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TN 72-1

Technical Note

NASA CR-
141554

Film Type SO-168 Radiation Study

Prepared Under

NAS 9-11500

Written by

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Photographic Technology Division

National Aeronautics and Space Administration

Manned Spacecraft Center

Houston, Texas

Film Type SO-168 Radiation Study

This Report has been reviewed

and is approved.

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SECTION I

SUMMARY

Under Task Order HT 32 investigations were preformed to determine optimum exposure and processing procedures necessary to partially offset the effect of radiation to which film type SO-168 will be exposed during the Skylab Mission. This task became necessary when it was determined that original predictions of 2 to 3 RADS of radiation to which the film will be exposed were too low, and that levels as high as 3.5 to 4.0 RADS may be incurred, thus reducing image quality below an acceptable level.

Test results provided information that lead to the conclusion that forced processing of type SO-168 film tended to reduce the density range to an unusable level, and that processing to a lower ASA value would provide greater image quality for the user.

SECTION II

PROCEDURES

In order to establish a procedure for offsetting the degrading effects of radiation to which the type SO-168 film would be exposed, several techniques, such as under-development, under-exposure, or some combination of these two techniques, were considered. Verification of the usefulness of this approach was attempted by means of the initial investigation. The experimental design for the initial investigation is outlined in Table 1. In addition to comparing data acquired at various radiation levels, a comparison was made between film radiated prior to and after exposure.

Indicated exposures were made on the Photographic Technology Division's I-B Sensitometer, Model DM-70-3, using step tablet #772-150. The film was radiated to the stated levels by the Manned Spacecraft Center's High Range Calibration Facility, and processed in ME-4 chemistry on the Houston Fearless Hi-Speed Processor located in the Motion Picture Laboratory. Resultant data is shown by the chart in Table 2.

Because inappropriate control strips were used during the processing phase of the initial investigation, it was decided

Table 1. Experimental Design, SO-168 Radiation Study

TEST #1

	Normal Exposure			1 Stop Under Exposure		
Process	ASA 500	ASA 320	ASA 250	ASA 500	ASA 320	ASA 250
Radiation						
3.50	Strip 1	Strip 4	Strip 7	Strip 10	Strip 13	Strip 16
3.75	Strip 2	Strip 5	Strip 8	Strip 11	Strip 14	Strip 17
4.00	Strip 3	Strip 6	Strip 9	Strip 12	Strip 15	Strip 18

Test #1. Film to be exposed to CO_{60} radiation prior to exposure of step wedges.

TEST #2

	Normal Exposure			1 Stop Under Exposure		
Process	ASA 500	ASA 320	ASA 250	ASA 500	ASA 320	ASA 250
Radiation						
3.50	Strip 1A	Strip 4A	Strip 7A	Strip 10A	Strip 13A	Strip 16A
3.75	Strip 2A	Strip 5A	Strip 8A	Strip 11A	Strip 14A	Strip 17A
4.00	Strip 3A	Strip 6A	Strip 9A	Strip 12A	Strip 15A	Strip 18A

Test #2. Test film to be exposed to CO_{60} radiation after the exposure of step tablets.

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Normal Exposure:

I-B Sensitometer
2850°K
1/100 second
5500 filter

Process:

