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TECHNICAL REPORT

CIBACHROME TESTING

Prepared Under

Contract NAS 9-11500

Task Order HT-121

Prepared By

Mark S. Weinstein

Photoscientist

December 1974

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INPUT BRANCH

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

JSC-09360

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Houston, Texas 77058

Technicolor Graphic Services, Inc.

CIBACHROME TESTING

This report has been reviewed

and is approved.

SUBMITTED BY: Mark S. Weinstein, Photoscientist

APPROVED: Gerard E. Sauer, Manager
Photo Science Office

CONCURRENCE: D. H. G. Howe, Operations Manager

APPROVED: Noel T. Lamar, Technical Monitor

CONCURRENCE: John R. Brinkmann, Chief
Photographic Technology Division

INTRODUCTION

The Photographic Technology Division's Photographic Sciences Office (PTD/PSO) first began investigating the use of Cibachrome Products in March 1972, as a possible solution to mottling problems encountered when contact printing Kodak film type SO-397 onto Kodak Ektachrome color reversal paper type 1993. Sample imagery was sent to Ilford Inc., Paramus, New Jersey, contact printed onto Cibachrome print film, processed and returned to PTD/PSO for evaluation. The resultant Cibachrome prints were free of mottle and exhibited improved sharpness and color saturation when compared to Kodak Ektachrome paper type 1993 Prints. However, difficulties in obtaining sufficient quantities of the product and the heavy workload within PTD for Apollo and Skylab precluded further consideration at that time.

In the Spring of 1974, the PTD was informed by Ilford Inc. that the construction of a new emulsion coating plant in Switzerland would greatly increase their production capabilities enabling them to supply sufficient product quantities to meet our projected requirements.

The ability to supply the product plus improvements in the chemistry made further investigation of this product desirable.

TEST PROGRAM

The initial testing was done by Ilford Inc. in New Jersey using original transparencies supplied by the PTD. The next step was to verify their results by contact printing a roll of original aerial imagery consisting of Kodak film types SO-397 and 2443 using the Precision Laboratory's Colorado printer operated by PTD personnel. Cibachrome print type CCP-D was supplied in 8" wide rolls with Cibachrome P-10 chemistry for test purposes. Individual test frames representing each type of imagery on the test roll were printed on the Colorado Printer and processed in a Unicolor drum to obtain correct color balance and exposure for each scene. The entire test roll was then printed and sent to Ilford for processing since the PTD did not have a processor set up for roll processing of Cibachrome materials.

Again, the results were excellent, both for the imagery processed at PTD in a drum processor and the roll of material processed by Ilford. The final test was to now print and process Cibachrome Print and Transparency materials entirely at the PTD using PTD personnel and equipment and prepare a direct comparison between Cibachrome and Kodak materials in terms of color quality, resolution, cost and compatibility with existing equipment and techniques.

The chief of the Technical Laboratory Branch made available to the Photo Science Office the Pako Processor located in the Precision Laboratory for testing Cibachrome products with the condition that no major modifications be made to the machine. On Wednesday, August 21, 1974, Ilford personnel, Mr. V. H. Link, Regional Sales Manager, and Mr. Bryan Sammartino, Technical Service Representative, arrived at PTD to help set up the Pako Processor and assist with the testing of Cibachrome Print and Transparency products. A special dye bleach solution was supplied containing a catalyst that would be noncorrosive to the stainless steel Pako tanks.

The Pako processor consists of 12 tanks (5 wash and 7 chemical) and a spray wash prior to entering the drum dryer. The existing configuration was not ideal for the Cibachrome process and required as a minimum the swapping of tanks 8 and 9. The Laboratory Branch approved the configuration change since no plumbing modifications were involved. In addition, an air turbulance bar was added to the first dye bleach tank and a wooden cover was constructed to make tanks 4, 5, and 6 light tight. The Pako processor configurations for the Kodak and Cibachrome chemistries are shown diagrammetrically in Figure 1. The Pako processor was operated for two months with Cibachrome chemistry. During that period, Precision Laboratory, Process Control and

Chemical Mixing personnel gained considerable experience in handling the process and materials. Sensitometric strips were processed on a daily basis, prints and transparencies were made utilizing the Colorado and Miller Holzwarth contact printers and the Durst Laborator 8" x 10" enlarger, and sensitometric tests were conducted varying the time and temperature in each of the solutions. Comparison prints were prepared on Cibachrome Print type CCP-D, and Kodak Ektachrome paper type Kind 2212 from the same original using the Miller Holzwarth contact printer. An internegative was also prepared from the original and printed onto Kodak Ektacolor type 37 paper. Comparison transparencies were prepared on Cibachrome Display Transparency film type CCT-D, and Kodak film type 2447, using the same original imagery and procedures as used for the print comparisons. These products are available for review in the Photo Science Office. The sensitometric test results are included in Appendix A.

PAKO PROCESSOR CONFIGURATION

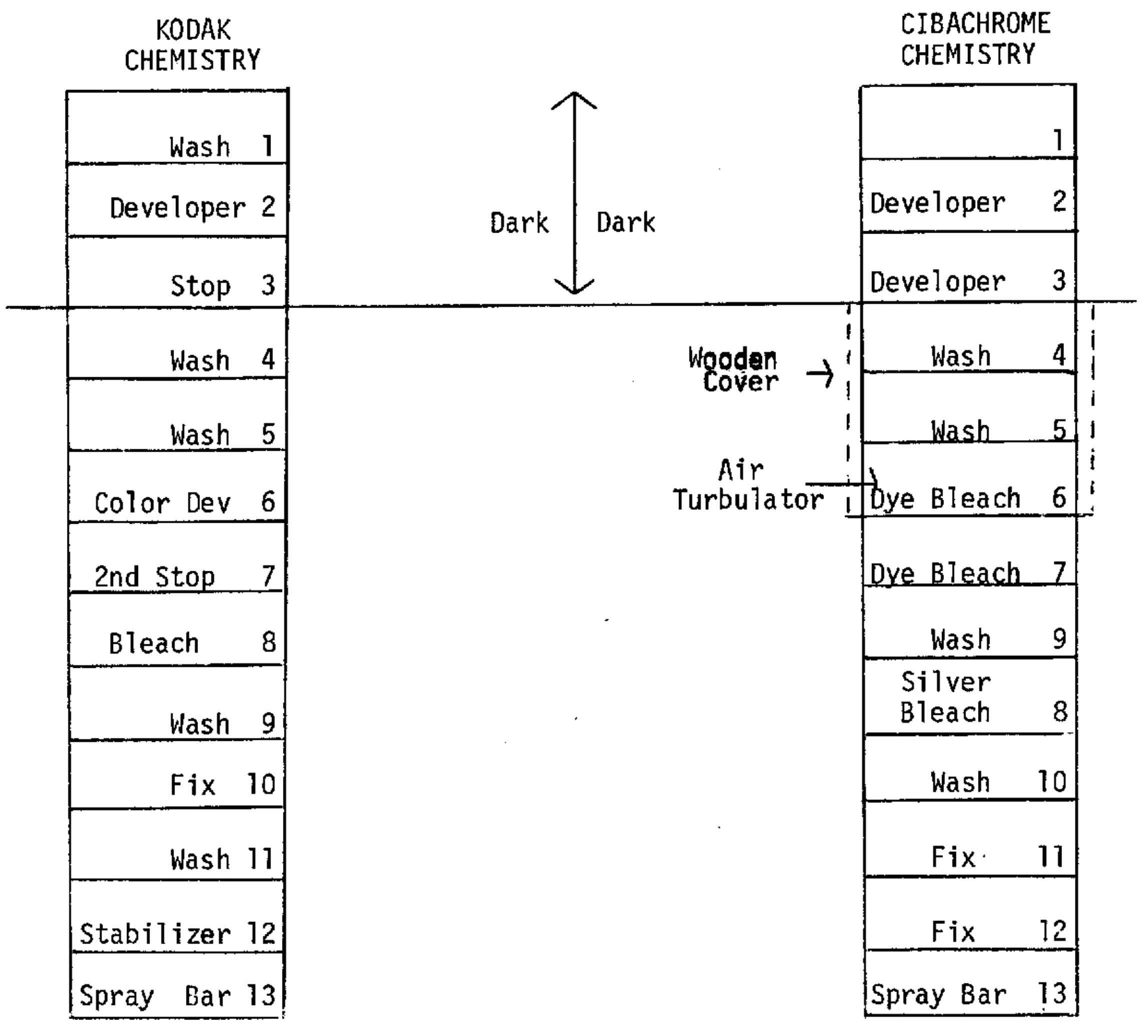


FIGURE 1

DISCUSSION AND TEST RESULTS

No major problems were encountered during any phase of the testing utilizing the Pako processor, even though the setup was jury-rigged. The final spray wash was insufficient due to the requirement that no plumbing modifications be made to the processor. This required the operator to remove the print or transparency material from the processor before entering the drum dryer, then manually wash the material in a sink, after which it was dryed in the hot air impingement dryer located in the PSO darkroom. There was also no automatic replenishment system. The operator was required to keep track of the material processed and replenish the solutions manually.

The results of the test program must necessarily be reported in both objective and subjective terms. The objective measurements are given in terms of resolution and sensitometric response. The comparison prints and transparencies were also viewed subjectively by members of the PTD and ranked according to overall quality and aesthetic appeal.

The results are as follows:

RESOLUTION:

Kodak Kind 2212	18 l/mm
Cibachrome Print CCP-D	38 l/mm

CONTRAST:

Process Configuration	Average Gradient Ciba Print CCP-D	Gamma Ciba Transparency CCT-D
75° Normal	0.95	0.98
75° + 2' Dye Bleach	0.96	1.16
80° Normal	0.95	1.03
80° + 2' Dye Bleach	1.10	1.22
85° Normal	0.81	1.06
85° + 2' Dye Bleach	0.94	1.24

Complete sensitometric curves for the above listed process configurations are included in Appendix A.

SUBJECTIVE EVALUATION:

The Cibachrome print was in all cases ranked superior to the Kodak Kind 2212 print and at least equal if not superior to the Kodak Ektacolor type 37 print produced from an internegative. It should be pointed out that it was not possible to accurately produce the green hues found in Kodak Aerochrome Infrared Film

Type 2443 when preparing Ektacolor type 37 prints from internegatives. The greens reproduced as shades of blue even though many attempts were made varying the color balance of the internegative and print. The Cibachrome print was a faithful reproduction of the colors found in the original imagery and had superior sharpness, latitude and color saturation.

The Cibachrome transparency product was found to be equal in quality on a subjective basis when compared to Kodak Ektachrome Aerographic Film type 2447.

Sample prints and transparencies used for evaluation are not included in this report, but are available for inspection in the Photo Science Office.

COST ANALYSIS:

Table 1 lists the Government costs for various film and print materials and chemicals involved in this project at the time of the test. Table 2 is a cost comparison for 8" x 10" color paper prints.

Table 1

COST COMPARISON

MATERIAL TYPE	SIZE	QUANTITY	COST	COST/SQ.FT.
Kodak Ektachrome Duplicating Film Type 6120	8x10"	100 sheets	$75.40	$1.36
Kodak Aerochrome Duplicating Film Type 2447	9 1/2 x 300'	1 roll	$147.44	$0.62
Cibachrome Display Transparency Film Type CCT-D	9 1/2" x 164'	1 roll	$294.72	$2.27
Kodak Ektachrome RC Paper Type 2212	9 1/2" x 250'	1 roll	$104.45	$0.53
Cibachrome Print Paper Type CCP-D	9 1/2" x 250'	1 roll	$118.75	$0.60
Kodak Ektacolor Internegative Film Type 6110	10" x 10"	10 sheets	$22.93	$3.30
Kodak Ektacolor Type 37 RC Paper	10" x 250'	1 roll	$68.06	$0.33

CHEMICAL COST:

Kodak Ektaprint R5 with Bleach Regeneration	$0.06
Cibachrome 4 Solution	$0.08
Cibachrome 3 Solution	$0.06

Table 2

COST COMPARISON FOR 8" x 10" COLOR PAPER PRINTS

(Chemicals and Labor Not Included)

Paper Type	Quantity 1	5	10	50
Kodak 2212*	$0.29	$1.47	$2.94	$14.70
Ciba CCP-D**	$0.33	$1.67	$3.33	$16.65
Kodak Type C ***	$2.02	$2.75	$3.66	$10.98

* GSA Price Good until 2/75 only; possible price increase.
** Government Price - 1975.
*** Includes one 8" x 10" sheet of internegative material.

All testing was conducted with Cibachrome process P10 consisting of four chemicals: Developer, Dye Bleach, Silver Bleach and Fixer. Total process time at 75°F. in a continuous processor is approximately 41 minutes. The P10 process has the advantage that both the print and transparency products use the same chemistry and the contrast of both materials can be varied by adjusting the time in the Dye Bleach solution.

In October 1974, CIBA-GEIGY announced the introduction of a three solution process designated P18 for the print material only. The total process time is 14 minutes at 87°F., and consists of a Developer, combination Silver and Dye Bleach and Fixer. The P18 process could be easily adapted to either the Pako or Simplex Processors. The amount of contrast control for the P18 process is not yet known.

Figure 2 shows schematically the leader belt and drum dryer configuration for the Pako processor in its normal configuration. The drum dryer is unsuitable for use with Cibachrome materials. These products require air impingement drying. If the Pako processor were to be used, some type of air impingement drying system would have to be added. Figures 3 and 4 show schematically two possible arrangements utilizing Cibachrome P18 chemistry and the addition of an air impingement dryer.

The use of Cibachrome P18 chemistry in the Simplex processor would be more desirable since that machine already has an air impingement dryer and has a higher throughput rate - 80 inches/ minute versus 16 inches/minute for the Pako. No major modification would be required to use the Simplex with the Cibachrome 3 solution chemistry. A light-tight cover would have to be added to some of the tanks as was done for the Pako, and the first tank of Bleach solution should be recirculated through a spray bar immersed in the solution for improved agitation. Figure 5 shows the proposed Simplex processor configuration.

FIGURE 2

STANDARD PAKO CONFIGURATION

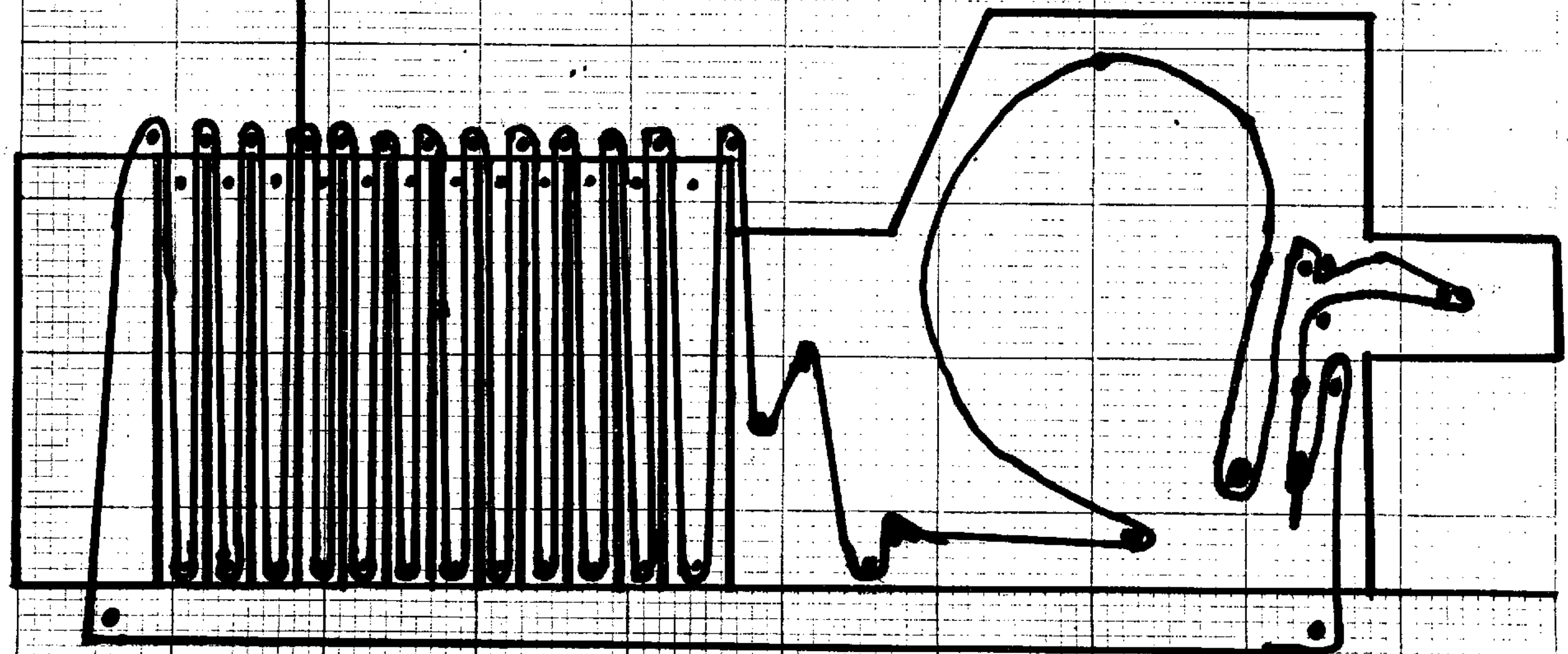
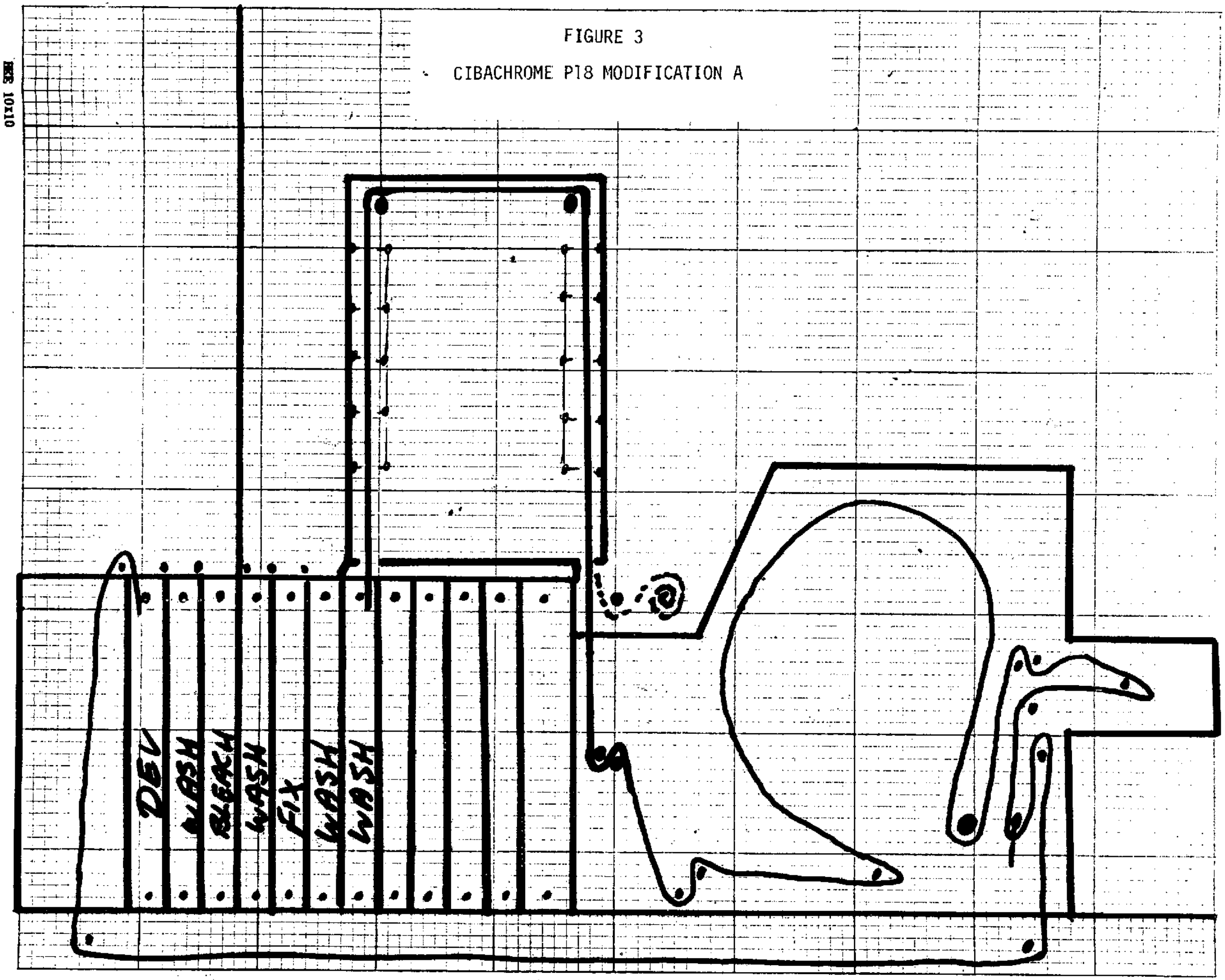


