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Density/Luminance
Evaluation Report

Mission 1043

18 September 1967

Declassified and Released by the NRO
In Accordance with E. O. 12958
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FOREWORD

This report includes an analysis of the density and luminance statistics of the original negative from Mission 1043.

An addendum to this report includes image evaluation data of the preflight portion of the film used in Mission 1043.

The detailed photographic evaluation by the processing station was published separately on 6 September 1967, Document Control Number

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INTRODUCTION

Summary

This report presents an analysis of the density of the processed original negative film record. Estimates were made of the luminance levels of the scenes photographed and the suitability of the exposure and process level used.

Sampling of Data

This data is collected from a representative sample of the photography which is not cloud or water covered. From each of the frames, the minimum and maximum densities containing discernible information were measured and recorded. These data were then analyzed to yield the density and luminance summary here.

Included are:

1. Density Tolerance Analysis.
2. Density/Luminance Profile.
3. Index Record Summary.

Process Curves Used in Analysis

To insure the greatest possible accuracy in the analysis of the film record, process curves based on the R-2 sample are used for establishing the tolerance limits and calculating luminances.

Density Tolerance Analysis

For each process curve, the densities corresponding to a gradient of 1.2 on the toe and shoulder are used as the density tolerance limits for frames processed at that level. Frames for which the minimum and/or maximum densities are outside these 1.2 gradient limits are out-of-tolerance for one of the reasons explained below.

Each sampled frame is assigned to one of several quality categories within the three major classifications of: (I) Satisfactory Exposure, (II) Unsatisfactory Exposure, and (III) Beyond System Capability. Classification into these categories is based on measurements of minimum and maximum densities and process level. In the brief description which follows, the numerical identity corresponds to the Density Tolerance Analysis, in which the percentages in each category are listed.

- I. Satisfactory Exposure - within capability of processing to bring minimum and maximum density of a frame within density tolerance extremes.

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IA. Within Tolerance - frames completely within density tolerance extremes.

IB. Out-of-Tolerance - those frames which would have been in-tolerance if processed at a different level.

IB1. Over-processed - out-of-tolerance frames which would have been within tolerance if processed at a lower level.

IB2. Under-processed - out-of-tolerance frames which would have been within tolerance if processed at a higher level.

II. Unsatisfactory Exposure

IIA. Overexposure - frames for which the highest density corresponds to exposure above the point on the shoulder of the primary level characteristic curve where the gradient is 1.2.

IIA1. Best Processed, Overexposed - overexposed frames processed at primary level.

IIA2. Over-processed, Overexposed - overexposed frames processed at intermediate or full level.

IIB. Underexposure - frames for which the lowest density corresponds to exposure below the point on the toe of the full level characteristic curve where the gradient is 1.2.

IIB1. Best Processed, Underexposed - underexposed frames processed at full level.

IIB2. Under-processed, Underexposed - underexposed frames processed at primary or intermediate level.

III. Beyond System Capability

IIIA. Beyond System Latitude - frames which have a larger log E range than the log E range of the in-tolerance density extremes.

IIIB. Out of Phase - frames within system latitude but for which only one density extreme (minimum or maximum) would be within the in-tolerance density limits for any process level.

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Density/Luminance Profile

The following paragraphs describe the various parts of the Density/Luminance Profile.

Density Tolerance Analysis. The categories described above are combined into six major groups for the Density/Luminance Profile and for mission-to-mission comparison. The following list of the six major groups used on the graph shows which categories are combined into each group.

- I Within Tolerance Limits IA
- II Underexposure IIB1
- III Under-processed
The sum of IB2 and IIB3
- IV Overexposure IIA1
- V Over-processed
The sum of IB1 and IIA2
- VI Beyond Latitude
The sum of IIIA and IIIB

NOTE: In the above six group summary, frames which are both incorrectly exposed and incorrectly processed are included only once--in an incorrectly processed group.

Density Summary. The eight bar graphs under the label "Density Summary" show the minimum and maximum density distributions of the sampled frames for each of the three process levels and the total density distributions for the film record.

Processing Summary. The "Processing Summary" is a graphical representation of the Process Breakdown. It shows the percentage of the mission processed at each level.

Luminance vs. Solar Altitude. The "Luminance versus Solar Altitude" scattergrams depict the variation of luminance values as a function of solar altitude, from the sampled frames.

Frequency vs. Solar Altitude. The "Frequency versus Solar Altitude" chart shows the percent of mission photography taken at each solar altitude.

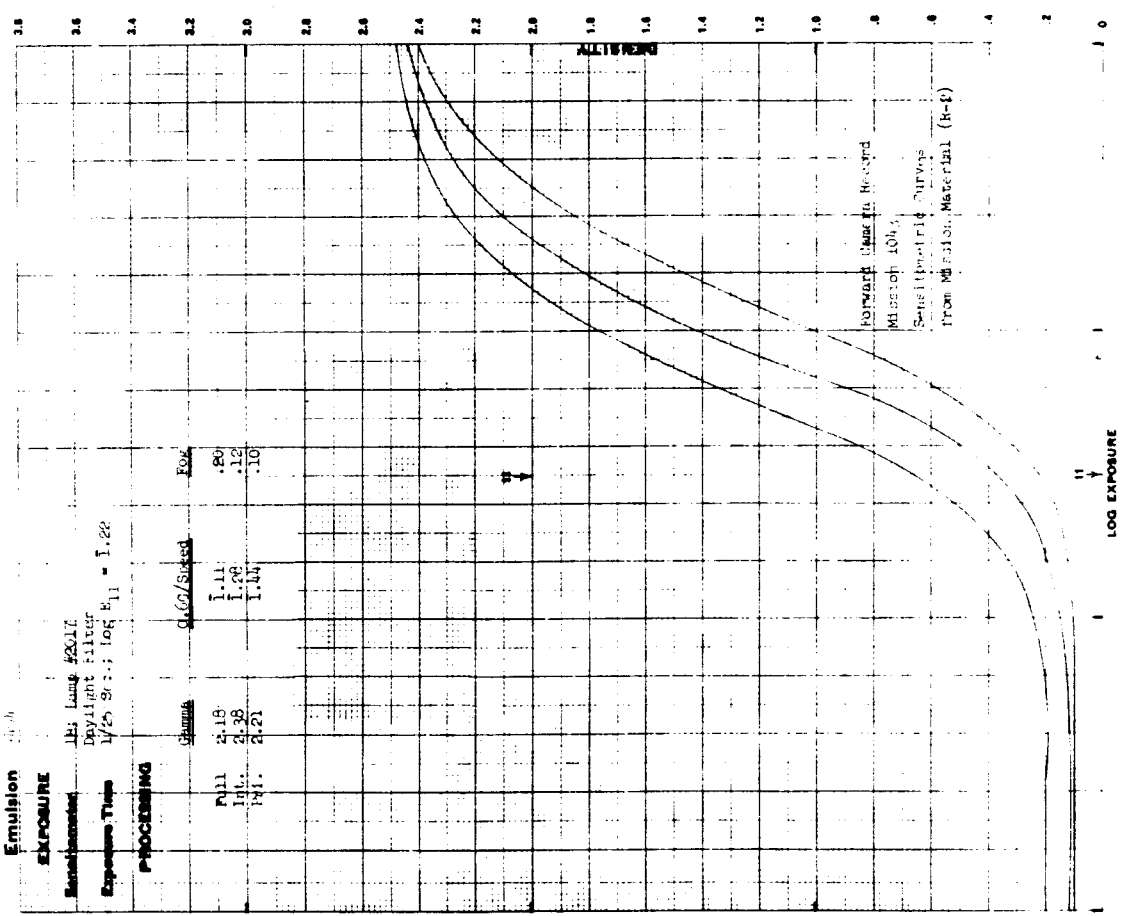
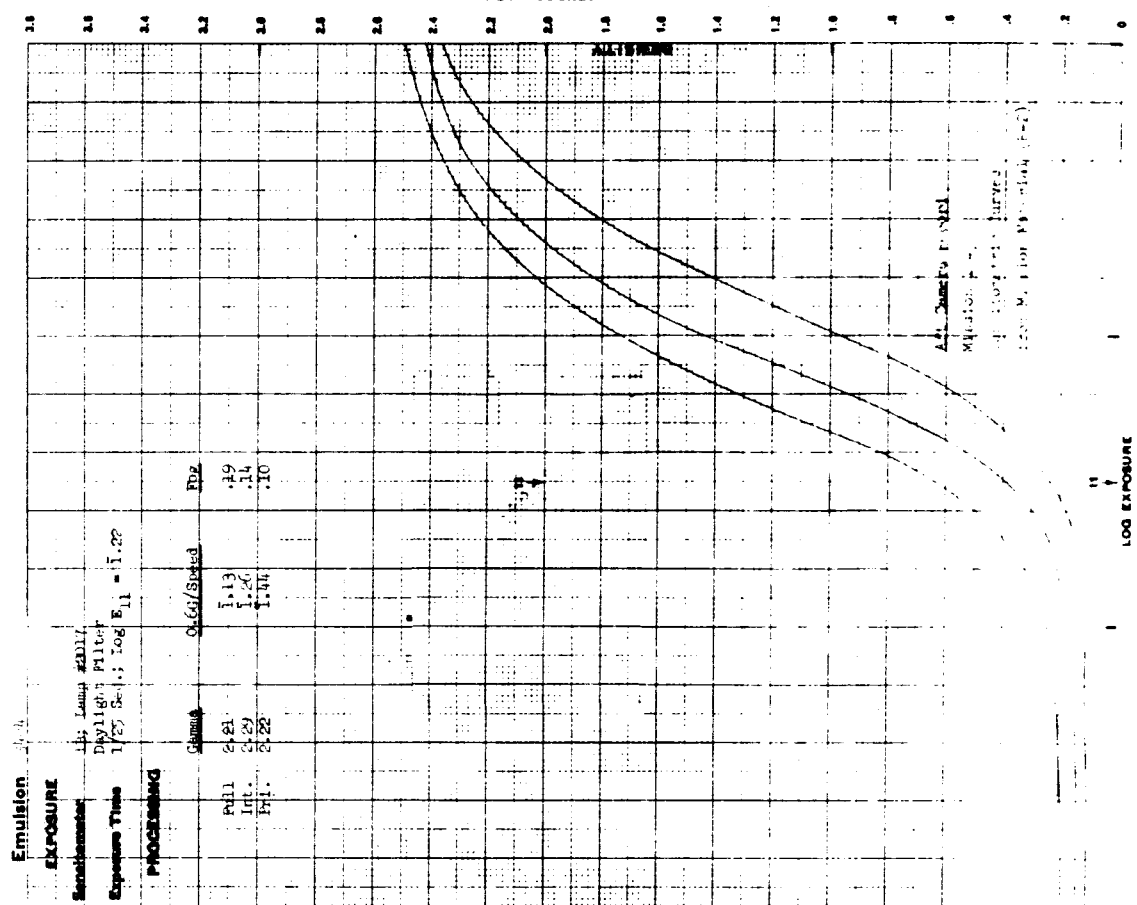
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Luminance Distribution. The "Minimum Luminance Distribution" is the percentage frequency distribution of the log minimum luminance obtained from the sampled frames taken at solar altitudes greater than 10 degrees. The "Maximum Luminance Distribution" is the percentage frequency distribution of the log maximum luminance obtained from the sampled frames taken at solar altitudes greater than 10 degrees.

B-Ratio. The "B-Ratio" is defined as the maximum luminance of a scene divided by the minimum luminance of the same scene. The graph presented is for the B-ratio data obtained for all sampled frames taken above 10 degrees solar altitude.

% of Frames Sampled. This figure represents the percentage of frames sampled in relation to the total number of frames photographed. All the frames sampled are free from cloud and water cover.

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CONCLUSIONS

1. The luminance values were somewhat lower than those of Mission 1042. This is the normally expected seasonal fluctuation as luminances are higher in June (Mission 1042) than they are in August (Mission 1043).

2. The overall exposure was less satisfactory than in any other recent mission, with the exception of Mission 1042, when judged by the 1.2 gradient criteria. The use of a wider slit to compensate for these lower brightnesses would have resulted in less underexposure. However, the slit widths for both the Forward and Aft cameras were narrower on Mission 1043 than they were on 1042. If the 0.4 density criteria used prior to Mission 1037 is applied, the amount of underexposure of this mission can be considered to be worse than seen in 1042. It should be pointed out that the use of a minimum density judgment method does not rule out the bias introduced by fog levels which exceed the criteria point; i.e., if a fog of 0.45 is encountered, the analysis would indicate that no frames were underexposed if the judgment point were 0.4, a conclusion which could be incorrect.

The following table compares the percentage of frames judged to be underexposed by the current 1.2 gradient method and the 0.4 density criteria used prior to Mission 1037.

<u>Mission</u>	<u>Judgment Criteria</u>	Percentage of Frames Considered Underexposed				<u>Overall</u>
		<u>-1 FWD</u>	<u>-1 AFT</u>	<u>-2 FWD</u>	<u>-2 AFT</u>	
1043	0.4	18.0	14.9	35.2	14.2	20.6
	0.47*	39.3	34.0	52.6	36.2	40.6
1042	0.4	2.2	8.6	2.5	0.0	3.3
	0.56*	50.6	50.4	48.2	38.9	47.0

* 1.2 gradient.

3. Less than 1% of the frames considered to be out of tolerance was correctable by a processing change.

4. The film latitude was adequate for the majority of the frames sampled.



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DENSITY TOLERANCE ANALYSIS

Mission: 1043-1, -2

	%				TOTAL MISSION
	-1 FWD	-1 AFT	-2 FWD	-2 AFT	
I. SATISFACTORY EXPOSURE	<u>60.7</u>	<u>66.0</u>	<u>46.1</u>	<u>63.8</u>	<u>59.1</u>
A. Within Tolerance	55.0	64.6	44.3	60.6	56.1
B. Out of Tolerance					
1. Over-processed	0.5	0.0	0.5	0.0	0.2
2. Under-processed	5.2	1.4	1.3	3.2	2.8
II. UNSATISFACTORY EXPOSURE	<u>39.3</u>	<u>34.0</u>	<u>52.6</u>	<u>36.2</u>	<u>40.6</u>
A. Overexposure					
1. Best (Primary) Process	0.0	0.0	0.0	0.0	0.0
2. Over-processed	0.0	0.0	0.0	0.0	0.0
B. Underexposure					
1. Best (Full) Process	39.1	34.0	52.3	36.0	40.4
2. Under-processed	0.2	0.0	0.3	0.2	0.2
III. BEYOND SYSTEM CAPABILITY	<u>0.0</u>	<u>0.0</u>	<u>1.3</u>	<u>0.0</u>	<u>0.3</u>
A. Beyond System Latitude	0.0	0.0	1.3	0.0	0.0
B. Out of Phase	0.0	0.0	0.0	0.0	0.0

DENSITY TOLERANCE LIMITS

CRITERIA USED FOR ANALYSIS: 1.2 GRADIENT

<u>W-23A FILTER (FWD SYSTEM)</u>			<u>W-21 FILTER (AFT SYSTEM)</u>	
<u>PROCESS</u>	<u>LOWER DENSITY</u>	<u>UPPER DENSITY</u>	<u>LOWER DENSITY</u>	<u>UPPER DENSITY</u>
PRI.	0.39	2.08	0.38	2.05
INT.	0.41	2.09	0.41	2.05
FULL	0.47	2.10	0.46	2.08

