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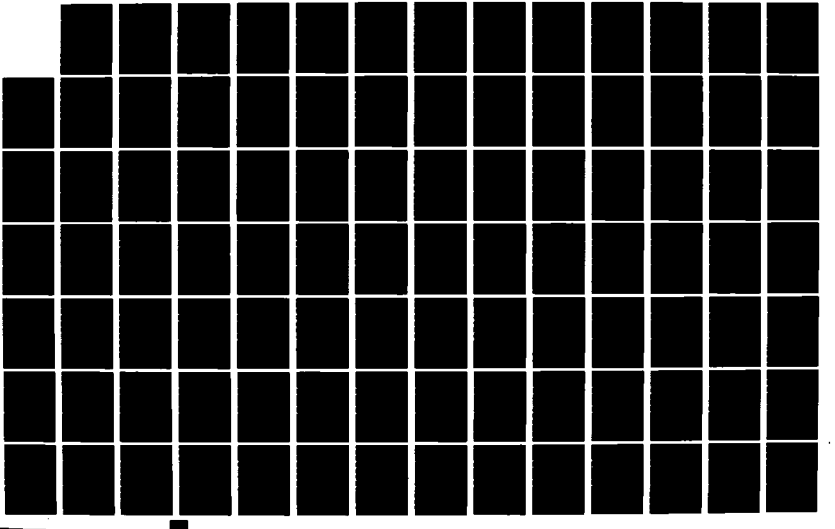

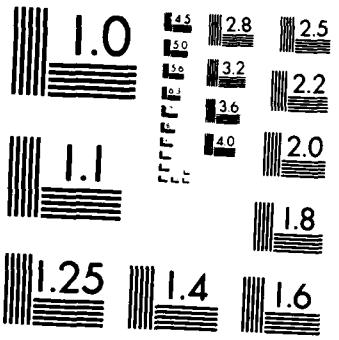

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EVALUATION AND COMPARISON OF INDUSTRIAL RADIOGRAPHIC FILM CHARACTERISTICS USED FOR NDI

By

R. D. Williams
C. M. Teller

FINAL ENGINEERING REPORT

Contract No. DLA 900-79-C-1266 (CLIN 001AB)
SwRI Project No. 15-5607-803

The investigation reported in this document was requested by the NDI Program Manager, MMETP, San Antonio ALC; Kelly Air Force Base, Texas 78241, under Government Contract No. DLA 900-79-C-1266 (CLIN 001AB), however, it does not necessarily bear the endorsement of the requesting agency.

March 1979 to October 1980

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A096721 / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)*: Evaluation and Comparison of Industrial Radiographic Film Characteristics Used for NDI	5. TYPE OF REPORT & PERIOD COVERED: Draft Final Engineering Report
	6. PERFORMING ORG. REPORT NUMBER: SwRI Project #15-5607-803
7. AUTHOR(s): R.D. Williams, C.M. Teller	8. CONTRACT OR GRANT NUMBER(s): DLA 900-79-C-1266 (CLIN 000 1AB)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Southwest Research Institute, 6220 Culebra Road, San Antonio, Texas 78284	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Air Force NDI Program Manager, San Antonio, ALC/MMETP, Kelly AFB, Texas 78241	12. REPORT DATE: September 25, 1980
	13. NUMBER OF PAGES: 149
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Nondestructive inspection, X-ray films, X-ray film speed comparisons, X-ray film contrast, X-ray film handling characteristics, radiographic step wedge calibration, radiography of aluminum.

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

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ABSTRACT

This report covers the approach, procedures and techniques employed in evaluating and comparing the speed, contrast, quality and handling characteristics of three different X-ray film types from each of three different manufacturers. Included are details on the fabrication and calibration of aluminum step-tablets used in the evaluations and comparisons. Calibration curves for four different kilovoltages, characteristic film curves for each of the films evaluated, and tables of relative film speed and contrast are presented. Subjective evaluation of each of the films for quality and handling characteristics is also presented. The effort of this project was limited to the range of 50 to 140 kilovolts with aluminum as the absorber; however, techniques and methods used could be extended to other energies and materials.

FOREWORD

This report was prepared by Mr. R.D. Williams, Senior Research Engineer and Dr. C.M. Teller, Manager NDE Research of the Instrumentation Research Division, Southwest Research Institute. The support rendered by Messrs. S.A. Wenk and C.C. Allen of the Quality Assurance Systems and Engineering Division at SwRI is gratefully acknowledged. Also, the technical assistance performed by Messrs. R.L. Youngblood and D.S. Jones of the Instrumentation Research Division is appreciated.

The project was sponsored by San Antonio Air Logistics Center, Kelly Air Force Base, Texas, as a separate task under Contract No. DLA-900-79-C-1266 (CLIN 0001AB). Technical direction was provided by Mr. B.W. Boisvert, CMS E. Gulley and CMS R.E. Muthart.

GLOSSARY OF TERMS AND ABBREVIATIONS AS USED IN THE TEXT OF THIS REPORT

DENSITY (D)	-	Refers to density as measured in H & D units.
LRE	-	Log Relative Exposure
M	-	Kodak Type M Film
R	-	Kodak Type R Film
T	-	Kodak Type T Film
45	-	Dupont Type NDE 45 Film
55	-	Dupont Type NDE 55 Film
65	-	Dupont Type NDE 65 Film
100	-	G.A.F. Type 100 Film
400	-	G.A.F. Type 400 Film
800	-	G.A.F. Type 800 Film
SPEED	-	All speeds are expressed in percent relative to Kodak Type M which is arbitrarily assigned 100% at all Kilovoltages.
CONTRAST	-	Slope of the characteristic curve for a specified Density interval i.e., Contrast = $\frac{\text{Density Interval}}{\text{LRE Difference}}$
K.V.	-	Kilovoltage
MAM	-	Milliampere - minutes
T	-	Time

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I. INTRODUCTION AND SUMMARY

This report provides information which will assist radiographers in the selection of film for specific applications. Most importantly, it should serve as an aid in determining suitable exposure parameters for films when substitution must be made due to shortages in supply or local availability.

Historically, when faced with the necessity of substitution, a radiographer would examine manufacturer's literature (if available) and then perform trial exposures with a new film. Using the first radiograph as a basis, the radiographer would then modify the exposure parameters and try again. Often this procedure would have to be repeated several times, depending on the experience of the radiographer and difficulty of subject, before an acceptable radiograph was produced. This iterative process involves considerable expenditure of time and the now significant cost of film. It is this basic problem that the X-ray film evaluation and comparison data presented in this report are designed to alleviate.

A detailed test plan prepared by the NDI Program Manager, San Antonio Air Logistics Center, Kelly Air Force Base was submitted to Southwest Research Institute with explicit instructions on the approach and procedures to be followed in performing each task. It was adhered to rigidly with the exception of the film speed comparisons which were accomplished by an alternate method (Appendix H). A copy of this test plan is included in APPENDIX G.

In addition to the specified tests a literature survey was carried out using the Nondestructive Testing Information Analyses Center facilities at SwRI. Although a detailed key word and subject index was prepared for the computerized search, it is significant that none of the literature obtained during the search contained information pertinent to the objectives of this project. This negative result indicates that, within the limits of the survey, no published results of a parallel nature are available.

Requests for available literature were made to each of the three manufactureres, Kodak, Dupont GAF, whose films were involved in this evaluation and comparison. Only basic information on the particular manufacturers film was provided by two of the manufacturers and no information by the third. The GAF brochure contains bar graphs showing relative speeds of their three films and curves of density vs. dose without notation as to kilovoltage. The Dupont literature was considerably more detailed and does contain a table of relative speeds for films of four manufacturers and also contains tables of recommended exposure, in milliampere-minutes, vs. material thickness, using a constant potential x-ray source. Neither of these manufacturers presents characteristic curves of density vs. relative exposure. The third manufacturer, Kodak, did not send literature. However, Kodak does publish a manual, available at nominal cost titled, "Radiography in Modern Industry". This manual with available supplements, presents detailed information including characteristic film curves for film types available from Kodak. It does not present comparisons of films

from other manufacturers.

While providing comparisons between films of a particular manufacturer, none of the above presents a viable solution to the problem of obtaining radiographically acceptable results when substituting between films of different manufacture.

The following sections present details of the film evaluation and comparison procedures and results, examples of how to use the data and conclusions and recommendations. Evaluation and comparison curves are presented in Appendices B through F. Hopefully, this information will enable radiographers to substitute films from the three manufacturers, Kodak, Dupont and GAF, with a minimum of lost time and expense.

II. FILM EVALUATION/COMPARISON PROCEDURES AND RESULTS

A. Laboratory Procedures

The requirements of this project demanded rigid control of the experimental set-ups to insure consistent exposure techniques, processing and measurement of the test film parameters. A Magnaflux 150 KVP X-ray Unit (with timer) was used for each test exposure. All exposures were carried out in an exposure chamber measuring 20 ft. (6.1 m) long X 12 ft. (3.66 m) wide by 20 ft. (6.1 m) high, enclosed by a 10 in. (254 mm) thick high density concrete wall. This chamber has a steel-grating floor with removable panels located at the midpoint of the 20 ft. (6.1 m) height. In order to minimize back-scattered radiation, the X-ray head was positioned over an opening in this floor from which the steel grating had been removed. A 1/4 in. (6.25 mm) thick hardboard (Masonite) panel was placed over this opening to support the exposure cassettes. A panel with 0.010 in. (0.25 mm) lead foil was suspended 12 in. (305 mm) below this opening to further minimize the effects of backscatter. Figure 1 is an illustration of the experimental setup and shows the dimensional configuration maintained throughout the experiments.

An initial calibration of this system was carried out to determine the dose rate incident at the film plane through various thicknesses of aluminum. These thicknesses were 1/8 in. (3.18 mm), 1/4 in. (6.25 mm), 1/2 in. (12.7 mm), 3/4 in. (19.05 mm), and 1 in. (25.40 mm) and dose rates were measured for 50, 80, 110, and 140 kilovolts. A standard Victoreen "R" meter was utilized for system calibration. No collimator tube was used since it was desired to obtain true dose rates at the film plane. True dose rates include the air scattering which occurs between the tube head and specimen surface. Results of these calibrations are shown in Figure 2 of this report.

Calibration was accomplished with a pair of step tablets fabricated from 2024 aluminum alloy. These tablets consist of steps 1/2 in. (12.70 mm) wide in thickness increments of 1/16 in. (1.59 mm) through 1 in. (25.40 mm) thickness. The 1 in. (25.40 mm) dimension being at the center and tapering to 1/16 in. (1.59 mm) at either end. After fabrication, these step tablets were serialized and dimensionally documented. Figure 3 is a drawing of these step tablets.

To maintain consistent exposure geometry, index marks were placed on the hardboard exposure platform to facilitate precise location of film and step tablets during the experiments. During these experiments Step Tablet No. 1 was always located to the left, facing the tube head active end, and No. 2 Step Tablet to the right; their respective serial numbers faced to the left side of the tablets.

Film was ordered from distributors of Kodak, Dupont and GAF in all available packagings. Purchasing specifications were that all films were to be fresh, 14 in. (355.6 mm) X 17 in. (431.8 mm) size, and that no special ordering be done for film packaging not normally stocked which could not be obtained within a reasonable lead time consistent with program schedule. Types

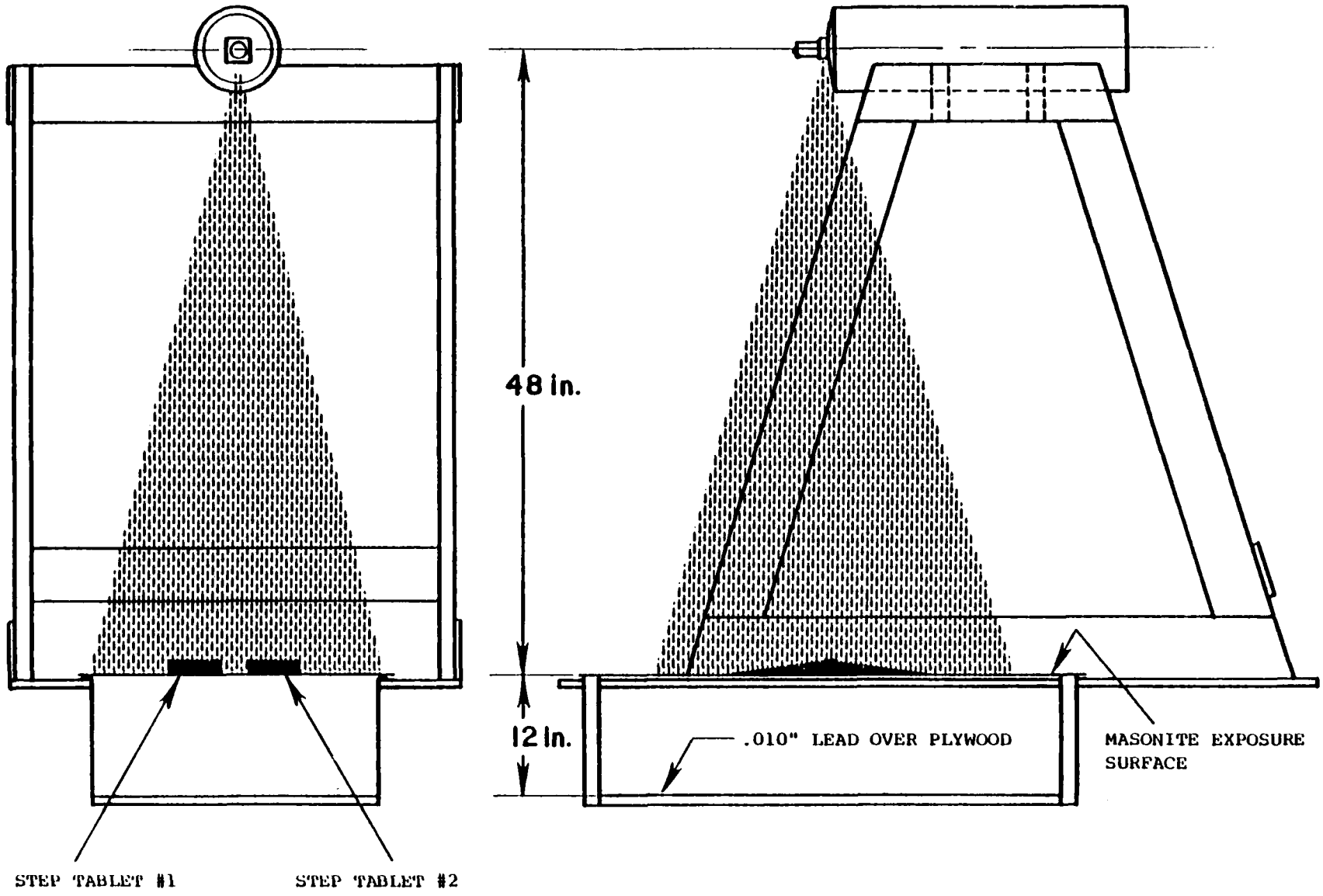

FIGURE 1. X-RAY EXPOSURE CONFIGURATION

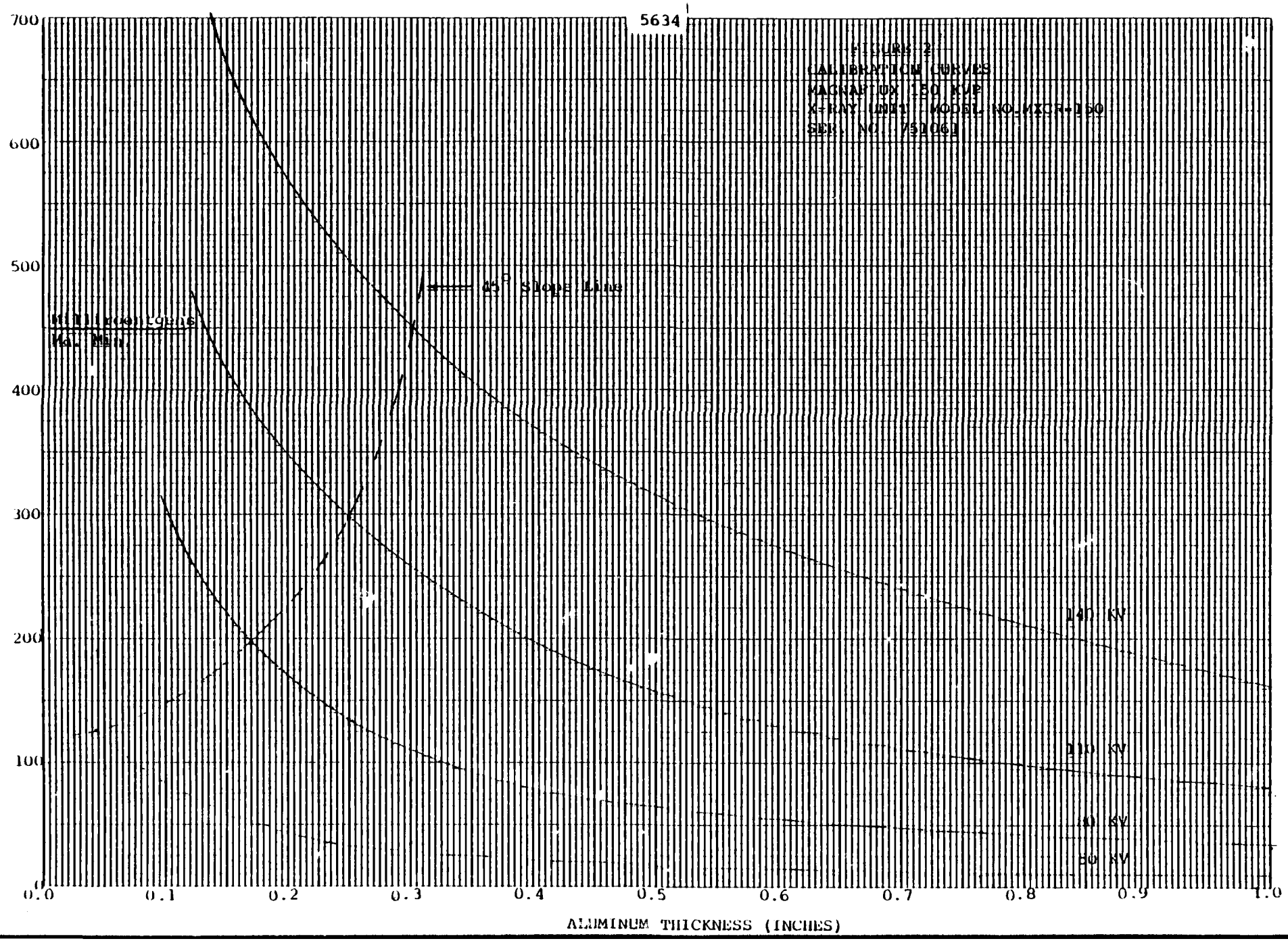
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FIGURE 2
CALIBRATION CURVES
MAGNAFLUX 150 KVP
X-RAY UNIT: MODEL NO. MXCR-150
SER. NO. 751061
45° Slope Line
140 KV
110 KV
80 KV
50 KV
700
600
500
400
300
200
100
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
ALUMINUM THICKNESS (INCHES)