FIGURE 3

CIBACHROME P18 MODIFICATION A



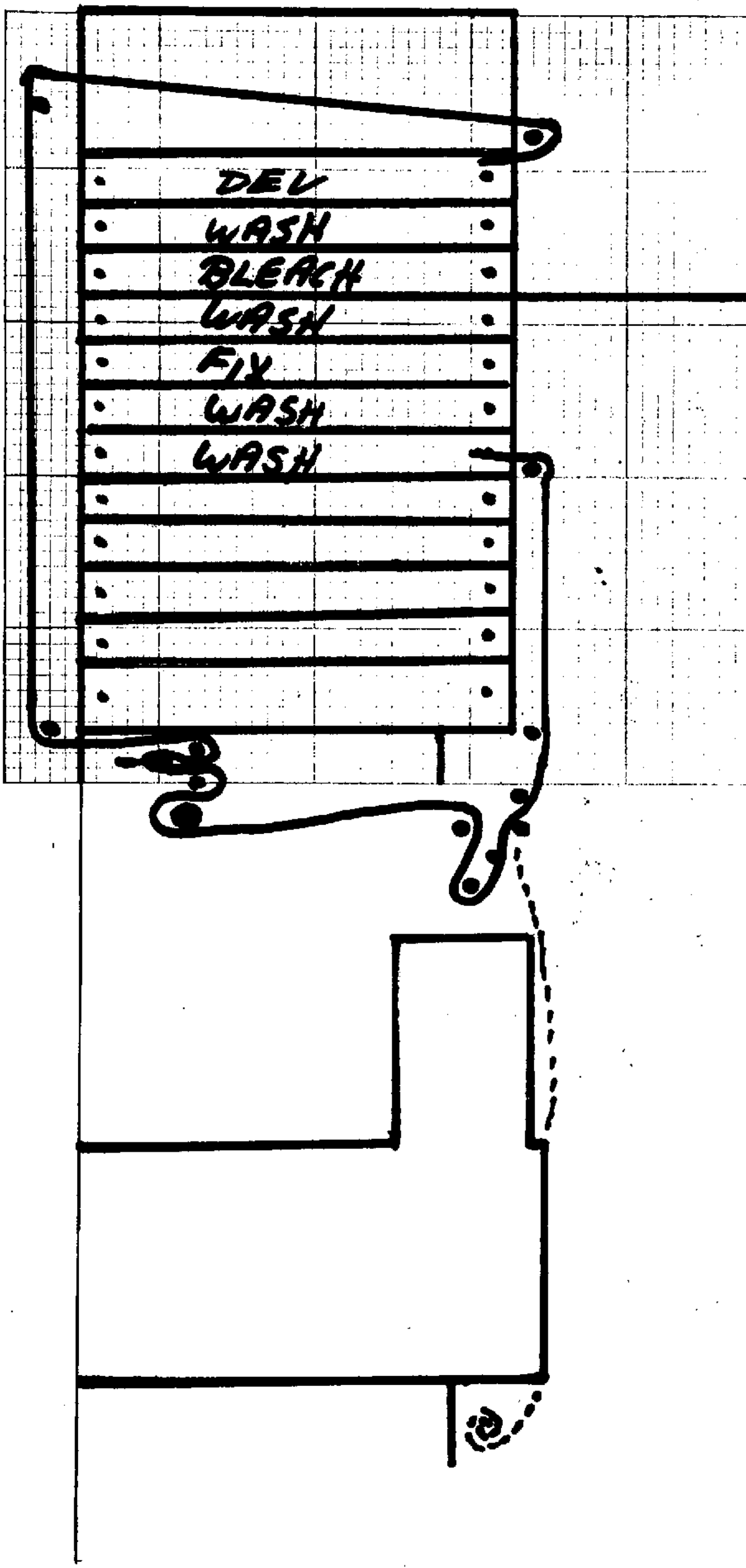
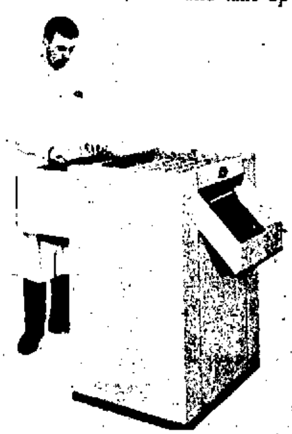


FIGURE 4
CIBACHROME P18 MODIFICATION B

■ **PAKOROL DRYER**

Automatic roller-transport film drying in seconds; cut-sheet or roll; continuous tone B&W; litho. Controls for drive and blower, plus variable speed control located on front panel; feeding easy and accurate; feed and take-up acces-



sory available for convenient handling of long continuous rolls; roller-transport moves film safely past vents of warm air for fast even and thorough drying; dry, dust-free negative drops into receiver only seconds after feeding. Temp. can be adjusted from 90°F to 150°F. Film speed travel may be adjusted from 6" to 30" per min. **Model 17**, **44x30x43¼"**, will handle roll or cut film up to 17" wide, not less than .005" minimum thickness or .004" min. polyester. **Model 24**, **44x37x43¼"**, will handle roll or cut film up to 24" wide. Check with us for further specifications and pricing.

SIMPLEX PROCESSOR CONFIGURATION

Tank	KODAK EKTAPRINT R CHEMISTRY	CIBACHROME P18 CHEMISTRY
1	1st Dev	Developer
2	1st Dev	Developer
3	1st Dev	Developer
4	1st Dev	Developer
5	1st Dev	Developer
6	Stop	— — —
7	Stop	
8	Wash	Wash
9	Wash	Wash
10	Wash	Wash
11	Wash	Wash
12	Wash	Wash
13	Color Dev	Bleach
14	Color Dev	Bleach
15	Color Dev	Bleach
16	Color Dev	Bleach
17	Color Dev	Bleach
18	Color Dev	Bleach
19	Wash	Wash
20	Blix	Fix
21	Blix	Fix
22	Blix	Fix
23	Blix	Fix
24	Wash	Wash
25	Wash	Wash
26	Wash	Wash
27	Wash	Wash
28	Stab	Wash
29	Stab	Wash
30	Spray	Spray

Agitate Spray Bar Chemistry (no air) → (Cibachrome tank 13)

FIGURE 5

CONCLUSIONS

Cibachrome Print material type CCP-D has approximately double the resolving power of Kodak Ektachrome Color Reversal paper type Kind 2212.

Cibachrome Transparency material type CCT-D is approximately equal in sharpness to Kodak Aerochrome Duplicating film type 2447.

In a subjective evaluation, prints made from original aerial imagery on Cibachrome Print type CCP-D were ranked superior to those made on Kodak Ektachrome Paper type Kind 2212, and at least equal to if not superior to those made on Kodak Ektacolor type 37 RC paper from internegatives.

In a subjective evaluation, transparencies made on Cibachrome Transparency film type CCT-D were rated equal in quality to those made on Kodak Aerochrome Duplicating film type 2447.

During the course of the test program, it was not possible to reproduce faithfully, the green hues found in Kodak Aerochrome Infrared film type 2443 when making Kodak type 37 prints via internegatives. This was not the case with Cibachrome Print type CCP-D.

Cibachrome materials tested use the silver-dye bleach process with specially selected Azo dyes incorporated in the emulsion that have been shown to have considerably more resistance to light fading than conventional color photographic processes. An article reprinted from the British Journal of Photography, 5 October 1973, entitled "The Conservation of Color Photographic Records", is included in Appendix B and describes testing done to determine image fading for various color photographic materials.

RECOMMENDATIONS

It is the recommendation of the Photographic Sciences Office that Cibachrome Print material type CCP-D be used by the PTD in place of Kodak Ektachrome RC paper type Kind 2212. This material can be most easily processed in the Simplex Processor utilizing Cibachrome 3 solution chemistry type P18. The cost for the Cibachrome materials is equivalent to the cost for the Kodak materials, no major modifications to the Simplex are required and the improved resolution, color quality, and image fade resistance will allow PTD to deliver an improved product to the customer.

The Cibachrome Transparency material is more expensive and does not offer any significant advantages over the transparency materials presently used by the PTD except for its increased resistance to image fading. It could be used advantageously for special projects such as display transparencies where its resistance to image fading would be cost effective.

APPENDIX A

DATE 8/29/74 CONTROL # 75° Normal TASK HT-121 PREPARED BY ____

FILM CCT-D EMULSION # ____ MFG CIBA-GEIGY EXPIRATION DATE ____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ____ °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME ____ SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE ____ MM	GAMMA
FILTER	TEMP °F 75 TIME	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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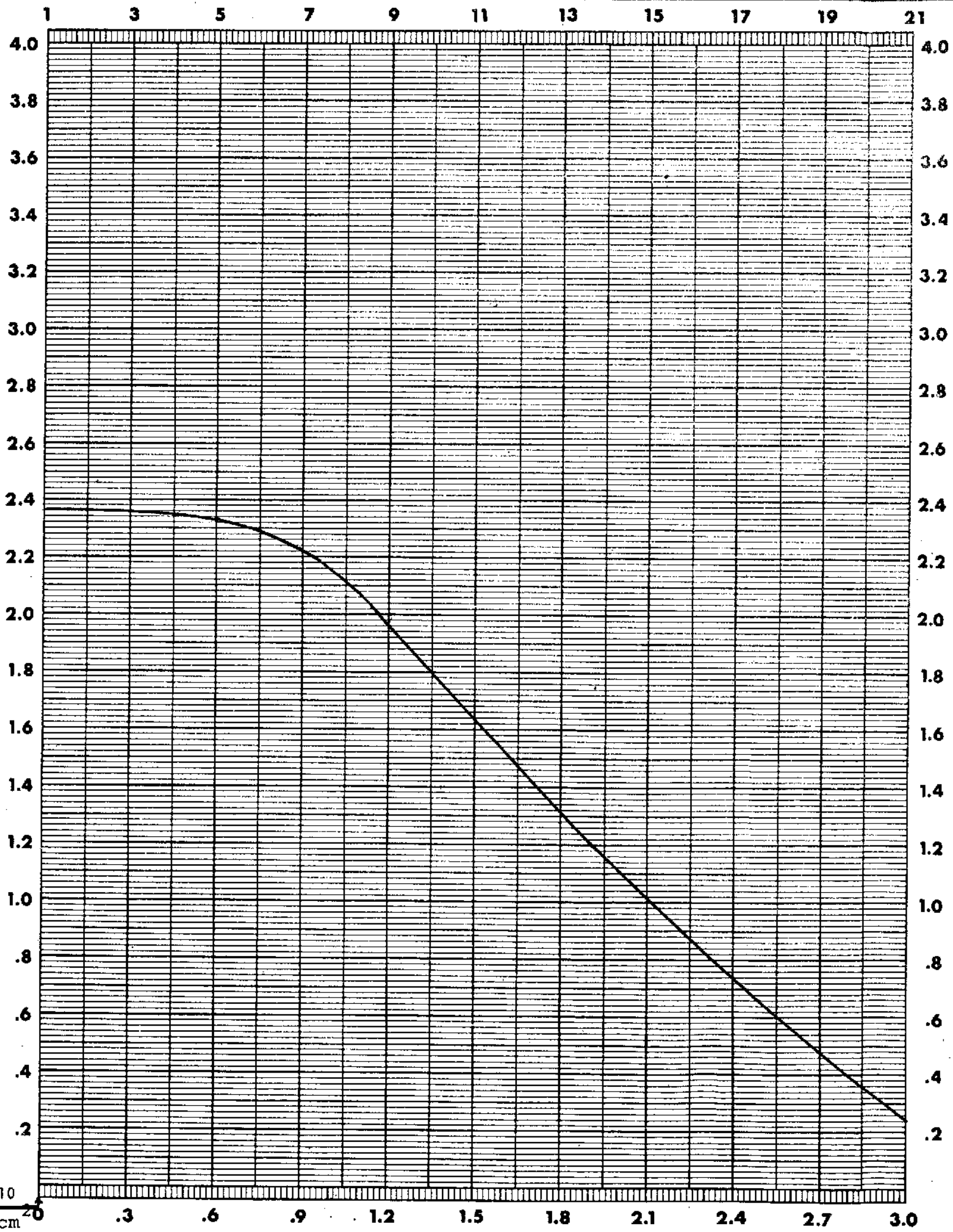

Technicolor

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

mcs ergs/cm^2

DATE 8/29/74 CONTROL # 75° Normal TASK HT-121 PREPARED BY ____

FILM CCT-D EMULSION # ____ MFG CIBA-GEIGY EXPIRATION DATE ____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-GEigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ____ °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME ____ SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE ____ MM	GAMMA
FILTER	TEMP °F 75 TIME	FILTER STatus D	BASE + FOG

CHEMICAL ANALYSIS

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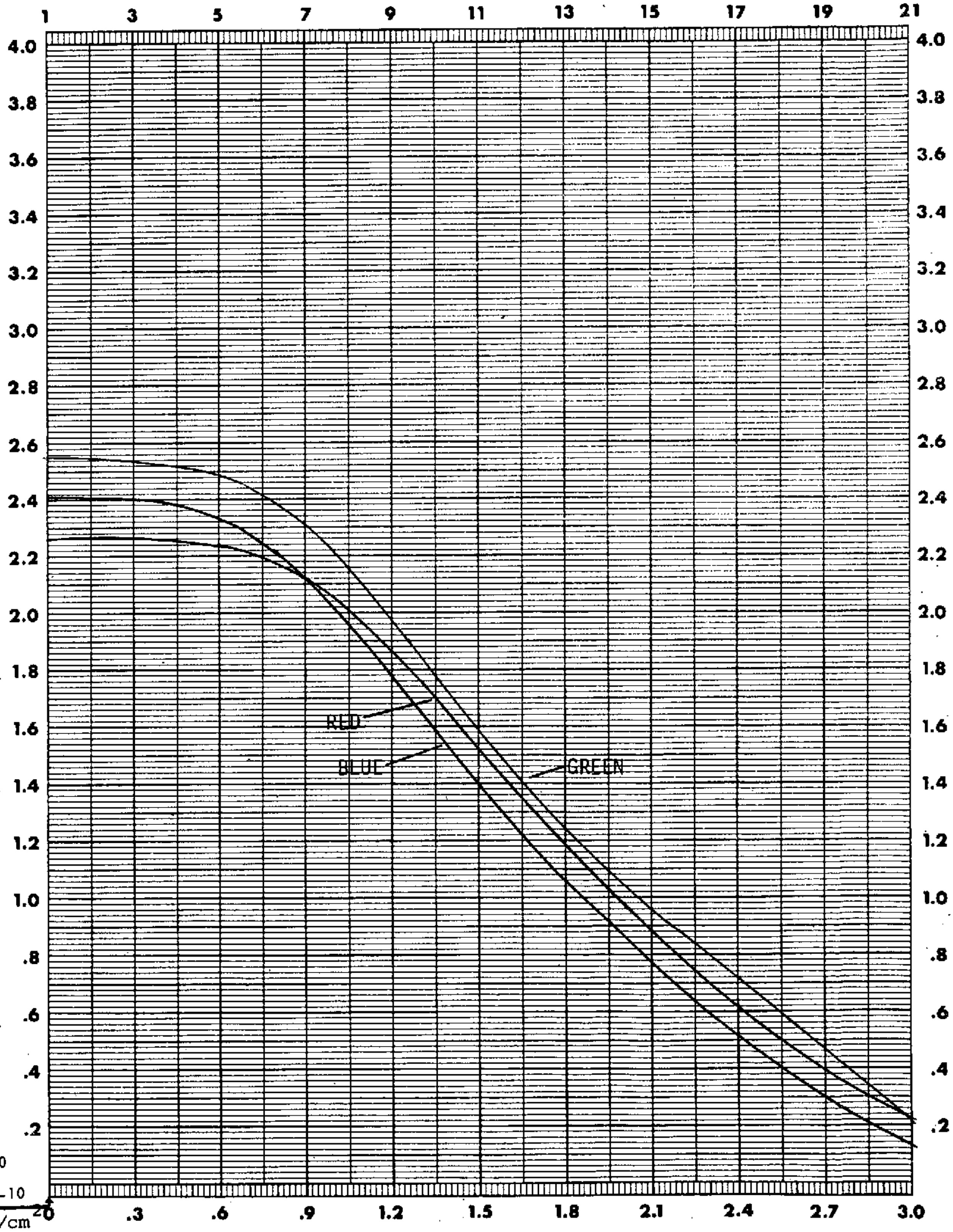