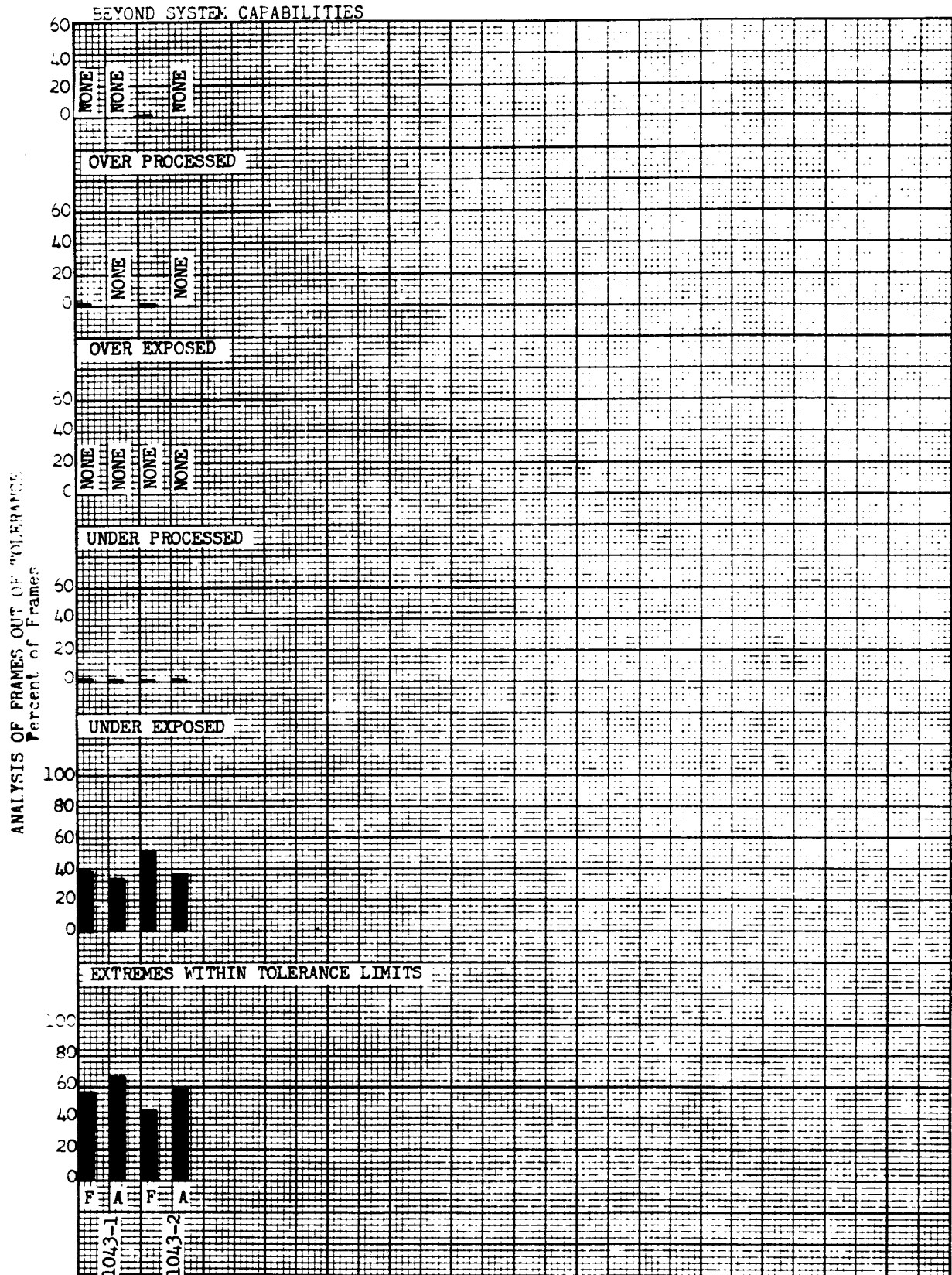


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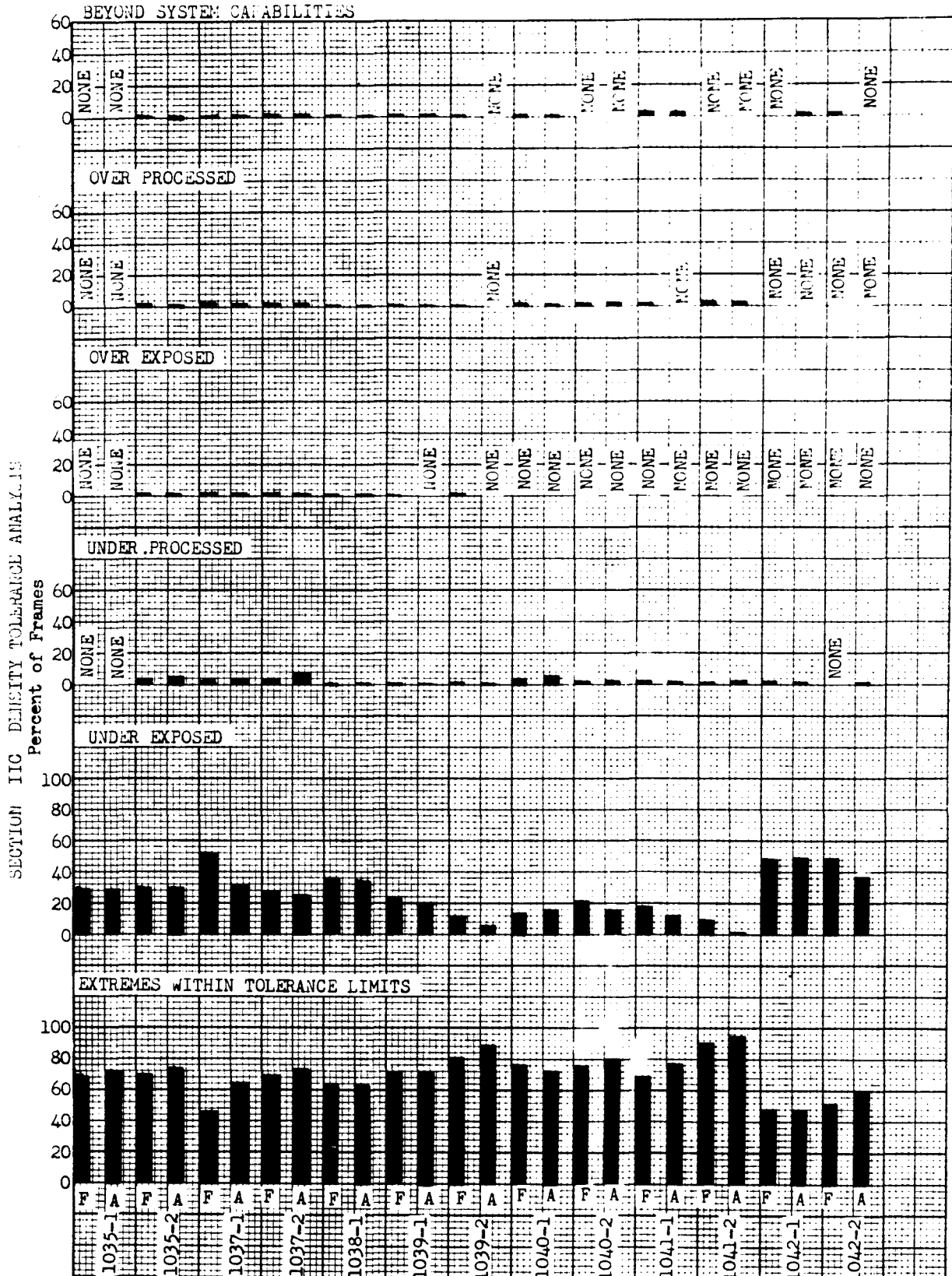
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DENSITY TOLERANCE LIMITS BASED ON 1.2 GRADIENT



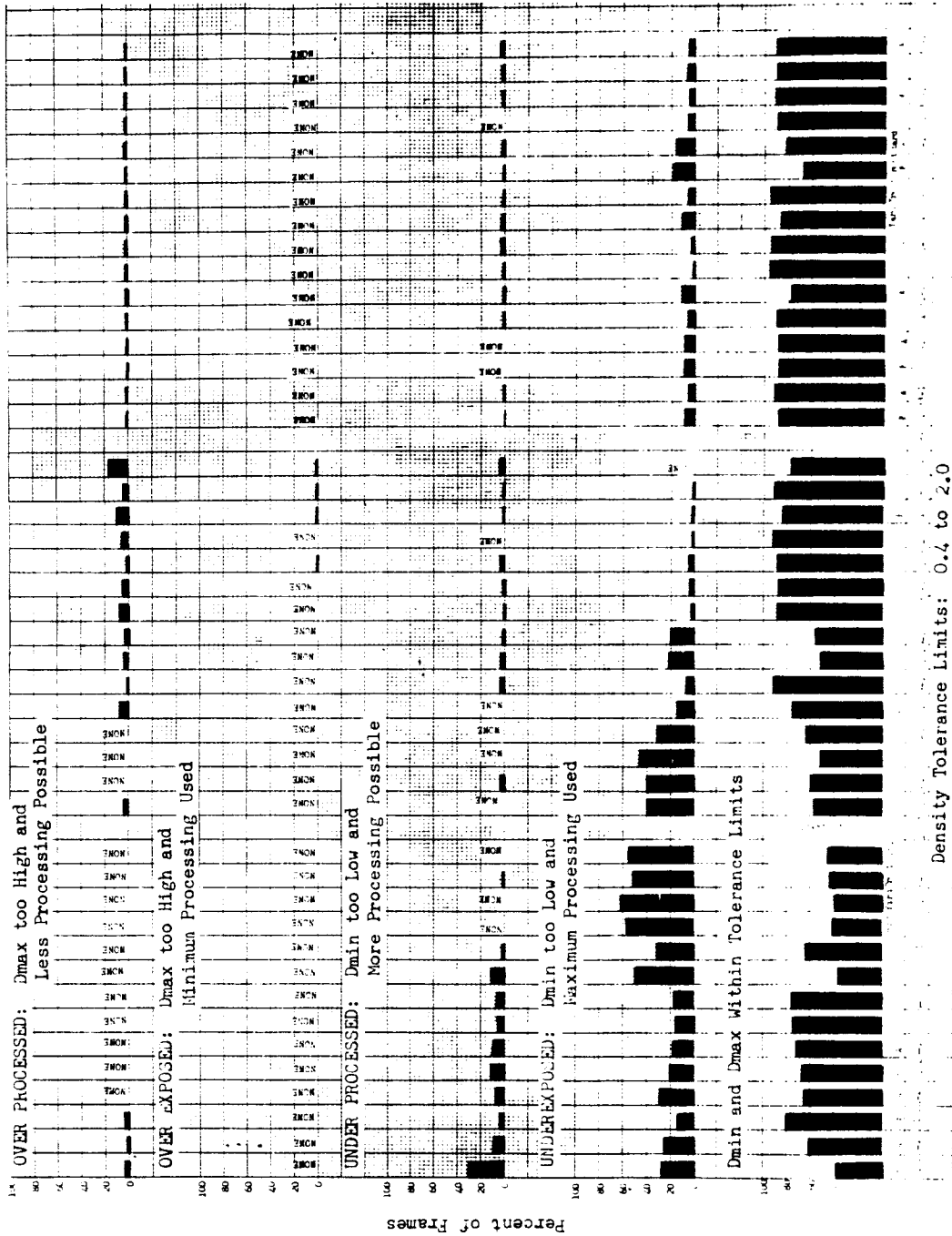
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DENSITY TOLERANCE LIMITS BASED ON IIC CONTRAST



[REDACTED]

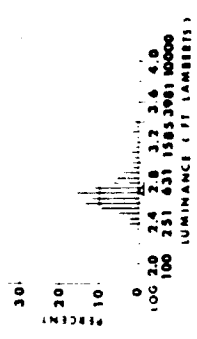
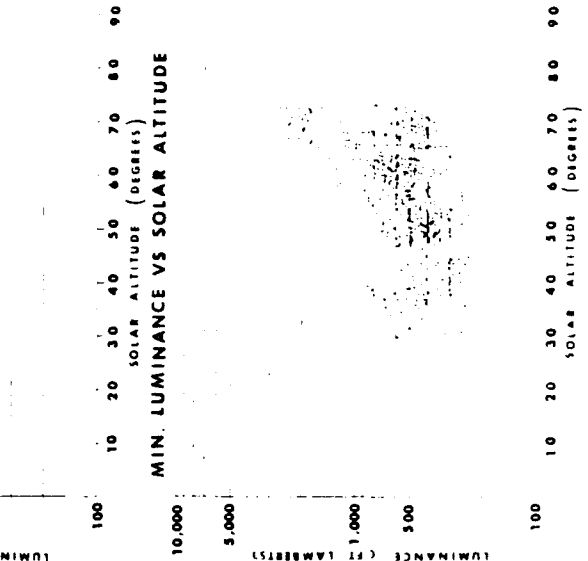
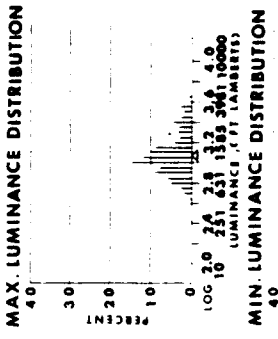
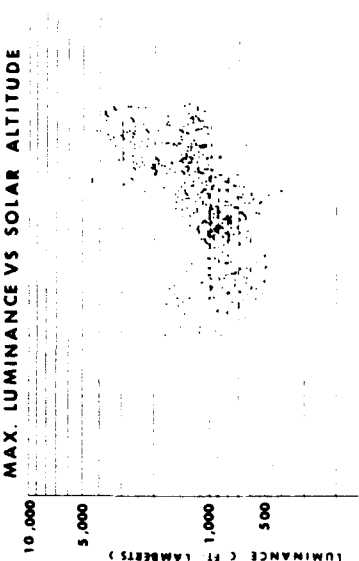
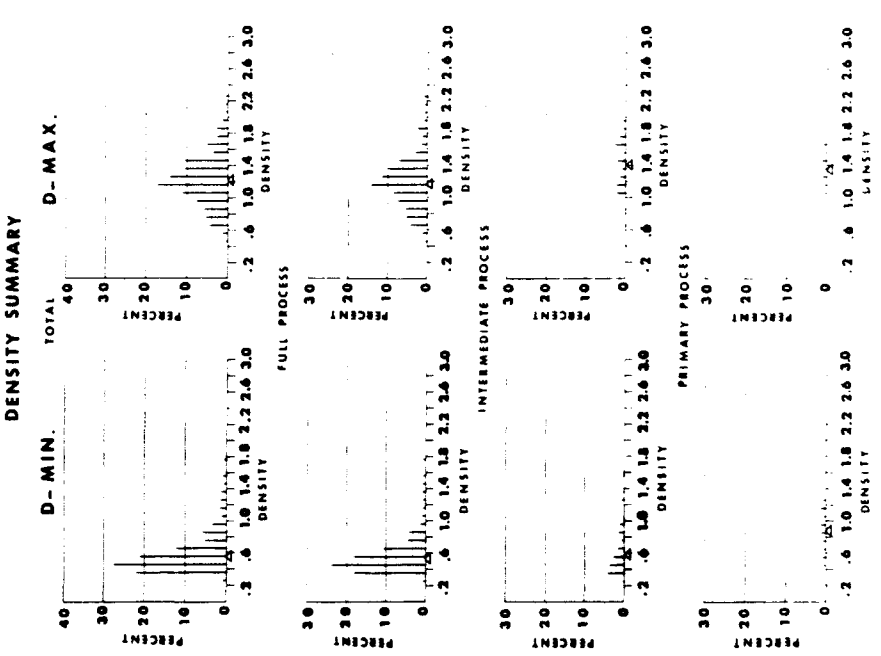
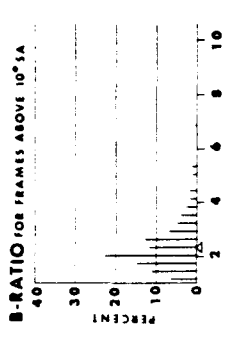
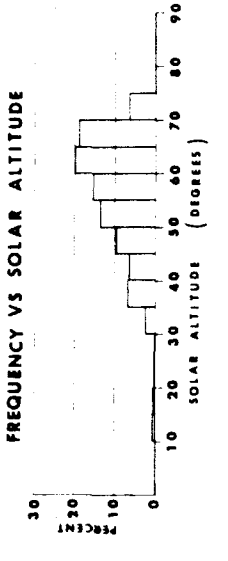
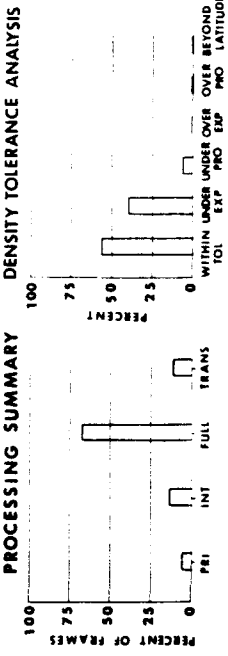
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Analysis of Frames Out of Tolerance Using Two Criteria (1000-Series Missions)