ME-4 chemistry
Temperature - 98°F

Table 2. Results of Initial Investigation

Sample Number Test 1	Sample Number Test 2	Exposure	Process ASA	Radiation Level	Dmax Test 1	Dmax Test 2	Dmin Test 1	Dmin Test 2	Maximum Density Range	
1	1A	1/100	500	3.50	0.55	0.52	0.10	0.10	0.45	0.42
2	2A	1/100	500	3.75	0.50	0.48	0.10	0.10	0.40	0.38
3	3A	1/100	500	4.00	0.46	0.47	0.10	0.10	0.30	0.37
4	4A	1/100	320	3.50	0.65	0.64	0.10	0.10	0.55	0.54
5	5A	1/100	320	3.75	--	0.56	--	0.10	--	0.46
6	6A	1/100	320	4.00	0.54	0.55	0.10	0.10	0.44	0.45
7	7A	1/100	250	3.50	1.30	1.28	0.15	0.15	1.15	1.13
8	8A	1/100	250	3.75	1.24	1.18	0.16	0.15	1.08	1.03
9	9A	1/100	250	4.00	1.20	1.14	0.16	0.15	1.04	0.99
10	10A	1/200	500	3.50	0.54	0.52	0.12	0.12	0.42	0.40
11	11A	1/200	500	3.75	0.49	0.48	0.11	0.11	0.38	0.37
12	12A	1/200	500	4.00	0.47	0.46	0.11	0.11	0.36	0.35
13	13A	1/200	320	3.50	0.64	0.62	0.12	0.12	0.52	0.50
14	14A	1/200	320	3.75	0.62	0.60	0.11	0.12	0.51	0.48
15	15A	1/200	320	4.00	0.60	0.60	0.11	0.11	0.49	0.49
16	16A	1/200	250	3.50	1.30	1.34	0.20	0.22	1.10	1.12
17	17A	1/200	250	3.75	1.24	1.20	--	0.21	—	0.99
18	18A	1/200	250	4.00	1.23	1.20	0.22	0.22	1.03	0.98

to run a secondary investigation. Although conclusions could be made from the initial investigation, data of an absolute nature was deemed more desirable.

The secondary investigation consisted of using a single exposure time (normal exposure), a single radiation level (4.0 RADS), and three processing conditions to produce ASA values of 500, 320, and 125. Three irradiated strips were processed at each ASA level along with appropriate control strips for a total of twelve strips. The results are shown in Table 3; in addition, the densities and visual curves are included in the appendix of this report.

Quantitative evaluation of the data from the secondary investigation was accomplished as follows. Using the given constraints of camera speed (maximum available 1/60 second), maximum lens aperature (f/2), and illumination level inside the capsule (20 foot candles), a value of maximum intensity falling on the film plane was calculated using the following formula*:

$$I' = \frac{.8}{4\ (f/2)}\ I$$

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* This formula is for an approximate value only, but it is considered to be sufficiently accurate for the purposes of this investigation.

Table 3. Results of Secondary Investigation

Exposure	Radiation Level	Process ASA	Averaged Dmax	Averaged Dmin	Averaged Dens. Range	Calculated* Dens. Range
1/100 sec	4.0	125	1.22	0.15	1.07	0.64
1/100 sec	4.0	320	0.83	0.13	0.70	0.40
1/100 sec	4.0	500	0.62	0.12	0.50	0.30

* These results are based on the calculations to determine an approximate value for the maximum exposure level to be received on the film and an assumed scene brightness range of 20:1.

where

I' = intensity falling on film plane

$f/$ = lens aperature

I = illumination intensity

The result was that the log E point of 2.255 on the relative log E scale was determined as the maximum exposure level capable of being received on the film under these conditions. Actual exposure values will undoubtedly be less than this value since it is primarily reflected light that is being recorded. An arbitrary scene brightness range of 20:1 was selected in order that a maximum density range for each processing condition could be calculated. The resultant calculated density range is also shown in Table 3.

SECTION III

RECOMMENDATIONS AND CONCLUSIONS

The results of the initial investigation indicated that forced processing of type SO-168 film to ASA 500 tended to reduce the density range to an unusable level when the film receives between 3.5 and 4.0 RADS of radiation. The data goes on to indicate a 50% drop in Dmax and 60% drop in usable density range when the film is forced processed as compared to when it is processed to ASA 250. Under the same conditions, the maximum density range dropped over 60%. The initial investigation also indicated there is no appreciable difference between the film being irradiated prior to or after exposure. The results of the secondary investigation verified those achieved during the initial investigation. All this leads to the basic conclusion that processing type SO-168 film to a lower ASA value will give more usable results. Usability in this particular instance means that which will produce results with the greatest amount of information rather than that which is of subjectively better quality. It also must be considered that the end use of this film is as an original printing master to produce third and second generation copies for the intended investigators.