Technicolor

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

mcs ergs/cm²

DATE 8/29/74 CONTROL # 75° + 2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba- Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 75 TIME +2'DB	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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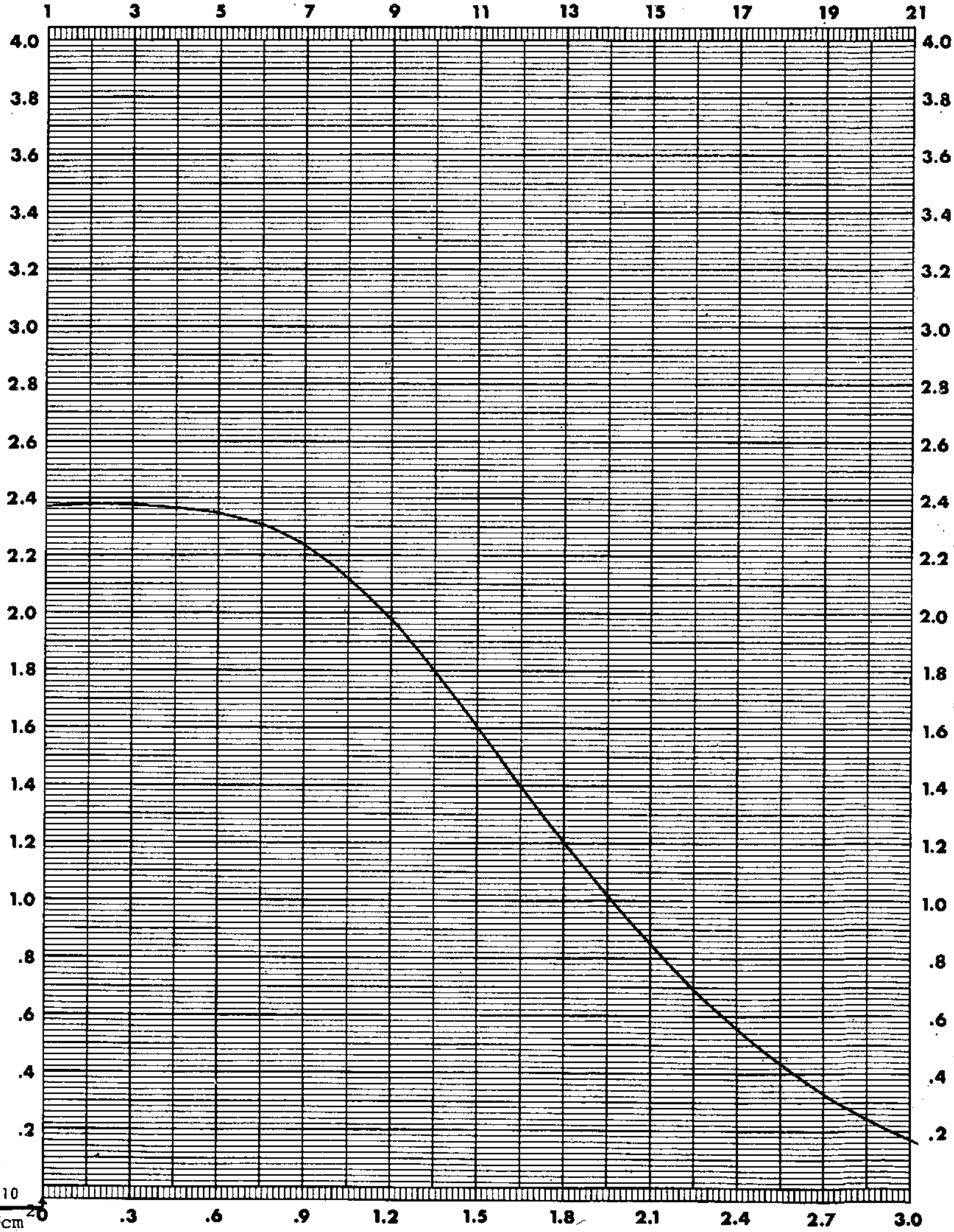

Technicolor

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mcs ergs/cm²

DATE 8/29/74 CONTROL # 75° +2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 75 TIME +2'DB	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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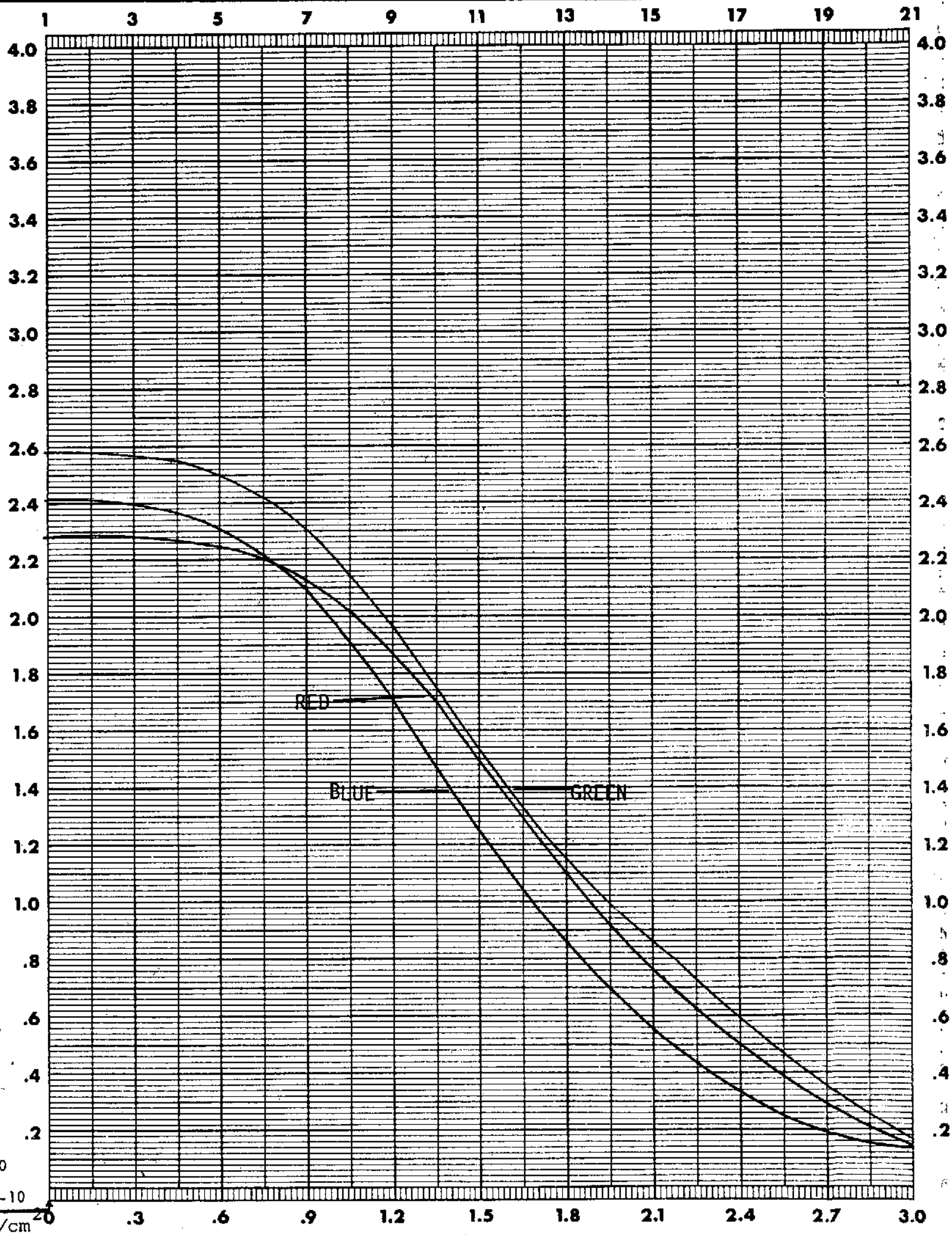

Technicolor

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

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mcs ergs/cm²

DATE 8/29/74 CONTROL # 80° Normal TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 80 TIME	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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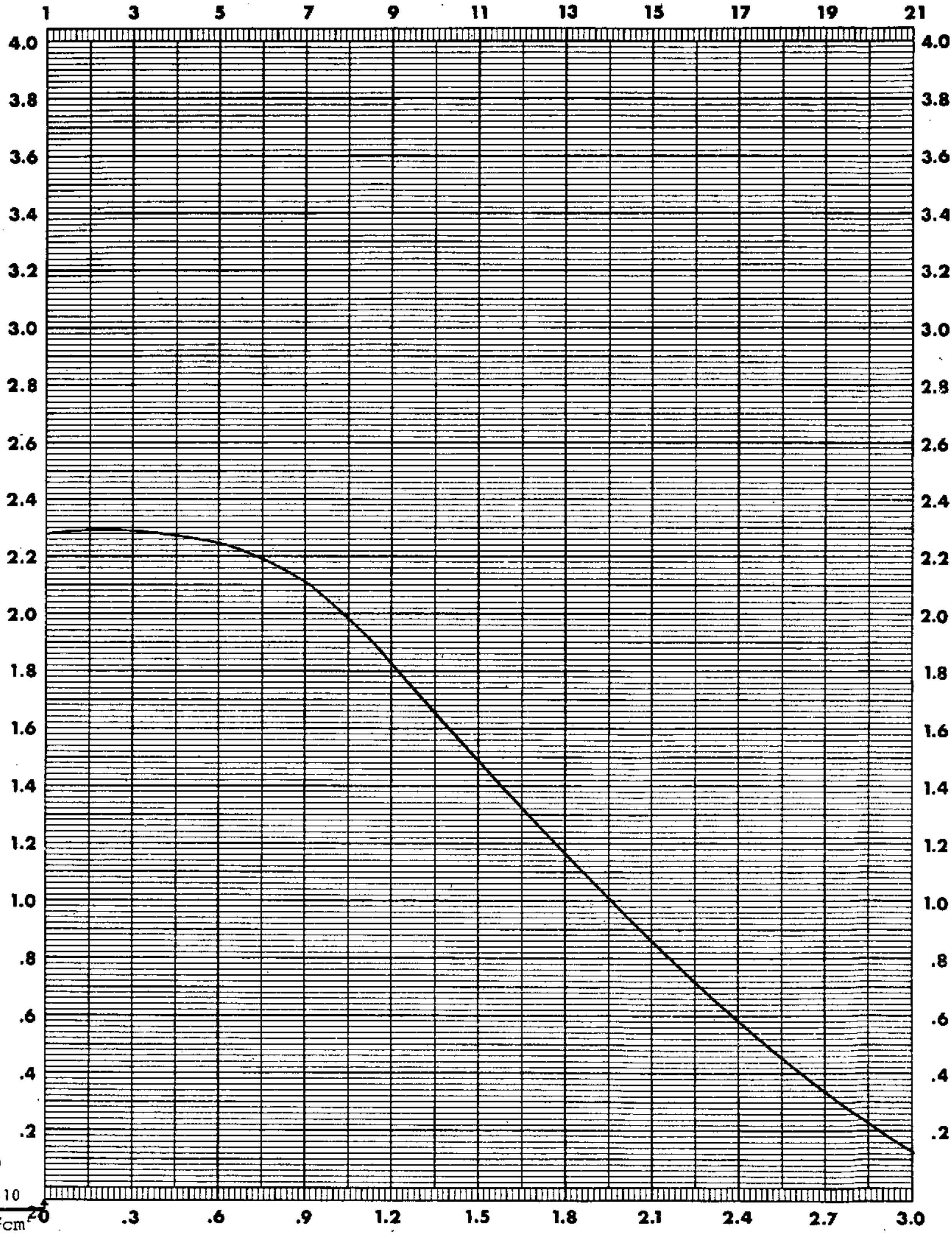

Technicolor

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−10 mcs ergs/cm²

DATE 8/29/74 CONTROL # 80° Normal TASK HT-121 PREPARED BY ______

FILM CCT-D EMULSION # ______ MFG CIBA-GEIGY EXPIRATION DATE ______

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ______ °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME ______ SEC.	SPEED ______ TANKS ______ FPM	APERTURE SIZE ______ MM	GAMMA
FILTER	TEMP °F 80 TIME	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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pH

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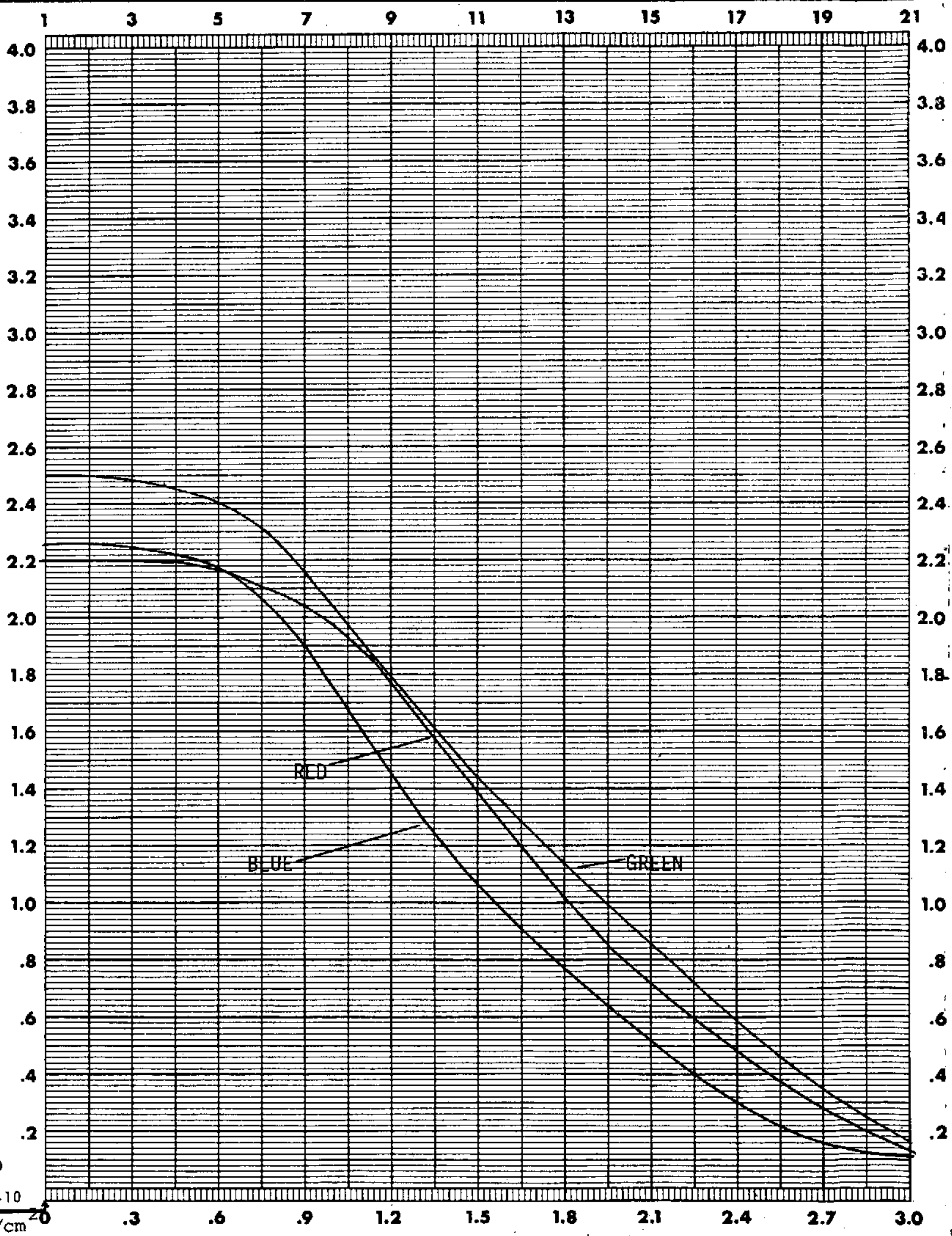

Technicolor

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

-10 mcs ergs/cm²

DATE 8/29/74 CONTROL # 80° + 2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 80 TIME + 2'DB	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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pH