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DENSITY / LUMINANCE

Launch Date: _____

Filter No: _____

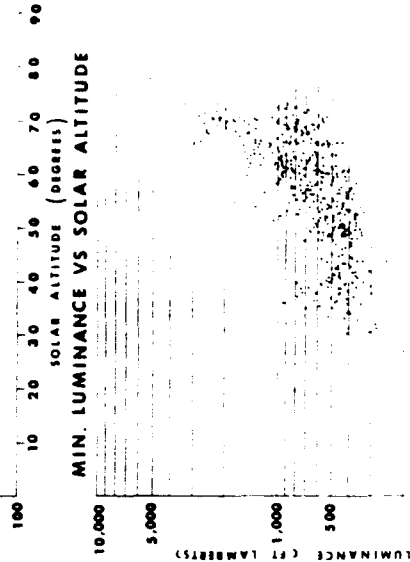
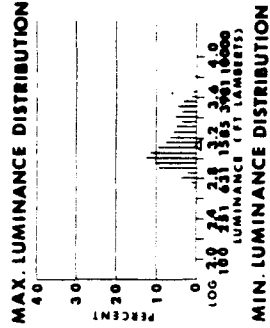
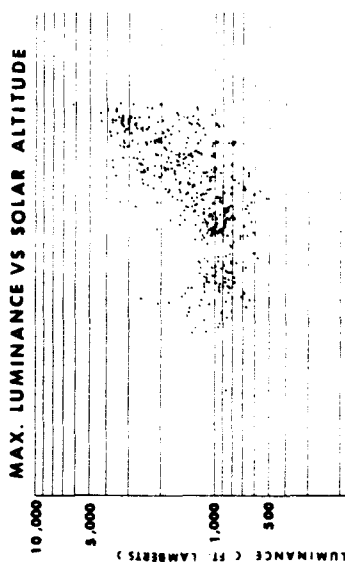
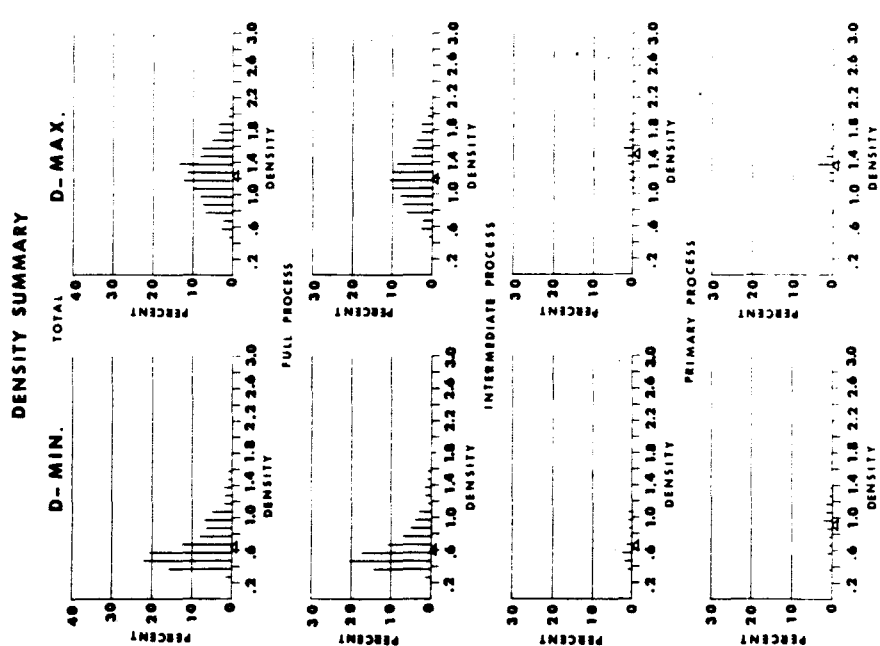
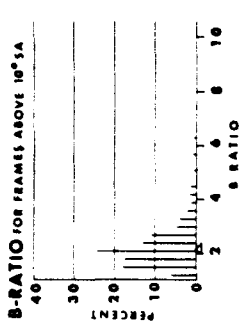
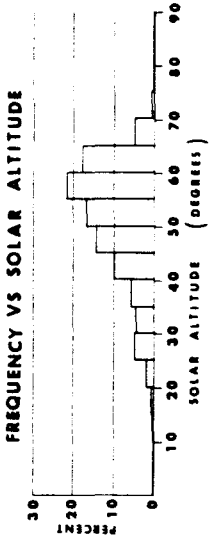
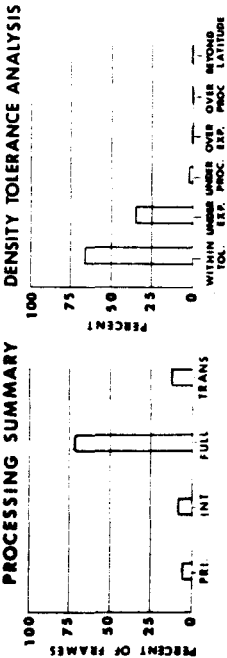
No Obs: _____

Slit Width: _____

% of frames Sampled: _____

Processor: _____

Δ=MEAN 1043



DENSITY / LUMINANCE

Launch Date

Filter No.

No. Ob.

Slit Width

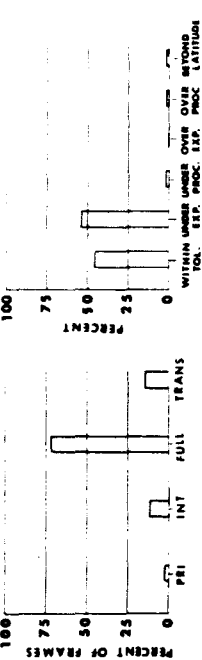
% of Frames Sampled

Processor

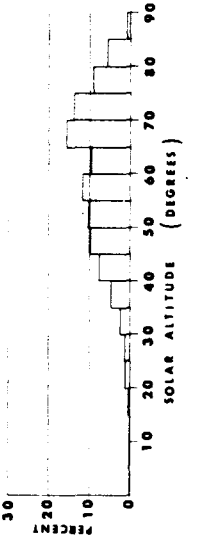
A=MEAN 1043

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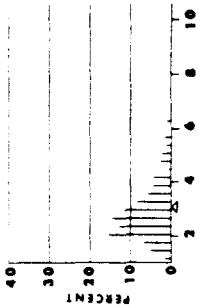
PROCESSING SUMMARY



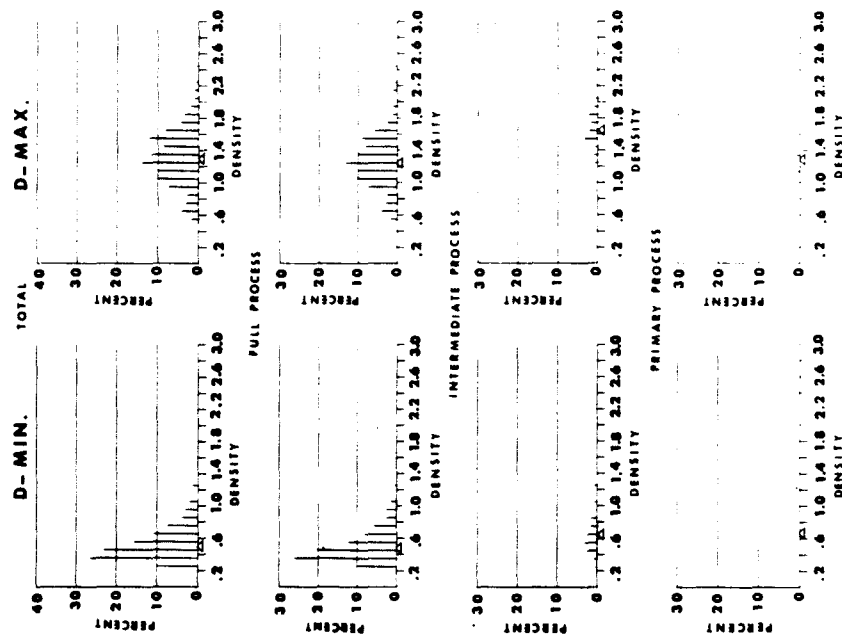
DENSITY TOLERANCE ANALYSIS



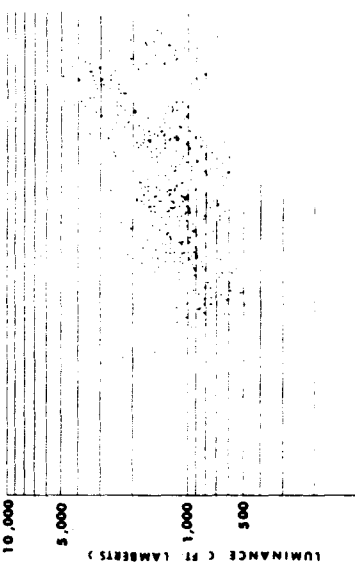
B-RATIO FOR FRAMES ABOVE 10° SA



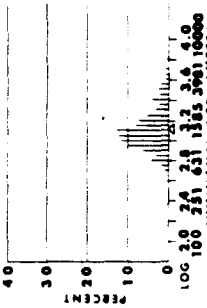
DENSITY SUMMARY



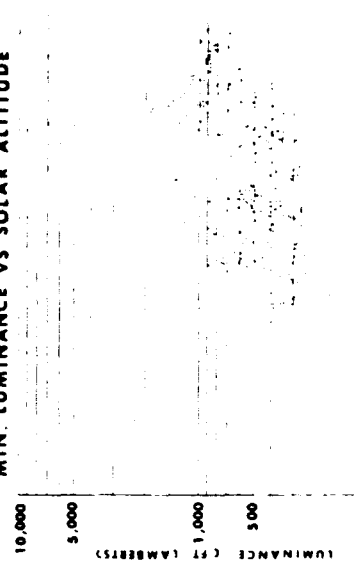
MAX. LUMINANCE VS SOLAR ALTITUDE



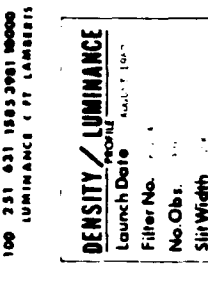
MAX. LUMINANCE DISTRIBUTION



MIN. LUMINANCE VS SOLAR ALTITUDE



MIN. LUMINANCE DISTRIBUTION



DENSITY / LUMINANCE

Launch Date: _____

Filter No.: _____

No. Obs.: _____

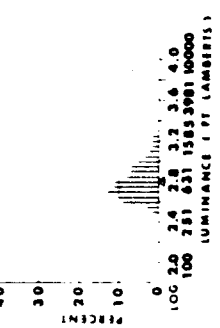
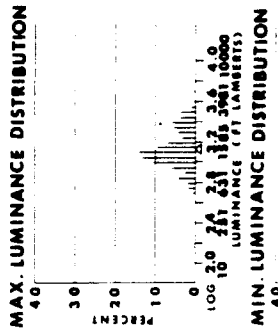
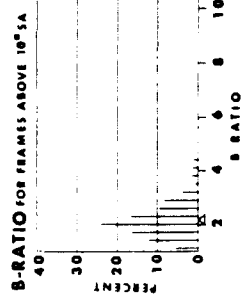
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% of Frames Sampled: _____

Processor: _____

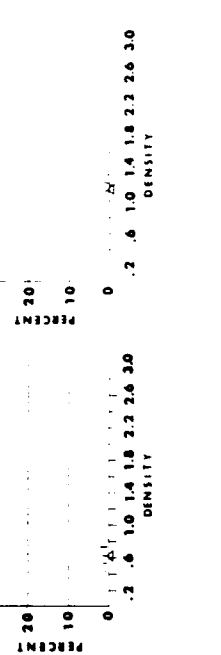
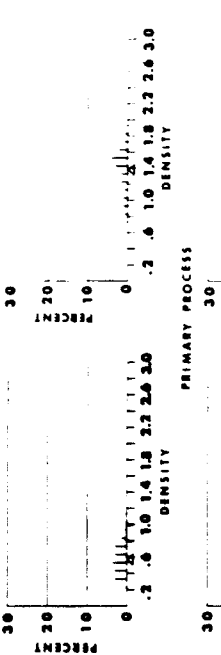
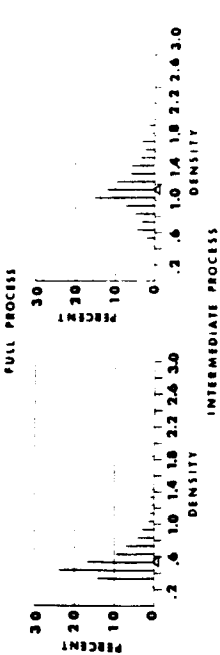
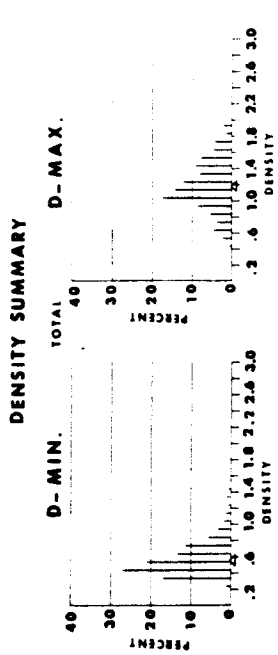
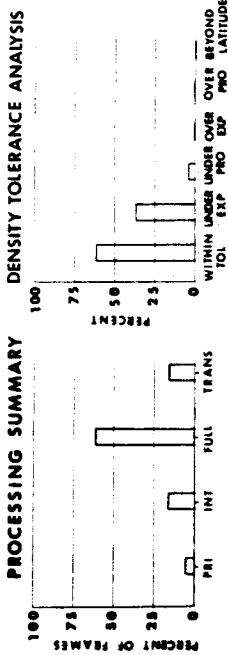
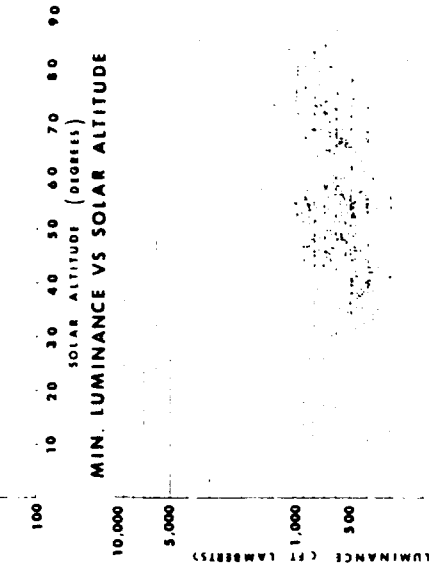
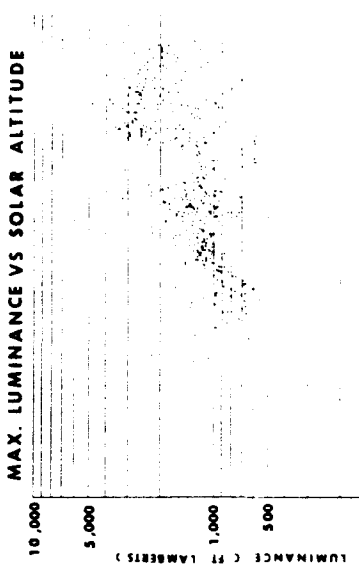
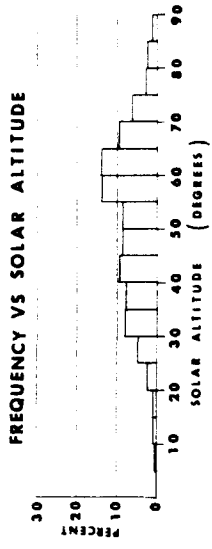
A-MEAN **1043** _{1/10}

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DENSITY / LUMINANCE PROFILE

Launch Date	
Filter No.	
No Obs.	
Slit Width	
% of frames Sampled	
Processor	
A-MEAN	1043.7



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INDEX SUMMARY

MISSION 1043

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PORTION

UNAVAILABLE

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ADDENDUM

Image Quality Data for Preflight Film
of Mission 1043-1

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PROCEDURE

Film from the preflight portion of Mission 1043-1 was removed from the master camera spool for special testing on image quality. Sensitometrically exposed samples were also included for calibration purposes. Exposed samples included:

1. Resolving power.) Microscope Resolution
2. Target edges.) Camera.
3. Sensitometric strips.) I-B sensitometer.
4. RMS granularity strips.)