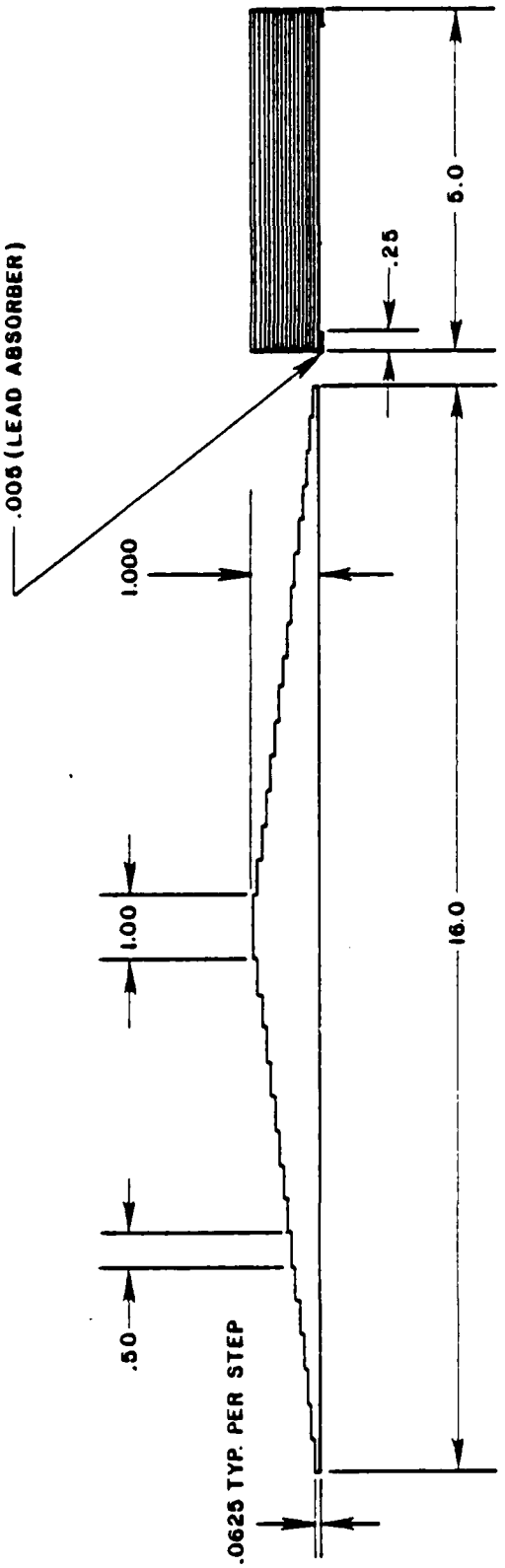


FIGURE 3. **Aluminum Step Wedge**

of film ordered were Kodak, Types M, R, and T: Dupont Types 45, 55, and 65 and GAF Types 100, 200 and 400 in all available packagings. It was determined that GAF Type 200 was no longer available and Type 800 was substituted to provide a wider range from this particular manufacturer.

All film processing, with the exception of the hand versus automatic processing comparison exposures, was carried out by hand processing. Kodak chemicals were used throughout, with the manufacturer's recommended replenishment schedule rigidly maintained. All processing was performed using a 6-minute development cycle. The developer was initially seasoned by processing unexposed films, after which the films for fog density determination were processed. Daily cleanup films were run before processing record films.

All density measurements on the films of this project were made using Macbeth densitometer, Model TD502, Serial No. 1118B. Calibration of the densitometer was accomplished using a calibrated density strip with traceability to NBS standards.

B. Fog Density Determinations

The first films processed after initial seasoning of the developer were those used in the fog density determinations. One each of all types of film were processed using a 6-minute processing cycle. A template was used for positioning the film in the densitometer to obtain twelve uniformly spaced density readings from each of the films. These were then averaged to obtain the following base plus fog densities.

Film	M	R	T	55	500	45	100	65	800
Density	0.100	0.112	0.110	0.140	0.134	0.100	0.120	0.210	0.166

C. Step Tablet Calibration

The procedures detailed in the Test Plan, Appendix G, were followed exactly in performing the step tablet calibrations for this project. The calibration curves and the data used for derivation are contained in Appendix A of this report. An all aluminum absorber was used in order to realistically simulate actual field conditions for radiographic exposure.

Unfortunately, when the test for accuracy was applied to these calibration curves, as defined in the Test Plan, a considerable deviation from linearity was observed at all kilovoltages for which the step tablets were calibrated. Examination of the curves in Figures 4 and 5 illustrates that the use of an average LRE per step will result in distorted and inaccurate results when applied to film speed comparison data.

The reasons for this are complex, and a complete theoretical analysis is beyond the scope of this report. Basically, however, due to the nature of the radiation absorption process, the quality (spectral content) of radiation incident on the film is different under each step of the step tablet and the quantum efficiency of the film, as a detector, decreases with decreasing energy. Other investigators [1,2] have overcome this problem by placing an additional absorber of 0.020 in. thick copper between the step tablet and the film. This

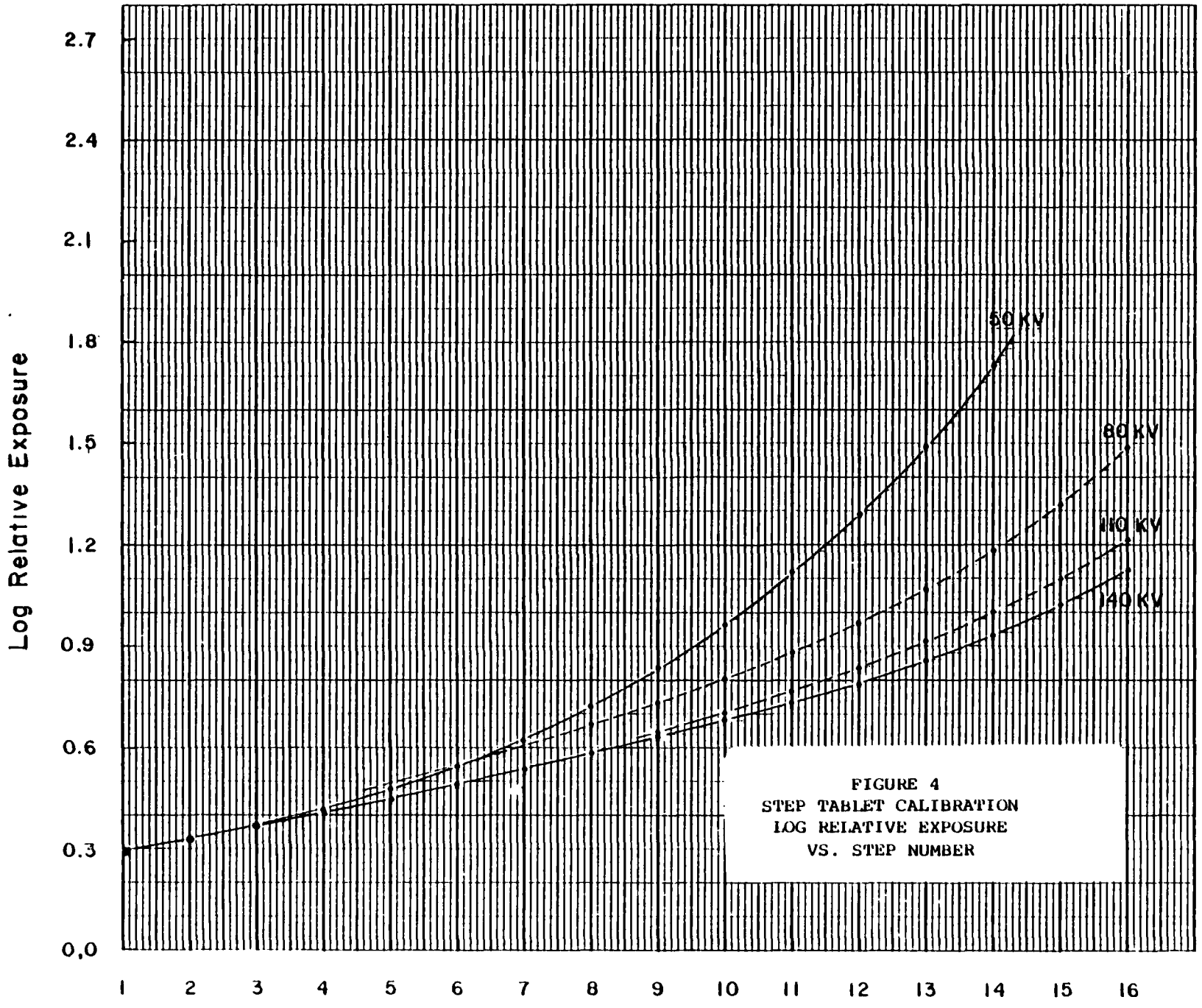


FIGURE 4
STEP TABLET CALIBRATION
LOG RELATIVE EXPOSURE
VS. STEP NUMBER

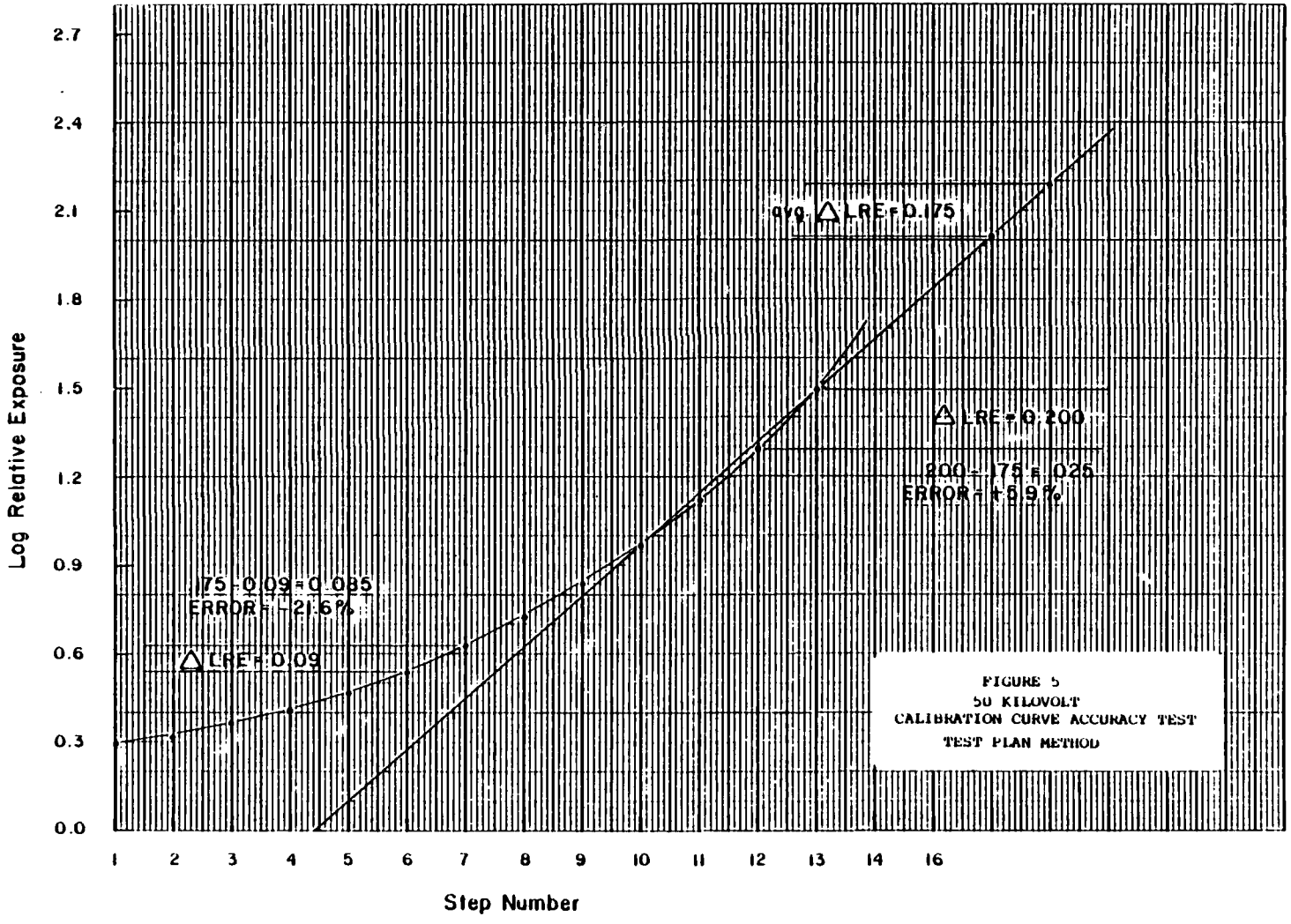


FIGURE 5
50 KILOVOLT
CALIBRATION CURVE ACCURACY TEST
TEST PLAN METHOD

layer of copper essentially absorbs all of the soft fluorescent radiation and reduced energy scattered radiation, generated within the step tablet. Thus only the higher energies contained in the primary beam contribute to the exposure. Using this copper absorber, an approximation to linear geometrical response for the step tablet was achieved down to 100 kilovolt X-ray energy levels. Due to the lower energies specified for this project (i.e., 50 and 80 kilovolts), it is uncertain that this same approximation to linearity could be achieved using a copper absorber since much greater absorption occurs at these lower energies.

During discussions with the sponsors technical representatives concerning this problem, it was determined that the exposures made with only the aluminum step tablet were preferable in that they more closely matched actual exposure conditions in the field. Subsequently, an alternate method for film speed comparisons was developed at SwRI which would allow the already completed step tablet calibration curves and speed comparison exposures to be used in reduction of data for this project. Essentially, the alternate method consists of comparing density differences, between two films exposed simultaneously, on a step by step basis to the calibration curve instead of applying the average LRE for a particular calibration curve. Since this method compares the density difference between the two films under each discrete step, the exposure time and radiation quality incident on the two films is identical and the density difference observed can only be a result of their difference in speed (sensitivity). Using the measured densitites of the two films, the step tablet calibration curves may be entered directly to obtain LRE values for each of the films. The difference between the two LRE values can be converted directly to speed difference, or may be added to or subtracted from the LRE value for the film used as a standard to obtain a data point for plotting a speed comparison curve relative to the curve for the standard film.

A more complete description of this alternate method and instructions for implementation are contained in Appendix H of this report.

D. Film Speed Comparisons

As mentioned in Section II.C above, an alternate method for speed comparison data reduction was developed at SwRI. Subsequent to verbal approval of this method, in lieu of the Test Plan method, by the Sponsor's technical representative, all previously obtained density data from the speed comparison exposures were reduced utilizing the alternate method.

The side-by-side exposure technique prescribed by the Test Plan, (Appendix G), was followed explicitly with the exception that both step tablets were used instead of one. These step tablets had previously demonstrated radiographic equivalence during the development of the step tablet calibration curves. The use of two step tablets doubles the number of data points within each step and increases the confidence level.

The results of these speed comparisons are contained in four Appendices to this report. Each Appendix contains data and curves pertaining to a particular kilovoltage, i.e.

Appendix B. 50 Kilovolt Film Speed Comparisons
Appendix C. 80 Kilovolt Film Speed Comparisons
Appendix D. 110 Kilovolt Film Speed Comparisons
Appendix E. 140 Kilovolt Film Speed Comparisons

All graphs presented, in these film speed comparison appendices, use density data which includes the effects of fog. These curves, therefore, show apparent relative speed comparisons as opposed to true speed comparisons.

Arrangement of each film speed comparison appendix is as follows:

Figure 1 - A composite graph showing relative speeds of all films compared to Kodak Type M.

Table 1 - a. Tabular listing of LRE values at selected densities from which the composite curves were constructed.

b. Table of speeds for all films expressed in percent relative to Kodak Type M.

c. Table of contrast values for all films at selected density intervals.

Figures 2 through 9 and Tables 2 through 9 - Curve pairs for each of the film speed comparison exposures. Each curve pair graph is immediately followed by a tabular data page listing data from which the curves were contructed.

Each Figure Number and Table Number also contains a prefix, i.e., B1, C1, etc., which indicates the appendix in which it is placed.

For construction of the composite speed comparison curves, LRE values for densities of 0.5, 1.0, 1.2, 1.5, 2.0, 2.2, 2.5, 3.0, 3.2, and 3.5 were determined from the film speed comparison curve graphs. In the cases of M vs R, T, 55 and 400, LRE values were plotted vs the elected densities directly, with the four LRE values for M averaged. Since film types R and T were used as transfer standards in the comparison exposures R vs 45 and 100, and T vs 65 and 800, the LRE differences were obtained at each of the above density levels. These LRE differences were then subtracted from the previously determined LRE values for R and T to obtain LRE values for 45, 100, 65 and 800 with respect to the LRE values for M. This results in a set of speed comparison curves where any film in the group may be compared to any other film in the same group to obtain relative speed differences.

Due to the fact that Kodak type M Leadpack film was not readily available and the projected delivery time was beyond the time limits imposed by the project scheule, the order for this film was cancelled. Consequently, speed comparison standard data could only be accomplished using type M vs type M Readypack. Upon reduction of data from these two films the data points were too close for a meaningful graph to be prepared. Operating on

the data points of these two films mathematically shows that speed of Type M Readypack relative to Type M film ranges from 105.9% at 50 KV to 104.7% at 140 KV.

E. Film Contrast Determination

Calculation of a film contrast number is accomplished by dividing a density interval, ΔD, by the log relative exposure difference, ΔLRE, observed in the same density interval. In other words, it is the slope of the characteristic film curve for a defined density region of this curve.

As directed by the Test Plan, calculations for contrast were carried out for the density intervals 1.0-3.0, 1.0-1.2, 2.0-2.2, and 3.0-3.2. Due to the fact that large errors could be introduced by incorrectly locating points along the LRE axis on the steeper portions of the curves, additional calculations were performed for the density intervals 1.5-2.5, 2.0-3.0, and 2.5-3.5. Tabular results of these calculations are located in Table 1 of each of the appendices pertaining to a particular kilovoltage.