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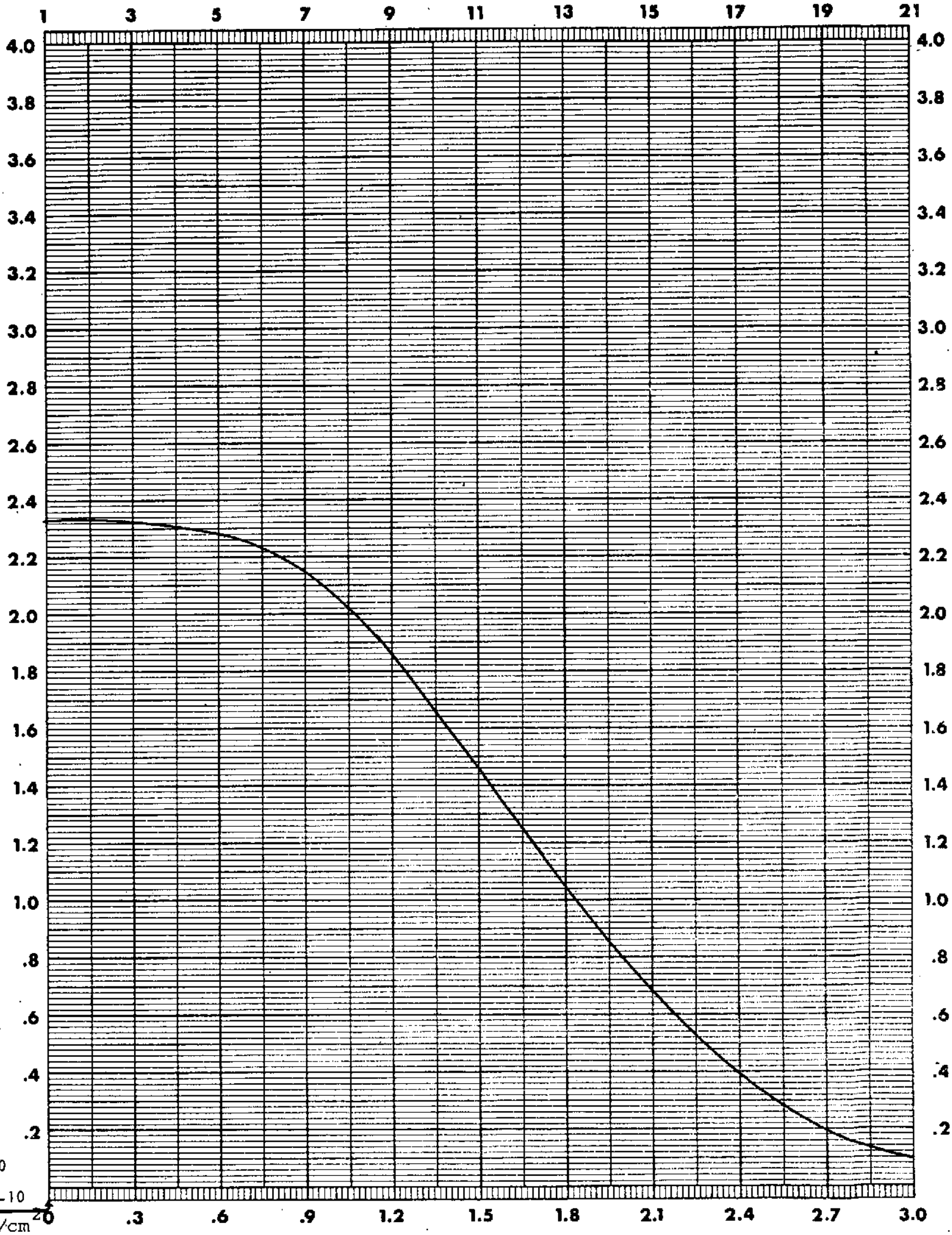

Technicolor

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mcs ergs/cm2

DATE 8/29/74 CONTROL # 80° + 2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 80 TIME	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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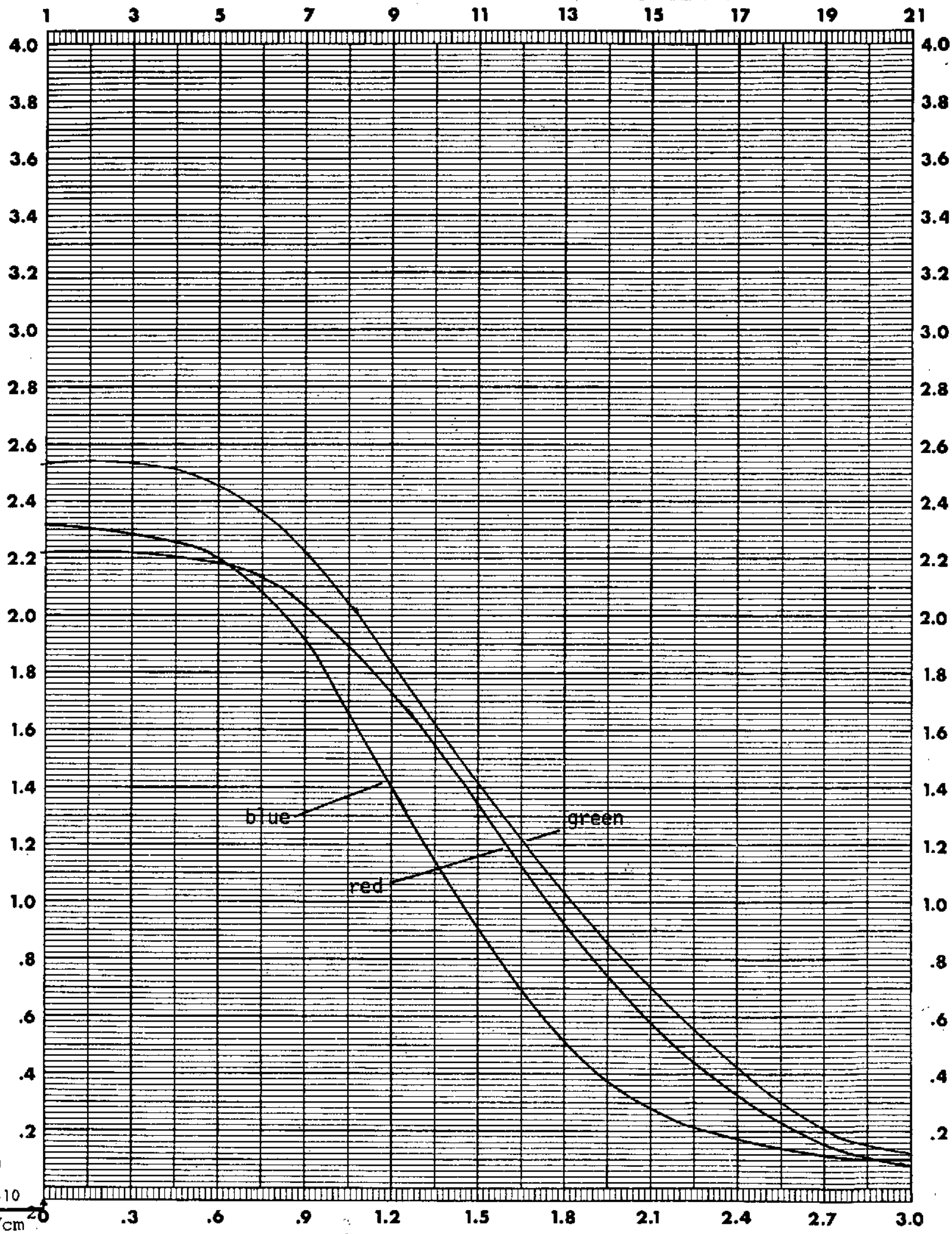

Technicolor

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

-10 mcs ergs/cm^{2}

DATE 8/29/74 CONTROL # 85° Normal TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR Pako	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP 85 TIME	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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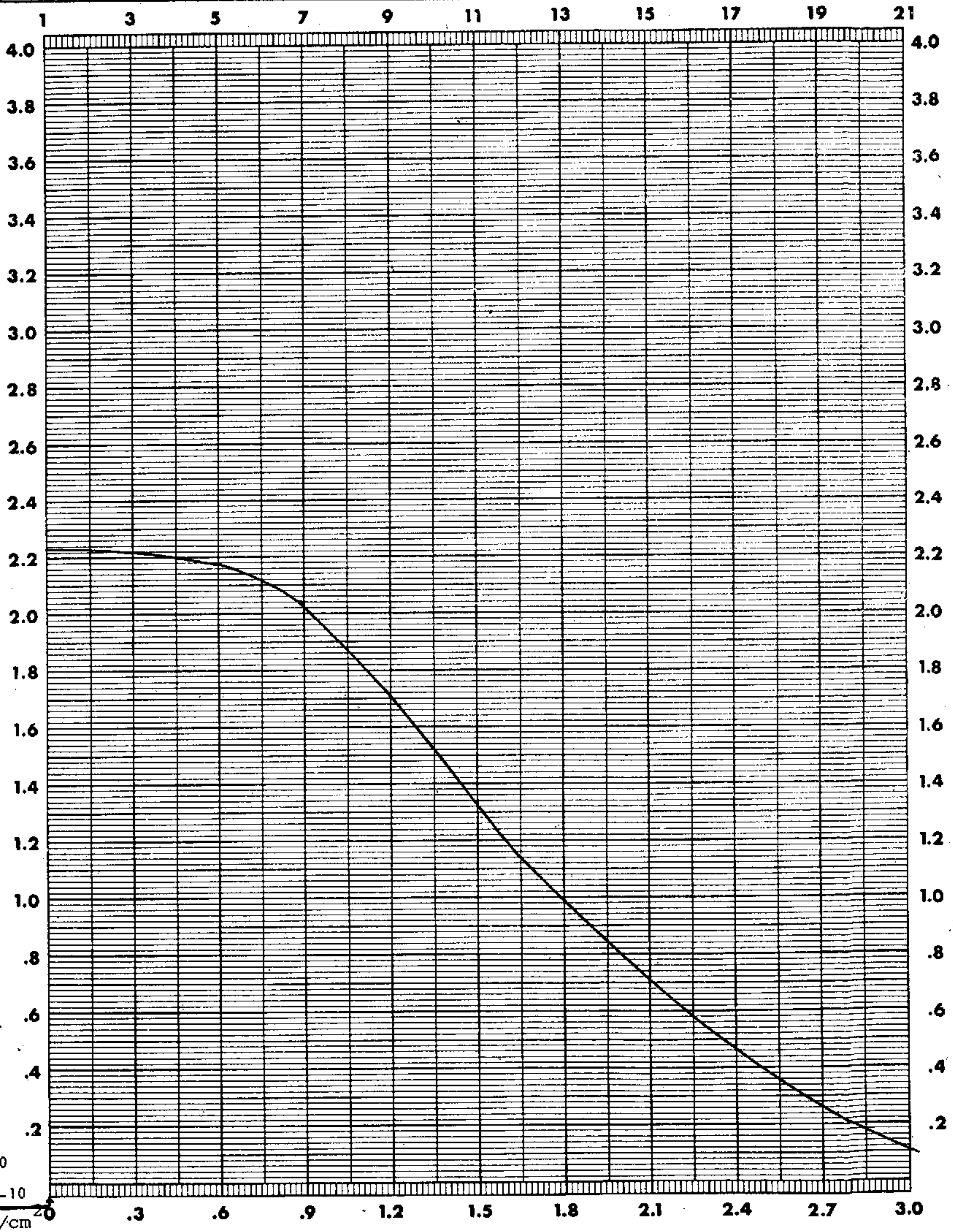

Technicolor

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

-10 mcs ergs/cm²

DATE 8/29/74 CONTROL # 85° Normal TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 85 TIME	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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pH

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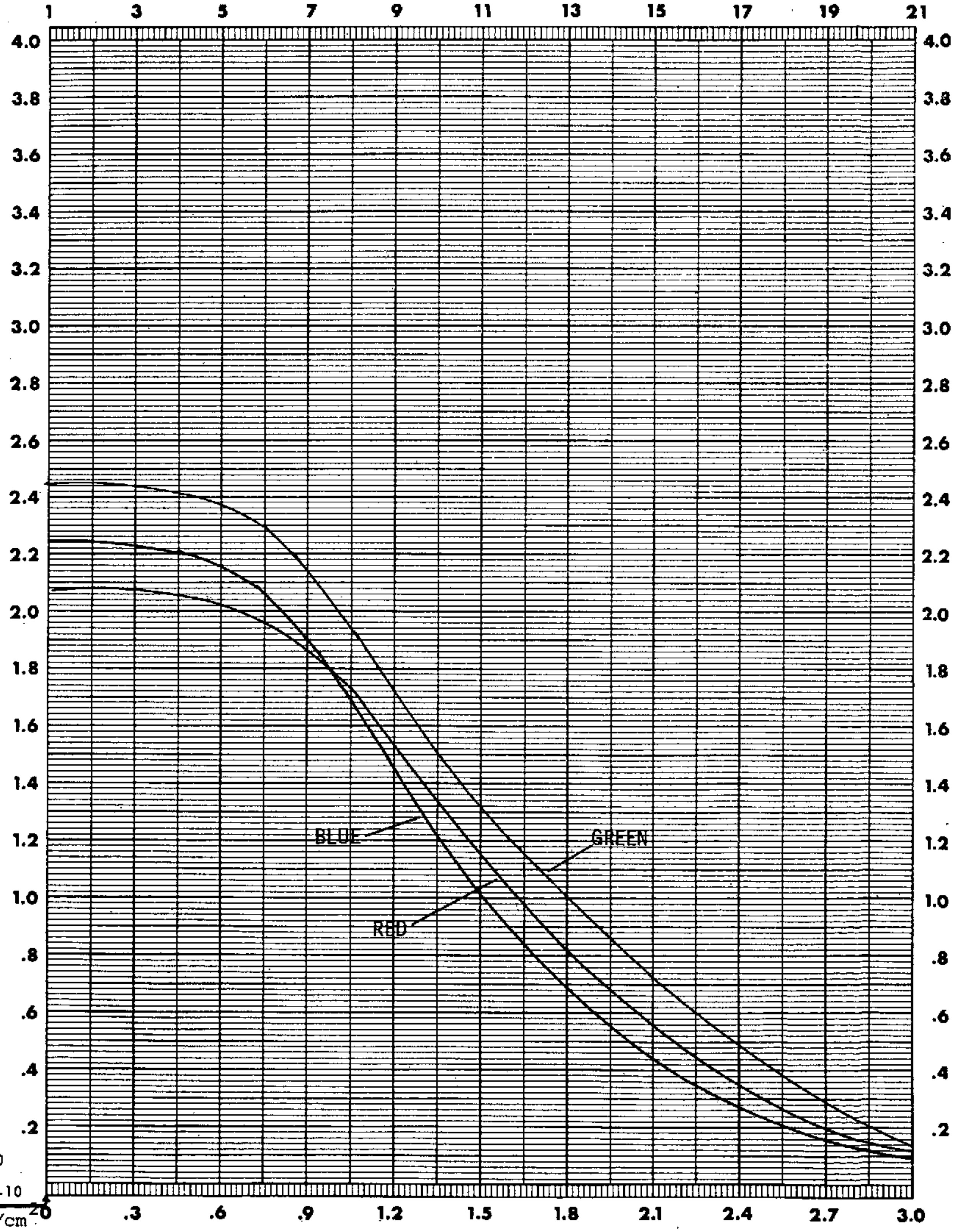

Technicolor

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

−10

mcs ergs/cm²

DATE 8/29/74 CONTROL # 85° + 2' Dye Bleach TANK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR Pako	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 85 TIME +2'DB	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

SP GR

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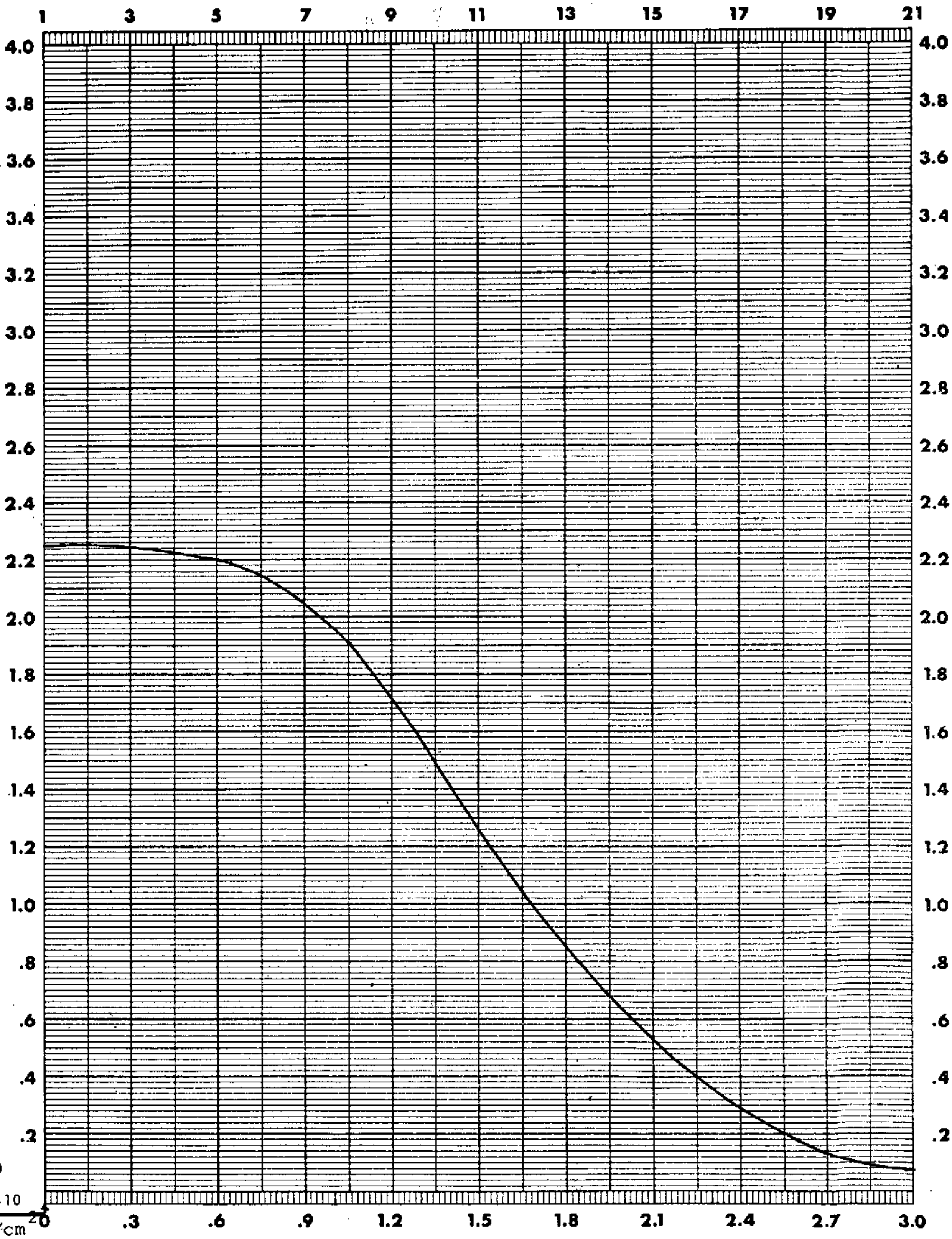

