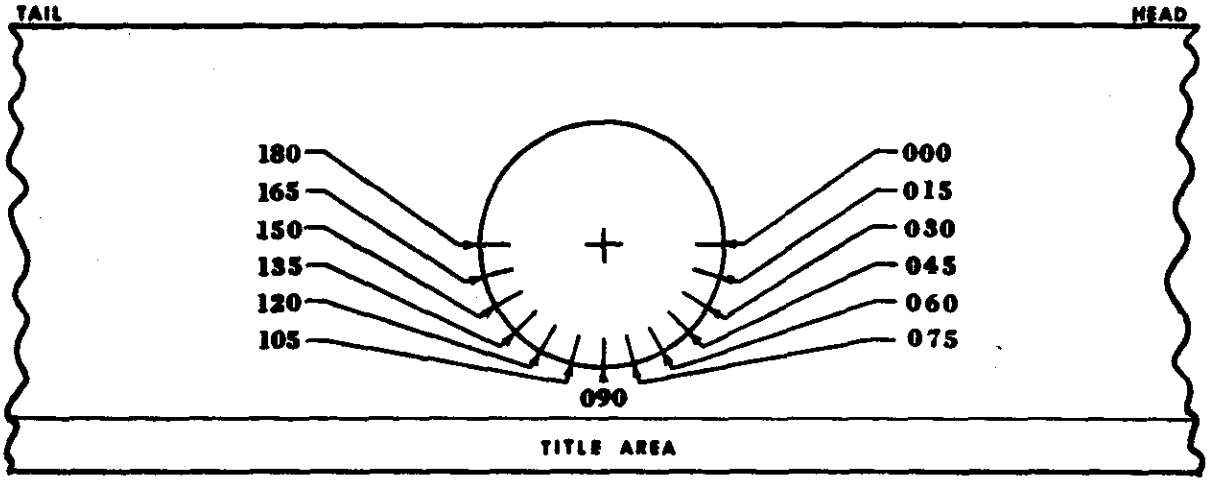
	Process Control Standard			Start Up		
	Primary	Intermed.	Full	Primary	Intermed.	Full
Fog	.08	.10	.19	.08	.11	.19
1						
2						
3						
4						
5			.19			.19
6		.10	.20	.08	.11	.20
7	.08	.12	.23	.09	.12	.21
8	.10	.14	.27	.10	.14	.27
9	.12	.18	.34	.12	.18	.34
10	.16	.26	.50	.16	.26	.50
11	.24	.42	.79	.24	.40	.74
12	.38	.67	1.10	.38	.65	1.04
13	.62	1.03	1.43	.61	.98	1.36
14	.93	1.40	1.72	.90	1.36	1.66
15	1.26	1.71	1.95	1.25	1.68	1.89
16	1.55	1.95	2.13	1.56	1.92	2.08
17	1.83	2.10	2.24	1.83	2.10	2.20
18	2.04	2.22	2.30	2.01	2.22	2.30
19	2.17	2.29	2.35	2.15	2.28	2.34
20	2.25	2.34	2.39	2.24	2.34	2.36
21	2.30	2.37	2.43	2.28	2.36	2.38
$\bar{f}$	2.15	2.38	2.20	2.22	2.30	2.07
0.6G/Speed	$\bar{1}$.48	$\bar{1}$.30	$\bar{1}$.13	$\bar{1}$.48	$\bar{1}$.32	$\bar{1}$.14

	Head and Tail Forward Camera		Head and Tail Aft Camera	
	Head	Tail	Head	Tail
Fog	.18	.19	.17	.18
1				
2				
3			.17	.18
4		.19	.18	.19
5	.18	.20	.19	.20
6	.20	.21	.20	.21
7	.22	.23	.22	.22
8	.26	.26	.26	.27
9	.34	.35	.33	.35
10	.50	.52	.48	.50
11	.76	.78	.72	.64
12	1.07	1.11	1.04	1.08
13	1.42	1.45	1.40	1.42
14	1.71	1.74	1.69	1.72
15	1.94	1.97	1.95	1.94
16	2.11	2.13	2.11	2.11
17	2.24	2.26	2.24	2.23
18	2.32	2.34	2.33	2.33
19	2.37	2.38	2.38	2.39
20	2.40	2.41	2.41	2.42
21	2.42	2.43	2.42	2.44
f	2.22	2.25	2.16	2.26
0.6G/Speed	$\bar{1}.14$	$\bar{1}.16$	$\bar{1}.14$	$\bar{1}.18$

APPENDIX "A"

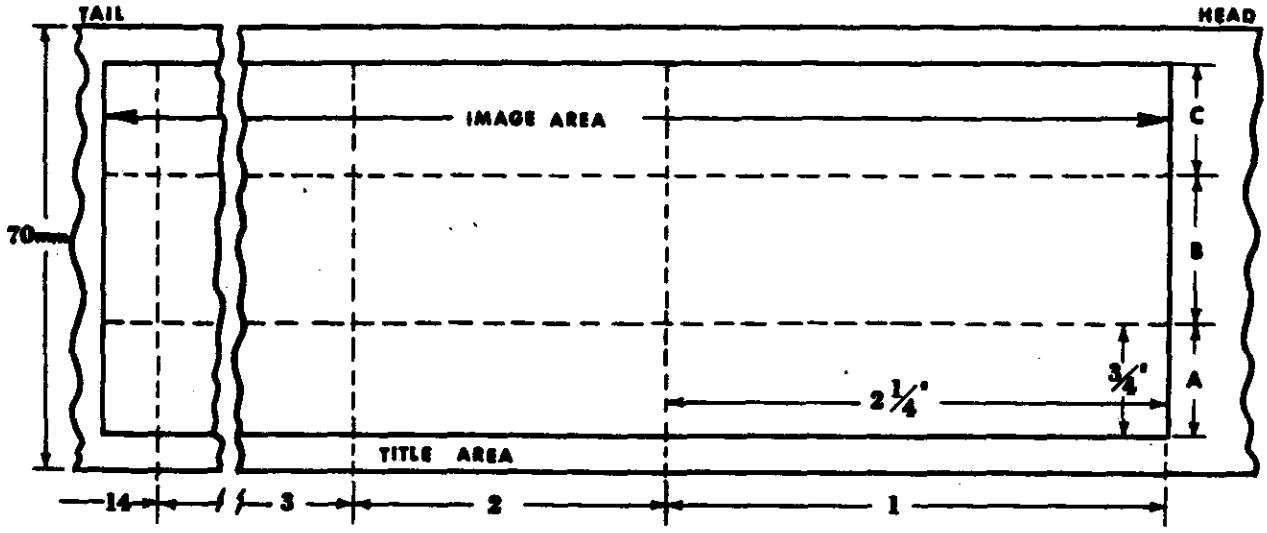
Reference System For Orientation Of C/M/J Mission Edges

original negative - - emulsion up



Grid For Position Of C/M/J Mission Edges

original negative - - emulsion up



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