Contrast bar graphs were prepared for the density intervals 1.0-3.0 and 2.0-3.0. These bar graphs are located in Appendix F of this report.

F. Emulsion Consistency Tests

For the emulsion consistency tests, one each of the nine types of film being studied was exposed, without an absorber, to a density of approximately 1.0 H & D unit. Energy used was 110 KV. Subsequent to processing these films were evaluated for uniformity of density, mottling, streaking and any other observed film artifacts. Individuals performing this evaluation were highly qualified in radiographic interpretation, with a combined experience level in excess of 75 years. Apparently, the evaluators do not believe a perfect X-ray film exists as the highest rating achieved was 8.0 All films examined rated good to excellent. The only films receiving less than 8.0 ratings were Dupont Type 65 (7.58) and GAF Type 800 (7.05). Transcripts of the rating sheets are included with this report in Tables 1, 2, and 3.

G. Film Handling Characteristics

1. Kink Sensitivity

For the kink sensitivity tests a fixture consisting of a 1/4" diameter rod mounted in blocks fastened to a plywood base was fabricated, (Figure 6). Films were subjected to kinking four times. Twice along the long axis before exposure and twice along the short axis after exposure. Figure 7 is a plan view of the kink orientation and Figure 8 is the schedule of kink exposures.

Reviewers ratings for this test varied the most for any of the subjective tests. In general, however, the trend in sensitivity appears to be that the slower films are least affected. GAF 800 and Dupont NDT 65 gave the worst sensitivity ratings. The general consensus is that none of

the effects on the films reviewed would seriously affect radiographic interpretation due to the relatively broad and gentle density transitions observed in the affected areas of the films. Transcripts of the rating sheets are included in Tables 4, 5, and 6 of this report without tabulation due to the relatively wide variance between reports by the evaluators.

2. Pressure Sensitivity

Figure 9 is a sketch of the fixture used to perform the pressure sensitivity tests. Prior to fabrication a series of experiments was performed to determine forces experienced during actual writing with a BIC medium ball point pen. Each film was subjected to three different writing forces both before and after exposure. Figure 10 is the schedule of pressure sensitivity exposures and Figure 11 is a plan view showing the orientation of the pressure marks.

Reviewers ratings for this test were very consistent. Type M Readypack being the least sensitive. It was generally agreed that in all cases, with the possible exception of Type M Readypack, interference with radiographic interpretation could or would occur in the location of such pressure marks. Both pre- and post-exposure treatment indicated similar magnitudes of the effect. However, the pre-exposure treatment resulted in visible lines of lesser density than background and post-exposure treatment results in lines of greater density than background. Transcripts of the rating sheets are included with this report in Tables 7, 8, and 9.

III. USE OF THE FILM EVALUATION/COMPARISON DATA

The following examples utilize the graphs and tables found in Appendices B through F of this report. These examples cover both exposure calculation and contrast comparison.

Example 1.

A radiographer has established an exposure schedule using Type M film of 50 KV and 4.2 MAM through an aluminum section 3/8 in. thick. This exposure produced a density average of 2.0 H&D units in the area of interest. Supplies of Type M film have been depleted and the only available film, having similar exposure and contrast characteristics, is DuPont Type NDE55. What exposure should be used to obtain an average density of 2.0 as experienced with Type M film?

Solution:

Referring to Appendix B, we find in Table B-I a direct speed comparison for Type M vs Type 55 at a density of 2.0. This Table indicates that the speed of Type 55 is 141.3% of M. Since Type 55 is faster than Type M, the correct exposure is found by multiplying the previous exposure in MAM by 100 and dividing by the percentage speed difference of 141.3; i.e.

$$\frac{4.2 \text{ MAM} \times 100}{141.3\%} = 2.97 \text{ MAM}$$

The correct exposure, using Type 55 film is then 50 KV and 2.97 MAM to achieve the desired density of 2.0. Since most X-ray unit self-timers do not have two place time resolution, this should be rounded to 50 KV and 3.0 MAM.

Example 2.

A radiograph has been taken of an aluminum section 1/2 in. thick using an exposure of 110 KV and 1.1 MAM with Type T film for an average density of 2.0 in the area of interest. During interpretation a suspected crack is located; however, it is poorly defined because of the low contrast between the crack image and background density. It is desired that a confirming radiograph be made with higher contrast to positively identify the suspected crack. Film availability is not a problem. Which film should be used, and what is the correct exposure for this film?

Solution:

Referring to Appendix D, 110 KV film speed comparisons, Table D-I, contrast numbers section, it is found that the contrast number for Type T, for a density of 2.0-3.0, is 4.65. For Type M the contrast number is 7.69 and for Type R the number is 11.76. In the interest of obtaining maximum possible contrast it is decided to utilize Type R film and to use a density of 2.5 to further enhance the contrast. From Appendix D, Figure D-I, determine the LRE for T at a density of 2.0 and then the LRE for R at a density of 2.5,

subtracting to obtain the difference in LRE. The antilog of this difference is a multiplier to be applied to the exposure value used for the previous radiograph.

$$\text{Log}^{-1}(\text{LRE}_{(R)} - \text{LRE}_{(T)}) = \text{Log}^{-1}\ (1.62 - 0.925)$$
$$= \text{Log}^{-1}\ 0.695$$

$$\text{Log}^{-1}\ 0.695 = 4.95$$

and 4.95×1.1 MAM $= 5.45 \approx 5.4$ MAM

The exposure with Type R film should be 110 KV and 5.4 MAM.

Example 3.

Radiography is requested on a wing section of an aircraft which experienced apparent excessive flight loading. The section to be radiographed is lapped and riveted. The total section thickness in the area of interest is approximately 0.15 in. (3.8 mm). Due to the location of the aircraft, the amount of radiation must be limited to avoid interference with other work in the area. Previous experience has shown that 50 Kilovolt X-ray energy will provide adequate penetration in the area of interest and will reduce the size of the necessary radiation posting zone.

1. What film should be chosen?
2. After a trial exposure of 2.5 MAM at 50 KV provides an average density of 3.4 in the area of interest what will be the required exposure to produce a desired average density of 2.0?

Solution:

1. Refer to Appendix B, Table B1 and find that GAF Type 400 film has the highest average contrast available (D = 1.0-3.0) and also the highest contrast number at the desired density of 2.0 (5.0 for D = 2.0-2.2).
   GAF Type 400 is chosen.

   Note: An alternate solution would be to enter Appendix F., Figures F1, F2, and find that Type 400 affords the highest contrast available at 50 Kilovolts.

2. Refer to Appendix B, Figure B1 and find tht for Type 400 film, a density of 3.4 gives a LRE of 1.45 and for a density of 2.0 the LRE is 1.20. Subtracting the observed LRE from the desired LRE, we obtain;

   $$\Delta\text{LRE} = 1.2 - 1.45 = -0.25$$

   The antilog of this ΔLRE is the multiplier to be applied to the original exposure.

Log^{-1} -0.25 = 0.562

and 2.5 MAM X 0.562 = 1.405 $\tilde{=}$ 1.4 MAM

The correct exposure is 1.4 MAM at 50 Kilovolts using Type 400 film.

IV. DISCUSSION

The specified Test Plan (Appendix G) completely details all procedures and proved an excellent guide for accomplishing the major portions of this project. Unfortunately, due to the lack of linearity observed during the step tablet calibrations, the concept of an average LRE value per step of the step tablet could not be used for data reduction. A study of the problems involved resulted in the development of an alternate method for data reduction. By eliminating the step which introduced the error, this method allowed the calibration curves to be used directly and without error.

The sensitometric techniques utilized in this proejct are not absolute. However, from a user's standpoint they are realistic and directly relate to practical radiography. The composite speed curves, speed tables and contrast tables developed by this project are useful to the radiographer in that they represent speed and contrast values obtained by measurements on radiographs of an engineering material of interest. The use of X-ray density data, uncorrected for fog, in the construction of the speed comparison tables permits direct use of the data and speed comparisons, by the radiographer, without serious error. It is assumed that the fog levels determined in Section II.B. of this report are typical for fresh films of the types investigated.

Every attempt has been made throughout this project to insure consistency in each step of the procedures involved. In an assessment of the errors which could occur, each step of the procedures is listed below along with estimated error limits.

1.	Exposure and Processing	-	Unknown	
2.	Densitometry	$\approx \pm$	0.0025	Density Unit
3.	Plotting, Density Vs. Step	$\approx \pm$	0.125	Div
4.	Extract Data for Calibration Curve (2 Curves)	$\approx \pm$	0.25	Div
5.	Plotting Calibration Curve	$\approx \pm$	0.125	Div
6.	Extract Data for Speed Curves (2 Curves)	$\approx \pm$	0.25	Div
7.	Plot Speed Curves	$\approx \pm$	0.125	Div
8.	Extract Speed Comparison Data (2 Curves)	$\approx \pm$	0.25	Div
	TOTAL	$\pm$	1.125 Divisions + .0025 Density Unit	

Converting to LRE units $\pm (0.02 \times 1.125) \pm 0.0025 = \pm 5.9\%$ Possible Error

In the above evaluation, final plotting of the composite speed curves is not included and the possible error figure of ± 5.9% applies to the speed comparison tables. In assigning the values shown above, a plotting accuracy, considering the scale of the graphs used, of ± 0.125 graph division, per data point was assumed. Each Division represents 0.02 LRE or 0.02 Density unit. If an additional ± 0.125 Division error is assumed when plotting the composite curves, an estimated total error of approximately ± 6.5% is possible.

The emulsion consistency evaluations show that all films rated good to excellent and would provide acceptable results when used within their speed and contrast capabilities. Although this test was subjective in nature, it is interesting to note that no one film is clearly superior to any other.

Results of the handling characteristics test for kink sensitivity indicate that although artifacts produced by bending or kinking are objectionable they would probably not interfere with radiographic interpretation.

Results of the pressure sensitivity tests definitely show that writing on a film cassette or envelope with a ball point pen, or other pointed writing instrument, should be avoided in that this procedure will produce artifacts which can seriously affect radiographic interpretation of the films.

V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

1. Since normal manufacturing tolerance for film speed is in the ± 10% range, the maximum possible error for the data, as derived and discussed in Section IV of this report, is not considered excessive. Exposure parameters derived through use of the data contained in this report will be correct within the limits of this tolerance.

2. Using the speed comparison data of this report, a radiographer now can rapidly determine exposure parameters for films of different type or manufacture.

3. Selection of film having desired contrast characteristics can be rapidly accomplished using the contrast number tables and contrast bar graphs presented in this report.

Recommendations:

1. No direct writing, using a ball point pen or pencil, should be permitted on cassettes or envelopes containing film. If identification is desired, self adhering labels should be used, with the necessary information inscribed before attaching to the film holder.

2. Kinking or rolling of the film should only be permitted where necessary for placement of the film. A note, describing the degree and direction of bending in the exposure record, could prove useful during interpretation of the radiograph.

3. Field testing, by use of the data contained in this report, has not been accomplished. It is recommended that a feed back mechanism be established, along with distribution of this report, whereby any errata which may be discovered is brought to the attention of responsible individuals in order that corrections may be issued.

VI. REFERENCES

(1) Seemann, H.E. and Roth, B., "A New Stepped Wedge Design for industrial Radiography", Nondestructive Testing, 20, 37. (1962)

(2) Corney, G.M. and Seemann, H.E., "A Logarithmic Step Tablet for X-Rays", Nondestructive Testing, 6, 27. (1947).

TABLE 1. EMULSION CONSISTENCY EVALUATION

FILM NO.	FILM TYPE	DENSITY UNIFORMITY	MOTTLING	STREAKING	OTHER	AVG.
116	R	8	8	8	8	8.0
117	T	8	8	8	8 scratches	8.0
118	45	8	8	8	8 scratches	8.0
119	55	8	7	8	8 scratches	7.75
120	65	8	8	8	8 scratches	8.0
123	800	6	8	8	8	6.75
125	M	8	8	8	8	8.0
126	100	8	8	8	8	8.0
127	400	8	8	8	8	8.0
RATING LEVELS						
9	Perfect					
8	Excellent					
7	Good					
6	Good					
5	Fair					
4	Fair					
3	Poor					
2	Poor					
1	Poor					
EVALUATOR: R.D.W.						

TABLE 2. EMULSION CONSISTENCY EVALUATION

FILM NO.	FILM TYPE	DENSITY UNIFORMITY	MOTTLING	STREAKING	OTHER	AVG.
116	R	8	8	8	8	8.0
117	T	8	8	8	8 scratches	8.0
118	45	8	8	8	8 scratches	8.0
119	55	7	7	8	8 scratches	7.5
120	65	8	8	8	8 scratches	8.0
123	800	7	8	8	8	7.2
125	M	8	8	8	8	8.0
126	100	8	8	8	8	8.0
127	400	8	8	8	8	8.0
RATING LEVELS						
9	Perfect					
8	Excellent					
7	Good					
6	Good					
5	Fair					
4	Fair					
3	Poor					
2	Poor					
1	Poor					
EVALUATOR:						
	C.C.A.					

TABLE 3. EMULSION CONSISTENCY EVALUATION

FILM NO.	FILM TYPE	DENSITY UNIFORMITY	MOTTLING	STREAKING	OTHER	AVG.
116	R	8	8	8	8	8.0
117	T	8	8	8	8 scratches	8.0
118	45	8	8	8	8 scratches	8.0
119	55	7	7	8	8 scratches	7.5
120	65	8	8	8	8 scratches	8.0
123	800	7	8	8	8	7.2
125	M	8	8	8	8	8.0
126	100	8	8	8	8	8.0
127	400	8	8	8	8	8.0
RATING LEVELS						
9	Perfect					
8	Excellent					
7	Good					
6	Good					
5	Fair					
4	Fair					
3	Poor					
2	Poor					
1	Poor					
EVALUATOR: S.A.W.						

TABLE 4. KINK SENSITIVITY EVALUATION

FILM NO	FILM TYPE	LONG AXIS		SHORT AXIS		AVG.
135	M	Slight	7	Slight	7	7
136	R	Slight	6	Slight	6	6
137	T	Slight	7	Slight	6	6.5
138	45	Mod.	4	Mod.	5	4.5
139	55	Mod.	4	Slight	6	5
140	65	Mod.	5	Slight	7	6
141	100	Slight	7	Slight	7	7
142	400	Slight	7	Slight	7	7
143	800	High	3	Mod.	4	3.5
144	M-R	Slight	7	Slight	7	7
145	45-R	None	8	Slight	7	7.5
146	55-R	Slight	7	None	8	7.5
147	65-R	Mod.	5	Slight	7	6
				RATING LEVELS		
		None	9	Perfect		
		Very Slight	8	Think you see something		
		Slight	7	Probably see something		
		Slight	6	Definitely see something		
		Mod.	5	(Better defined than 6.		
		Mod.	4	Grade by degree.)		
		High	3	Strongly defined.		
		High	2	(Grade by		
		High	1	degree)		
EVALUATOR: R.D.W.						

TABLE 5. KINK SENSITIVITY EVALUATION

FILM NO	FILM TYPE	LONG AXIS		SHORT AXIS				AVG.
135	M	None	9	None	(except	on edges)	9	9.0
136	R	Slight	7	Slight			7	7.0
137	T	None	9	None	(except	on edge)	9	9.0
138	45	None	9	None	(except	on edge)	9	9.0
139	55	None	9	None	except	on edge)	9	9.0
140	65	None	9	None	(except	on edge)	9	9.0
141	100	None	9	None	(except	on edge)	9	9.0
142.	400	None	9	None	(except	on edge)	9	9.0
143	800	Slight	7	None	(except	on edge)	9	8.0
144	M-R	None	9	None	(except	on edge)	9	9.0
145	45-R	None*	9	None	(except	on edge)	9	9.0
146	55-R	None*	9	None	(except	on edge)	9	9.0
147	65-R	Slight	7	None	(except	on edge)	9	8.0

*High finger-nail looking kink

RATING LEVELS

None	9	Perfect
Very Slight	8	Think you see something
Slight	7	Probably see something
Slight	6	Definitely see something
Mod.	5	(Better defined than 6.
Mod.	4	Grade by degree)
High	3	Strongly defined.
High	2	(Grade by
High	1	degree.)

EVALUATOR: C.C.A.

TABLE 6. KINK SENSITIVITY EVALUATION

FILM NO	FILM TYPE	LONG AXIS		SHORT AXIS		AVG.
135	M	very Slight	8	very slight	8	8.0
136	R	slight	6	slight	6	6.0
137	T	very slight	8	slight	7	7.5
138	45	moderate	5	moderate	5	5.0
139	55	severe	3	slight	6	4.5
140	65	severe	3	none	9	6.0
141	100	slight	6	slight	6	6.0
142	400	slight	6	slight	6	6.0
143	800	high	3	high	3	3.0
144	M-R	slight	7	slight	7	7.0
145	45-R	none	9	slight	7	8.0
146	55-R	slight	7	none	9	8.0
147	65-R	high	3	slight	6	4.5
		Processing mottling on all				
				RATING LEVELS		
		None	9	Perfect		
		Very Slight	8	Think you see something		
		Slight	7	Probably see something		
		Slight	6	Definitely see something		
		Mod.	5	(Better defined than 6.		
		Mod.	4	Grade by degree)		
		High	3	strongly defined		
		High	2	(Grade by		
		High	1	degree)		
EVALUATOR: S A W						

TABLE 7. PRESSURE SENSITIVITY EVALUATION

FILM NO.	FILM TYPE	LONG AXIS		SHORT AXIS		AVG.
152	M	High	3	High	3	3
153	R	High	2	High	3	2.5
154	T	High	2	High	3	2.5
155	45	Mod.	4	High	3	3.5
156	55	High	3	High	3	3
157	65	High	2	High	3	2.5
158	100	High	3	High	3	3
159	400	High	2	High	3	2.5
160	800	High	2	High	3	2.5
161	M-R	Slight	6	Slight	6	6
162	45-R	Mod.	5	Slight	6	5.5
163	55-R	High	3	Slight	6	4.5
164	65-R	High	2	None	9 ?	2 ? See Note

RATING LEVELS

None	9	Perfect
None	8	Think you see something
Slight	7	Probably see something
Slight	6	Definitely see something
Mod.	5	(Better defined than 6.
Mod.	4	Grade by degree)
High	3	Strongly defined
High	2	(Grade by
High	1	Degree)

NOTE: Technician probably forgot to mark along Short Axis.

EVALUATOR: R.D.W.