Because of the 50% increase in density range achieved, processing to lower ASA values must be considered significant and the most feasible approach to reducing the effects of the radiation levels to which this film will likely be exposed.

APPENDIX

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DATE _____ CONTROL # 4.0 RAD TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 8-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth
ILLUMINANT	2850 °K	CHEMISTRY	ME-4	TYPE	TD 217 DR
TIME	1/100 SEC.	SPEED ____ TANKS ____ FPM		APERTURE SIZE	4 MM
FILTER	5500	TEMP °F ____ TIME ____		FILTER	Visual
				SPEED ( )	
				D-MAX	
				GAMMA	
				BASE + FOG	

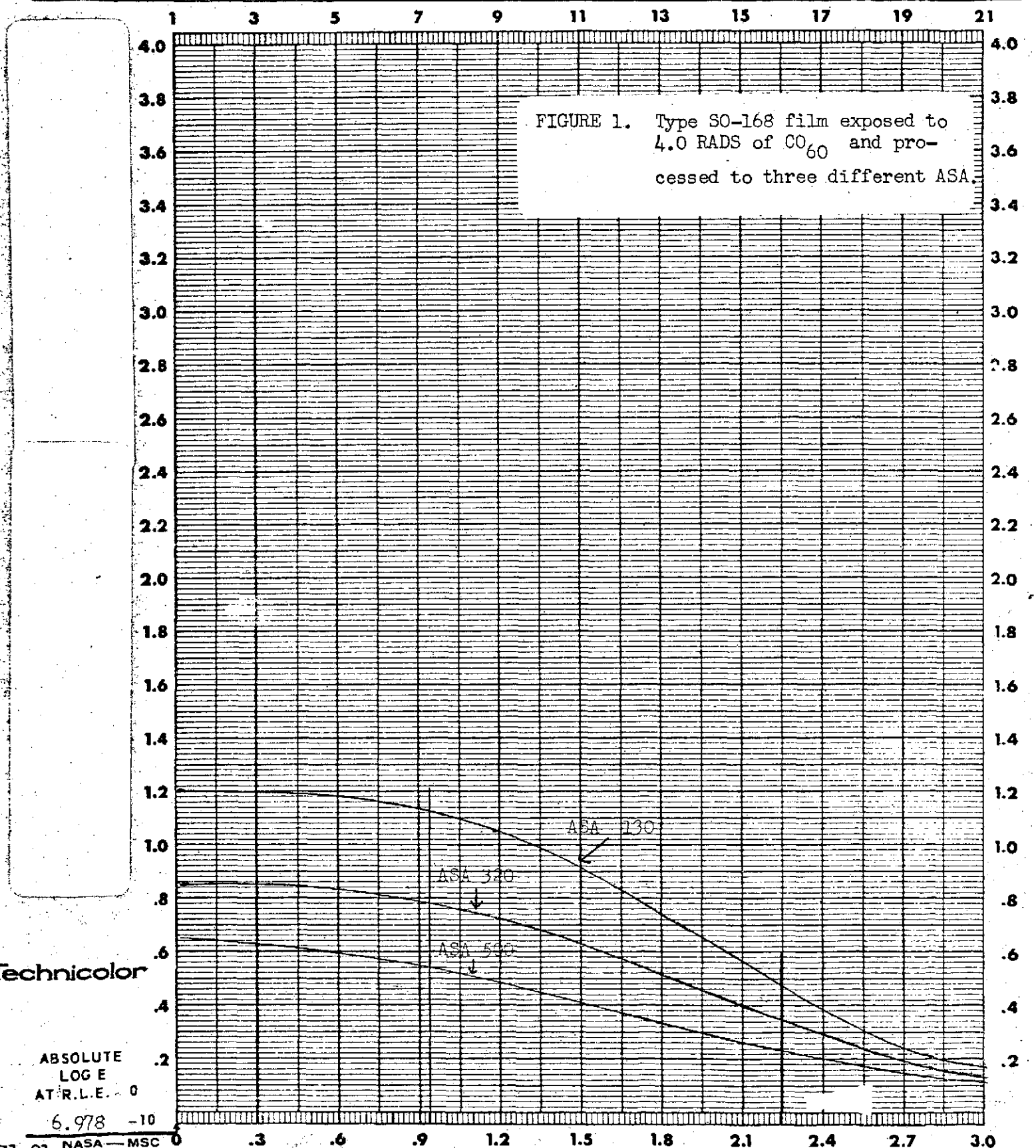

FIGURE 1. Type SO-168 film exposed to 4.0 RADS of CO_{60} and processed to three different ASA.

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Technicolor

ABSOLUTE LOG E AT R.L.E. 0

6.978 -10

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Table 4. List of Calculations

$f/ = f/2$

$I = 20$ foot candles $= 215.280$ meter candles

$t = 1/60$ second

$I' = \frac{.8}{4 f^2} I$

$I = .72$ meter candle seconds

$\log I = 9.233^{-10}$ = maximum intensity falling on film plane