Technicolor

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

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mcs ergs/cm²

DATE 8/29/74 CONTROL # 85° + 2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCT-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE TD504	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 85 TIME +2' DB	FILTER STatus D	BASE + FOG

CHEMICAL ANALYSIS

SP GR

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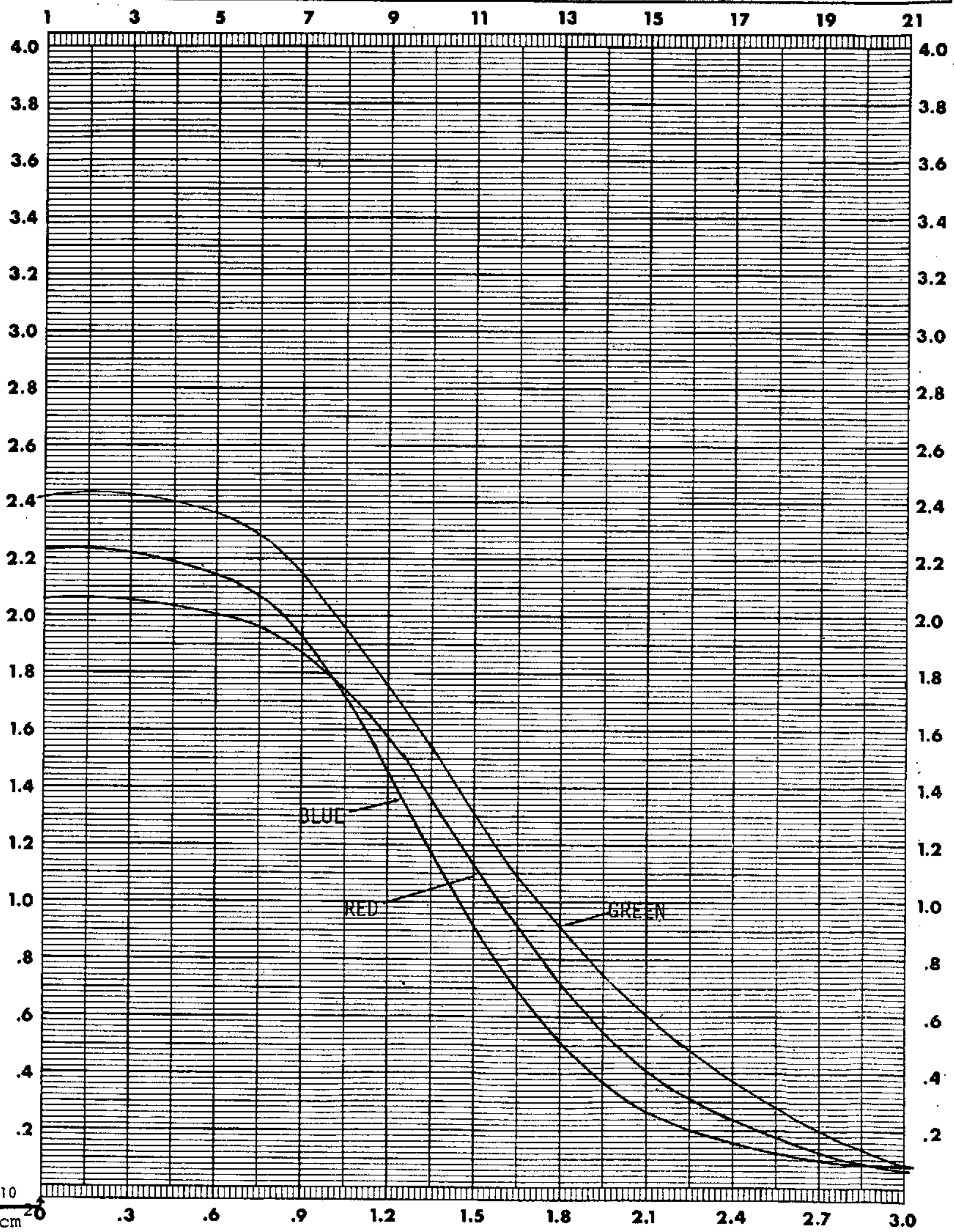

Technicolor

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

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mcs ergs/cm^2

DATE 8/29/74 CONTROL # 75° Normal TASK HT-121 PREPARED BY ____

FILM CCP-D EMULSION # ____ MFG CIBA-GEIGY EXPIRATION DATE ____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY CIBA P10	TYPE RD400D	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 75 TIME	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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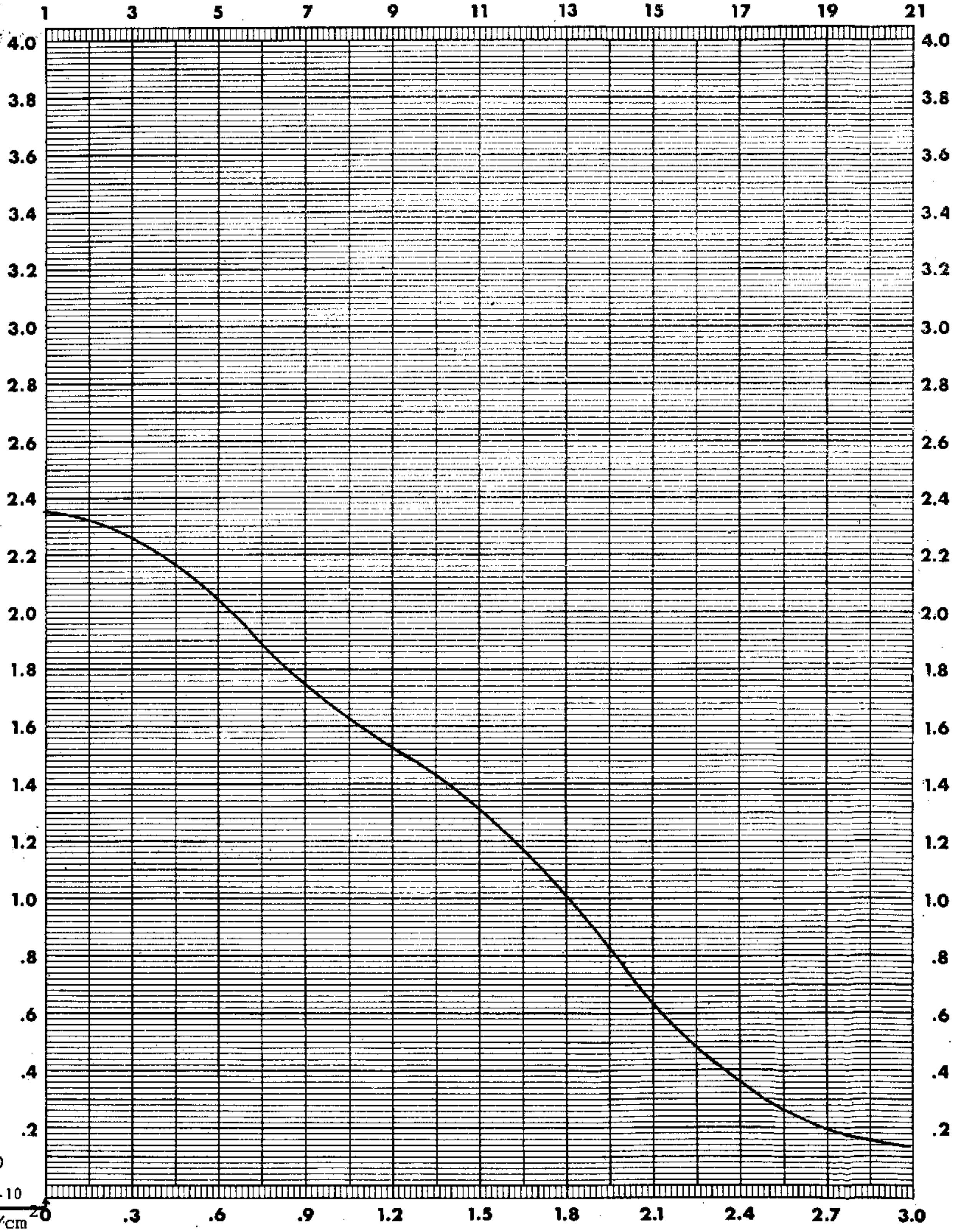

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ABSOLUTE LOG E AT R.L.E. = 0

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mcs ergs/cm2

DATE 8/29/74 CONTROL # 75° TASK HT-121 PREPARED BY ________

FILM CCP-D EMULSION # ________ MFG CIBA-GEIGY EXPIRATION DATE ________

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ____ °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME ____ SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE ____ MM	GAMMA
FILTER	TEMP °F 75 TIME	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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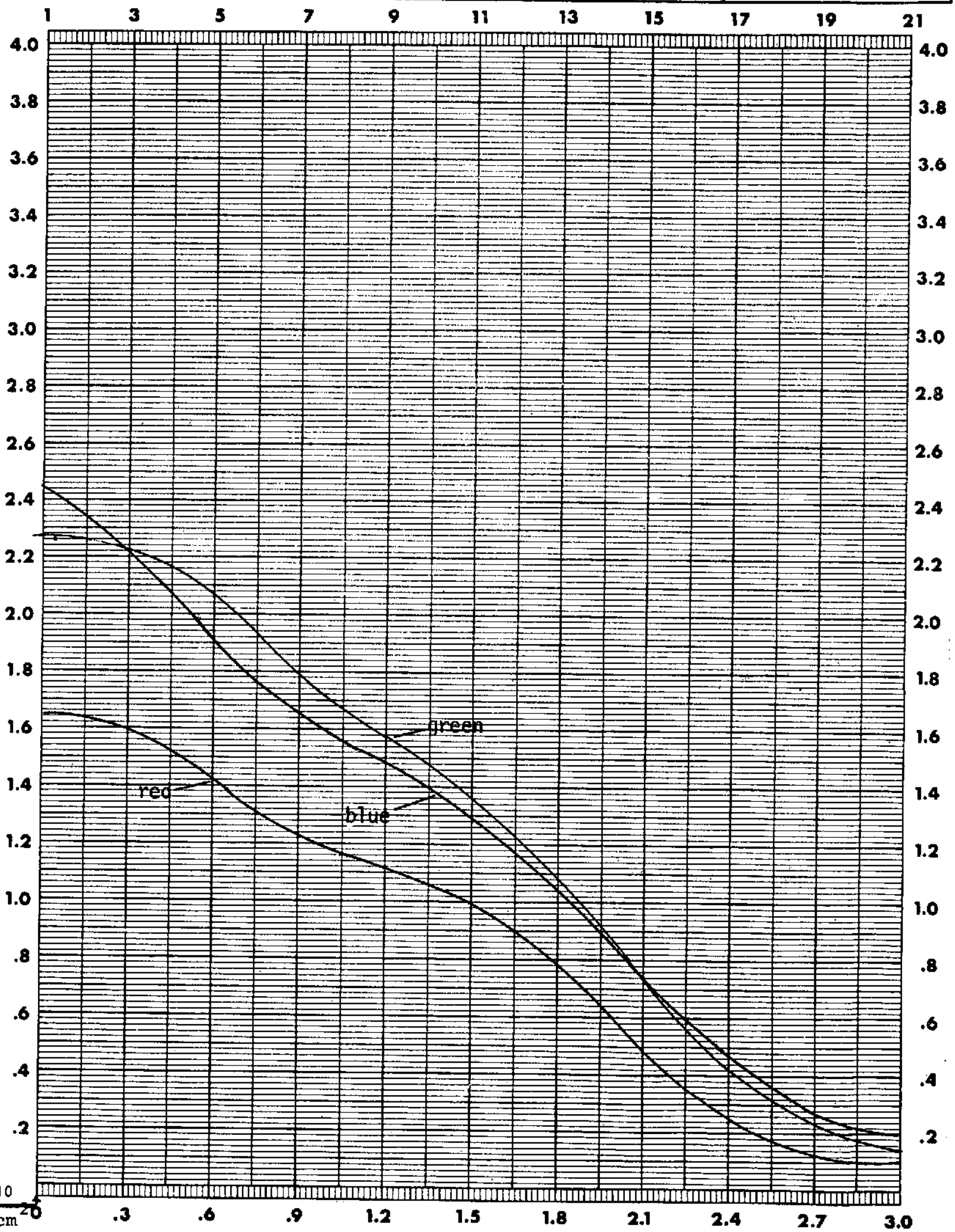

Technicolor

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

−10 mcs ergs/cm²

DATE 8/29/74 CONTROL # 75° +2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCP-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY CIBA P10	TYPE RD400D	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 75 TIME +2' DB	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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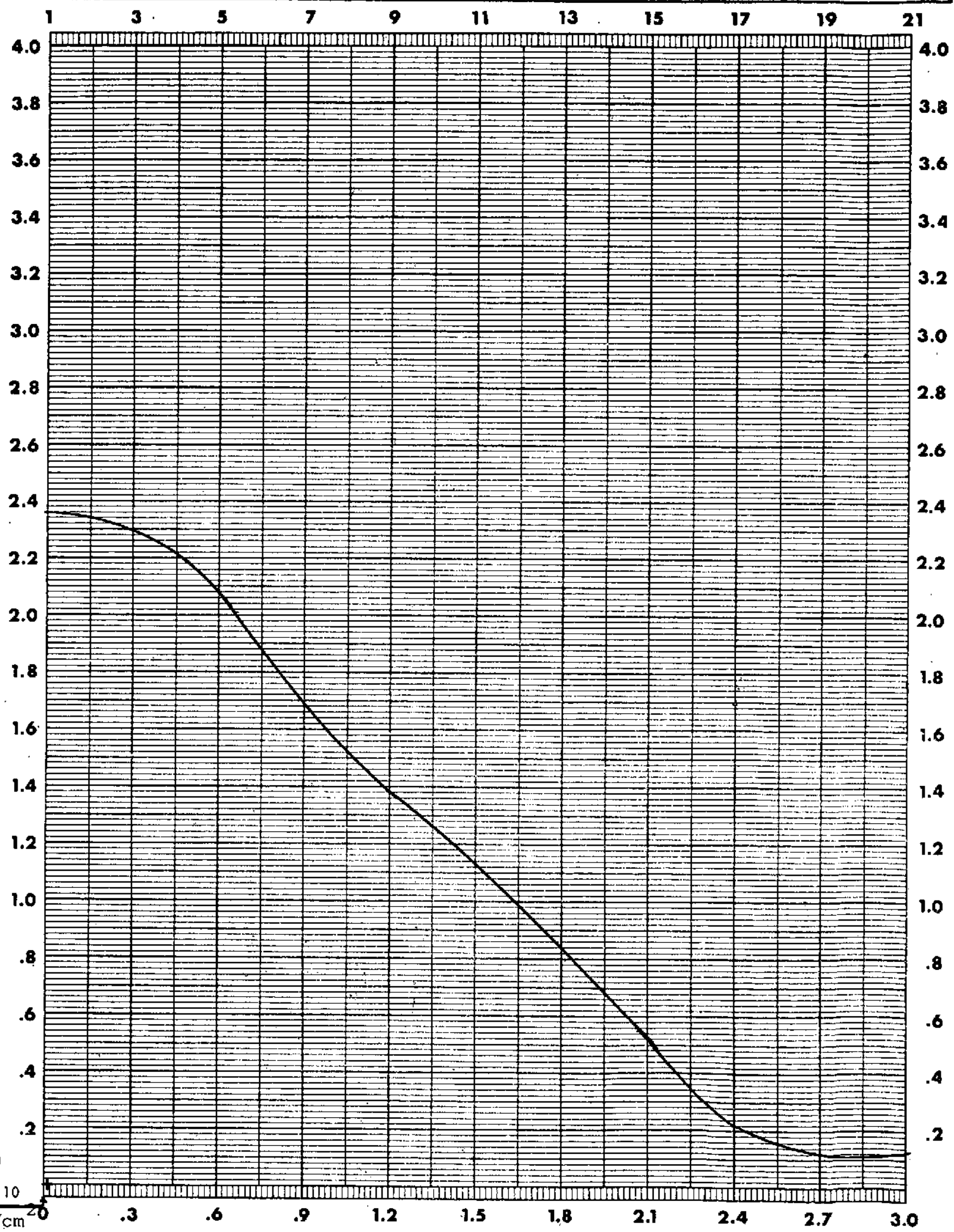