TABLE 8. PRESSURE SENSITIVITY EVALUATION

FILM NO.	FILM TYPE	LONG AXIS		SHORT AXIS		AVG.
152	M	High	3	High	3	3.0
153	R	High	3	High	3	3.0
154	T	High	3	High	3	3.0
155	45	Moderate	4	High	3	3.5
156	55	High	3	High	3	3.0
157	65	High	2	High	3	2.5
158	100	High	2	High	2	2.0
159	400	High	2	High	3	2.5
160	800	High	2	HIgh	3	2.5
161	M-R	Slight	6	Slight	6	6.0
162	45-R	Moderate	5	Slight	6	5.5
163	55-R	High	3	Slight	6	4.5
164	65-R	High	2	None	9	
161 would interfere with interpretation						
RATING LEVELS						
None	9	Perfect				
None	8	Think you see something				
Slight	7	Probably see something				
Slight	6	Definitely see something				
Mod.	5	(Better defined than 6.				
Mod.	4	Grade by degree)				
High	3	Strongly defined				
High	2	(Grade by				
High	1	degree.)				
EVALUATOR: C.C.A.						

TABLE 9. PRESSURE SENSITIVITY EVALUATION

FILM NO.	FILM TYPE	LONG AXIS		SHORT AXIS			AVG.
152	M	High	3	High	3 -		3.5
153	R	Very High	2	High	3		2.5
154	T	Very High	2	High	3		2.5
155	45	Moderate	4	High	3		3.5
156	55	High	3	High	3		3
157	65	Very High	2	High	3		2.5
158	100	High	2	High	3		2.5
159	400	Very High	1	High	3		2.0
160	800	Very High	1	High	2		1.5
161	M-R	Slight	6	Slight	6		6.0
162	45-R	Moderate	5	Slight	6		5.5
163	55-R	High	3	Slight	6		4.5
164	65-R	Very High	2	None	--		

All except 161 would interfere with interpretation.

RATING LEVELS

None	9	Perfect
None	8	Think you see something
Slight	7	Probably see something
Slight	6	Definitely see something
Mod.	5	(Better defined than 6.
Mod.	4	Grade by degree)
High	3	Strongly defined.
High	2	(Grade by
High	1	Degree)

NOTE: Technician probably forgot to mark along Short Axis.

EVALUATOR: S.A.W.

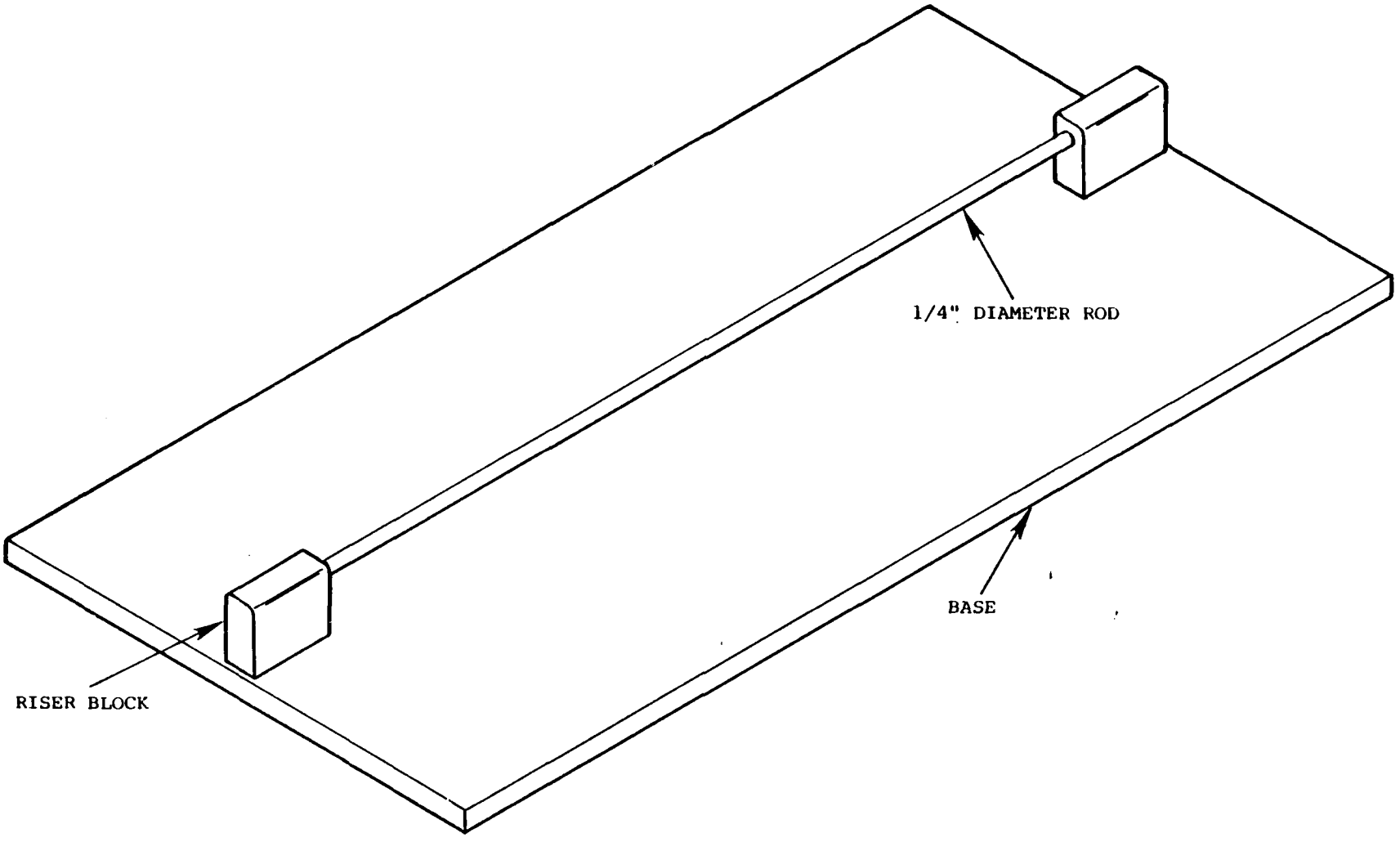
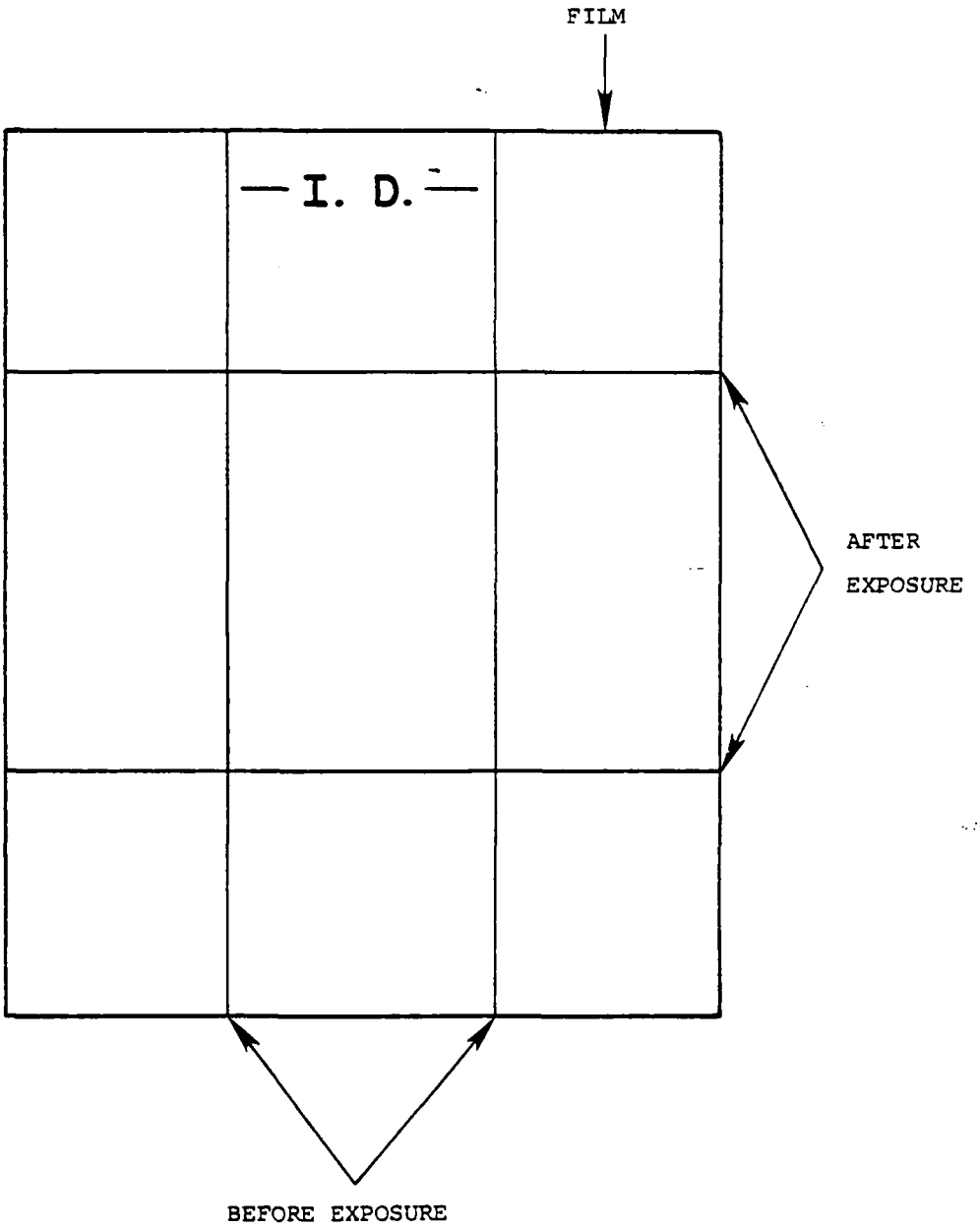
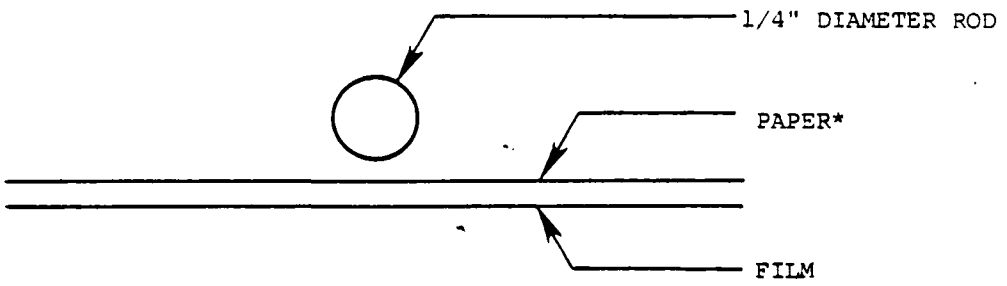


FIGURE 6. KINK TEST FIXTURE



5711

FIGURE 7. KINK TEST



*Paper used on unpacked films for protection. Paper not used on redipack films.

5712

Schedule of exposures for kink test.

FILM #	FILM TYPE AND PACKAGING	
135	M	Film holder
136	R	Film holder
137	T	Film holder
138	45	Film holder
139	55	Film holder
140	65	Film holder
141	100	Film holder
142	400	Film holder
143	800	Film holder
144	M	Ready Pack
145	45	Ray Pack
146	55	Ray Pack
147	65	Ray Pack

FIGURE 8. KINK TEST SCHEDULE

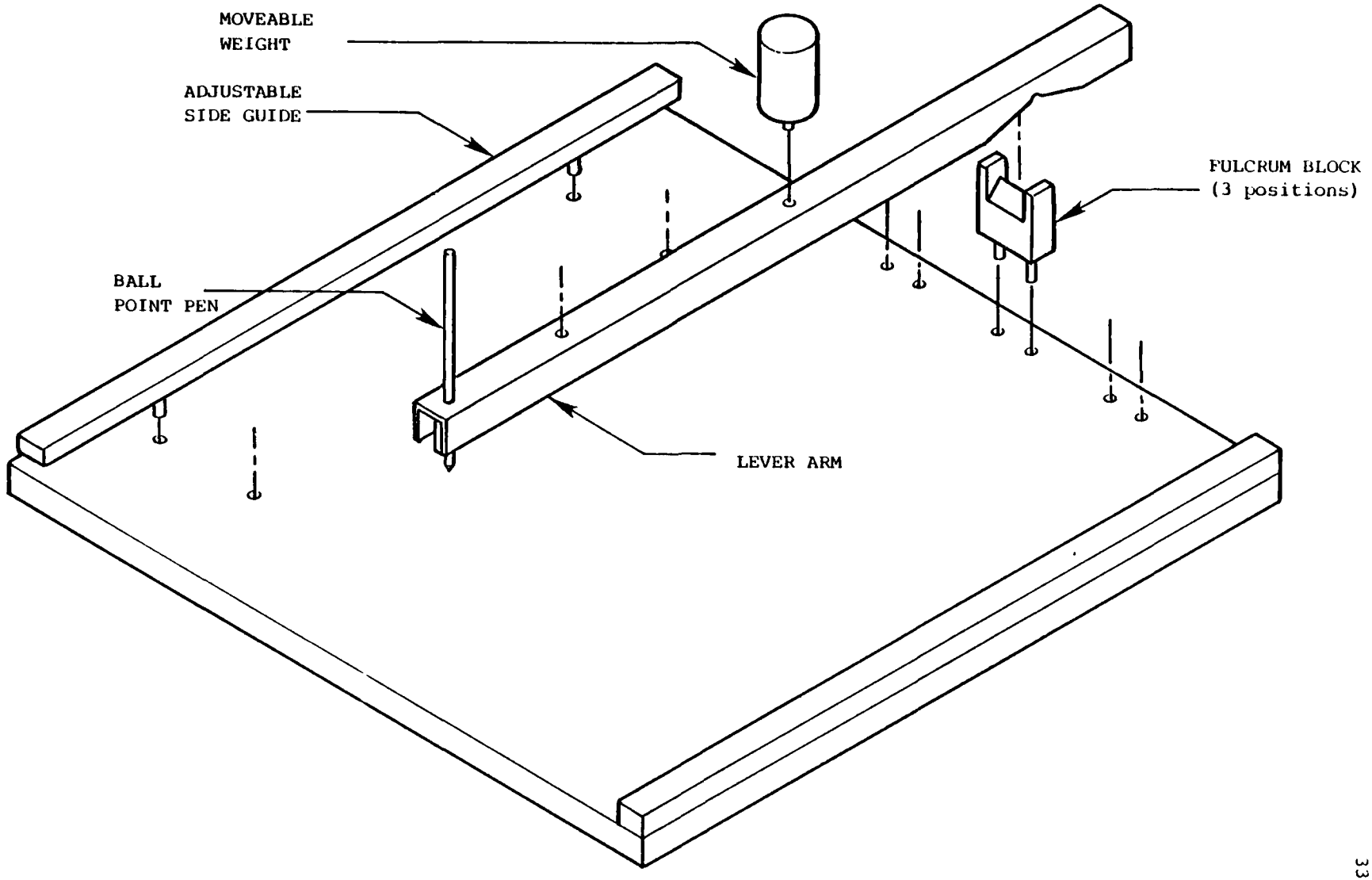
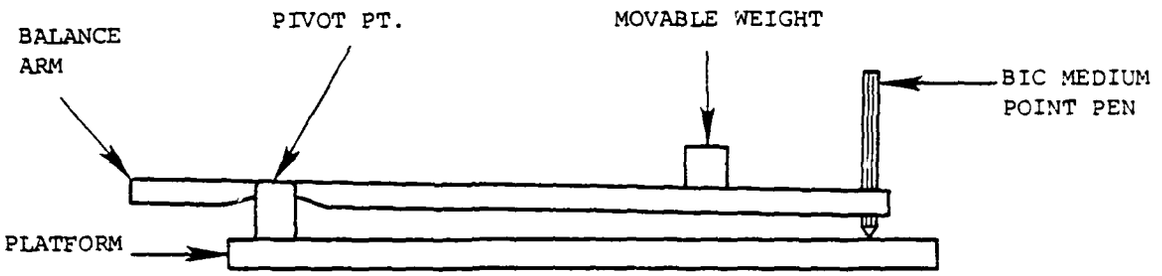


FIGURE 9. PRESSURE TEST FIXTURE



Balance Arm used by itself for 160 grams.

Movable weight is set at two other positions on balance arm for 333 and 500 grams.

160 grams $\approx$ 5.6 ounces

333 grams $\approx$ 11.7 ounces

500 grams $\approx$ 17.6 ounces

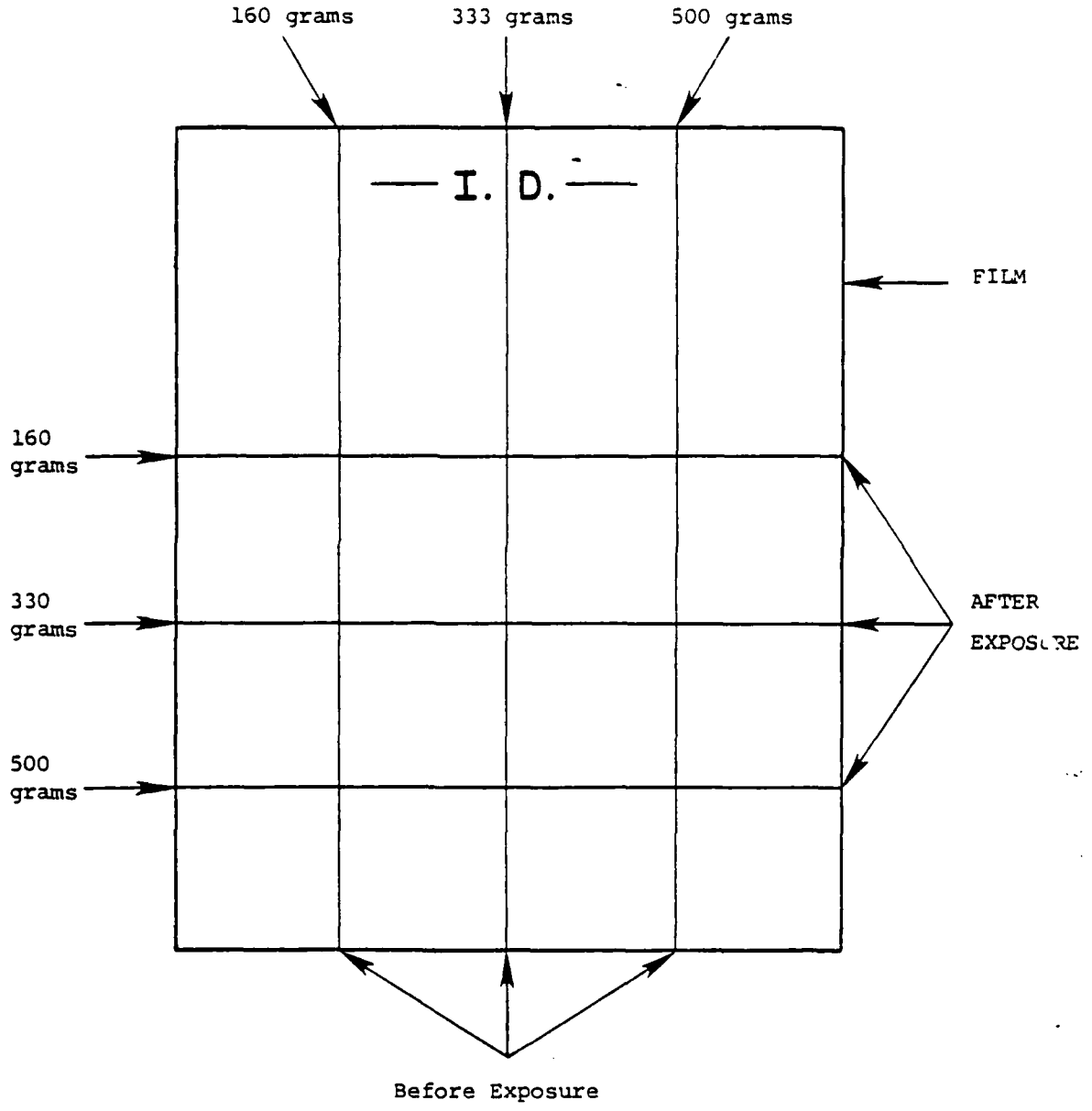
5714

Paper cover used on unpacked films for protection.