DATE _____ CONTROL # 4.0 RADS TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 8-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER I-B	PROCESSOR Houston	INSTRUMENT MacBeth	SPEED (ASA) 320
ILLUMINANT 2850 °K	CHEMISTRY ME-4	TYPE TD 217 DR	D-MAX
TIME 1/100 SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE 4 MM	GAMMA
FILTER 5500	TEMP °F ____ TIME ____	FILTER Visual	BASE + FOG

FIGURE 2. Density Results of Secondary Investigation (ASA 320)

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DATE _____ CONTROL # Control TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # _____ MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth	SPEED (ASA)	330
ILLUMINANT	2850 °K	CHEMISTRY	ME4	TYPE	TD 203	D-MAX	
TIME	1/100 SEC.	SPEED ____ TANKS ____ FPM		APERTURE SIZE	4 MM	GAMMA	
FILTER	C5500	TEMP °F 98	TIME 3'51"	FILTER	Visual	BASE + FOG	

FIGURE 2A. Control Strip(ASA 320)

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DATE _____ CONTROL # 4.0 RADS TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 8-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth	SPEED (ASA)	130
ILLUMINANT	2850 °K	CHEMISTRY	ME-4	TYPE	TD 217 DR	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	5500	TEMP °F	TIME	FILTER	Visual	BASE + FOG	