The data for exposed samples of resolving power and edges is included in Figure 1.

All film samples were exposed to:

1. Daylight.
2. Daylight + W21.
3. Daylight + W23A.

Film samples are classified as:

1. "Control Stock" which is the current process control emulsion Film Type 3404-277.
2. "Payload Control" which is the refrigerated sample of the same emulsion batch included in the vehicle payload and is 3404-284.
3. "Preflight Sample" (3404-284) which was removed from the recovery capsule prior to processing.

RESOLVING POWER

In exposing sensitometric strips, the log E at the 11th step is given in terms of daylight exposure and is shown as $1.22 \log E$ (Figures 2-4). When Wratten filters are placed in the light source, the log E value in terms of the graph paper is not changed, and so the plotted curve falls to the right of the normal daylight exposure curve. This method of plotting indicates how much exposure change there is for a given filter/film combination. In film Type 3404, the following shift in log exposure occurred:

- (1) Daylight + W21 $-.29 \log E$.
- (2) Daylight + W23A $-.37 \log E$.

Figure 1

FILM EVALUATION AND TESTING FACILITY
RESOLVING POWER TEST CONDITIONS

LOG NUMBER 253

DATE 15 Aug 67

A. EXPOSURE

- 1. Camera MRT "A" MRT "B" MRT "C"
- 2. Reduction -189X Lenses Zeiss (1)
- 3. Exposure Series 0.10 Increments by intensity; 1.0 Log E range.
- 4. Lamp Color Temp 6100°K c W78A Filters footnote (2)
- 5. Exposure Time 1/50 Sec. Type of Film 3404
- 6. T.O.C. 1.1,1.2,1.6,2.0,2.8,5.1 + 4:1 Polarity of Target Neg.
edge.
- 7. Target Type ASA 20 10 Frequency Range 0.1 to 7.94
- 8. Number of Strips 3 replicate exposures each TOC

B. PROCESS

- 1. Machine Trenton.
- 2. Time _____
- 3. Temp. _____
- 4. Agitation _____
- 5. Developer _____
- 6. Specification Number 603 Full Level.

C. EVALUATION

- 1. D-logE curve supplied Yes No Number of Readers (N) 3.
- 2. Microdensity Analysis on edges only.

(1) Zeiss Planapochromat objective 0.65NA, 25X; Komplan Ocular, 8X.

(2) Daylight - 0.80 N.D.
Daylight + W21 + 0.50 N.D.
Daylight + W23A + 0.40 N.D.

Emulsion 3404-277 (Control Stock)

Figure 2

EXPOSURE 1. Day 2. Day + W21 3. Day + W23A

Sensitometer I-B

Exposure Time 1/25 Sec. $\log E_{11} \bar{1}.22$

PROCESSING Trenton Full Level

	<u>Fog</u>	<u>Gamma</u>	<u>Speed</u>
1.	0.20	2.20	$\bar{1}.16$
2.	0.20	2.10	$\bar{1}.40$
3.	0.20	2.10	$\bar{1}.50$

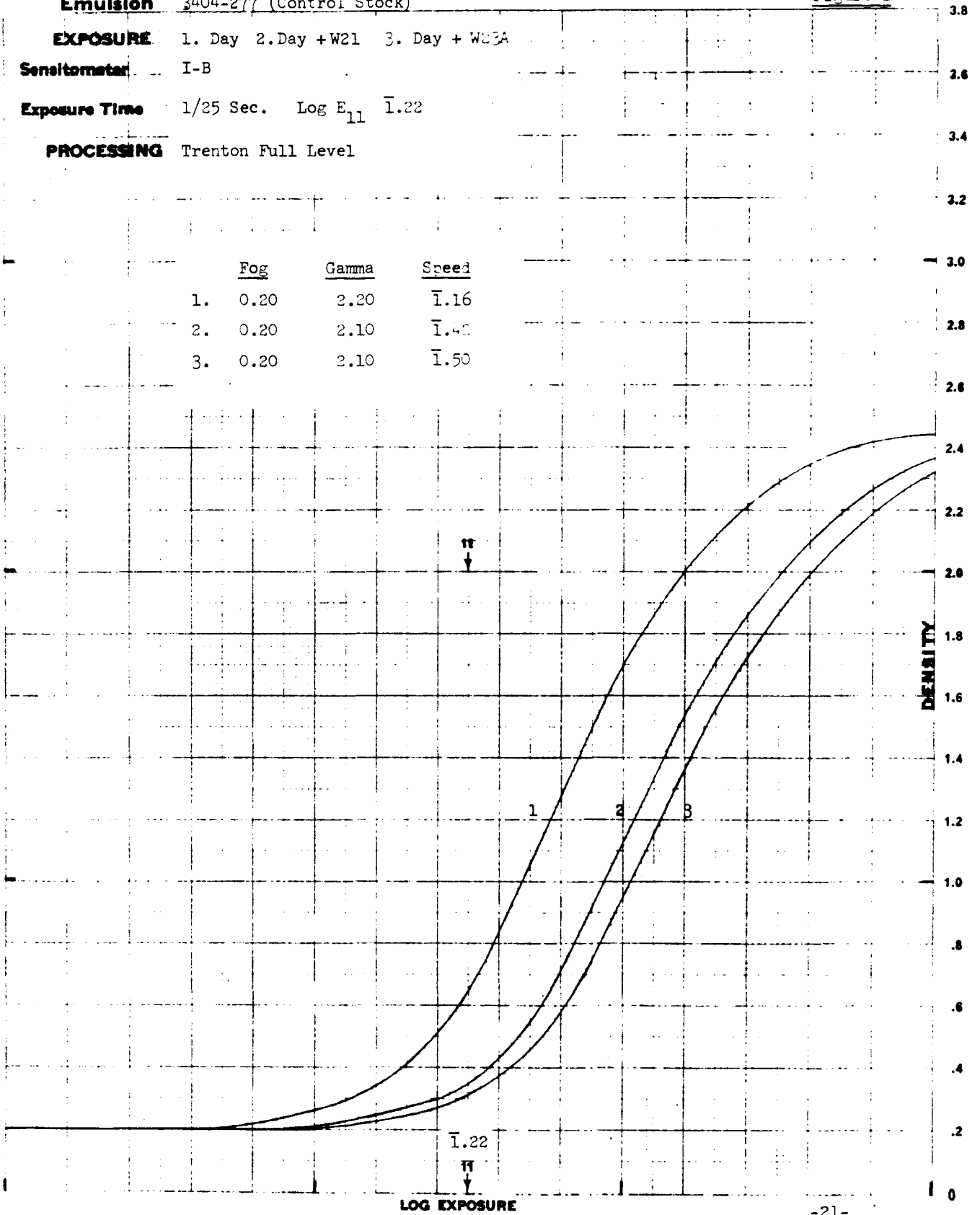


Figure 3

Emulsion 3404-284 (Payload Control)

EXPOSURE 1. Day 2. Day+W21 3. Day+W23A

Sensitometer I-B

Exposure Time 1/25 Sec. $\log E_{11}$ 1.22

PROCESSING Trenton Full Level

	<u>Fog</u>	<u>Gamma</u>	<u>Speed</u>
1.	0.20	2.26	1.17
2.	0.20	2.10	1.42
3.	0.20	2.08	1.48

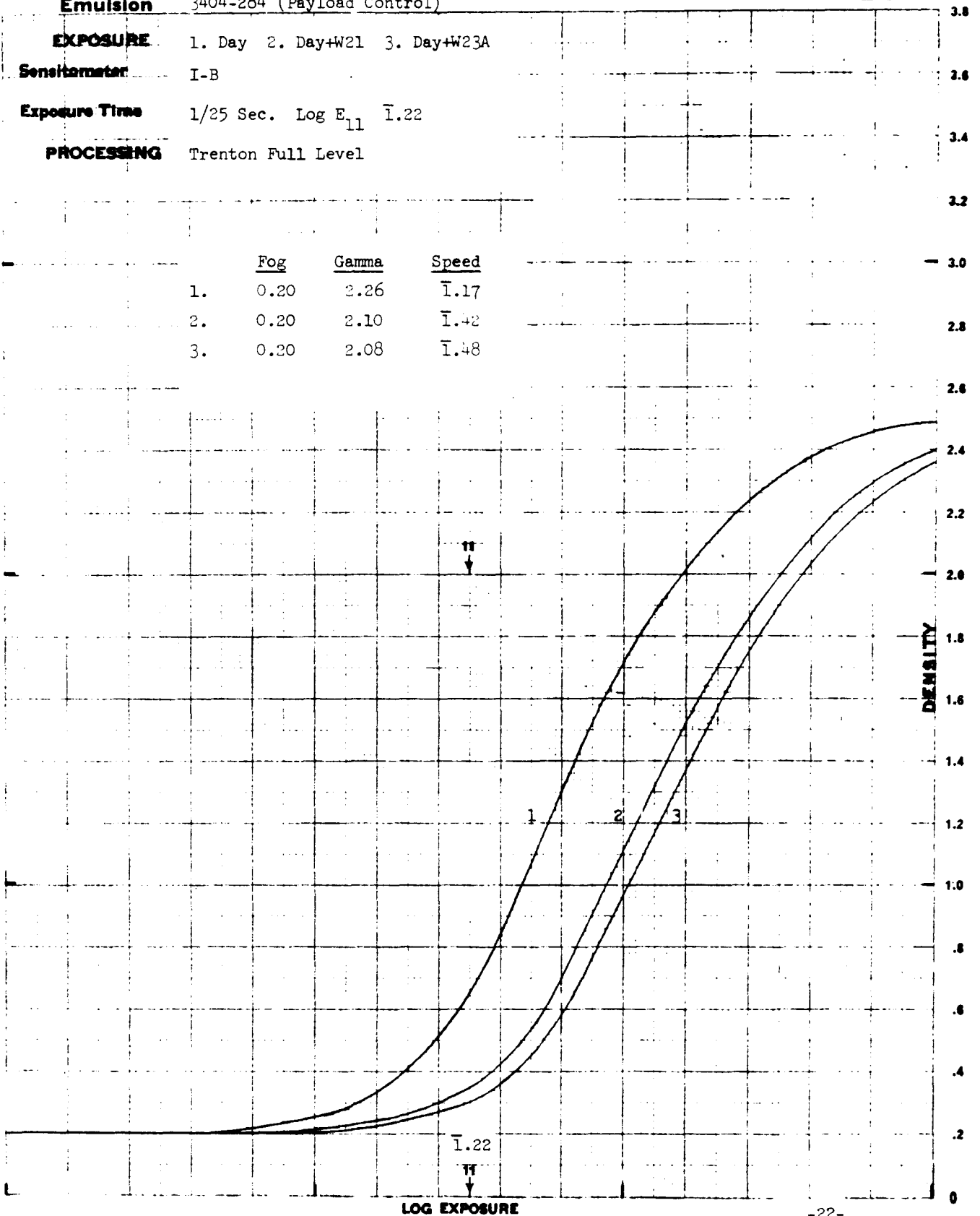


Figure 4

Emulsion 3404-284 (Preflight Sample)

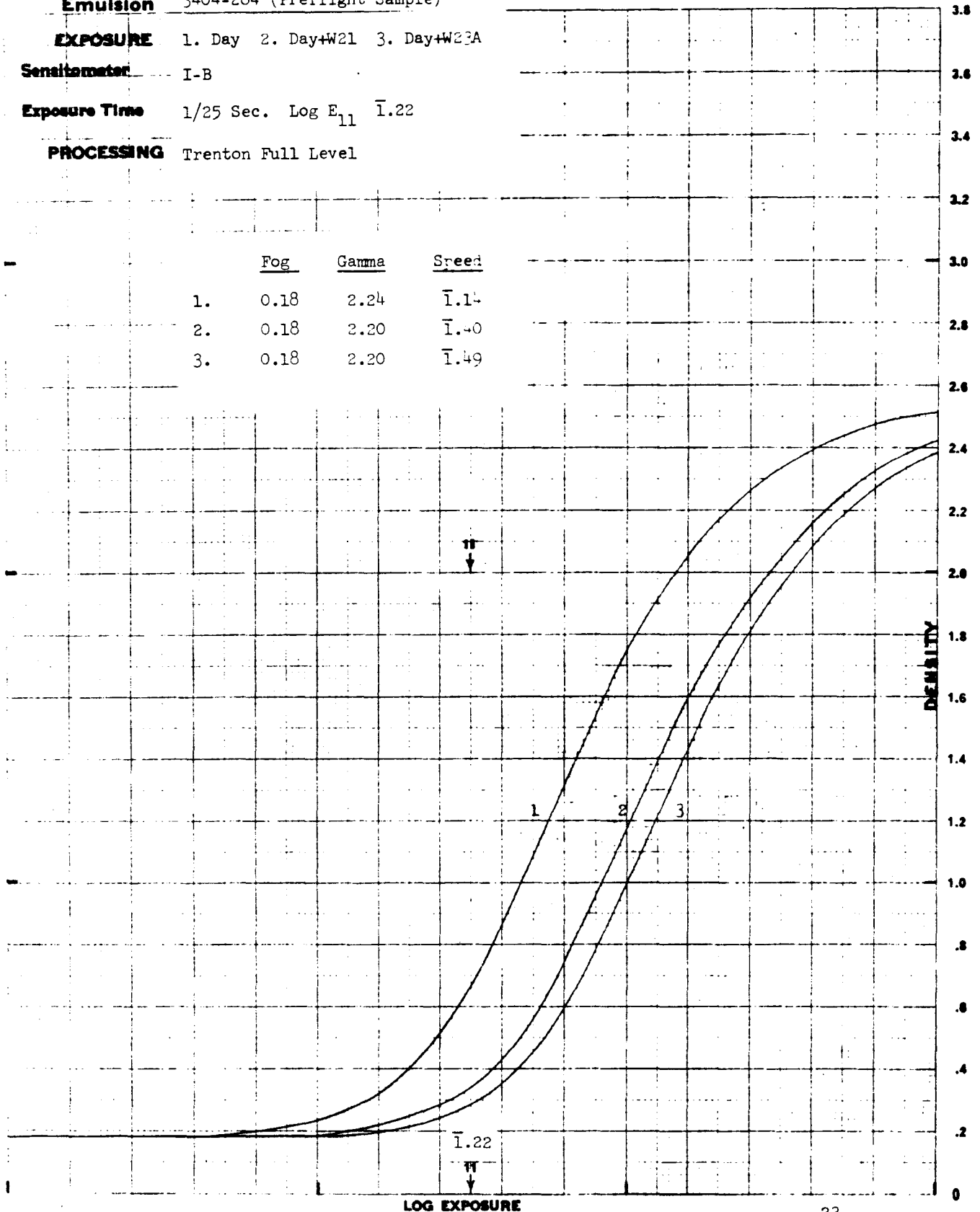
EXPOSURE 1. Day 2. Day+W21 3. Day+W23A

Sensitometer I-B

Exposure Time 1/25 Sec. $\log E_{11}$ $\bar{1}.22$

PROCESSING Trenton Full Level

	<u>Fog</u>	<u>Gamma</u>	<u>Speed</u>
1.	0.18	2.24	$\bar{1}.14$
2.	0.18	2.20	$\bar{1}.40$
3.	0.18	2.20	$\bar{1}.49$



In effect the film log E at the 11th step is:

- (1) Daylight $\bar{1}.22$.
- (2) Daylight + W21 $\bar{2}.93$ ($\bar{1}.22 - .29$).
- (3) Daylight + W23A $\bar{2}.85$ ($\bar{1}.22 - .37$).