Technicolor

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

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mcs ergs/cm^2

DATE 8/29/74 CONTROL # 75° + 2' Dye Bleach HT-121 PREPARED BY

FILM CCP-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY CIBA P10	TYPE RD400D	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 75 TIME +2'DB	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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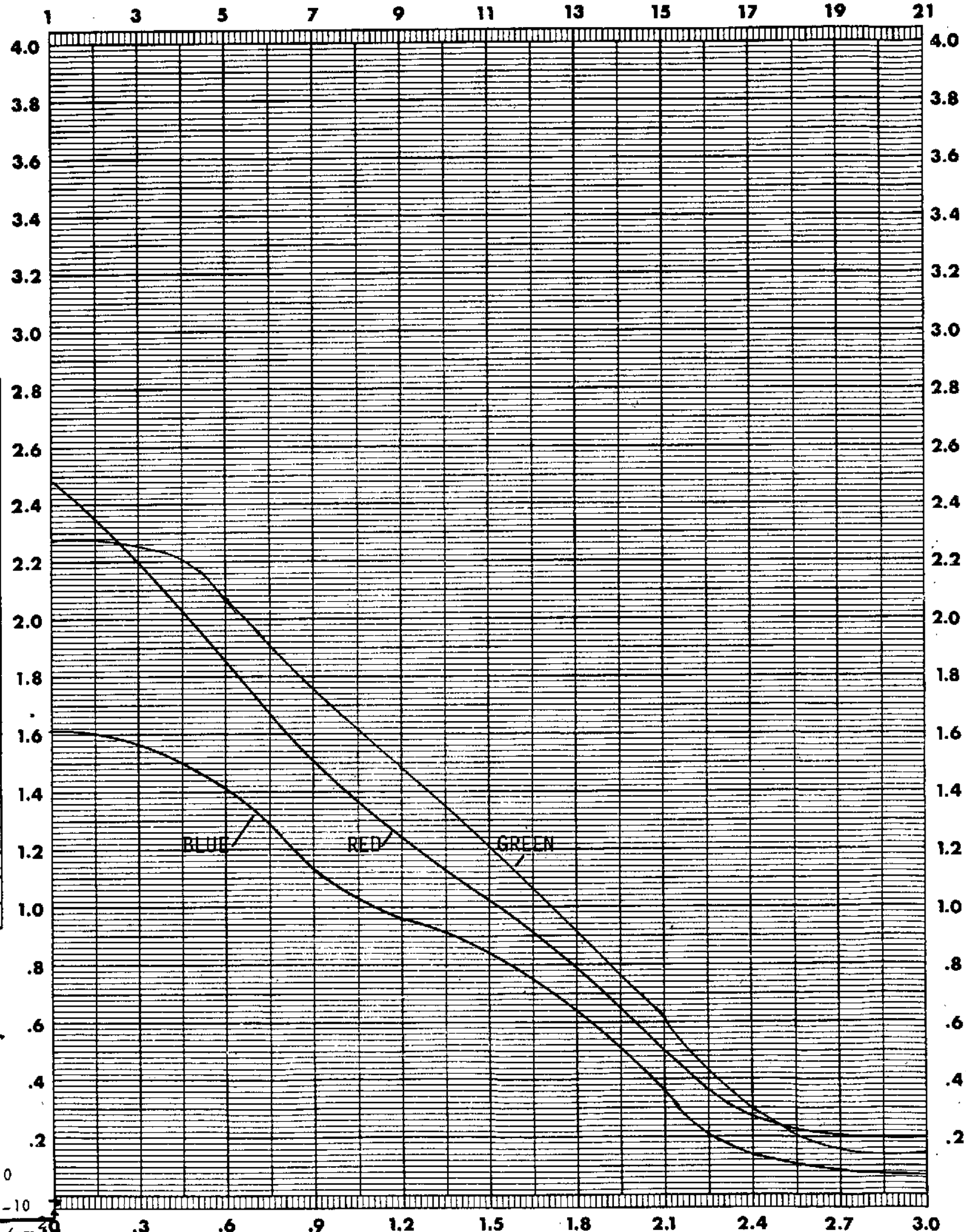

Technicolor

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

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mcs ergs/cm

DATE 8/29/74 CONTROL # 80° Normal TASK HT-121 PREPARED BY ____

FILM CCP-D EMULSION # ____ MFG CIBA-GEIGY EXPIRATION DATE ____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ____ °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME ____ SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE ____ MM	GAMMA
FILTER	TEMP °F 80 TIME	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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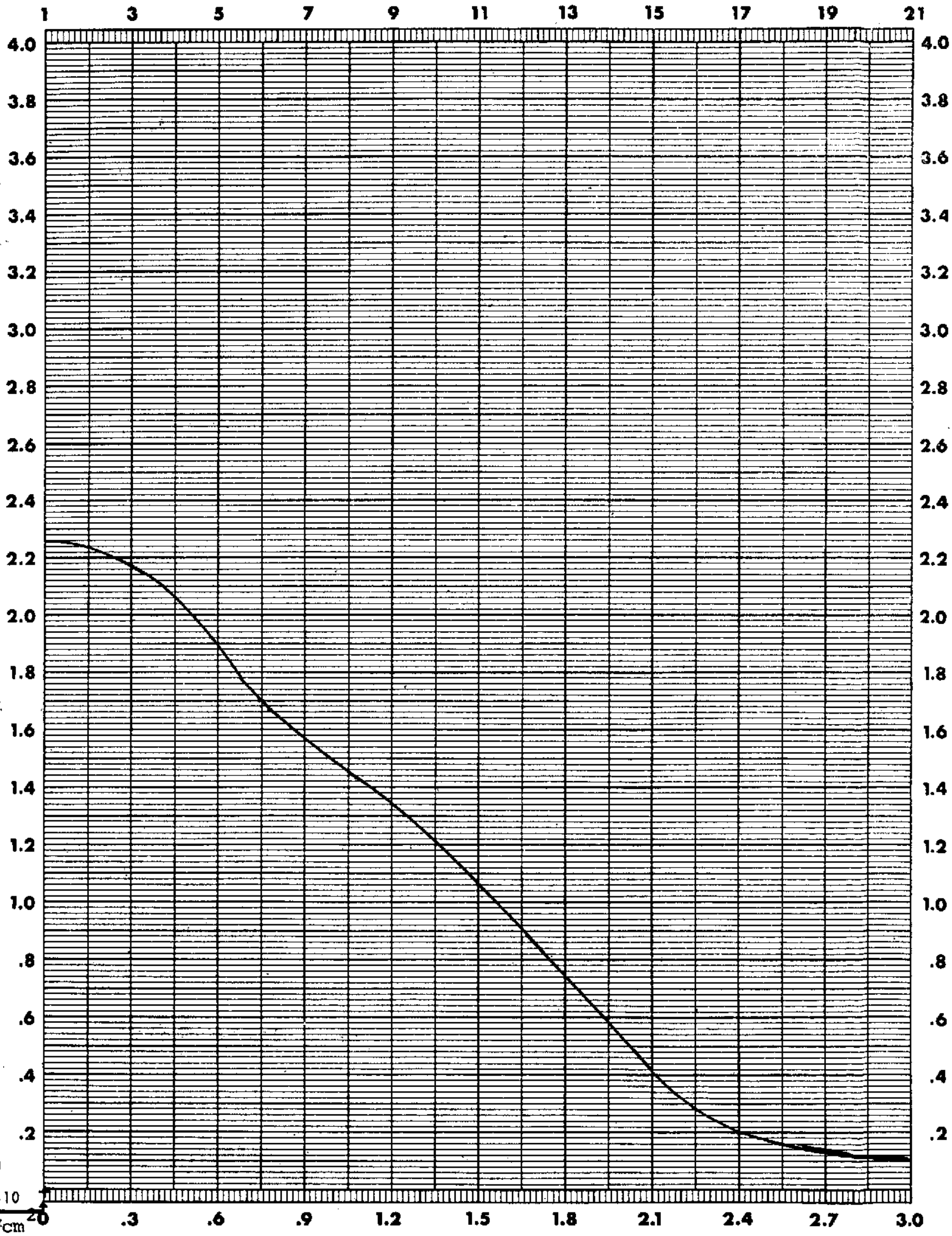

Technicolor

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

-10 mcs ergs/cm²

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FILM CCP-D EMULSION # ______ MFG CIBA-GEIGY EXPIRATION DATE ______

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ______ °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME ______ SEC.	SPEED ______ TANKS ______ FPM	APERTURE SIZE ______ MM	GAMMA
FILTER	TEMP °F 80 TIME	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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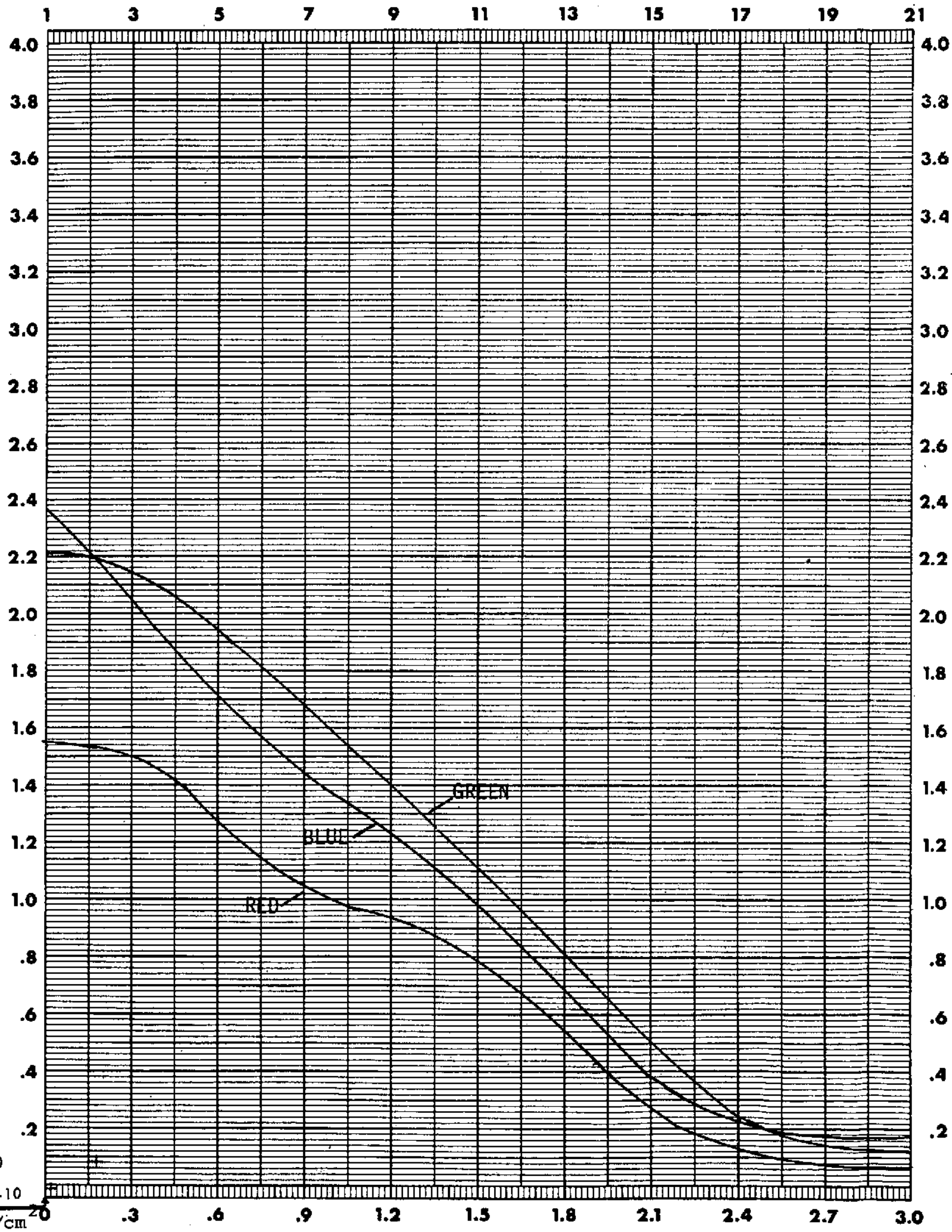

Technicolor

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

−10 mcs ergs/cm²

DATE 8/29/74 CONTROL # 80° + 2'Dye Bleach TASK HT-121 PREPARED BY ______

FILM CCP-D EMULSION # ______ MFG CIBA-GEIGY EXPIRATION DATE ______

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ______ °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME ______ SEC.	SPEED ______ TANKS ______ FPM	APERTURE SIZE ______ MM	GAMMA
FILTER	TEMP °F 80 TIME +2'DB	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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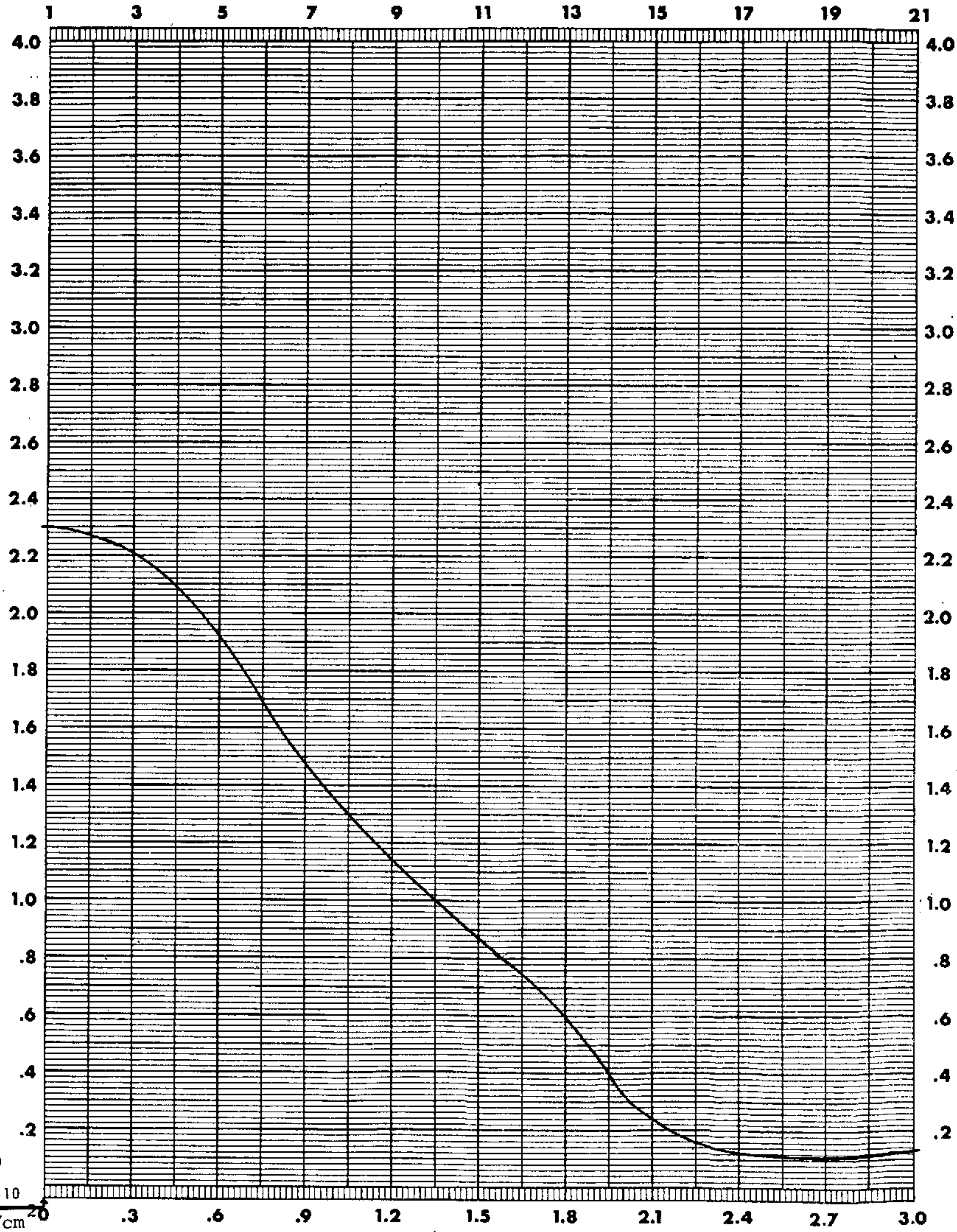

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ABSOLUTE LOG E AT R.L.E. = 0

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DATE 8/29/74 CONTROL # 80° + 2'Dye Bleach TASK HT-121 PREPARED BY

FILM CCP-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 80 TIME +2'DB	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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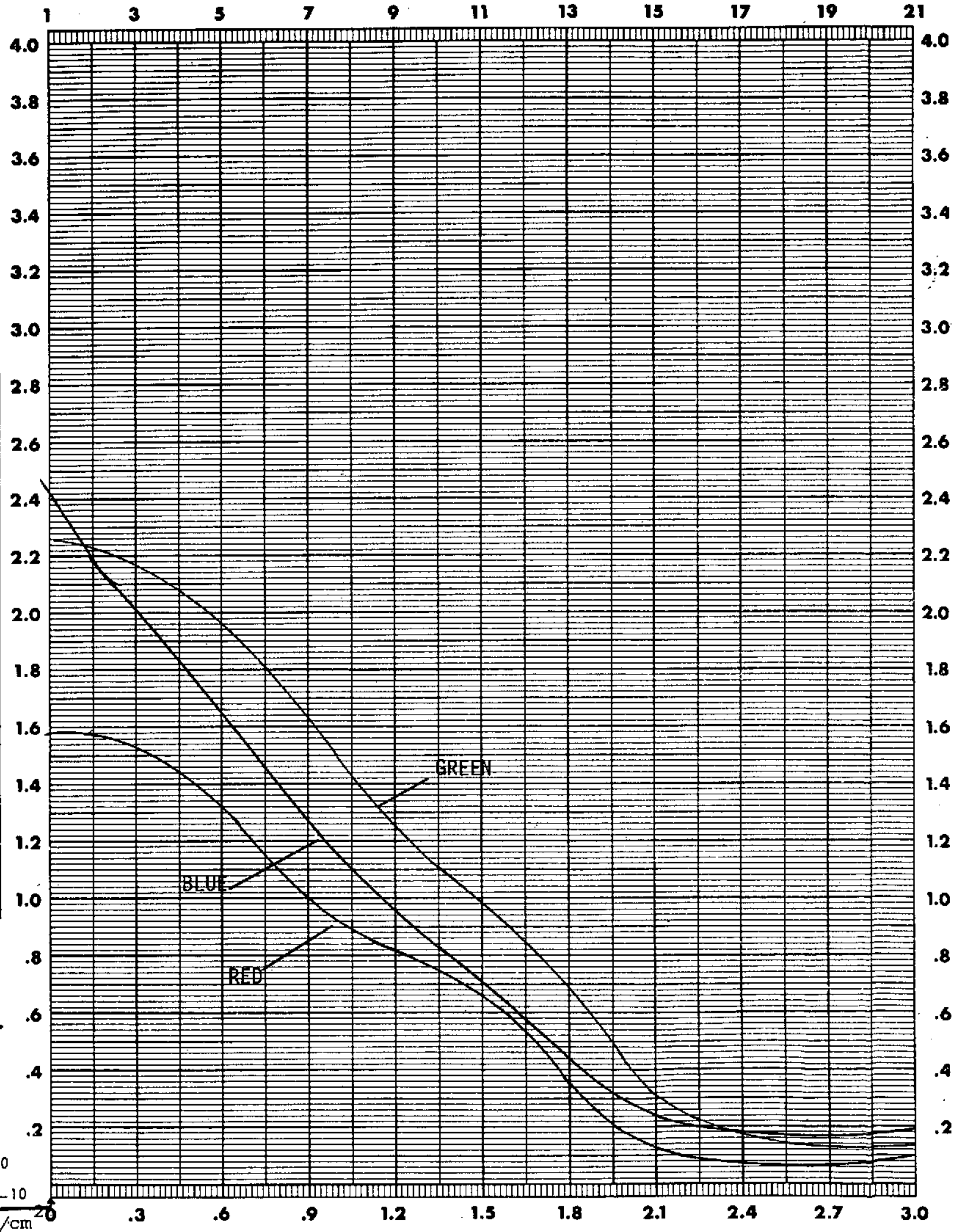