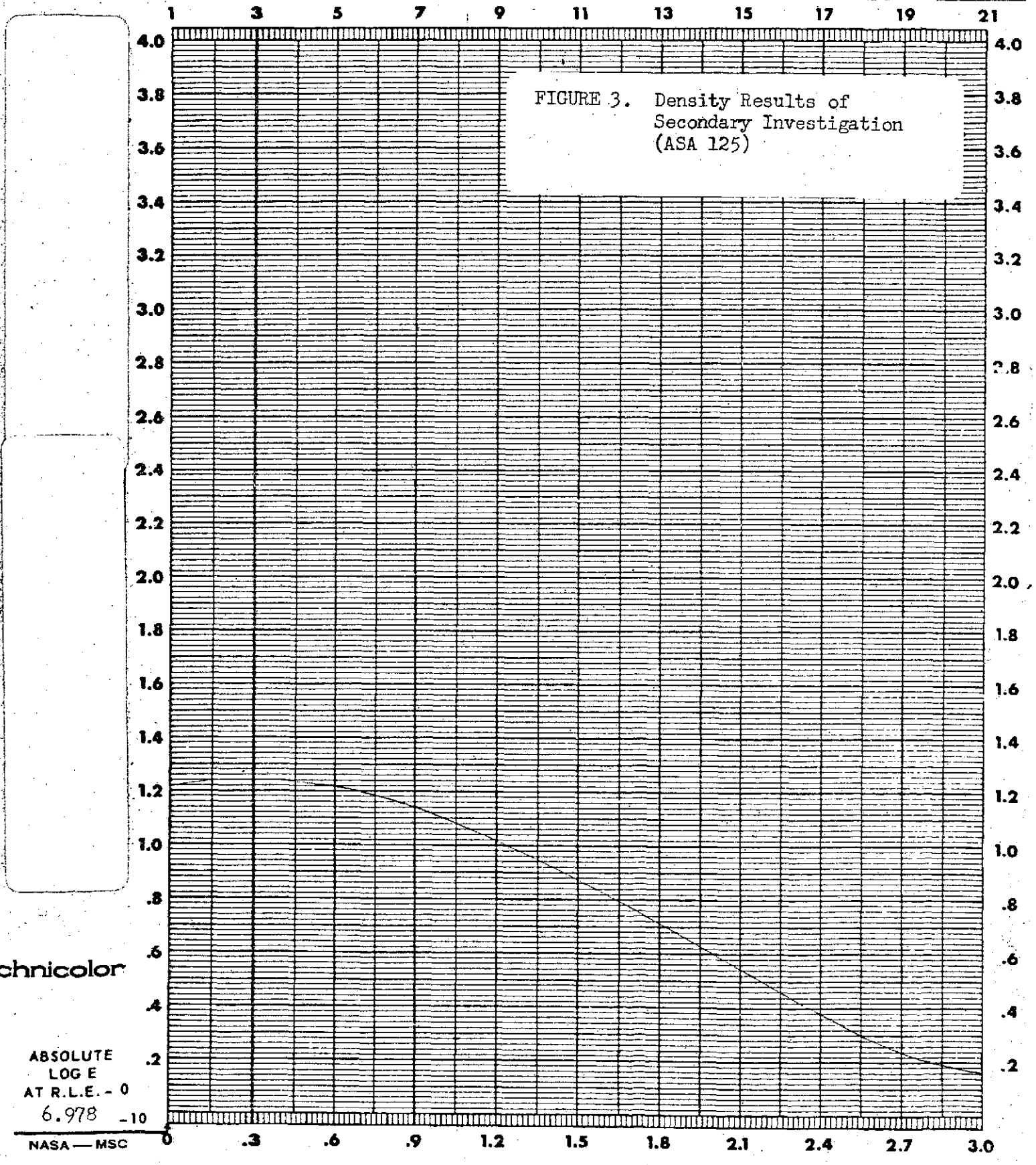

FIGURE 3. Density Results of Secondary Investigation (ASA 125)