In order to have a good resolving power exposure series, different N.D. filters were used to compensate for the exposure difference caused by the Wratten filters. This was accomplished in the following manner:

- 1. Log exposure range for resolving power = 1.0 (11 exposures at .10 increments).
- 2. Log exposure of Bar component of test object with .80 N.D. at lowest exposure = $\bar{1}.04$ \therefore exposure range = $\bar{1}.04 - 0.04$ log E.
- 3. Compensating for the filter factors, the film equivalent log exposure is as follows:
 - a) .80 N.D. (Daylight) $\bar{1}.04$ to 0.04 log E.
 - b) .50 N.D. + .29 (W21) $\bar{1}.05$ to 0.04 log E.
 - c) .40 N.D. + .37 (W23A) $\bar{1}.07$ to 0.07 log E.

This procedure resulted in resolution curves all being referenced to the daylight exposed curve, and allows for direct comparison of resolving power curves. If it is desired to match the resolving power curves to the correct filter exposed D-log E curves, then it will be necessary to:

- 1. Shift resolution curves to the right by .29 log E for W21 filter.
- 2. Shift resolution curves to the right by .37 log E for W23A filter.

The same conditions of exposure were applied to the edges exposed through the microscope resolution camera.

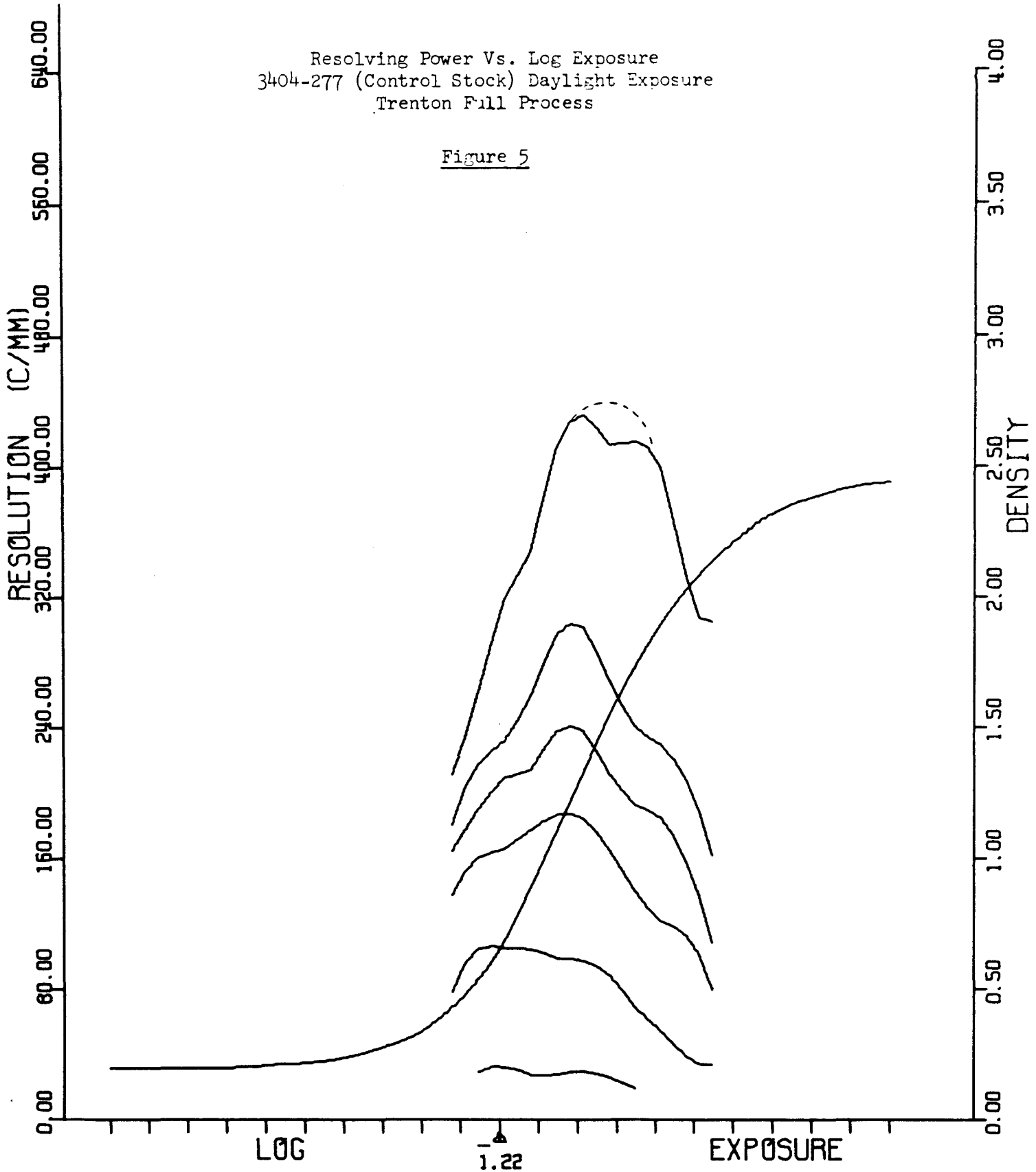
Figures 5-13 show Resolving Power vs. Log E for each emulsion batch and filter combination. The resolving power curves are graphed in terms of exposure of the bar component of the test object. The dotted portion of the resolution curve represents the computer fitted curve which resulted from averaging all resolution values. Table 1 shows the mean target log exposure value for peak resolving power values. Mean target log exposure (\bar{M}) is defined as:



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Resolving Power Vs. Log Exposure
3404-277 (Control Stock) Daylight Exposure
Trenton Film Process

Figure 5



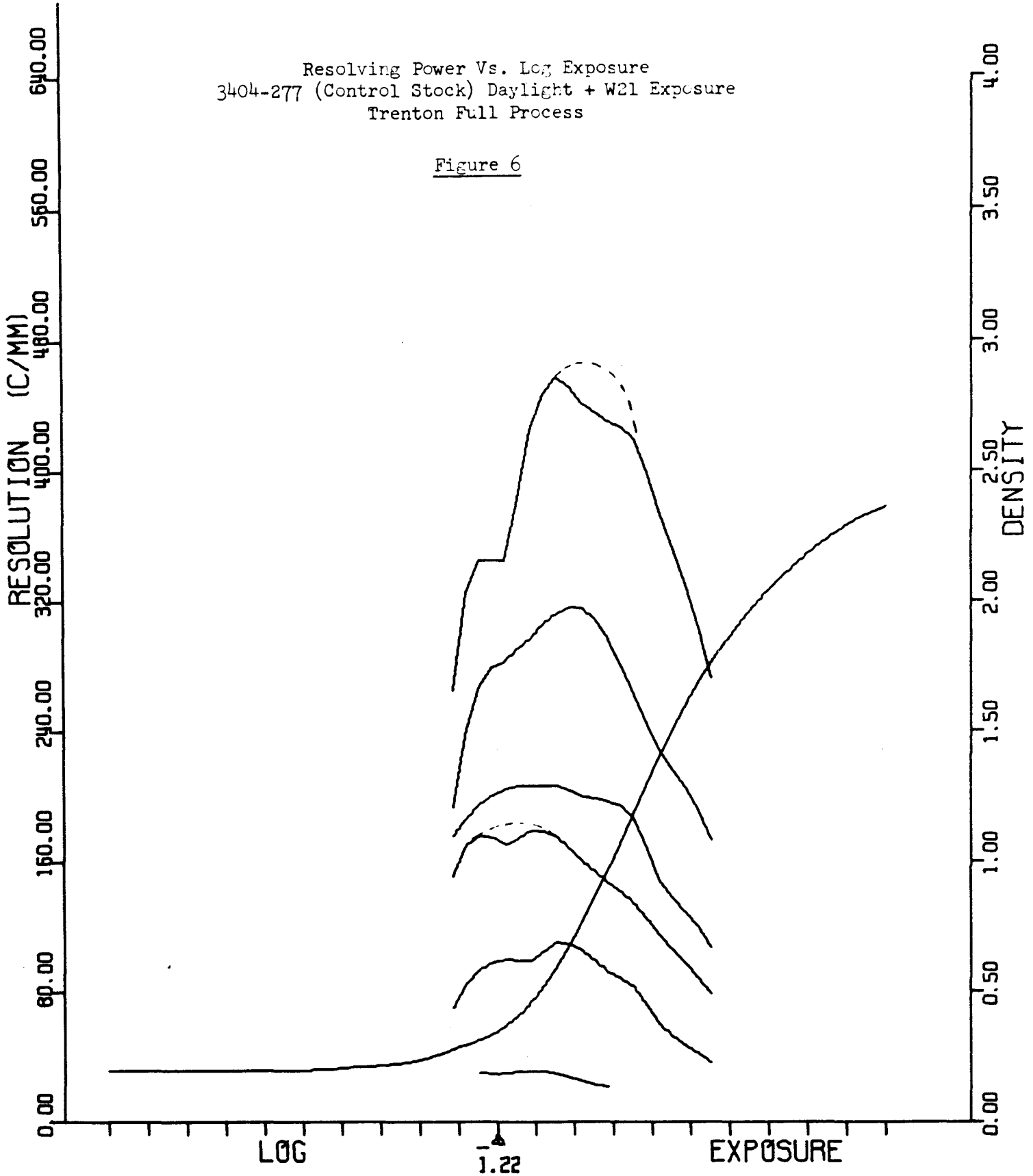
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Resolving Power Vs. Log Exposure
3404-277 (Control Stock) Daylight + W21 Exposure
Trenton Full Process

Figure 6



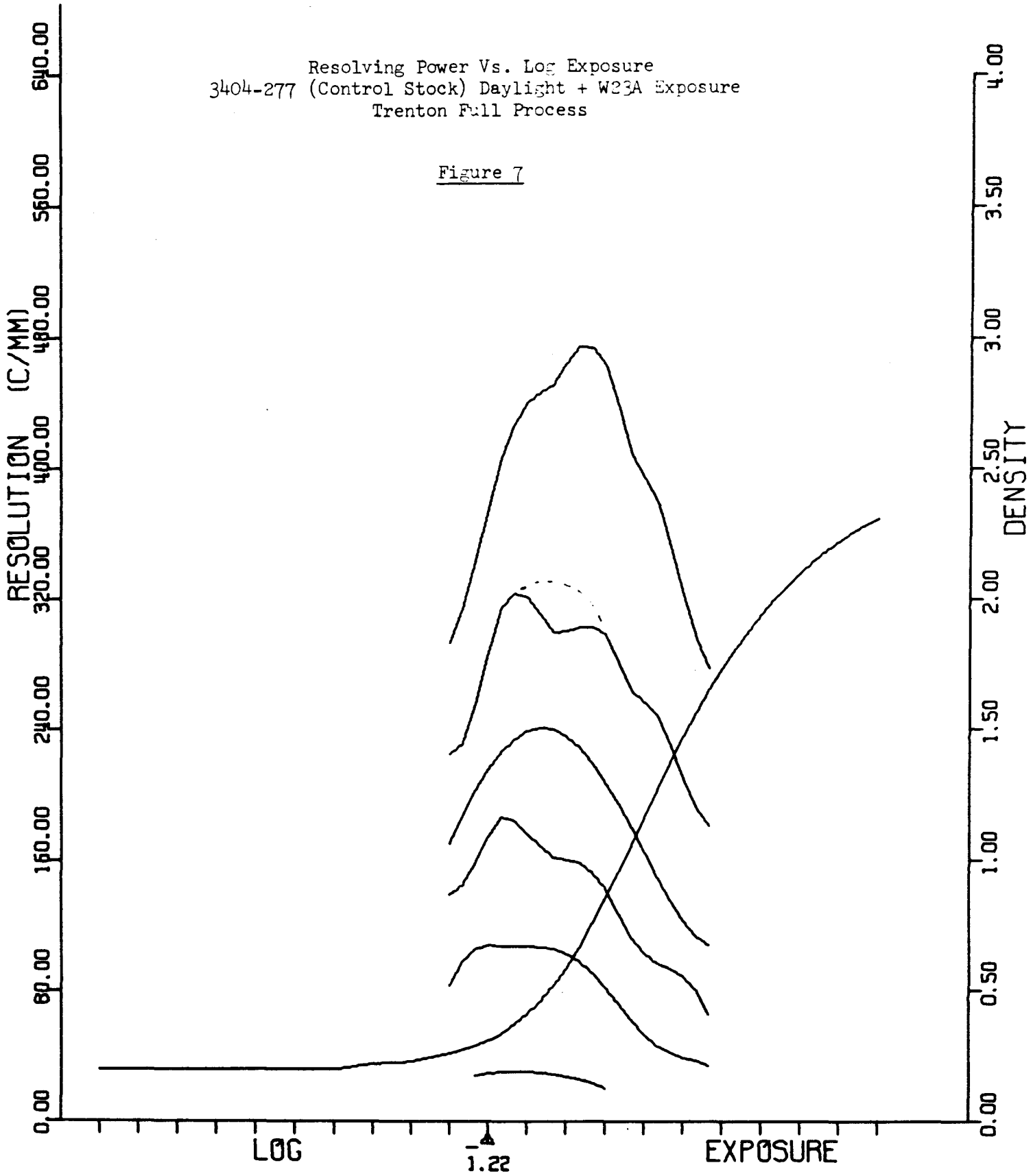
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Resolving Power Vs. Log Exposure
3404-277 (Control Stock) Daylight + W23A Exposure
Trenton Full Process

Figure 7



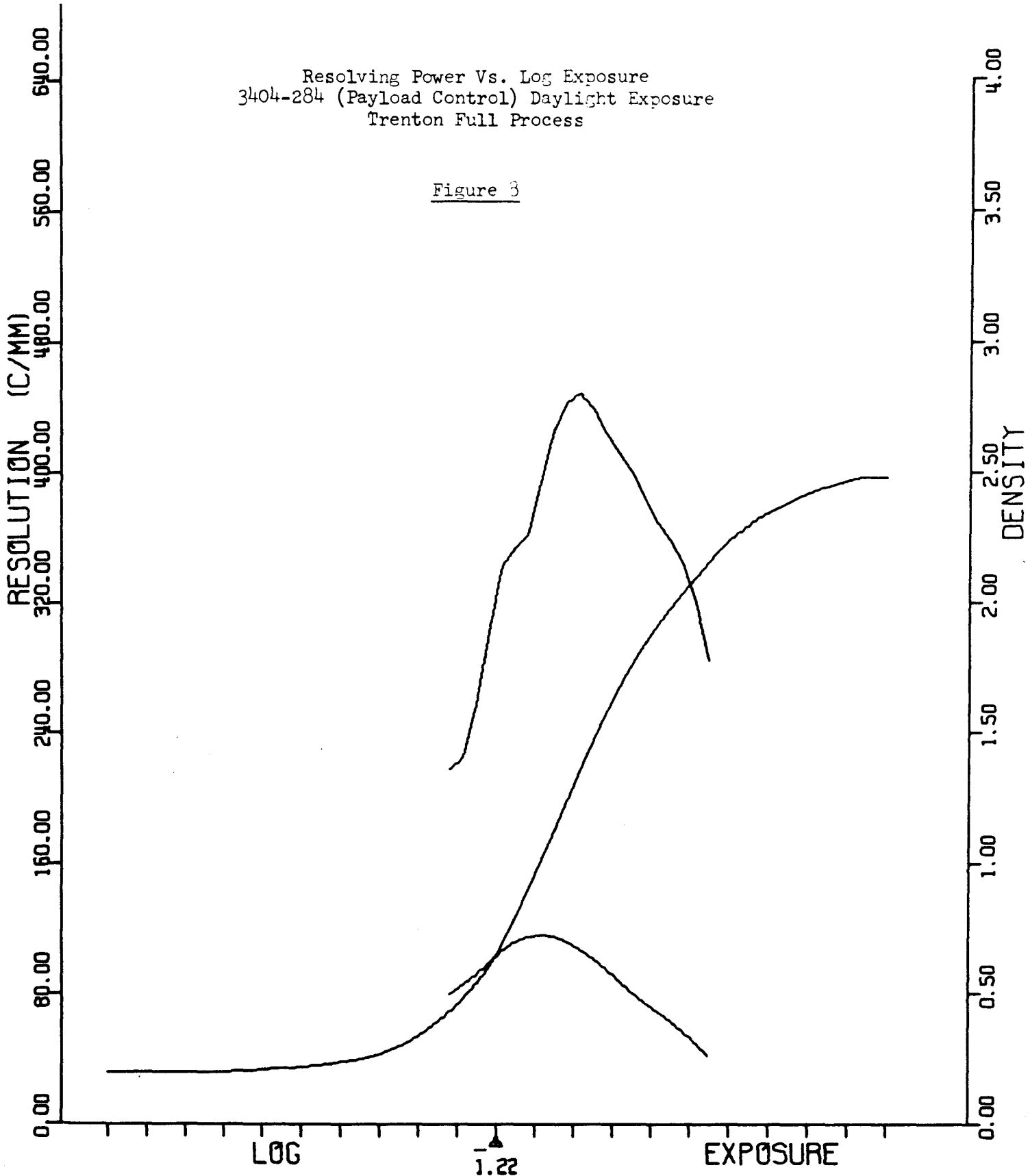
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Resolving Power Vs. Log Exposure
3404-284 (Payload Control) Daylight Exposure
Trenton Full Process