Technicolor

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

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mcs ergs/cm²

DATE 8/29/74 CONTROL # 85° Normal TASK HT-121 PREPARED BY

FILM CCP-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 85 TIME	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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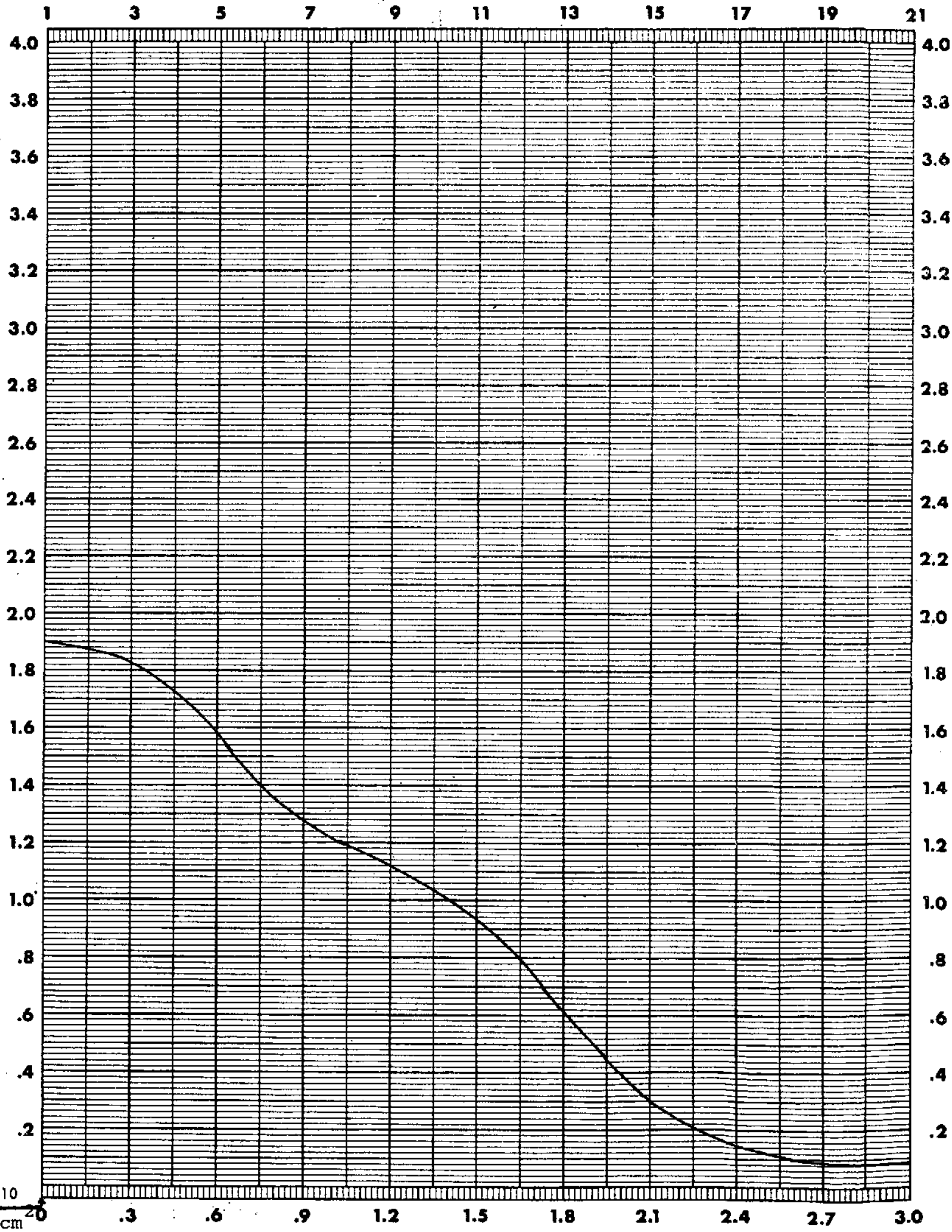

Technicolor

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

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mcs ergs/cm²

DATE 8/29/74 CONTROL # 85° Normal TASK HT-121 PREPARED BY ____

FILM CCP-D EMULSION # ____ MFG CIBA-GEIGY EXPIRATION DATE ____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ____ °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME ____ SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE ____ MM	GAMMA
FILTER	TEMP °F 85 TIME	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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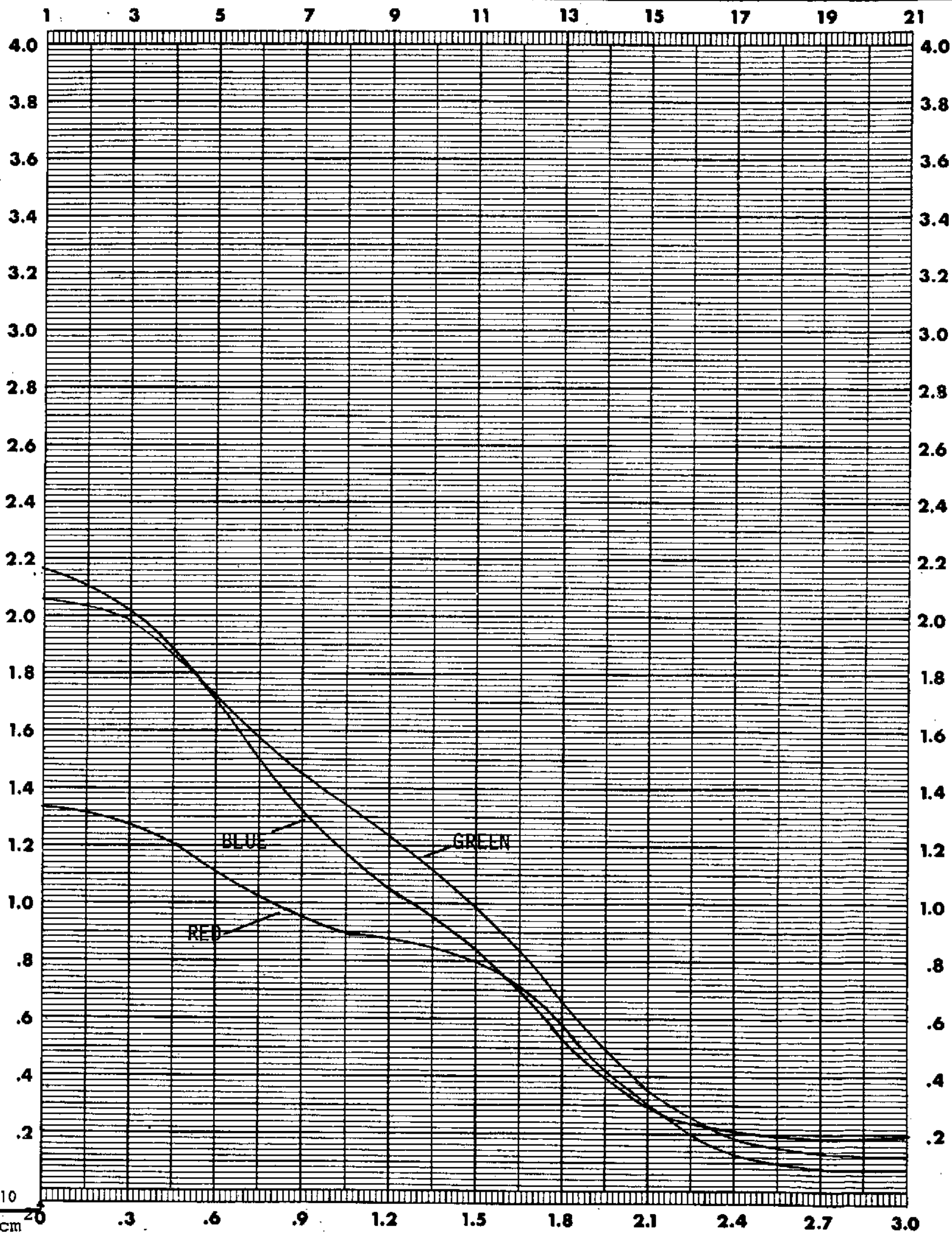

Technicolor

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

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mcs ergs/cm 2

DATE 8/29/74 CONTROL # 85° + 2'Dye Bleach TASK HT-121 PREPARED BY ________

FILM CCP-D EMULSION # ________ MFG CIBA-GEIGY EXPIRATION DATE ________

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT ____ °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME ____ SEC.	SPEED ____ TANKS ____ FPM	APERTURE SIZE ____ MM	GAMMA
FILTER	TEMP °F 85 TIME +2'DB	FILTER Visual	BASE + FOG

CHEMICAL ANALYSIS

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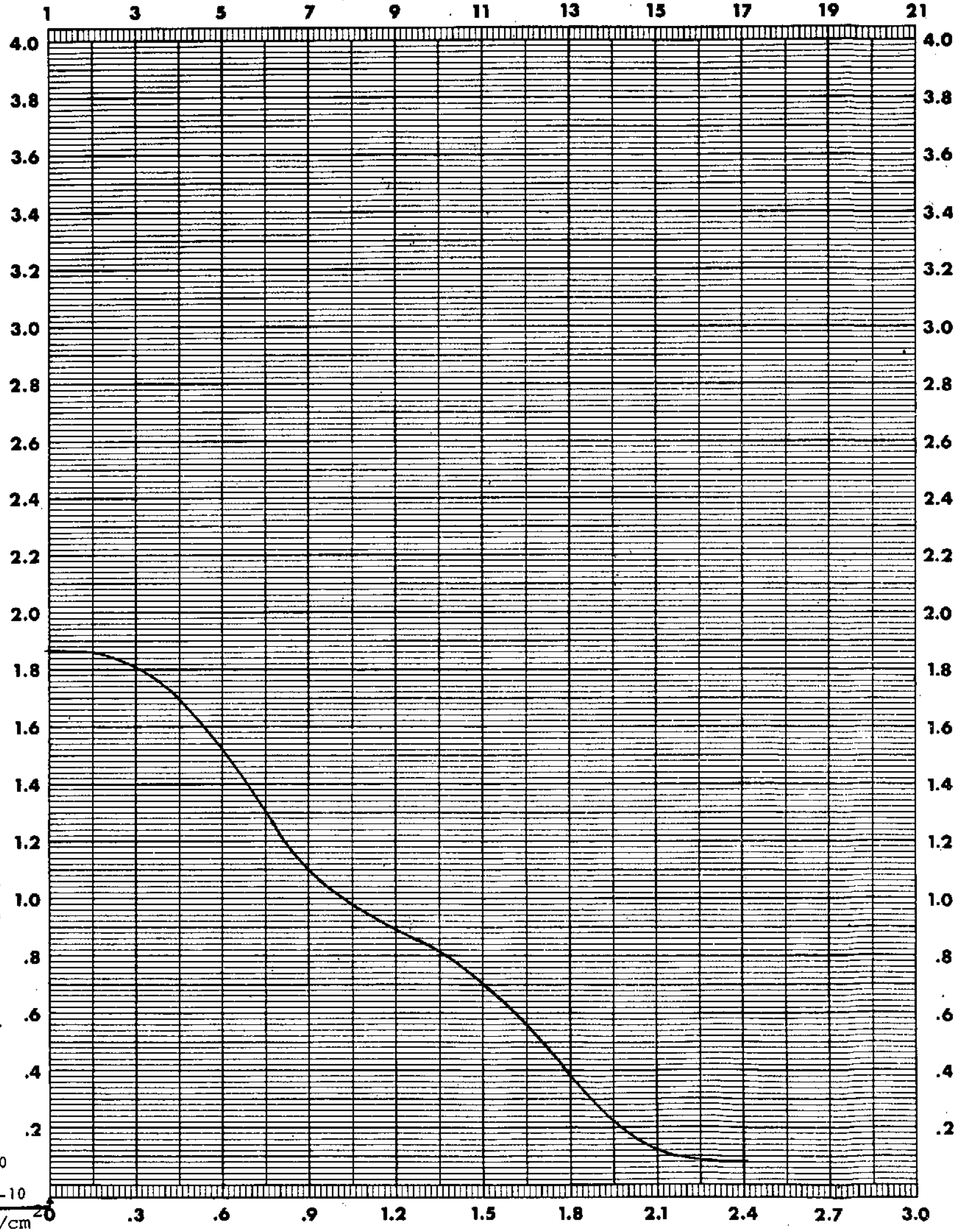

Technicolor

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

mcs ergs/cm2

DATE 8/29/74 CONTROL # 85° + 2' Dye Bleach TASK HT-121 PREPARED BY

FILM CCP-D EMULSION # MFG CIBA-GEIGY EXPIRATION DATE

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY	
SENSITOMETER Ciba-Geigy	PROCESSOR PAKO	INSTRUMENT MacBeth	SPEED ( )
ILLUMINANT °K	CHEMISTRY Ciba P10	TYPE RD400D	D-MAX
TIME SEC.	SPEED TANKS FPM	APERTURE SIZE MM	GAMMA
FILTER	TEMP °F 85 TIME + 2'DB	FILTER Status D	BASE + FOG

CHEMICAL ANALYSIS

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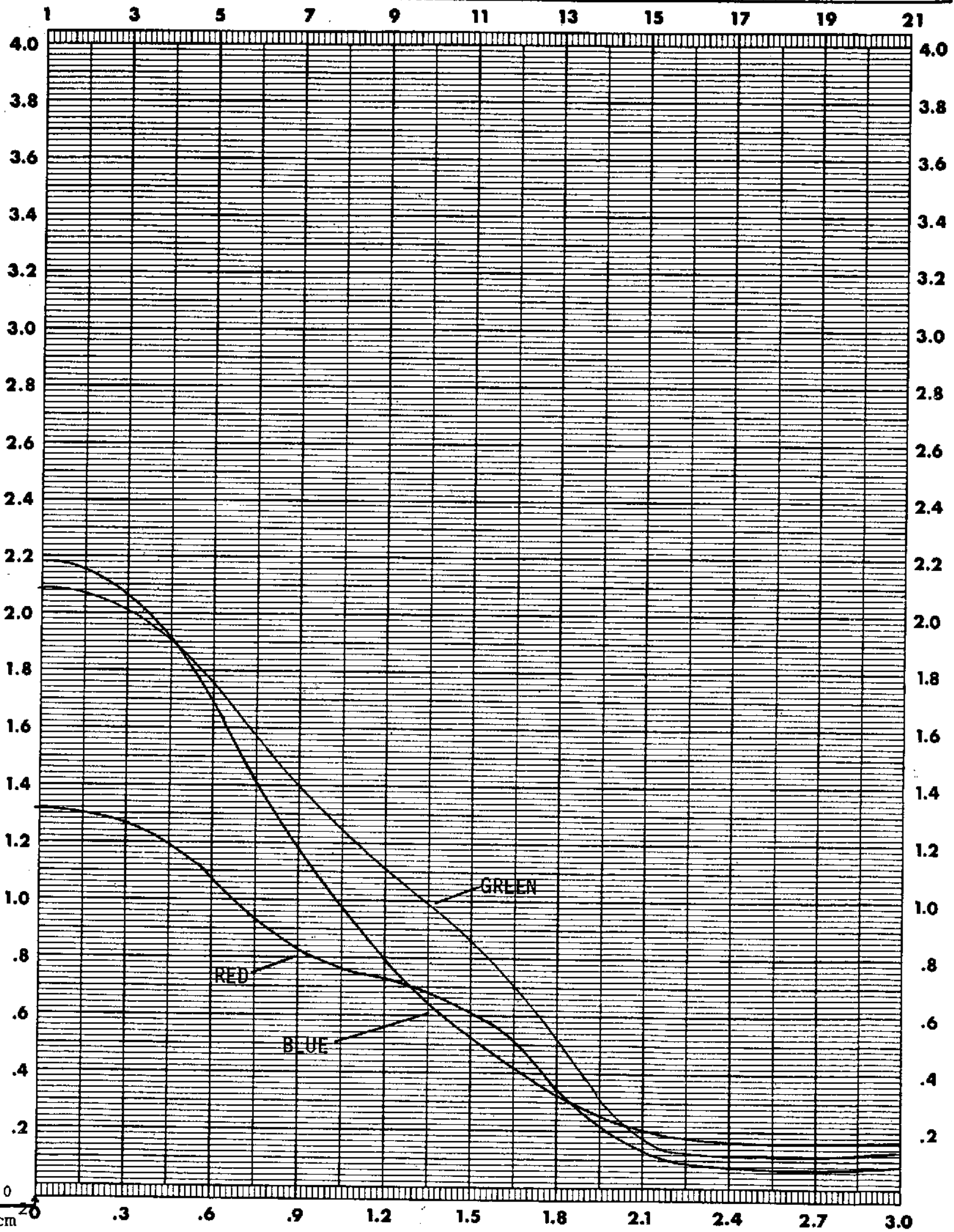

Technicolor

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

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mcs ergs/cm²

APPENDIX B

Reproduced from
THE BRITISH JOURNAL OF PHOTOGRAPHY
5th October 1973

The Conservation of Colour Photographic Records

®Cibachrome-Print

The title of the RPS Colour Group's symposium* on 20 September and its venue, the Victoria and Albert Museum, suggest immediately that the original prime aim would have been the establishment of methods of achieving archival permanence in colour photography. That being so, the archivists among the attendance could have derived little comfort from the papers and discussion, at least in terms of preserving existing colour photographs in their original form.