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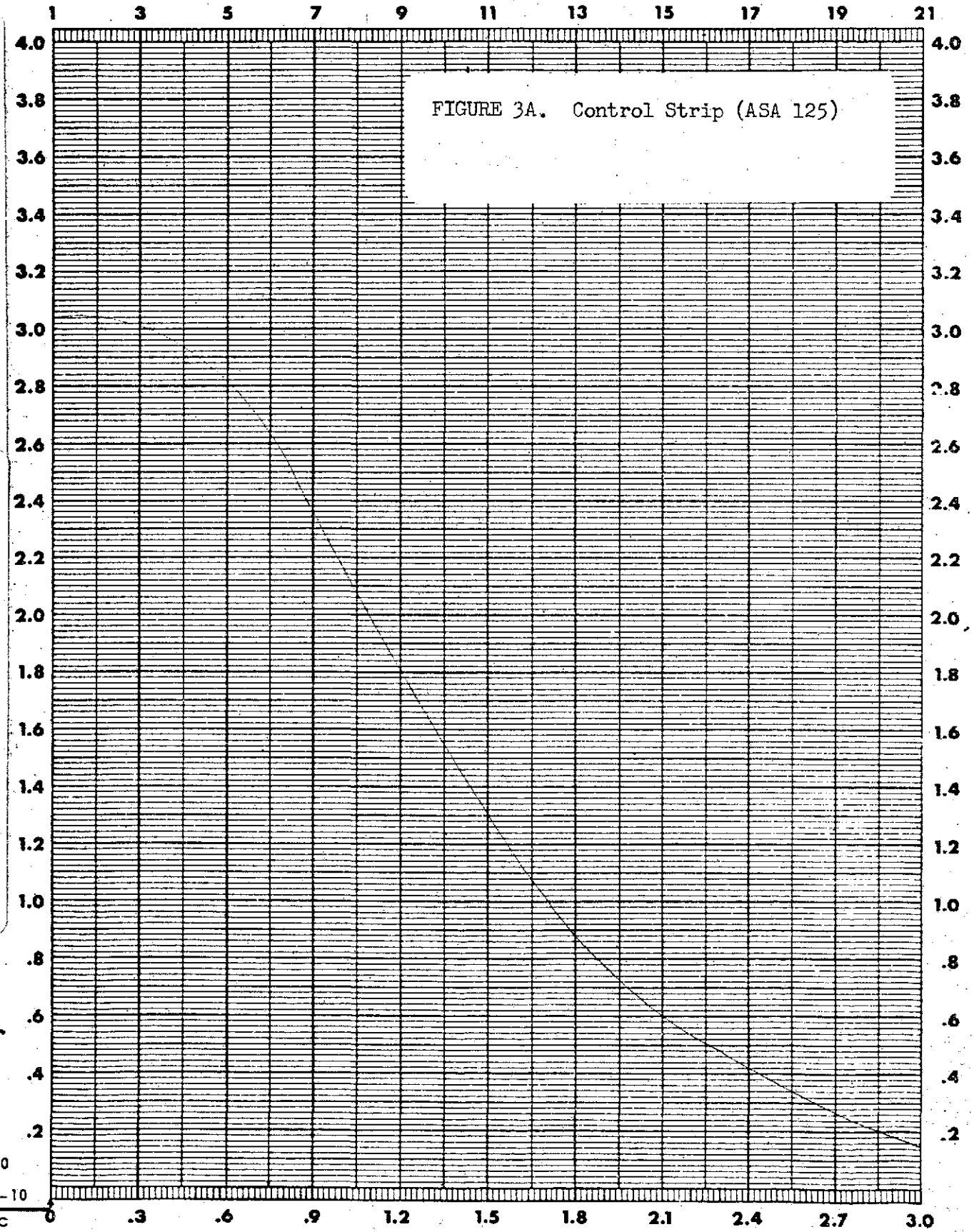
DATE _____ CONTROL # Control TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 8-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth	SPEED (ASA)	130
ILLUMINANT	2850 °K	CHEMISTRY	ME-4	TYPE	TD 217 DR	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	5500	TEMP °F	TIME	FILTER	Visual	BASE + FOG	

FIGURE 3A. Control Strip (ASA 125)



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ABSOLUTE LOG E AT R.L.E. - 0

6.978 -10

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DATE _____ CONTROL # 4.0 RADS TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 8-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth	SPEED (ASA)	500
ILLUMINANT	2850 °K	CHEMISTRY	ME-4	TYPE	TD 217 DR	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	5500	TEMP °F	TIME	FILTER	Visual	BASE + FOG	

FIGURE 4. Density Results of Secondary Investigation (ASA 500)

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DATE _____ CONTROL # Control TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # _____ MFG _____ EXPIRATION DATE _____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER I-B	PROCESSOR Houston	INSTRUMENT MacBeth	SPEED (ASA) 500
ILLUMINANT 2850 °K	CHEMISTRY ME-4	TYPE TD 203	D-MAX
TIME 1/100 SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE 4 MM	GAMMA
FILTER 5500	TEMP °F ____ TIME ____	FILTER Visual	BASE + FOG