Figure 3



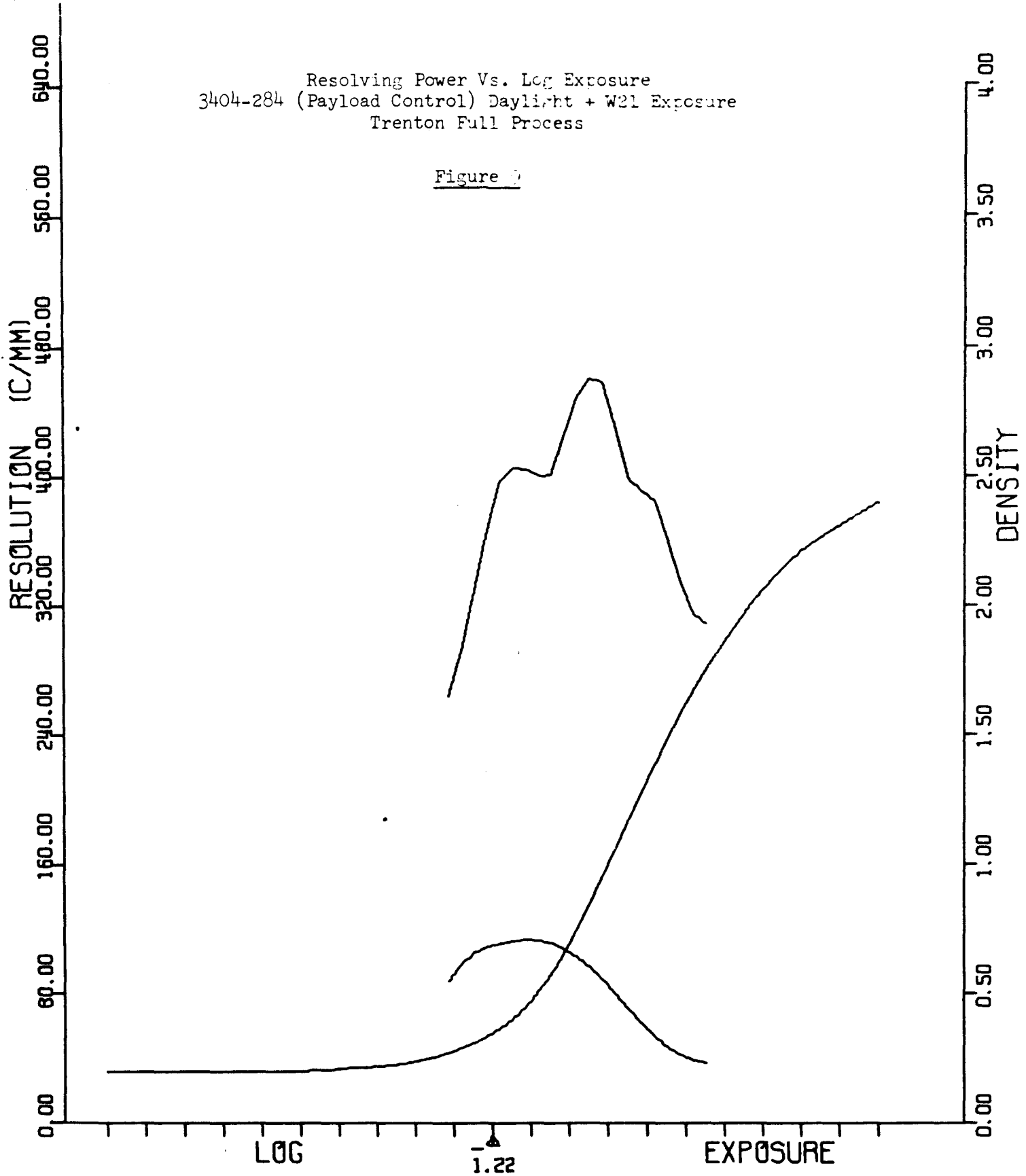
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[REDACTED]

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Resolving Power Vs. Log Exposure
3404-284 (Payload Control) Daylight + W21 Exposure
Trenton Full Process

Figure 2



[REDACTED]

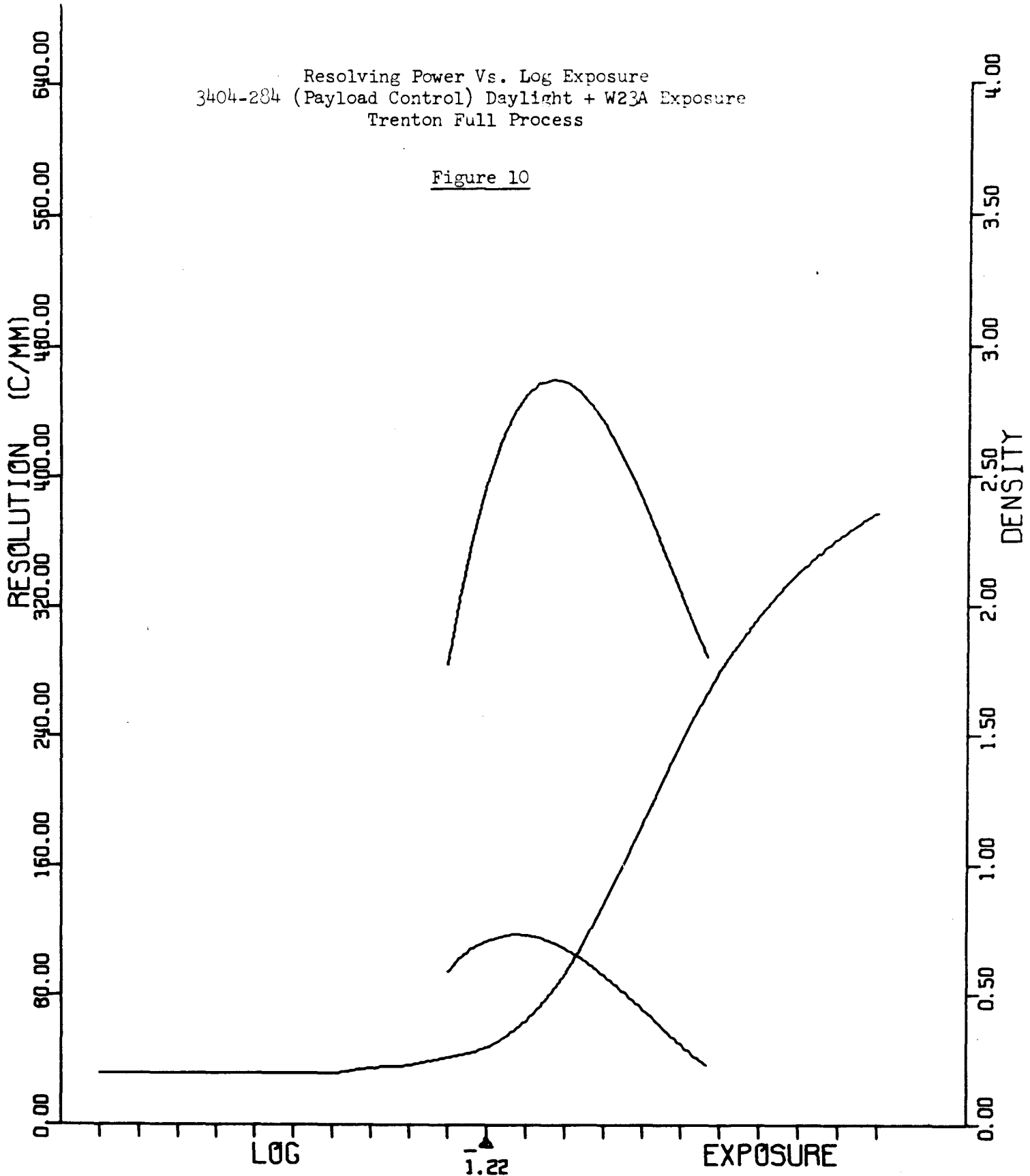
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Resolving Power Vs. Log Exposure
3404-284 (Payload Control) Daylight + W23A Exposure
Trenton Full Process

Figure 10



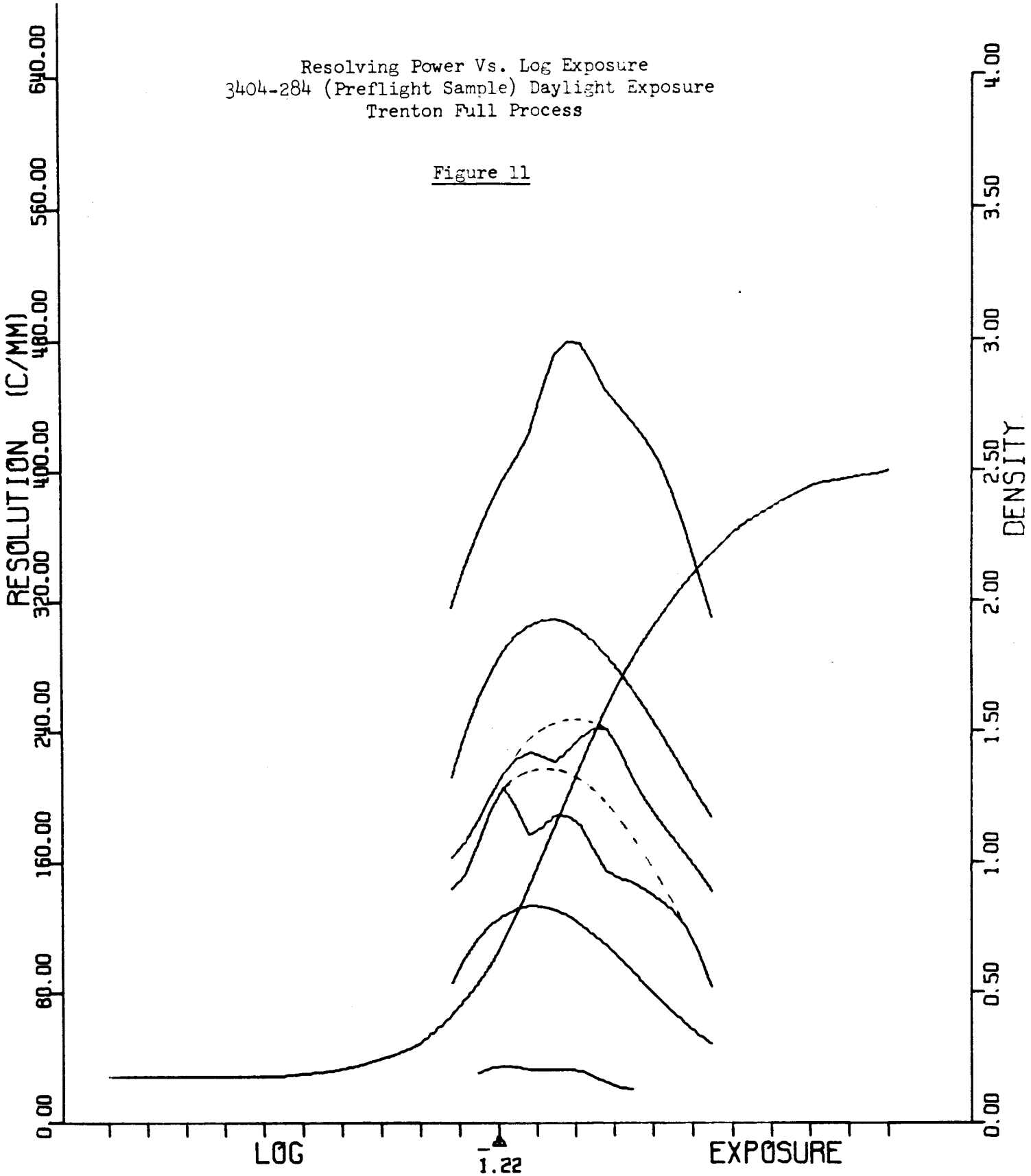
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[REDACTED]

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Resolving Power Vs. Log Exposure
3404-284 (Preflight Sample) Daylight Exposure
Trenton Full Process

Figure 11



[REDACTED]

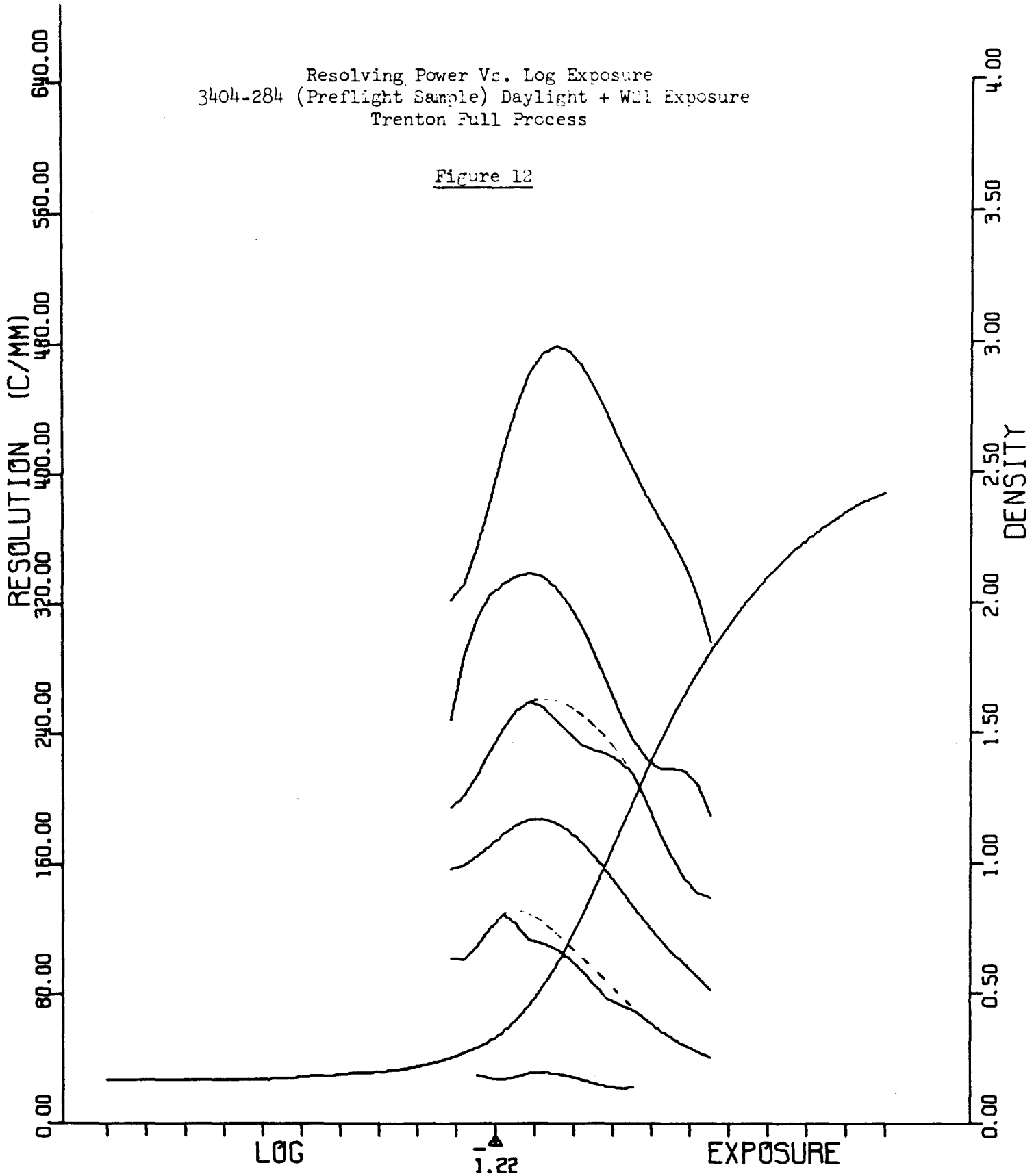
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Resolving Power Vs. Log Exposure
3404-284 (Preflight Sample) Daylight + W21 Exposure
Trenton Full Process