Paper not used on Ready & Day Pack films.

FILM #	FILM TYPE AND PACKAGING	
152	M	Film holder
153	R	Film holder
154	T	Film holder
155	45	Film holder
156	55	Film holder
157	65	Film holder
158	100	Film holder
159	400	Film holder
160	800	Film holder
161	M	Ready Pack
162	45	Day Pack
163	55	Day Pack
164	65	Day Pack

FIGURE 10. PRESSURE TEST SCHEDULE



5715

FIGURE 11. PRESSURE TEST PLAN

APPENDIX A

STEP TABLET CALIBRATION CURVES

TABLE OF CONTENTS

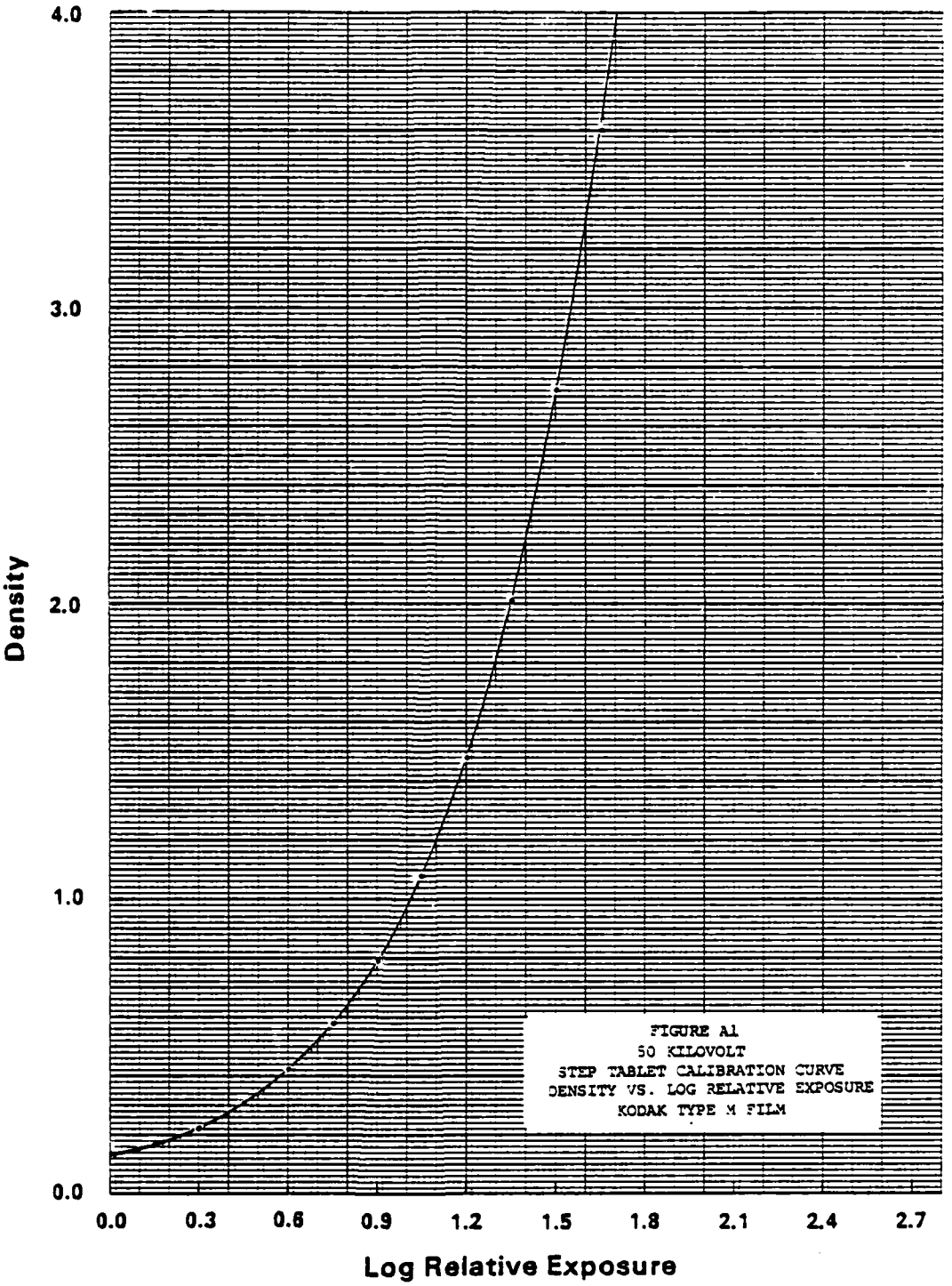


FIGURE A1
50 KILOVOLT
STEP TABLET CALIBRATION CURVE
DENSITY VS. LOG RELATIVE EXPOSURE
KODAK TYPE M FILM

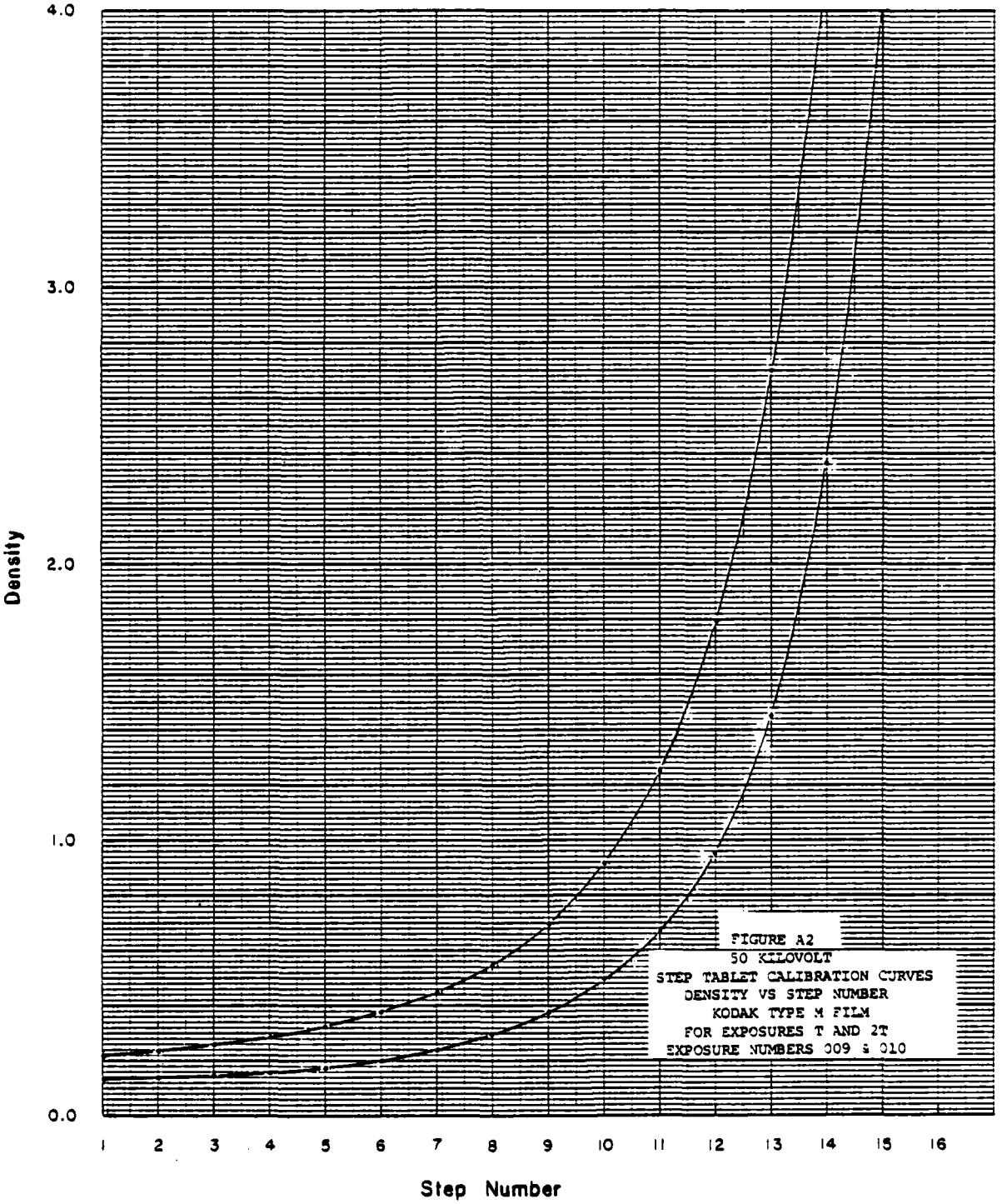


FIGURE A2
50 KILOVOLT
STEP TABLET CALIBRATION CURVES
DENSITY VS STEP NUMBER
KODAK TYPE M FILM
FOR EXPOSURES T AND 2T
EXPOSURE NUMBERS 009 & 010

TABLE A1
CALIBRATION DATA

FILM NO. 009 KV 50 EXPOSURE T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.
1	5.058	4.890	4.974	1	4.938	4.838	16
2	4.165	4.183	4.174	2	4.117	4.017	15
3	2.440	2.490	2.465	3	2.463	2.363	14
4	1.528	1.563	1.546	4	1.554	1.454	13
5	1.025	1.055	1.040	5	1.052	0.952	12
6	0.755	0.768	0.762	6	.767	0.667	11
7	0.585	0.590	0.588	7	.589	0.489	10
8	0.475	0.470	0.473	8	.473	0.373	9
9	0.388	0.398	0.393	9	.395	0.295	8
10	0.333	0.345	0.339	10	.339	0.239	7
11	0.298	0.303	0.301	11	.300	.200	6
12	0.270	0.273	0.272	12	.272	0.172	5
13	0.255	0.260	0.258	13	.258	0.158	4
14	0.253	0.245	0.249	14	.246	0.146	3
15	0.240	0.243	0.242	15	.238	0.138	2
16	0.233	0.233	0.233	16	.235	0.135	1
17	0.235	0.238	0.237				
18	0.235	0.233	0.234				
19	0.245	0.240	0.243				
20	0.258	0.255	0.257				
21	0.270	0.273	0.272				
22	0.298	0.300	0.299				
23	0.335	0.340	0.338				
24	0.393	0.398	0.396				
25	0.468	0.475	0.472				
26	0.585	0.595	0.590				
27	0.763	0.780	0.772				
28	1.053	1.073	1.063				
29	1.553	1.568	1.561				
30	2.453	2.468	2.461				
31	4.065	4.055	4.060				
32	4.970	4.833	4.902				

TABLE A2

CALIBRATION DATA

FILM NO. 010 KV 50 EXPOSURE 2T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.
1	4.83	4.83	4.83	1	4.830	4.730	16
2	4.83	4.83	4.83	2	4.830	4.730	15
3	4.273	4.310	4.292	3	4.267	4.167	14
4	2.788	2.828	2.808	4	2.800	2.700	13
5	1.873	1.895	1.884	5	1.893	1.793	12
6	1.333	1.358	1.346	6	1.350	1.250	11
7	1.005	1.018	1.012	7	1.014	0.914	10
8	0.793	0.803	0.798	8	.800	0.700	9
9	0.653	0.658	0.656	9	.652	0.552	8
10	0.553	0.558	0.556	10	.551	0.451	7
11	0.475	0.480	0.478	11	.475	0.375	6
12	0.420	0.423	0.422	12	.422	0.322	5
13	0.385	0.388	0.387	13	.385	0.285	4
14	0.355	0.358	0.357	14	.360	0.260	3
15	0.330	0.335	0.333	15	.336	0.236	2
16	0.315	0.320	0.318	16	.322	0.222	1
17	0.318	0.333	0.326				
18	0.338	0.340	0.339				
19	0.355	0.368	0.362				
20	0.378	0.385	0.382				
21	0.420	0.423	0.422				
22	0.468	0.475	0.472				
23	0.545	0.545	0.545				
24	0.648	0.648	0.648				
25	0.795	0.808	0.802				
26	1.013	1.018	1.016				
27	1.343	1.363	1.353				
28	1.893	1.908	1.901				
29	2.765	2.818	2.792				
30	4.223	4.260	4.242				
31	4.83	4.83	4.83				
32	4.83	4.83	4.83				