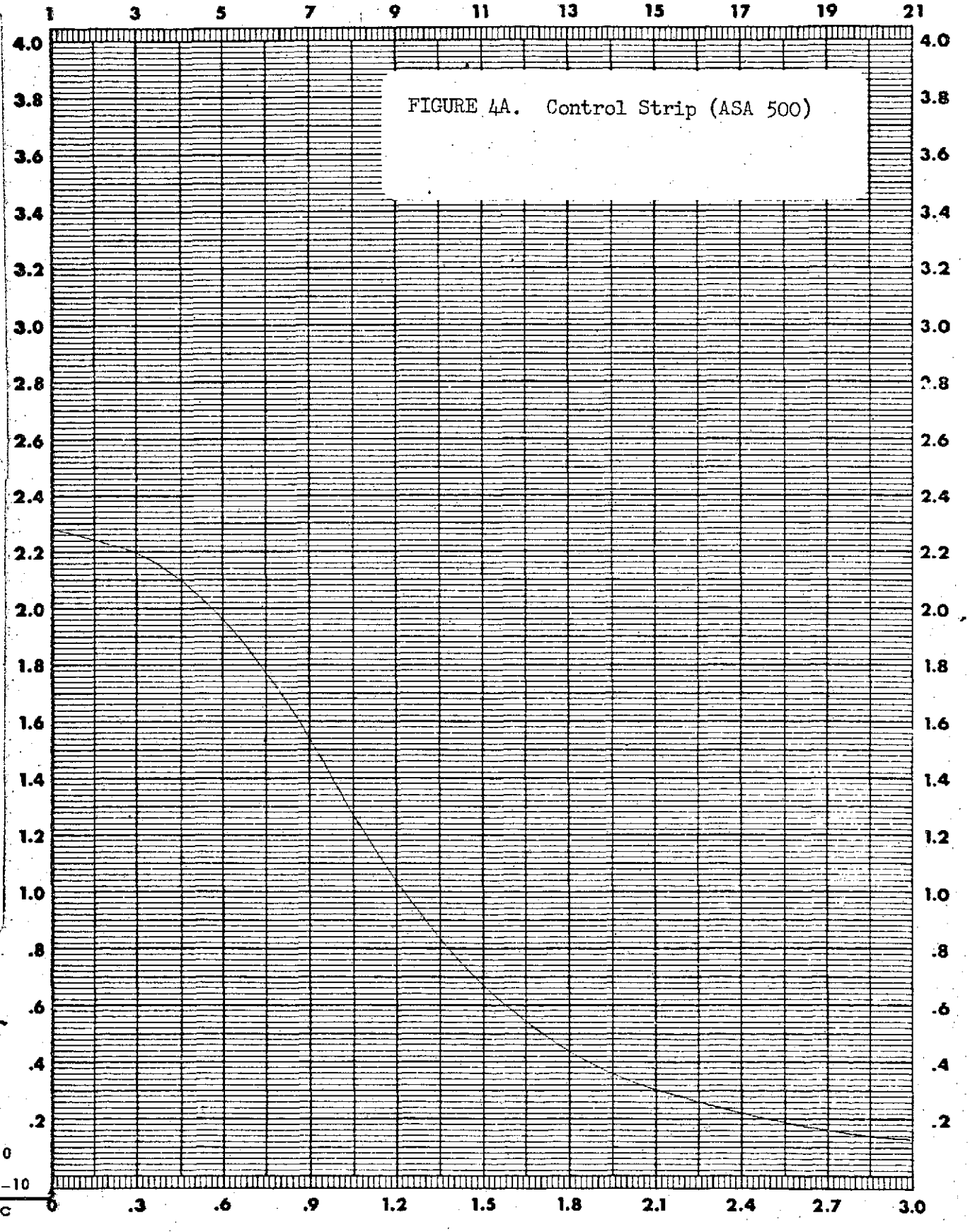

FIGURE 4A. Control Strip (ASA 500)

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ABSOLUTE LOG E AT R.L.E. = 0

6.978 -10

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