Figure 12



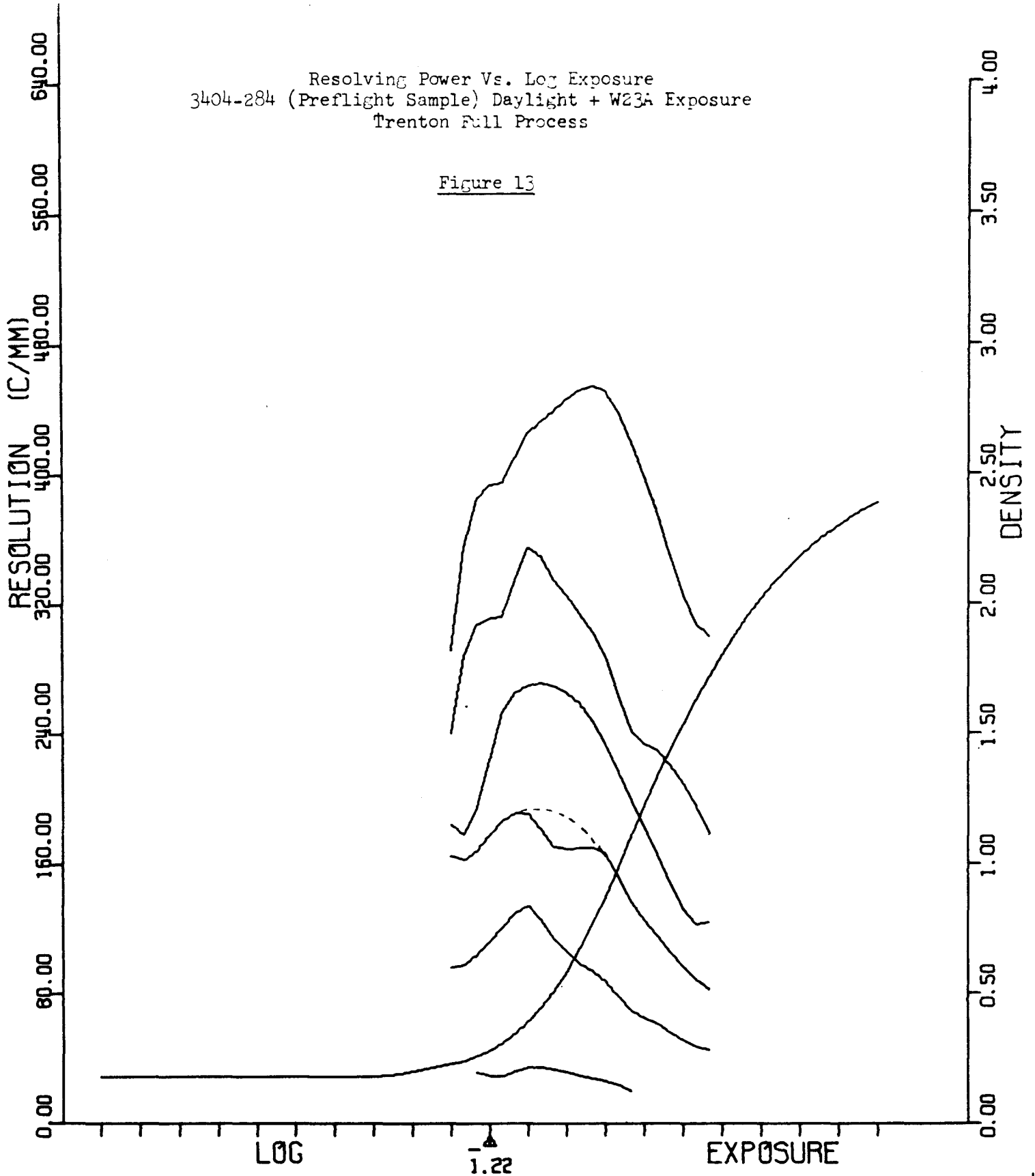
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Resolving Power Vs. Log Exposure
3404-284 (Preflight Sample) Daylight + W23A Exposure
Trenton Full Process

Figure 13



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Table 1

MEAN TARGET LOG EXPOSURE
CALIBRATED TO EQUIVALENT DAYLIGHT EXPOSURE
AT PEAK RESOLVING POWER

TOC	Daylight		Daylight + W21		Daylight + W23A		
	Resolving Power	Mean Log E	Resolving Power	Mean Log E	Resolving Power	Mean Log E	
3404-277 (Control)	1.08:1	34	$\bar{1}.16$	32	$\bar{1}.32$	31	$\bar{1}.32$
	1.28:1	108	$\bar{1}.15$	111	$\bar{1}.41$	108	$\bar{1}.20$
	1.70:1	189	$\bar{1}.34$	182	$\bar{1}.25$	187	$\bar{1}.26$
	1.95:1	243	$\bar{1}.34$	208	$\bar{1}.24$	241	$\bar{1}.27$
	2.63:1	305	$\bar{1}.28$	317	$\bar{1}.30$	327	$\bar{1}.26$
5.14:1	433	$\bar{1}.16$	457	$\bar{1}.10$	477	$\bar{1}.25$	
3404-284 (Payload Control)	1.28:1	117	$\bar{1}.33$	114	$\bar{1}.32$	118	$\bar{1}.30$
	5.14:1	451	$\bar{1}.16$	465	$\bar{1}.25$	460	$\bar{1}.11$
3404-284 (Preflight)	1.08:1	36	$\bar{1}.20$	32	$\bar{1}.36$	35	$\bar{1}.37$
	1.28:1	134	$\bar{1}.30$	132	$\bar{1}.26$	136	$\bar{1}.29$
	1.70:1	213	$\bar{1}.30$	188	$\bar{1}.25$	195	$\bar{1}.28$
	1.95:1	245	$\bar{1}.27$	260	$\bar{1}.27$	271	$\bar{1}.26$
	2.63:1	309	$\bar{1}.20$	339	$\bar{1}.13$	360	$\bar{1}.16$
5.14:1	482	$\bar{1}.15$	478	$\bar{1}.09$	455	$\bar{1}.26$	
		(\bar{M}) = $\bar{1}.24$		$\bar{1}.25$		$\bar{1}.26$	
	Average density =	.69-.70		.70-.71		.72-.74	



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$$\frac{S \log E + B \log E}{2} = \bar{M}$$

where:

S log E = exposure from surround component.

B log E = exposure from bar component.

\bar{M} = mean target log exposure.

Table 2 describes the test object characteristic used in exposing resolving power on test material for Mission 1043-1.

Table 2

TEST OBJECT CHARACTERISTICS

<u>Nominal TOC</u>	<u>TOC</u>	<u>Density of Bar</u>	<u>Density of Surround</u>	<u>Density</u>	<u>Modulation*</u>
1.1:1	1.08:1	.14	.17	.03	.0336
1.2:1	1.28:1	.13	.24	.11	.1228
1.6:1	1.70:1	.14	.37	.23	.2592
2.0:1	1.95:1	.14	.43	.29	.3220
2.6:1	2.63:1	.14	.47	.33	.4490
5.1:1	5.14:1	.13	.84	.71	.6743

From the data in Tables 1 and 2, three graphs of Test Object Modulation vs. Spatial Frequency were drawn and are shown in Figures 14-16.

* Mod = $\frac{C-1}{C+1}$

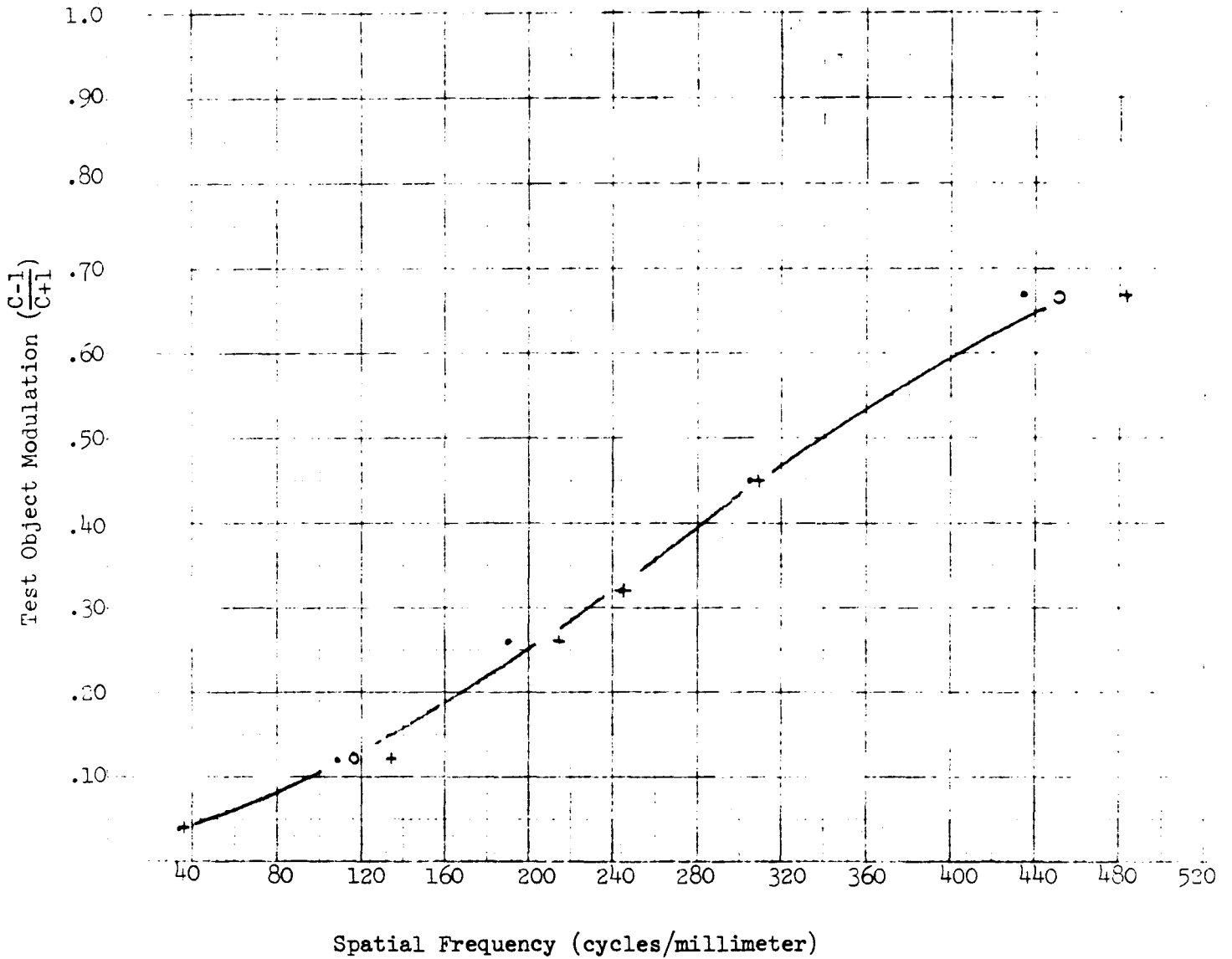


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Test Object Modulation Vs. Spatial Frequency
Daylight Exposure
Trenton Full Process

- 3404-277 Control Stock
- ⊙ 3404-284 Payload Control
- + 3404-284 Preflight Sample

Figure 14



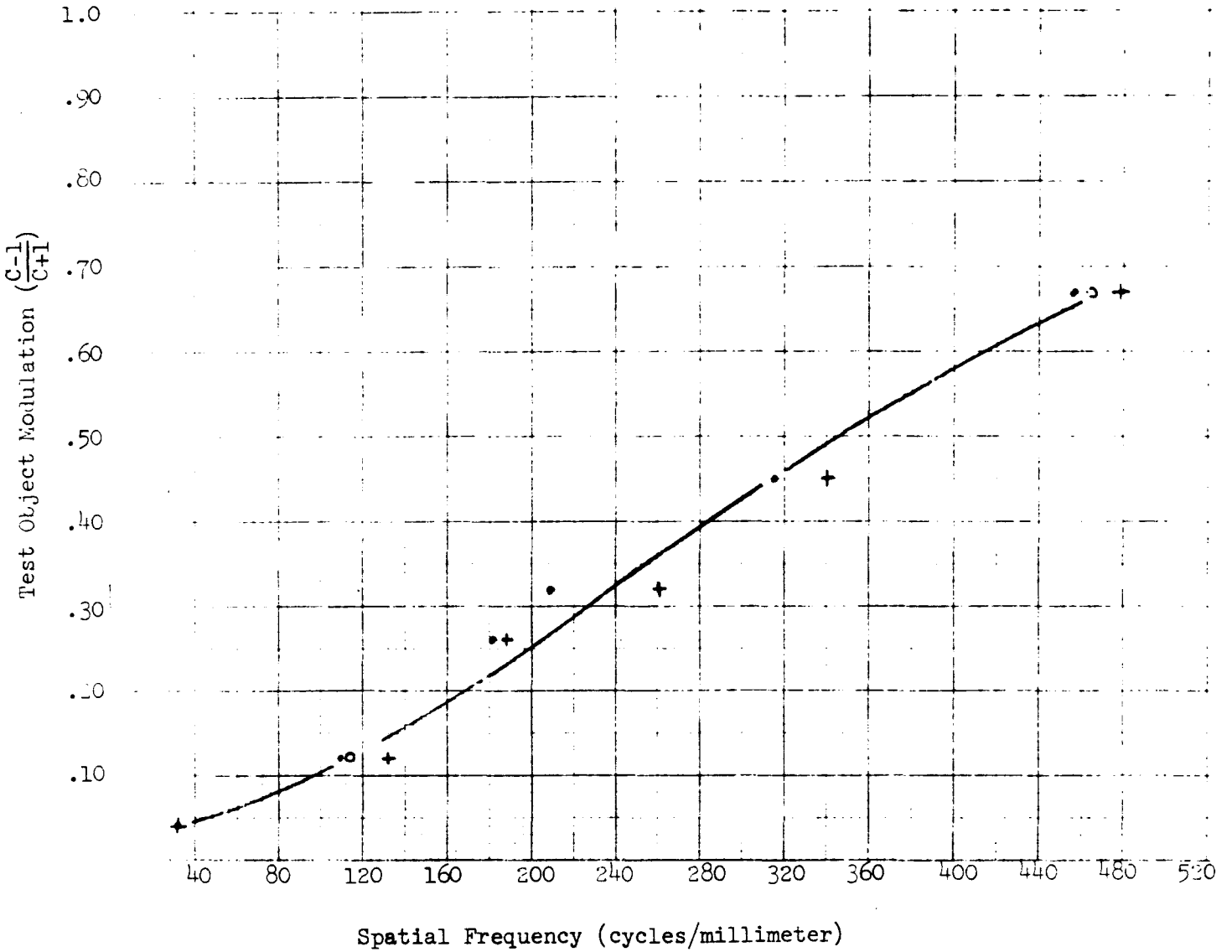


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Test Object Modulation Vs. Spatial Frequency
Daylight + W21 Exposure
Trenton Full Process