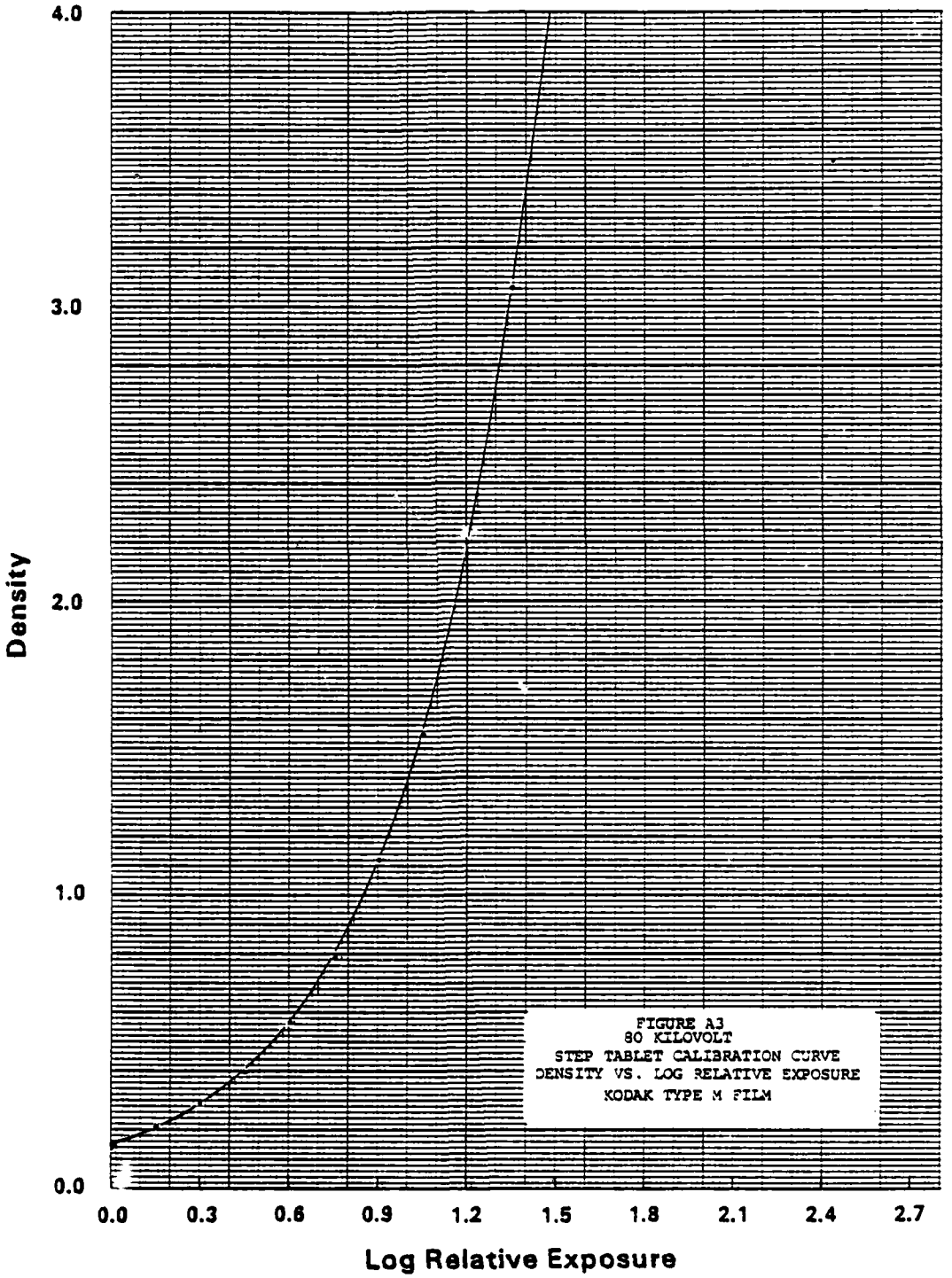


FIGURE A3
80 KILOVOLT
STEP TABLET CALIBRATION CURVE
DENSITY VS. LOG RELATIVE EXPOSURE
KODAK TYPE M FILM

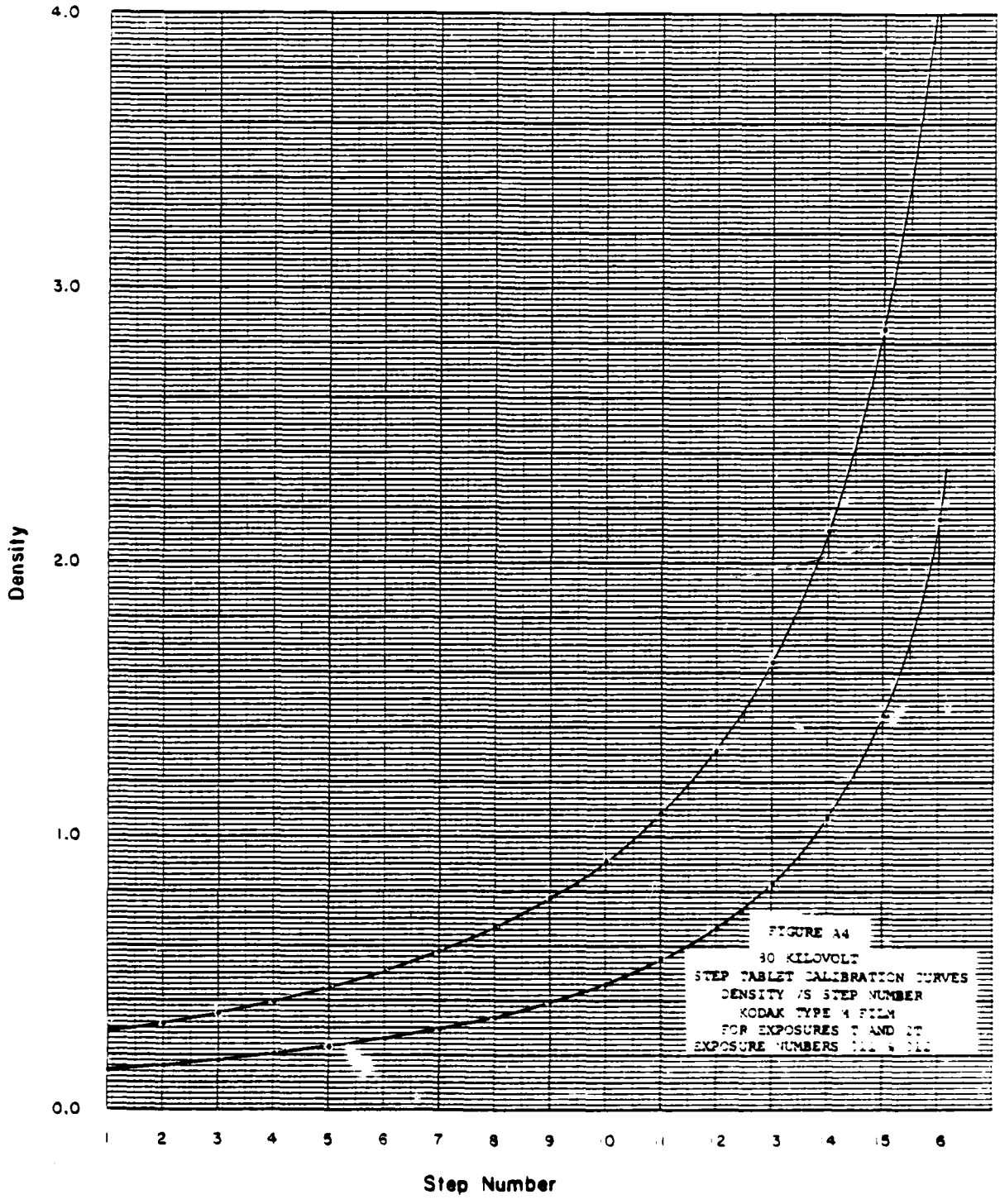


FIGURE A4
80 KILOVOLT
STEP TABLET CALIBRATION CURVES
DENSITY VS STEP NUMBER
KODAK TYPE 4 FILM
FOR EXPOSURES T AND 2T
EXPOSURE NUMBERS [illegible]

TABLE A3

CALIBRATION DATA

FILM NO. 011 KV 80 EXPOSURE T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.
1	2.388	2.413	2.401	1	2.259	2.159	16
2	1.600	2.613	1.607	2	1.543	1.443	15
3	1.198	1.203	1.201	3	1.169	1.069	14
4	0.943	0.953	0.948	4	0.931	0.831	13
5	0.768	0.783	0.776	5	0.766	0.666	12
6	0.650	0.660	0.655	6	0.651	0.551	11
7	0.563	0.570	0.567	7	0.565	0.465	10
8	0.498	0.503	0.501	8	0.498	0.398	9
9	0.435	0.443	0.439	9	0.441	0.341	8
10	0.395	0.398	0.397	10	0.398	0.298	7
11	0.355	0.358	0.357	11	0.359	0.259	6
12	0.325	0.328	0.327	12	0.329	0.229	5
13	0.300	0.298	0.299	13	0.299	0.199	4
14	0.278	0.275	0.277	14	0.278	0.178	3
15	0.255	0.260	0.258	15	0.263	0.163	2
16	0.243	0.245	0.244	16	0.244	0.144	1
17	0.240	0.245	0.243				
18	0.255	0.263	0.267				
19	0.275	0.280	0.278				
20	0.295	0.305	0.298				
21	0.328	0.333	0.331				
22	0.358	0.363	0.361				
23	0.393	0.403	0.398				
24	0.438	0.448	0.443				
25	0.490	0.500	0.495				
26	0.560	0.565	0.563				
27	0.638	0.653	0.646				
28	0.750	0.760	0.755				
29	0.908	0.918	0.913				
30	1.128	1.145	1.137				
31	1.465	1.490	1.478				
32	2.098	2.133	2.116				

TABLE A4

CALIBRATION DATA

FILM NO. 012 . KV 80 EXPOSURE 2T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.
1	4.355	4.373	4.364	1	4.182	4.082	16
2	3.050	3.073	3.062	2	2.949	2.849	15
3	2.268	2.278	2.273	3	2.216	2.116	14
4	1.765	1.775	1.770	4	1.740	1.640	13
5	1.425	1.430	1.433	5	1.416	1.316	12
6	1.195	1.198	1.197	6	1.186	1.086	11
7	1.015	1.015	1.015	7	1.012	0.912	10
8	0.878	0.878	0.878	8	0.878	0.778	9
9	0.768	0.768	0.768	9	0.770	0.670	8
10	0.683	0.675	0.687	10	0.684	0.584	7
11	0.608	0.605	0.607	11	0.606	0.506	6
12	0.543	0.543	0.543	12	0.545	0.445	5
13	0.493	0.493	0.493	13	0.493	0.393	4
14	0.453	0.445	0.454	14	0.454	0.354	3
15	0.418	0.415	0.417	15	0.415	0.315	2
16	0.388	0.383	0.386	16	0.387	0.287	1
17	0.388	0.388	0.388				
18	0.413	0.413	0.413				
19	0.453	0.453	0.453				
20	0.493	0.490	0.492				
21	0.545	0.548	0.547				
22	0.605	0.605	0.605				
23	0.680	0.680	0.680				
24	0.768	0.773	0.771				
25	0.878	0.878	0.878				
26	1.005	1.013	1.009				
27	1.170	1.178	1.174				
28	1.395	1.403	1.399				
29	1.705	1.713	1.709				
30	2.153	2.163	2.158				
31	2.828	2.843	2.836				
32	3.993	4.005	3.999				

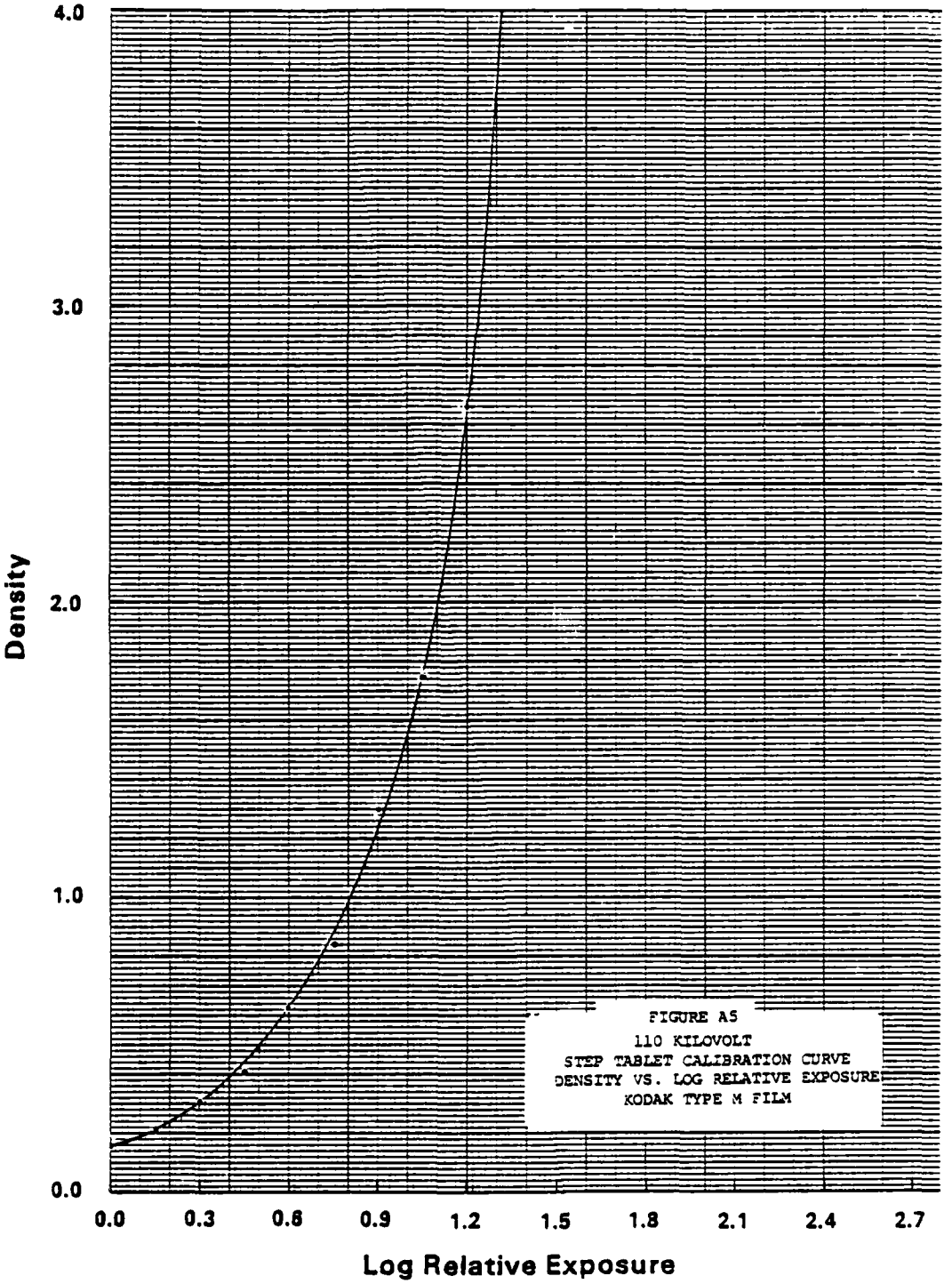


FIGURE A5
110 KILOVOLT
STEP TABLET CALIBRATION CURVE
DENSITY VS. LOG RELATIVE EXPOSURE
KODAK TYPE M FILM

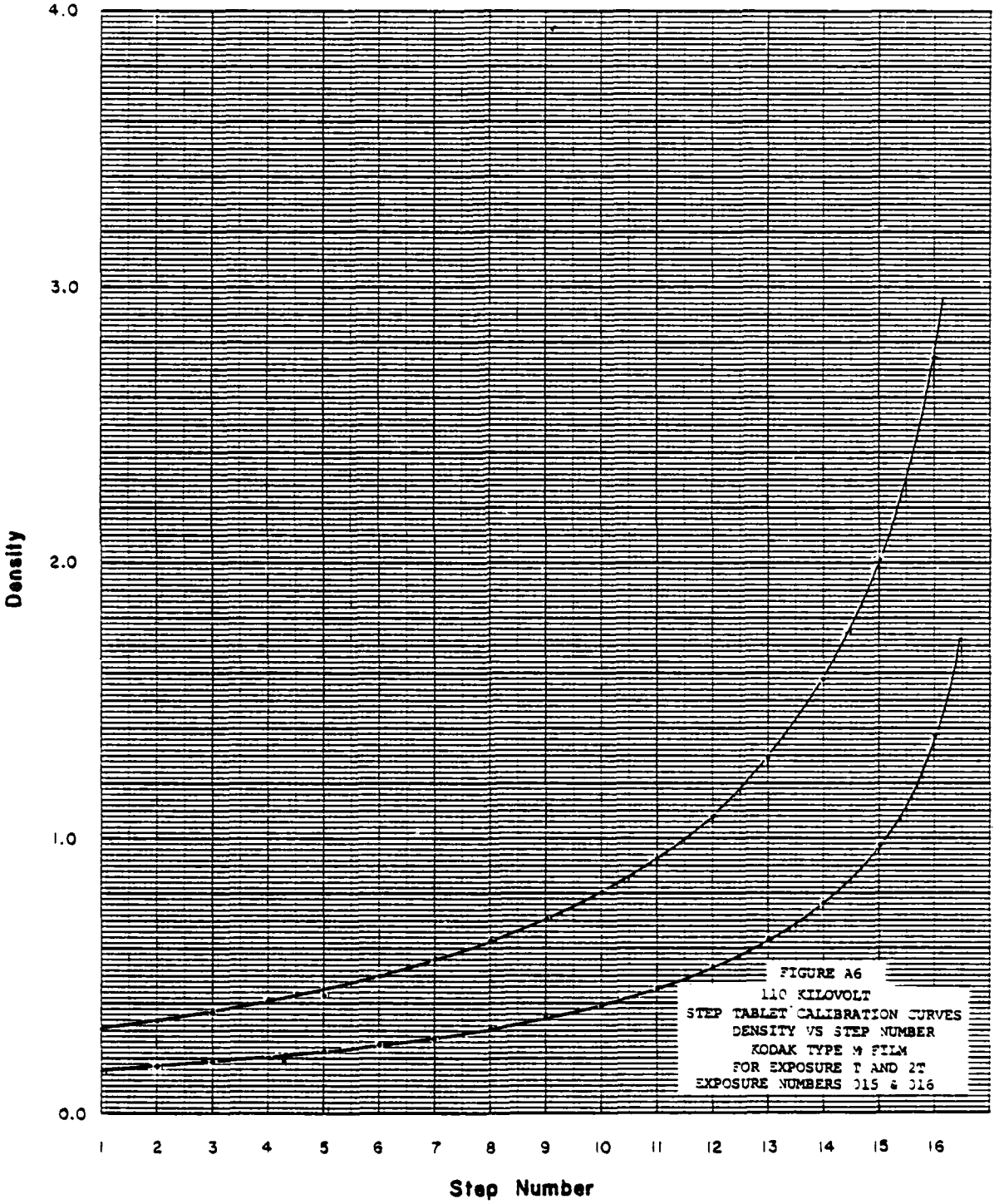


FIGURE A6
110 KILOVOLT
STEP TABLET CALIBRATION CURVES
DENSITY VS STEP NUMBER
KODAK TYPE M FILM
FOR EXPOSURE 1 AND 2T
EXPOSURE NUMBERS 015 & 016

TABLE A5
CALIBRATION DATA

FILM NO. 015 . KV 110 EXPOSURE T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.
1	1.560	1.580	1.590	1	1.475	1.375	16
2	1.095	1.108	1.102	2	1.073	0.973	15
3	0.875	0.880	0.878	3	.866	0.766	14
4	0.728	0.735	0.732	4	.737	0.627	13
5	0.625	0.630	0.628	5	.627	0.527	12
6	0.550	0.553	0.552	6	.553	0.453	11
7	0.490	0.495	0.493	7	.494	0.394	10
8	0.445	0.450	0.448	8	.449	0.349	9
9	0.408	0.410	0.409	9	.410	0.310	8
10	0.370	0.380	0.375	10	.377	0.277	7
11	0.343	0.350	0.347	11	.349	0.249	6
12	0.320	0.325	0.323	12	.326	0.226	5
13	0.300	0.300	0.300	13	.301	0.201	4
14	0.280	0.285	0.283	14	.285	0.185	3
15	0.270	0.270	0.270	15	.270	0.170	2
16	0.260	0.260	0.260	16	.260	0.160	1
17	0.258	0.260	0.259				
18	0.273	0.265	0.269				
19	0.290	0.283	0.287				
20	0.303	0.300	0.302				
21	0.330	0.325	0.328				
22	0.350	0.350	0.350				
23	0.380	0.378	0.379				
24	0.410	0.410	0.410				
25	0.450	0.450	0.450				
26	0.495	0.495	0.495				
27	0.553	0.553	0.553				
28	0.623	0.628	0.626				
29	0.723	0.720	0.722				
30	0.853	0.853	0.853				
31	1.040	1.045	1.043				
32	1.358	1.362	1.360				

TABLE A6
CALIBRATION DATA

FILM NO. C16 KV 110 EXPOSURE 2T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.		
1	3.033	3.055	3.044	1	2.843	2.743	16		
2	2.183	2.205	2.194	2	2.108	2.008	15		
3	1.710	1.730	1.720	3	1.678	1.578	14		
4	1.403	1.425	1.414	4	1.389	1.289	13		
5	1.190	1.200	1.195	5	1.180	1.080	12		
6	1.030	1.038	1.034	6	1.026	0.926	11		
7	0.908	0.915	0.912	7	.906	0.806	10		
8	0.810	0.813	0.812	8	.808	0.708	9		
9	0.728	0.730	0.729	9	.727	0.627	8		
10	0.658	0.663	0.661	10	.662	0.562	7		
11	0.598	0.600	0.599	11	.601	0.501	6		
12	0.548	0.553	0.551	12	.532	0.432	5		
13	0.503	0.505	0.504	13	.506	0.406	4		
14	0.465	0.470	0.468	14	.468	0.368	3		
15	0.433	0.435	0.434	15	.435	0.335	2		
16	0.405	0.408	0.407	16	.408	0.308	1		
17	0.405	0.413	0.409						
18	0.435	0.435	0.435						
19	0.465	0.468	0.467						
20	0.505	0.508	0.507						
21	0.548	0.555	0.512						
22	0.600	0.603	0.602						
23	0.660	0.663	0.662						
24	0.725	0.725	0.725						
25	0.803	0.805	0.804						
26	0.900	0.898	0.899						
27	1.018	1.015	1.017						
28	1.165	1.165	1.165						
29	1.365	1.360	1.363						
30	1.635	1.635	1.635						
31	2.023	2.020	2.022						
32	2.630	2.653	2.642						