In fact the discussion and the papers themselves, as well as the list of the 150 participants' affiliations, showed the interests to be divided into three fairly distinct classes: the archivists, who seek —as a starting point—preservation for a century; colour photographers who wish their transparencies and negatives to last for as long as they require them, of the order of decades; and photographic manufacturers and display organisers who wish to avoid visible deterioration of colour rendering over the period, days or weeks, that material is on view to the public.

These groups, then, had interests in two types of deterioration—that occurring in use, and that taking place during storage.

A century of colour

That colouring materials—including transparent ones—could be considered permanent for the sort of period the archivist requires was demonstrated by the opening paper by Mr J. C. Strand, Officer-in-Charge of the Slide Loan Collection of the Victoria and Albert Museum. Little exhibited examples from the Museum's collection of Victorian hand-coloured slides, many of them antedating photography itself with others on a monochrome photographic base, showed as far as one could judge, undimmed colour on projection. There followed a rapid review of colour slide making methods employed in the past to record the Museum's exhibits as an educational visual aid, culminating in the current 35mm transparency.

The light fastness of colour photographs

Several of the speakers dealt with the fading of colour transparencies and prints under normal and abnormal conditions of use. It is reasonable to suppose that materials which are resistant to fading under extreme conditions might also be more resistant to deterioration under normal exposure, so that several more or less empirical accelerated test methods were described, and, in some cases, correlated with less severe tests.

Unfortunately the withdrawal of the paper billed in the provisional programme to be given by Dr G. I. P. Levenson on 'The Conservation of Kodak Materials' deprived the meeting of an anticipated authoritative comparison of different Kodak materials, which are of course used to make the bulk of the colour records to be conserved.

Dr C. H. Giles, Department of Pure and Applied Chemistry, University of Strathclyde, deal in his contribution with several of the topics covered by his paper on the subject published earlier this year[1]. Working in accordance with BS1006:1961 — which covers light fastness of textile materials—Dr Giles' group had exposed materials to high levels of radiation from a Microscal fading lamp. This employs a tungsten-mercury vapour 500W lamp in a fluorescent envelope with samples and controls mounted on the inside wall of a cylindrical container surrounding the lamp.

The BSI light-fastness scale has 8 categories, 1 being the least resistant to fading and 8 the most. The degree of fading on a standard textile specimen can be shown to be close to a linear function of log (exposure time). The curves in Fig 1 show the change in light fastness of single-colour wedges of the three dyes used in non-substantive reversal films as a function of, effectively, the density of the original colour. These show that (a) resistance to fading increases with increasing original density, (b) the different dyes show very different fastness, in this case cyan being the best and magenta the worst, and (c) the rate of change of light fastness with density is different for the three dyes, again in this case cyan being the most density-dependent. The practical result of this is that when a transparency fades not only does its overall density decrease but the colour balance of areas of different density changes in different ways. The general observation in this particular material is a change towards the blue-green most evident in areas of originally high density.

It had proved possible to effect a rough correlation of the laboratory findings with practical empirical tests of actual transparencies illuminated for long periods in a slide projector. Exposures were in steps of 1, 2, 4 and 8 hours. One significant point that emerged was that cumulative short exposures have much the same effect as long ones. The laboratory and 'field' observations that the slowest film tested (Kodachrome II) had the greatest light fastness (in the range 2-4) and the faster films less was attributed by Dr Giles to an inverse relationship

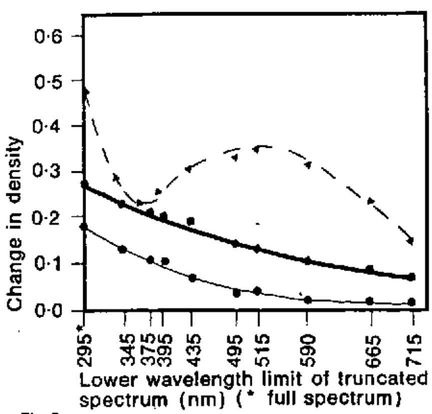

Fig 2
Spectral dependence of fading in Cibachrome-type dyes. Change in density (from an arbitrary standard initial density) produced by a given exposure to xenon lamp spectrum truncated at various wavelengths. Upper curve—cyan, centre—magenta, lower—yellow. The percentage of the total spectrum energy at the given cut-offs is 295—100%, 345—98.5%, 375—96%, 395—94%, 435—90%, 495—87%, 515—84%, 590—79%, 665—65.5%, 715—57.5% (Courtesy CIBA–GEIGY).

between original emulsion speed and stability. To an outsider it remains unresolved however, whether some at least of the differences could arise from the nature of the dyes used in the slower non-substantive film compared with the others and, possibly, to the presence of residual couplers in the substantive films.

The laboratory results and normal exposure tests, combined with measurements on the actual illumination levels involved have allowed approximate estimates to be made of the exposure time to various sources to which different print and transparency materials can be subjected before just noticeable fading (following broadly the definition in BS1006:1961) occurs. These are given in Table 1[1].

Further practical observations confirming many of these points were given by Mr L. B. Happé, of Technicolor Limited, in his paper on both light-fading and storage-fading of colour negatives. The professional use of colour negative cine film dates, in this country, from about 1953 and standard samples of a test subject with grey scale were prepared on Eastmancolor Negative Film Type 5248 in 1958. Some of this material was stored in cans under relatively uncontrolled conditions; temperatures ranged from 50-75°F and relative humidity from 40-60%. A further sample of the same material was spliced into a demonstration film which received heavy use over the 15-year period. Measurements of fog level and grey-scale densities of the demonstration material showed the blue density (i.e. the yellow layer) to be most affected, with a marked decrease in slope of the blue *D*/log *E* curve, enough to render the negative quite unprintable.

Dye development, bleach or diffusion?

A very thorough quantitative treatment of the factors involved in light fading, with special reference to dye-bleach processes, was given by Dr D. Bermane of Ciba-Geigy. The bulk of the work had been carried out on Cibachrome transparency material, subjected to three types of radiation: natural daylight (wavelengths from 330nm upwards, the lower ones being screened out by window glass) with a total radiant energy flux of about 100cal/cm²/day, fluorescent tube illumination at 80cal/cm²/day, and accelerated testing in a test rig with xenon arc illumination at 3250cal/cm²/day. One factor emerging from comparative tests with these three illuminants was that there was some apparent breakdown of the total energy/fading proportionality at high radiant energy levels.

A series of experiments in which the spectrum of the xenon arc lamp was cut off in steps from the lower end by edge filters enabled a set of curves to be constructed (Fig 2) showing the spectral response of the three Cibachrome dyes. Cyan is shown to be the least resistant and most wavelength-dependent.

Very marked differences were shown to occur in the characteristics of fading between conditions of back and front illumination, arising partly from the different cut-off of lower wavelengths arriving at the emulsion layers and also from the masking action of the layers themselves. Not only do the fading

*It is the intention of the Colour Group to publish the proceedings of the symposium as a separate volume in due course.

characteristics differ in degree between front and back illumination, but the fading suffered by the individual layers (Cibachrome has the classic yellow - magenta - cyan - base configuration) and the balance between them also differ. This leads to considerable differences between the colour change on exposure between back and front illuminated transparencies. In one case—front exposure—the fading is less in magnitude and colour remains nearer its original balance, whereas illumination from the other side caused a marked shift towards the yellow.

Similar effects could be demonstrated in chromogenic (dye - developed) reversal films, although the differing nature of the dyes caused different colour shifts. Since the choice of dyes possible in colour - developed materials is much more restricted than in dye - bleach material such as Cibachrome where light fastness can be one consideration in choosing the dye, the overall fading effect was also more marked (Fig 3).

Dr Bermane concluded by a warning that test methods must be carefully examined to avoid misinterpretation in extrapolating high - intensity accelerated tests to long - term predictions if the total energy/fading proportionality does in fact break down at high intensities. The radiant energy - temperature - humidity - oxidation inter - relationship must be carefully studied to separate the effects of these variables.

Further support for the use of the silver dye - bleach process in an application where colour images are subjected to extremely high illumination levels in use was given by Mr K. R. Honick of the Royal Aircraft Establishment, Farnborough. The use of colour map transparencies in aircraft navigation displays, in which a projected image is presented to the navigator centred by the aircraft's instruments on the position of the aircraft, involves an illumination level in the film plane of about 10^7lux over an 8-9mm circle of the transparency. This treatment results—with chromogenic materials—in the bleaching of the film in a matter of hours, especially if flying is restricted to a small area, as in training near base. A switch from chromogenic to silver dye - bleach transparencies had resulted in a 6-7 fold increase in useful life, from some 14hr to 85-100hr.

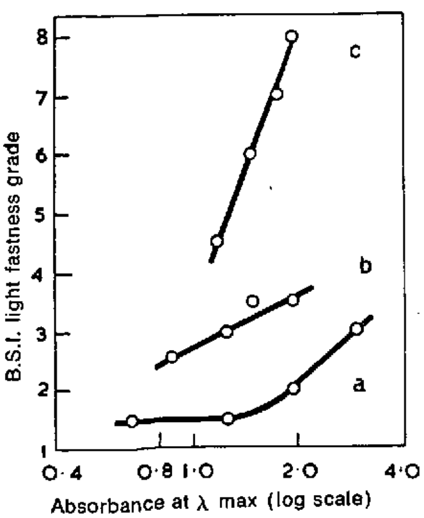

Fig 1
Variation of colour fastness with original density: characteristic fastness grade curves for examples of pure colour-developed dyes in gelatine (low-speed) non-substantive film) (1). Densities are measured at the wavelength of maximum absorption; curve *a*—magenta (maximum absorption at 540nm), *b*—yellow (maximum absorption at 442nm), *c*—cyan (maximum absorption at 645nm).

The effects of exposure to moderate illumination levels over long periods were demonstrated by Mr Howard Moore of Woodmansterne Limited. Woodmansterne 35mm transparencies for sale and educational use are produced on Eastmancolor print film by reduction from 6 x 9cm or 5 x 4in Ektacolor negatives and point - of - sale displays are maintained by many dealers. Woodmansterne find it necessary to renew these displays sets at regular intervals to avoid presenting faded examples of their product. The process of fading involves eventually all three layers unequally—an extreme example of a window display shown retained no more than a yellow - green ghost image.

Mr Ronald Churchill of the Polaroid Corporation showed the results of comparative exposure tests carried out on Polaroid SX-70 material, a commercial chromogenic material (said to be the best of five types examined) and an experimental Polaroid material, not yet available commercially. Three illuminants were used, xenon - arc illumination in a Fadeometer at 5000-6000ft-candles, natural sunlight at 10,000ft - candles, and fluorescent illumination at 300ft - candles. The dyes in both the Polaroid materials are metal complexes and, since the formation of the colour image is dependent on dye diffusion rather than the dye formation of the chromogenic processes, might well be expected to show light fastness advantages. Against this—at least in SX-70 material—must be set the possible effect on the dye of the continued presence of the reagents within the sealed environment of the print.

The light fastness of SX-70 was shown to be generally of the same order as the chromogenic material overall, the cyan and magenta dyes performing rather better and the yellow rather worse. The new experimental Polaroid had markedly increased stability, measured as percentage dye retention, throughout the tests.

Storage characteristics of colour photographs

None of the papers given related solely to an examination of the longevity of colour records under storage conditions although most speakers dealt in more or less detail with the subject.

The control strips used by Mr L. B. Happé in his comparison of storage and light - fading showed, over the 15-year storage period in film cans at uncontrolled temperature in the 50-75°F range and 40-60% relative humidity, slight but progressive loss of density in all three layers, coupled with a decrease in the slope of the *D*/log *E* curves. There was some tendency in this masked negative film for the blue density to show the greatest decrease, but all negatives had remained well within printing tolerances during storage. The test is, of course, continuing.

The Ektacolor negatives used by Woodmansterne are preserved from physical damage by being cemented with Canada balsam between polished ¼in plate glass. Mr Howard Moore showed examples which suggested that some change might have taken place; there also appeared to be a risk that some chemical reaction between components of the film - balsam system might be occurring, manifested as orange spots on the final print transparencies.

The relatively short times for which the newest processes—Cibachrome and Polaroid SX-70—had been in use, even under development conditions, precluded any authoritative predictions of their longevity in storage. SX-70 prints in experimental notebooks at Polaroid were said to show no measurable density change after 7 years, despite unfavourable storage conditions (in a corner of the boiler room!), and no change had been detected in any stored Cibachrome prints or transparencies.

Except in some extreme cases (some 10-15 year old Gevacolor transparencies on display had lost all yellow and cyan density) it was difficult to state—in the absence of densitometer measurements at the outset when the material was newly processed—whether some of the early materials on view appeared of lower quality because of comparison with more recent standards or had in fact deteriorated.

The role of moisture

Some of the problems arising in the case of the 35mm transparency mounted between glass and projected intermittently were demonstrated by Mr A. G. Tull of Technicolor Limited. The temperature distribution across any transparency was likely to be uneven because of the different absorptions of areas of different density: temperature rises of 0·5°C/sec in highlight areas and 9°C/sec in shadows were not uncommon. Such rates of rise led to temperatures of perhaps 70°C in the film gate. In these conditions moisture would be driven out of the transparency (an interesting observation was that the moisture content of the film base was likely to be at least as high as that of the much thinner emulsion layers) and would migrate to, and condense on,

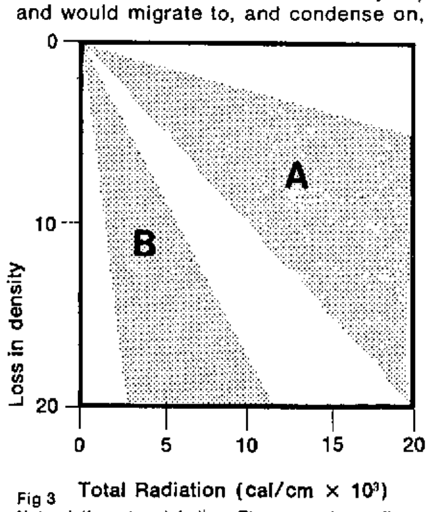

Fig 3
Natural (long term) fading. The approximate fields within which curves of density loss against total radiation lie for *A* silver-dye bleach materials and *B* chromogenic materials (Courtesy CIBA–GEIGY).

cooler areas. Such effects could only be avoided by dry storage, pre-drying before projection and using non-hygroscopic materials as masks. The most effective mounting method to allow transparency and cover glass to rise in temperature together without introducing undesirable materials into the slide, appeared to be the use of a single aluminium foil mask between the back of the transparency and the rear cover glass.

Several other undesirable effects of imperfect storage or unsuitable mounting materials were shown—corrosion products from foil masks, fungal attack and spread of material from the binding tape.

Is archival permanence possible?

Is archival permanence even necessary? Mr Charles Gibbs-Smith, Keeper Emeritus of the Victoria and Albert Museum and chairman of the symposium, would be prepared to accept preservation of current material for a century—on the basis that technology ought by them to have devised methods of reproducing material meriting preservation in more lasting fashion.

Discussion suggested that, apart from the known methods of slowing physico-chemical processes such as low humidity, low temperature, darkness and inert atmosphere, there were no certain methods of preserving colour dye transparencies for long periods. The question then became one of whether there is any method of preserving the information contained in the colour photograph in a more lasting form. Here there was more hope. Inorganic black - and - white silver or carbon images are much more stable than dyes and the many examples of pioneering 19th century photography which still exist show that even without very elaborate precautions conservation for long periods is feasible. It is standard practice in the motion picture field to prepare separation positives from colour negative material considered worth preserving. These can, of course, later be recombined: the result will not be the original but a facsimile.

Suggested methods of preserving the colour and tone information of still photographs included separation negatives or positives, recopying on an additive photographic material with the screen rulings in inorganic colours, electronic recording on videotape or, preferably, disc, or recording the same scanned image data digitally. Presumably the spectral distribution of the filters used for the separation should be recorded at the same time to allow precise reconstruction.

These, then, are the possibilities at present for the archivist. The ordinary photographer who wants to ensure that his own photographs last as long as possible within the limitations of the process will have, as Mr K. G. Moreman said in his summing-up, to 'play it cool and keep it dark'.

Tim Hughes

Table 1

Estimated approximate exposure time under normal conditions for just noticeable fading of colour photographs

Type of material		Fading lamp (hr)	Projector lamp (IQ) (hr) 100 W	250 W	Daylight indoors (months) nr. window	15ft from window
Colour - developed transparencies emulsion speed						
	slow	40	4	1·6	35	130
	medium	15	1·5	0·6*	15	55
	fast	8	0·8	0·3	8*	30
	very fast	5	0·5	0·2	5	18
Silver-dye bleach transparencies		80	8		70	210
Colour-developed paper prints						
	Manufacturer A	5			5*	18
	Manufacturer B	10			10	35
Silver-dye bleach process paper prints		80			70	210
'Instant' colour paper prints		5			5	18

* These approximate figures were confirmed in an exposure test in the laboratory.

Reference

1 C. H. Giles, S. D. Forrester, R. Haslam and R. Horn, Light fastness evaluation of colour photographs. *J Phot Sci*, Vol 21(1), 1973: pp19-24.

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