- 3404-277 Control Stock
- 3404-284 Payload Control
- + 3404-284 Preflight Sample

Figure 15

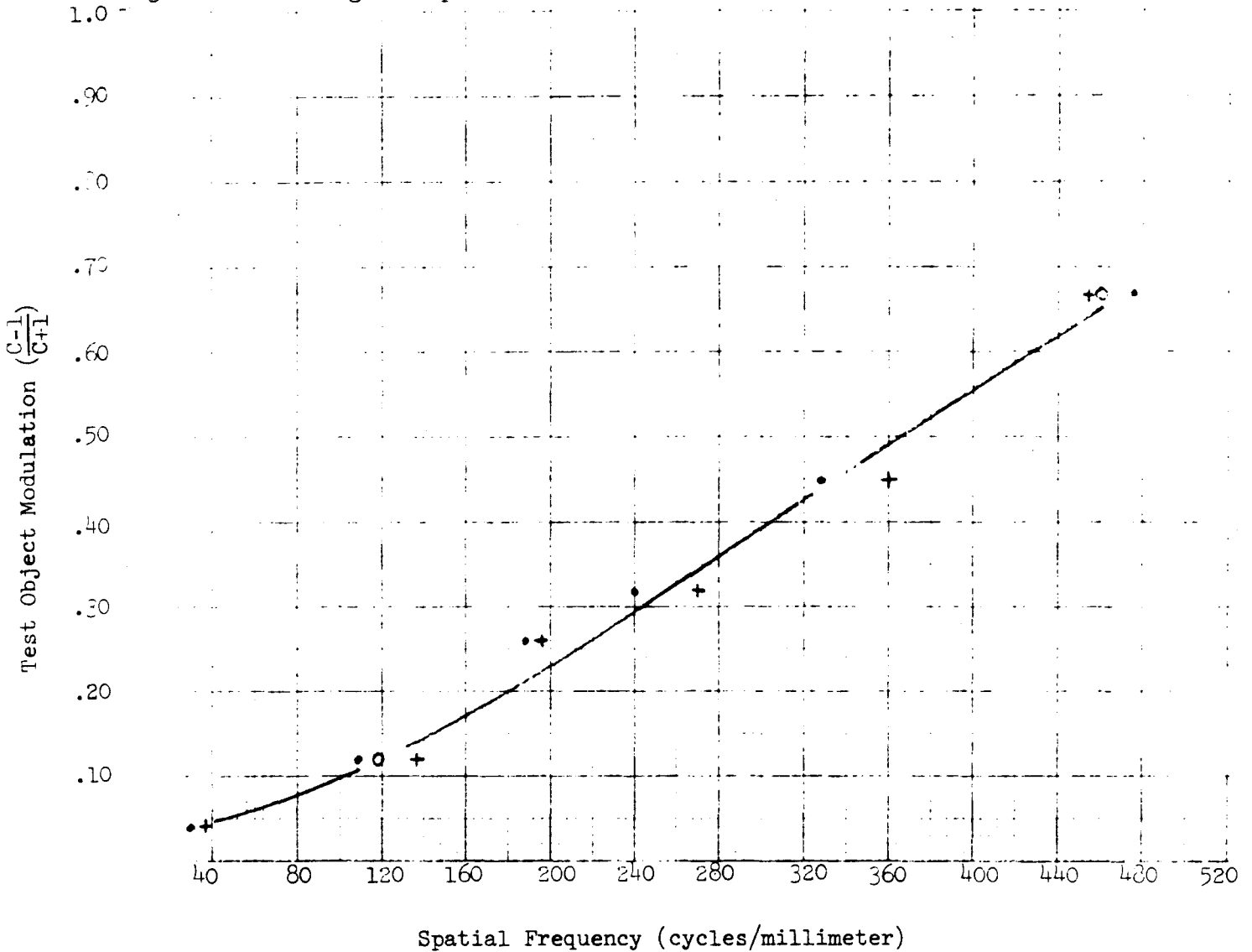


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Test Object Modulation Vs. Spatial Frequency
Daylight + W23A Exposure
Trenton Full Process

- 3404-277 Control Stock
- 3404-284 Payload Control
- + 3404-284 Preflight Sample

Figure 16



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RMS GRANULARITY

No significant difference was noted from data already published for Type 3404 film for any of the various exposure conditions.

SYSTEM MTF

Figures 17-19 show system MTF curves for each exposure condition and the various test emulsions. System MTF includes in the resulting curve:

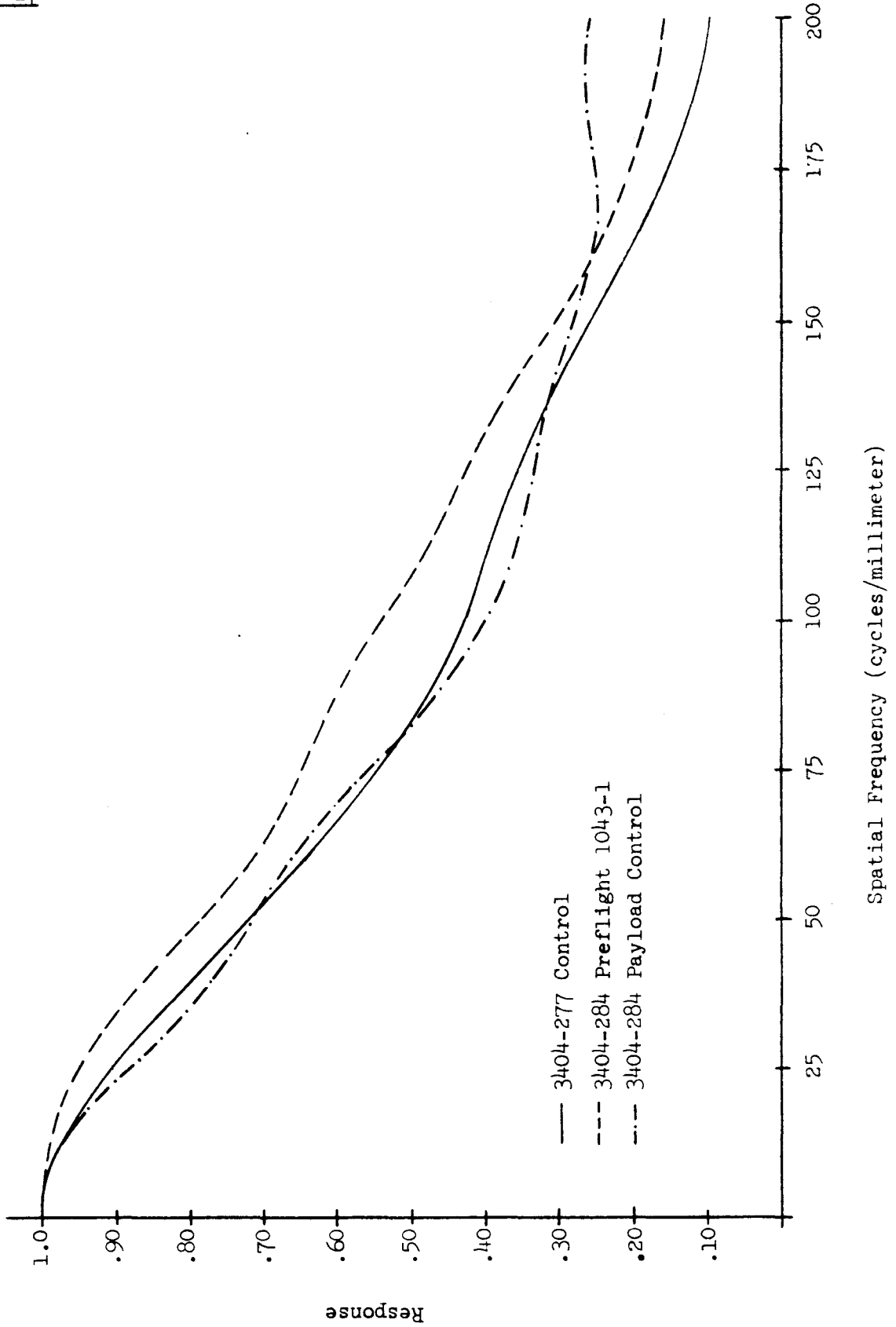
1. Microscope camera optics.
2. Film.
3. Process.
4. Microdensitometer.

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Figure 17

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System MTF for Daylight Exposure - TOC 4:1

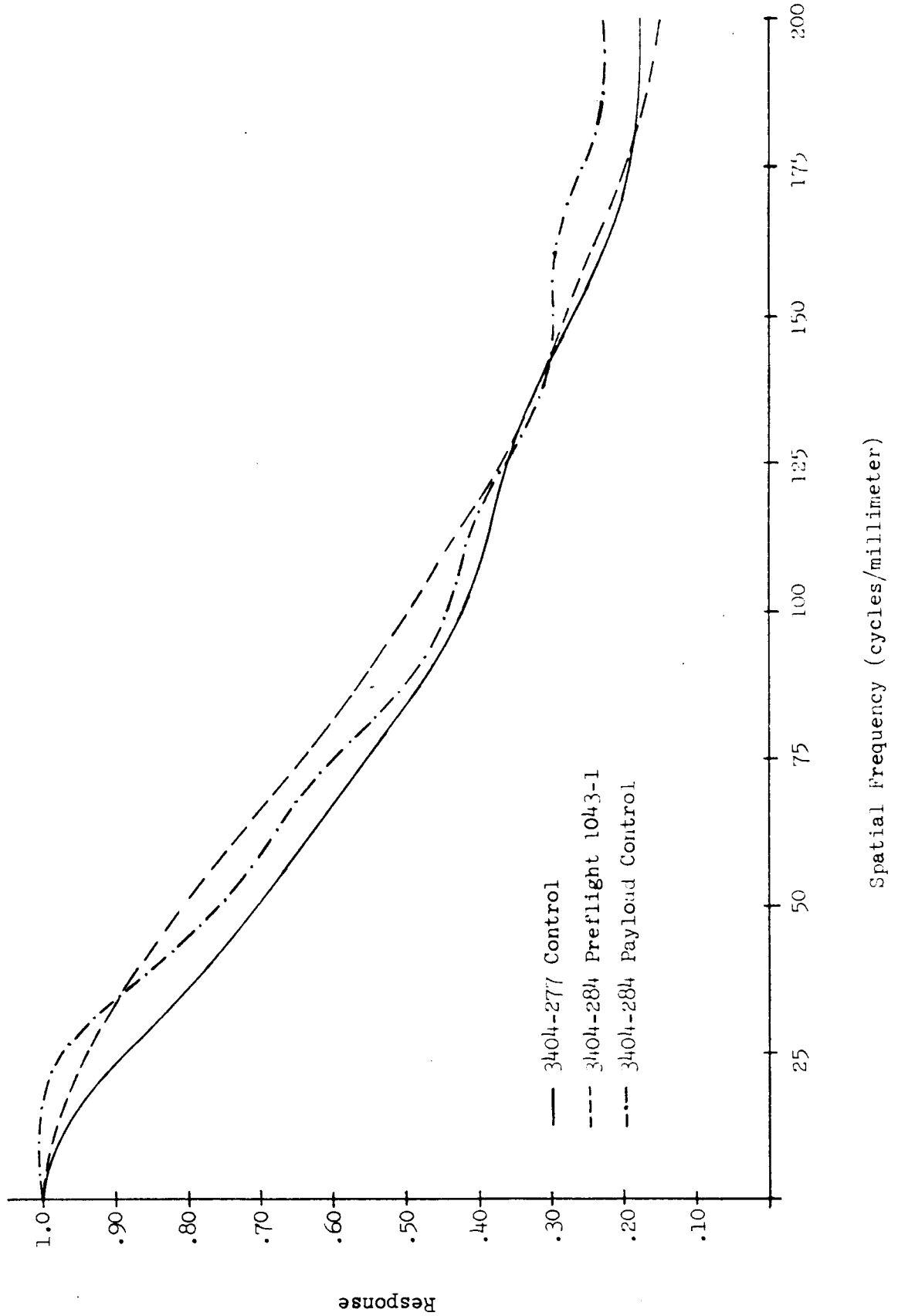


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Figure 18

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System MTF for Faylight + M21 Exposure - SOC 4:1

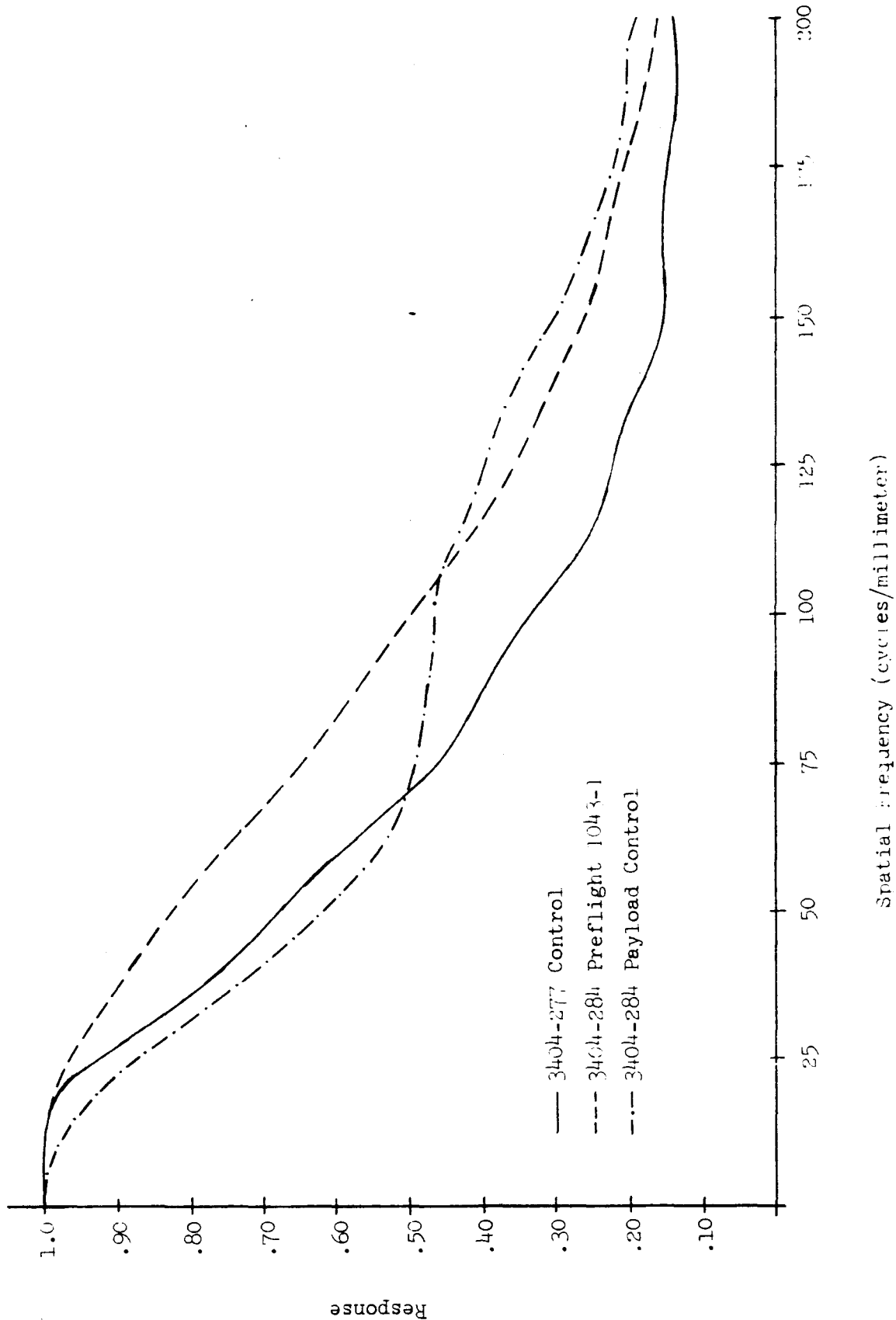


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Figure 19

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System III for Daylight + 23A Exposure - 100 4:1



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