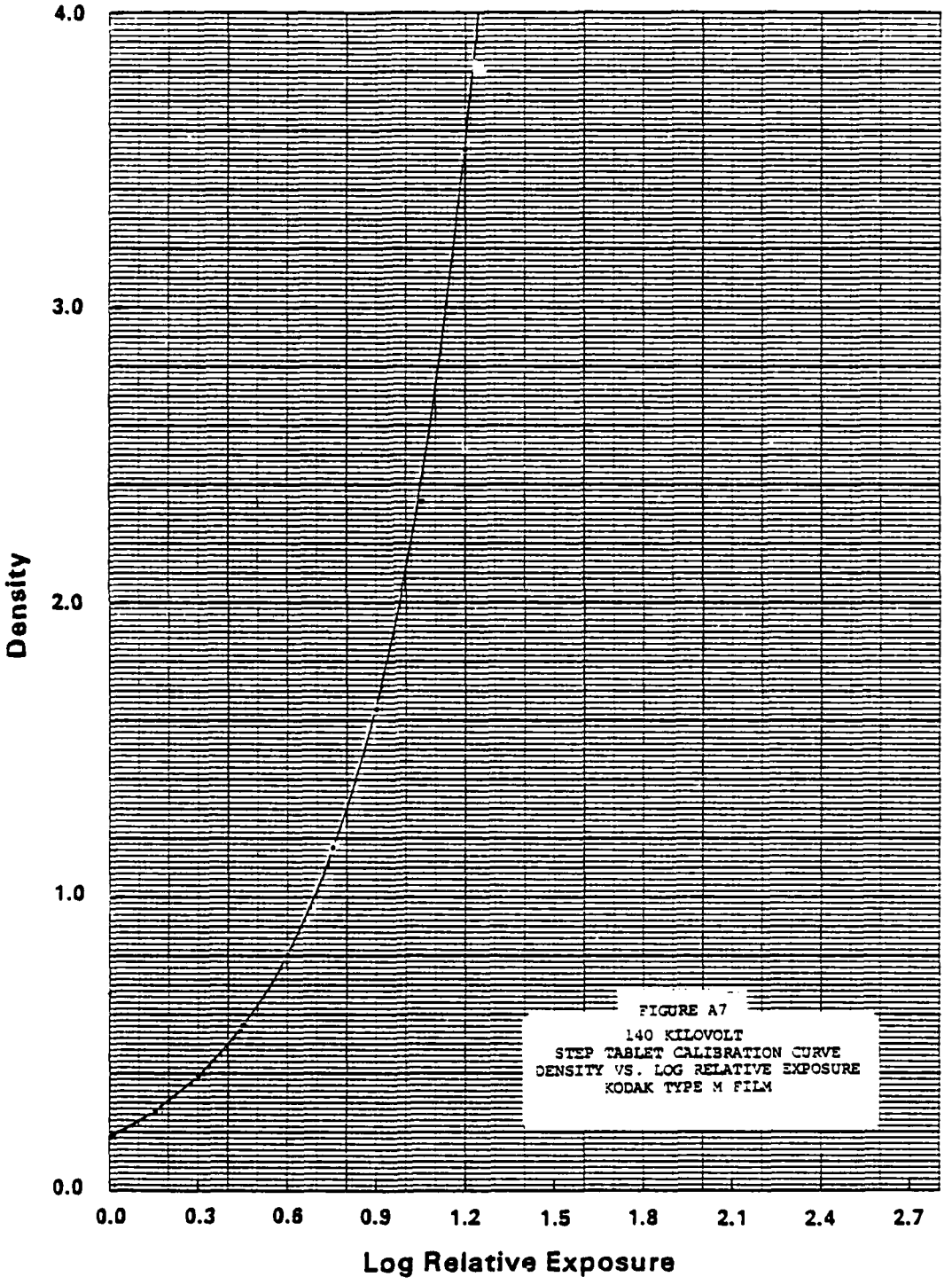


FIGURE A7

140 KILOVOLT
STEP TABLET CALIBRATION CURVE
DENSITY VS. LOG RELATIVE EXPOSURE
KODAK TYPE M FILM

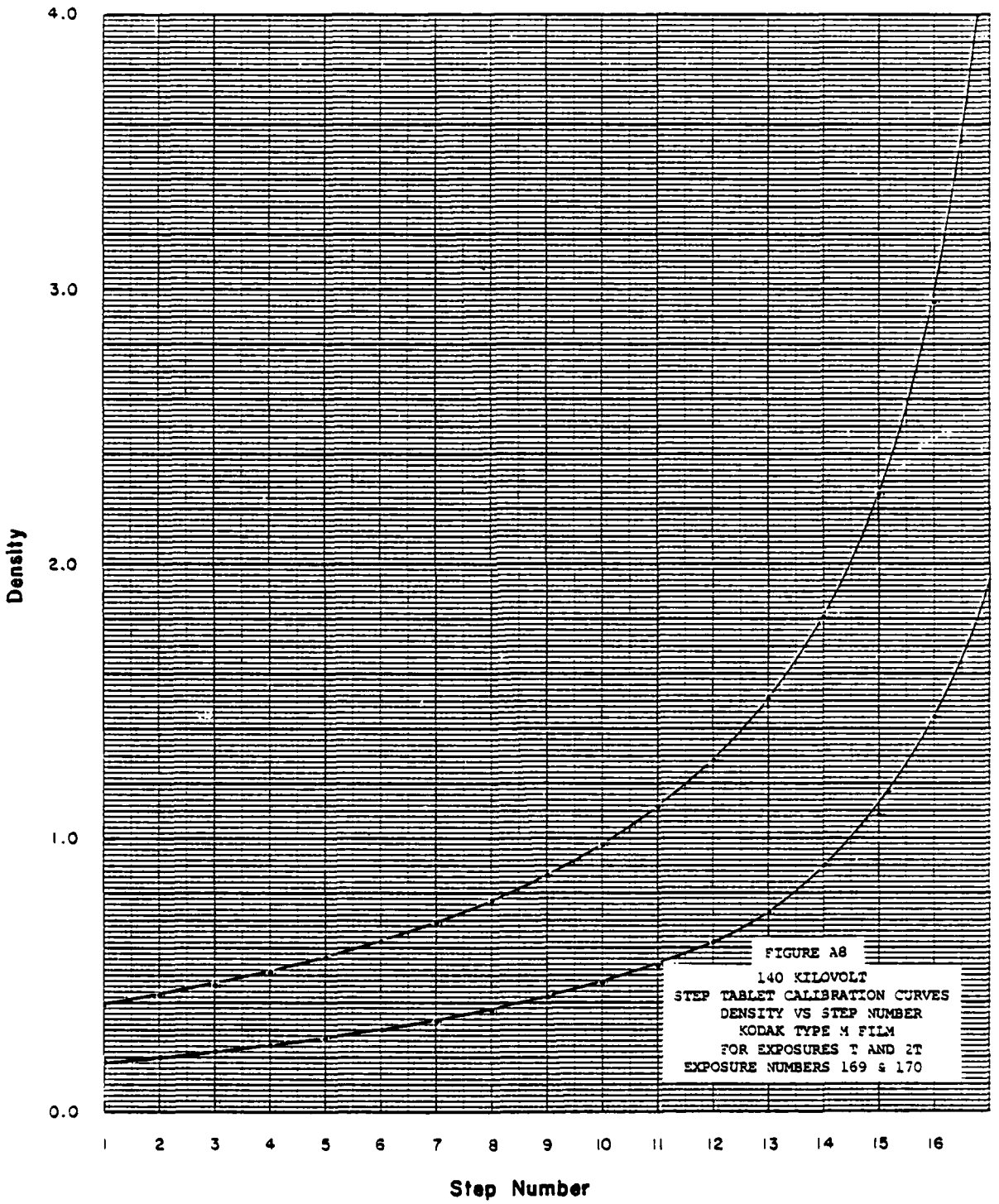


FIGURE A8
140 KILOVOLT
STEP TABLET CALIBRATION CURVES
DENSITY VS STEP NUMBER
KODAK TYPE M FILM
FOR EXPOSURES T AND 2T
EXPOSURE NUMBERS 169 & 170

TABLE A7

CALIBRATION DATA

FILM NO. 169 KV 140 — EXPOSURE T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.		
1	1.655	1.648	1.652	1	1.543	1.443	16		
2	1.233	1.233	1.233	2	1.183	1.083	15		
3	1.003	0.998	0.500	3	0.722	0.622	14		
4	0.843	0.840	0.842	4	0.825	0.725	13		
5	0.728	0.728	0.728	5	0.718	0.618	12		
6	0.640	0.645	0.643	6	0.637	0.537	11		
7	0.573	0.575	0.574	7	0.572	0.472	10		
8	0.520	0.520	0.520	8	0.520	0.420	9		
9	0.473	0.475	0.474	9	0.474	0.374	8		
10	0.433	0.435	0.434	10	0.434	0.334	7		
11	0.400	0.403	0.402	11	0.401	0.301	6		
12	0.370	0.373	0.372	12	0.371	0.271	5		
13	0.343	0.345	0.344	13	0.345	0.245	4		
14	0.320	0.320	0.320	14	0.321	0.221	3		
15	0.300	0.300	0.300	15	0.302	0.202	2		
16	0.280	0.285	0.283	16	0.284	0.184	1		
17	0.280	0.288	0.284						
18	0.300	0.305	0.303						
19	0.320	0.323	0.322						
20	0.343	0.348	0.346						
21	0.370	0.370	0.370						
22	0.400	0.400	0.400						
23	0.430	0.438	0.434						
24	0.470	0.475	0.473						
25	0.418	0.520	0.519						
26	0.568	0.570	0.569						
27	0.628	0.633	0.631						
28	0.708	0.705	0.707						
29	0.808	0.808	0.808						
30	0.940	0.945	0.943						
31	1.133	1.133	1.133						
32	1.428	1.440	1.434						

TABLE A8

CALIBRATION DATA

FILM NO. 170 KV 140 EXPOSURE 2 T

STEP NO.	LEFT	RIGHT	AVERAGE PER STEP	STEP NO.	AVERAGE END/END	AVERAGE - FOG	STEP NO.
1	3.230	3.240	2.235	1	3.057	2.957	16
2	2.428	2.438	2.433	2	2.349	2.249	15
3	1.955	1.963	1.959	3	1.907	1.807	14
4	1.633	1.633	1.633	4	1.603	1.503	13
5	1.398	1.398	1.398	5	1.380	1.280	12
6	1.223	1.223	1.223	6	1.213	1.113	11
7	1.088	1.085	1.087	7	1.078	0.978	10
8	0.970	0.968	0.969	8	0.966	0.866	9
9	0.875	0.873	0.874	9	0.873	0.773	8
10	0.793	0.793	0.793	10	0.791	0.691	7
11	0.723	0.723	0.723	11	0.721	0.621	6
12	0.663	0.665	0.664	12	0.663	0.563	5
13	0.608	0.610	0.609	13	0.610	0.510	4
14	0.560	0.560	0.560	14	0.561	0.461	3
15	0.520	0.523	0.522	15	0.523	0.423	2
16	0.490	0.490	0.490	16	0.490	0.390	1
17	0.490	0.488	0.489				
18	0.523	0.523	0.523				
19	0.563	0.560	0.562				
20	0.610	0.610	0.610				
21	0.663	0.660	0.662				
22	0.718	0.720	0.719				
23	0.788	0.790	0.789				
24	0.870	0.873	0.872				
25	0.960	0.965	0.963				
26	1.068	1.068	1.068				
27	1.203	1.200	1.202				
28	1.363	1.360	1.362				
29	1.575	1.568	1.572				
30	1.855	1.855	1.855				
31	2.260	2.268	2.264				
32	2.863	2.895	2.879				

APPENDIX B

50 KILOVOLT FILM SPEED COMPARISONS

TABLE OF CONTENTS

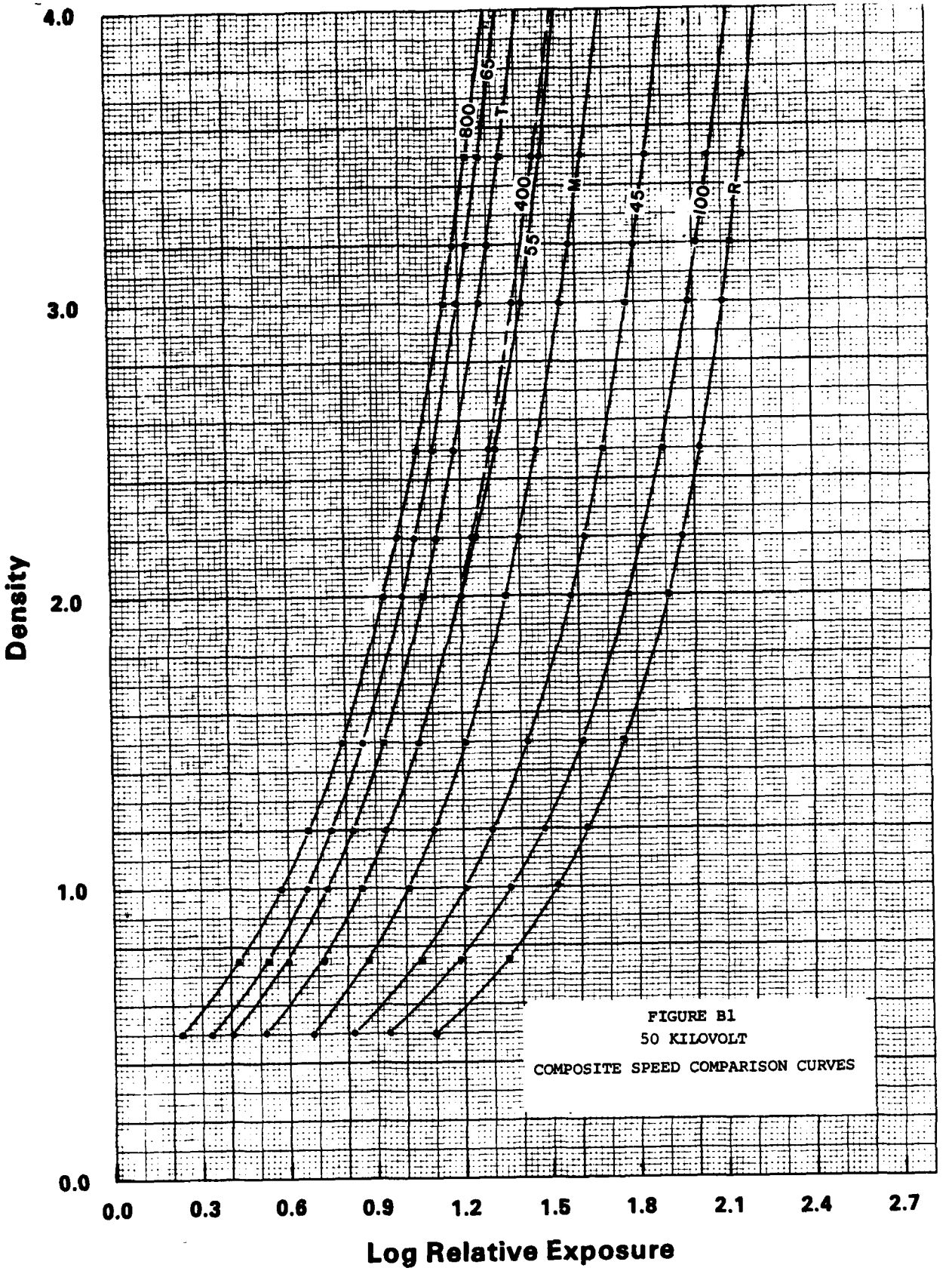


FIGURE B1
50 KILOVOLT
COMPOSITE SPEED COMPARISON CURVES

50 KV LRE Values For Speed Comparison Curves

Density	M	R	T	55	400	45	100	65	800
0.5	.68	1.1	.405	.52	.52	.28 / 0.82	.16 / .94	.07 / .335	.17 / .235
0.75	.872	1.35	.595	.715	.72	.3 / 1.05	.165 / 1.185	.07 / .525	.17 / .425
1.0	1.01	1.52	.735	.85	.86	.315 / 1.205	.16 / 1.36	.075 / .66	.16 / .575
1.2	1.1	1.625	.82	.935	.945	.325 / 1.3	.15 / 1.475	.075 / .745	.15 / .67
1.5	1.21	1.75	.925	1.05	1.06	.325 / 1.425	.14 / 1.61	.07 / .855	.145 / .78
2.0	1.35	1.905	1.07	1.20	1.20	.33 / 1.575	.135 / 1.77	.075 / .995	.135 / .935
2.2	1.398	1.955	1.115	1.25	1.24	.33 / 1.625	.13 / 1.825	.075 / 1.04	.135 / .98
2.5	1.46	2.02	1.18	1.32	1.30	.33 / 1.69	.125 / 1.895	.075 / 1.105	.13 / 1.05
3.0	1.545	2.10	1.27	1.41	1.38	.33 / 1.77	.115 / 1.985	.075 / 1.195	.125 / 1.145
3.2	1.582	2.13	1.30	1.44	1.42	.33 / 1.8	.12 / 2.01	.07 / 1.23	.12 / 1.18
3.5	1.628	2.175	1.345	1.48	1.46	.33 / 1.845	.12 / 2.055	.07 / 1.275	.12 / 1.225

Speed Relative To M in Percent

Density	M	R	T	55	400	45	100	65	800
0.5	100	38.0	188.4	144.5	144.5	72.4	55.0	221.3	278.6
1.0	100	30.9	188.4	144.5	141.3	63.8	44.7	223.9	272.3
1.5	100	28.8	192.8	144.5	141.3	61.0	39.8	226.5	269.2
2.0	100	27.8	190.5	141.3	141.3	59.6	38.0	226.5	260.0
2.5	100	27.5	190.5	138.0	144.5	58.9	36.7	226.5	257.0
3.0	100	27.8	188.4	136.5	146.2	59.6	36.3	223.9	251.2
3.5	100	28.4	191.9	140.6	147.2	60.7	37.4	225.4	252.9

Contrast Numbers

Density	M	R	T	55	400	45	100	65	800
1.0-3.0	3.74	3.45	3.74	3.57	3.85	3.54	3.2	3.74	3.51
1.0-1.2	2.22	1.90	2.35	2.35	2.35	2.11	1.74	2.35	2.11
2.0-2.2	4.17	4.00	4.44	4.00	5.0	4.0	3.64	4.44	4.44
3.0-3.2	5.41	6.67	6.67	6.67	5.0	6.67	8.0	5.71	5.71
1.5-2.5	4.0	3.70	3.92	3.70	4.17	3.77	3.51	4.0	3.70
2.0-3.0	5.13	5.13	5.0	4.76	5.56	5.13	4.65	5.0	4.76
2.5-3.5	5.95	6.45	6.06	6.25	6.25	6.45	6.25	5.88	5.71

TABLE B1

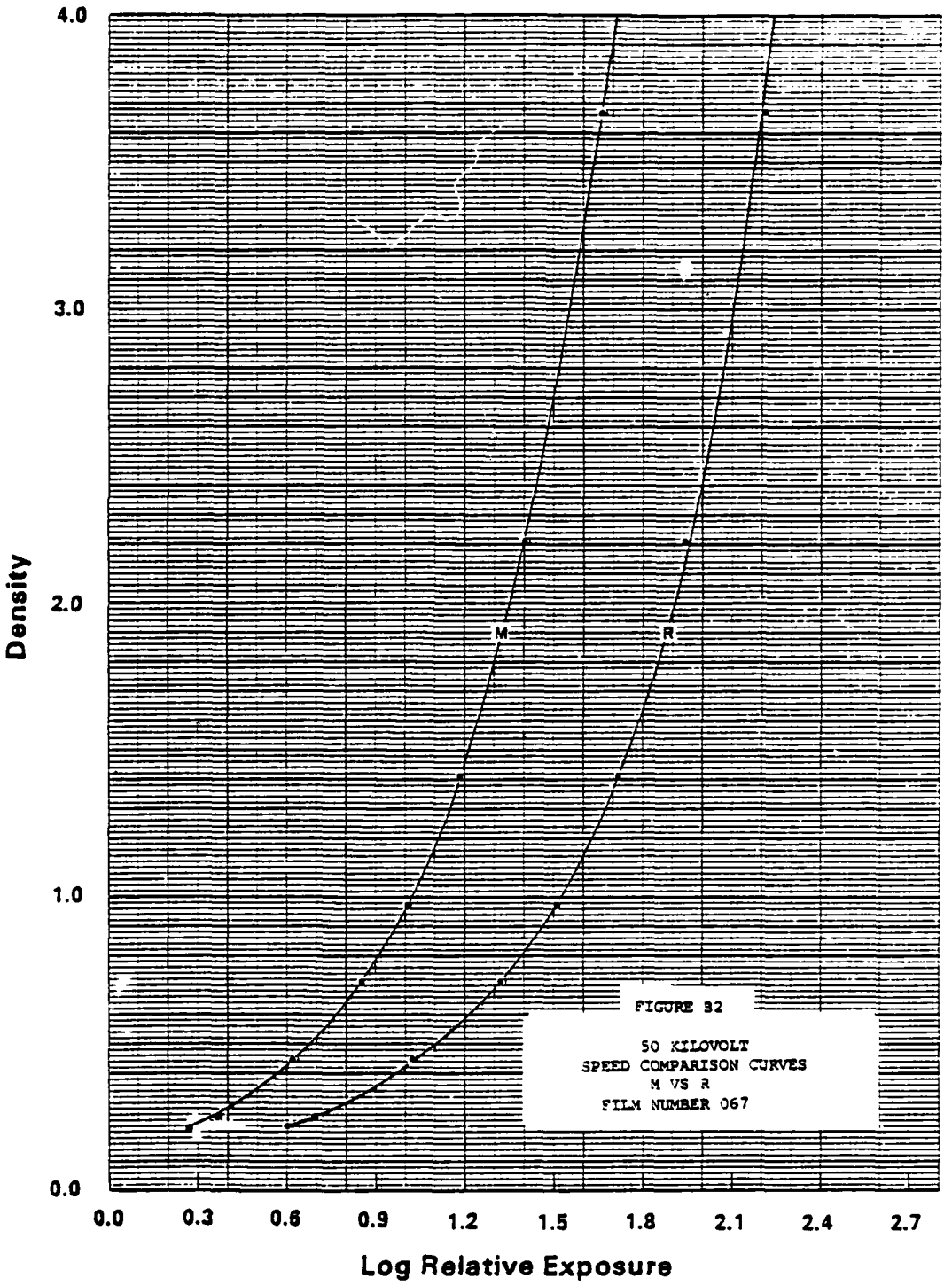


FIGURE B2

50 KILOVOLT
SPEED COMPARISON CURVES
M VS R
FILM NUMBER 067

50 KV

FILM TYPE

M VS. R FILM NO. 067

STEP NO.	D avg. M	LRE M	LRE R	DIFF.	LRE M ⊕ −DIFF.
1	.210	.265	-	-	-
2	.218				
3	.226	.300	0	-.30	.60
4	.239				
5	.257	.360	.06	-.30	.69
6	.289				
7	.321	.465	.13	-.335	.80
8	.404				
9	.444	.615	.215	-.40	1.015
10	.553	.72	.29	-.43	1.15
11	.717	.85	.38	-.47	1.32
12	.977	1.00	.49	-.51	1.51
13	1.418	1.18	.645	-.535	1.715
14	2.212	1.395	.85	-.545	1.94
15	3.674	1.66	1.11	-.55	2.21
16	4.995				

TABLE B2

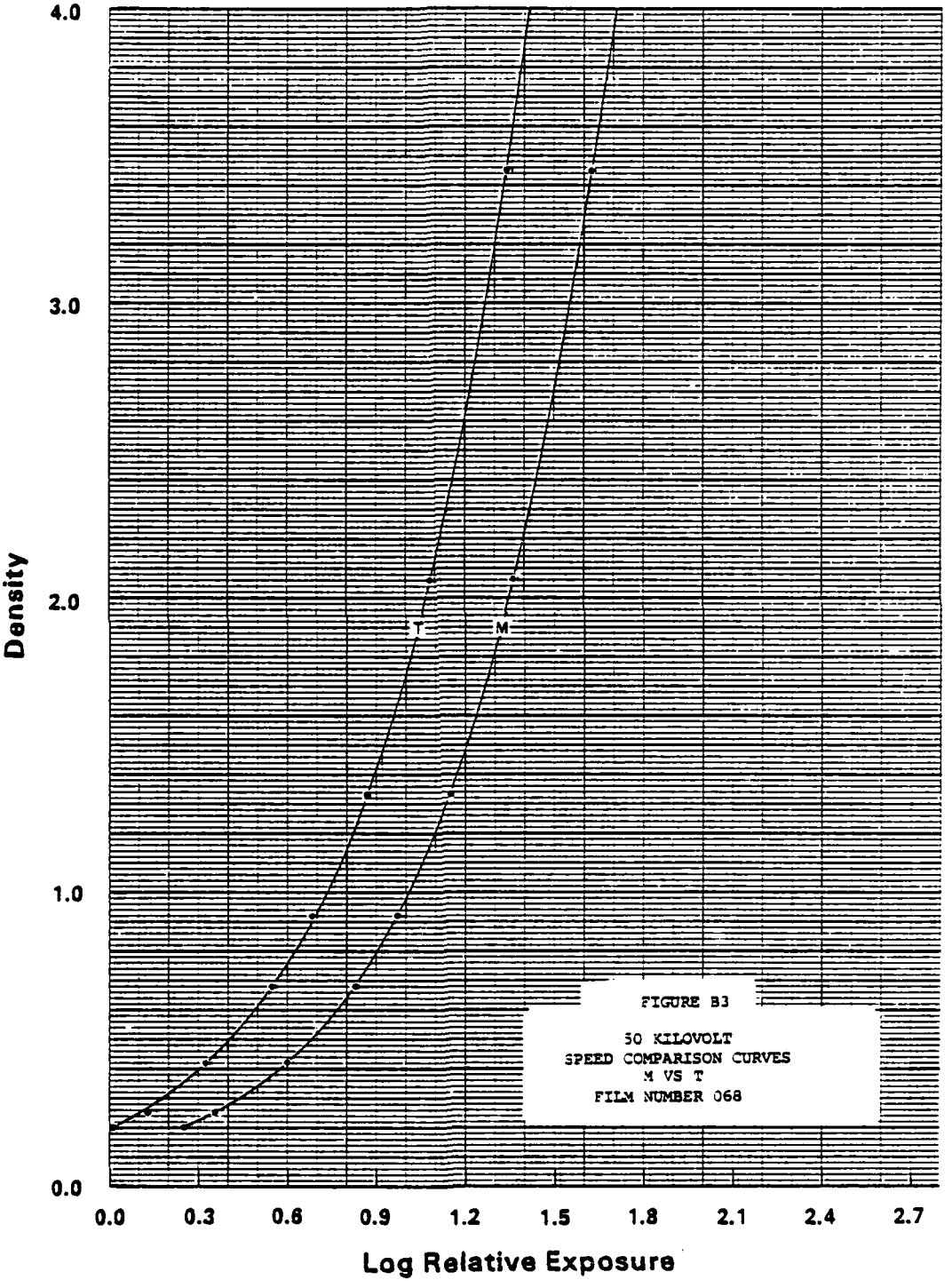


FIGURE B3

50 KILOVOLT
SPEED COMPARISON CURVES
M VS T
FILM NUMBER 068

50 KV

FILM TYPE

M VS. T FILM NO. 068

STEP NO.	D avg. M	LRE M	LRE T	DIFF.	LRE M ± DIFF.
1	.204	.25	.495	+ .245	.005
2	.214				
3	.222	.30	.515	+ .215	.108
4	.235				
5	.256	.36	.59	+ .23	.13
6	.275				
7	.31	.45	.71	+ .26	.19
8	.357				
9	.425	.60	.88	+ .28	.32
10	.528	.695	.99	+ .295	.40
11	.681	.83	1.115	+ .285	.545
12	.924	.97	1.26	+ .29	.68
13	1.329	1.15	1.44	+ .29	.86
14	2.067	1.36	1.64	+ .28	1.08
15	3.453	1.625			
16	4.867				

TABLE B3

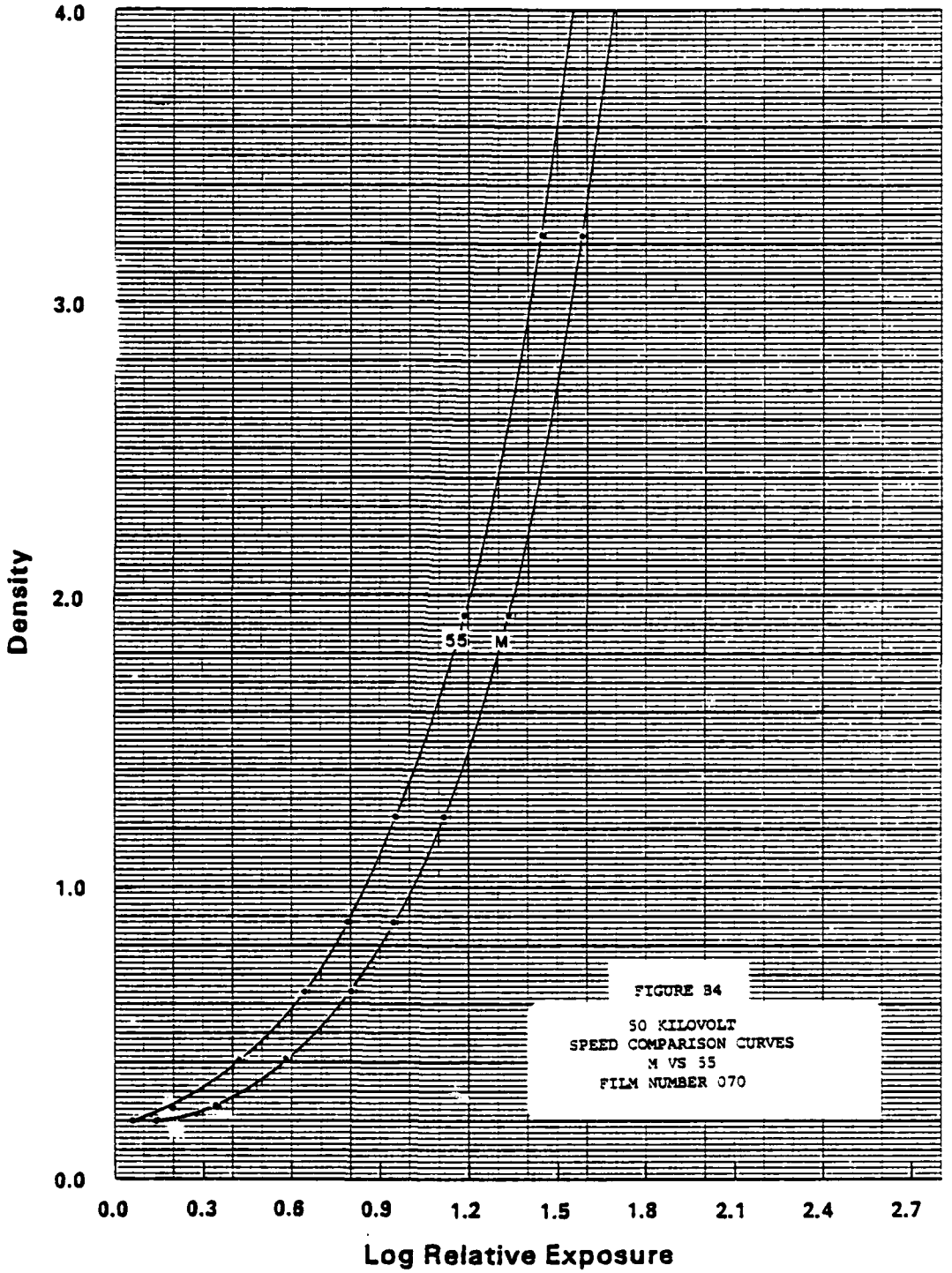


FIGURE B4

50 KILOVOLT
SPEED COMPARISON CURVES
M VS 55
FILM NUMBER 070

50 KV

FILM TYPE

M VS. 55 FILM NO. 070

STEP NO.	D avg. M	LRE M	LRE 55	DIFF.	LRE M ± DIFF.
1	.199	.235	.41	+ .175	.06
2	.203				
3	.214	.275	.425	+ .15	.125
4	.227				
5	.244	.34	.485	+ .145	.195
6	.267				
7	.302	.44	.585	+ .145	.295
8	.347				
9	.409	.45	.74	+ .16	.42
10	.503	.675	.84	+ .165	.51
11	.646	.80	.96	+ .16	.64
12	.873	.945	1.105	+ .16	.785
13	1.244	1.115	1.28	+ .165	.95
14	1.933	1.335	1.485	+ .15	1.185
15	3.223	1.585	1.72	+ .135	1.45
16	4.897				

TABLE B4

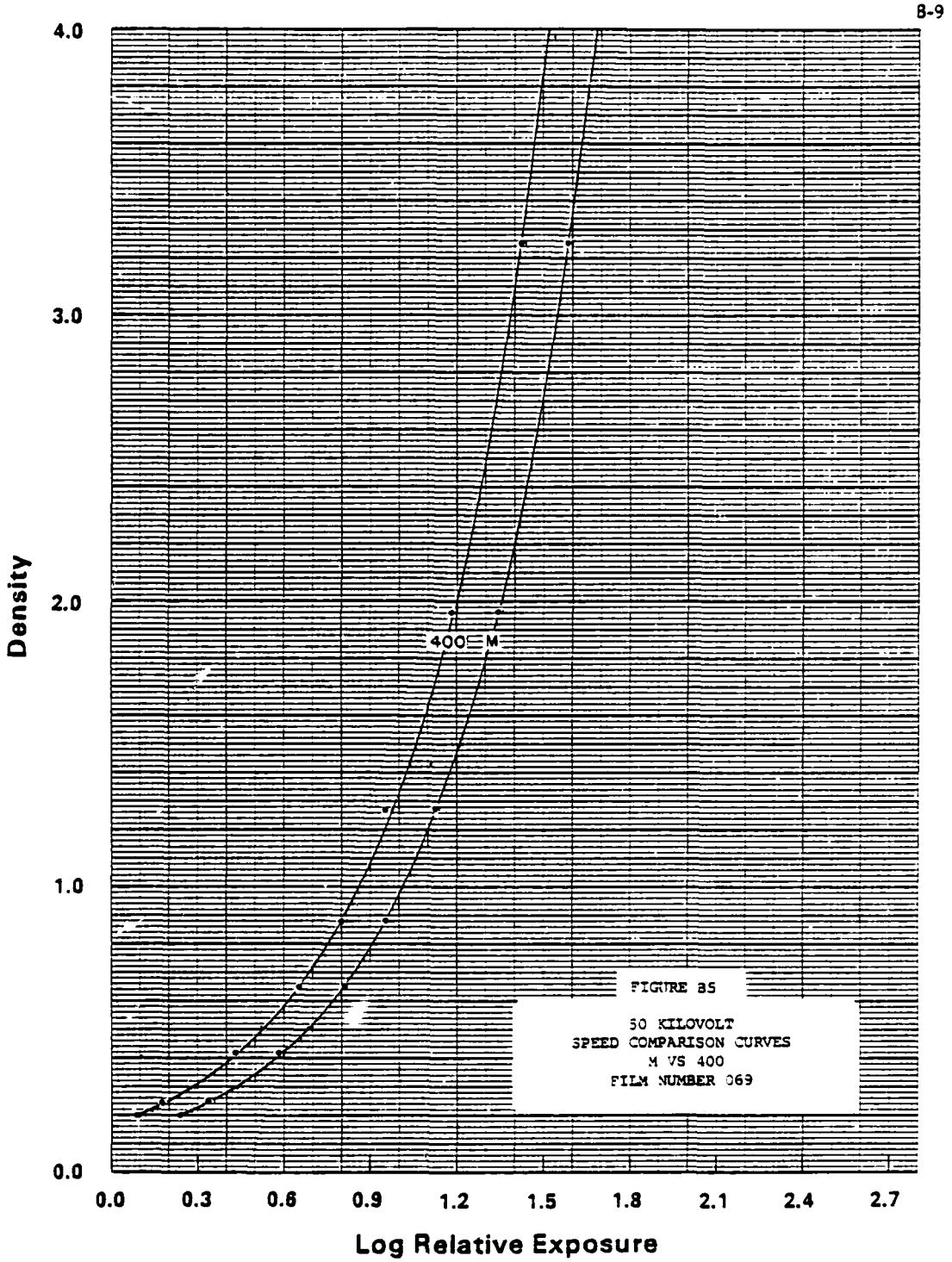


FIGURE B5

50 KILOVOLT
SPEED COMPARISON CURVES
M VS 400
FILM NUMBER 069

50 KV

FILM TYPE

M VS. 400 FILM NO. 069

STEP NO.	D avg. M	LRE M	LRE 400	DIFF.	LRE M ± DIFF.
1	.202	.24	.39	+ .15	.09
2	.206				
3	.215	.28	.42	+ .14	.14
4	.229				
5	.243	.335	.50	+ .165	.17
6	.267				
7	.298	.435	.58	+ .145	.29
8	.344				
9	.412	.58	.735	+ .155	.452
10	.508	.68	.84	+ .16	.52
11	.652	.805	.965	+ .16	.645
12	.880	.95	1.105	+ .155	.795
13	1.269	1.12	1.29	+ .17	.95
14	1.964	1.34	1.50	+ .16	1.18
15	3.251	1.585			
16	4.815				

TABLE B5

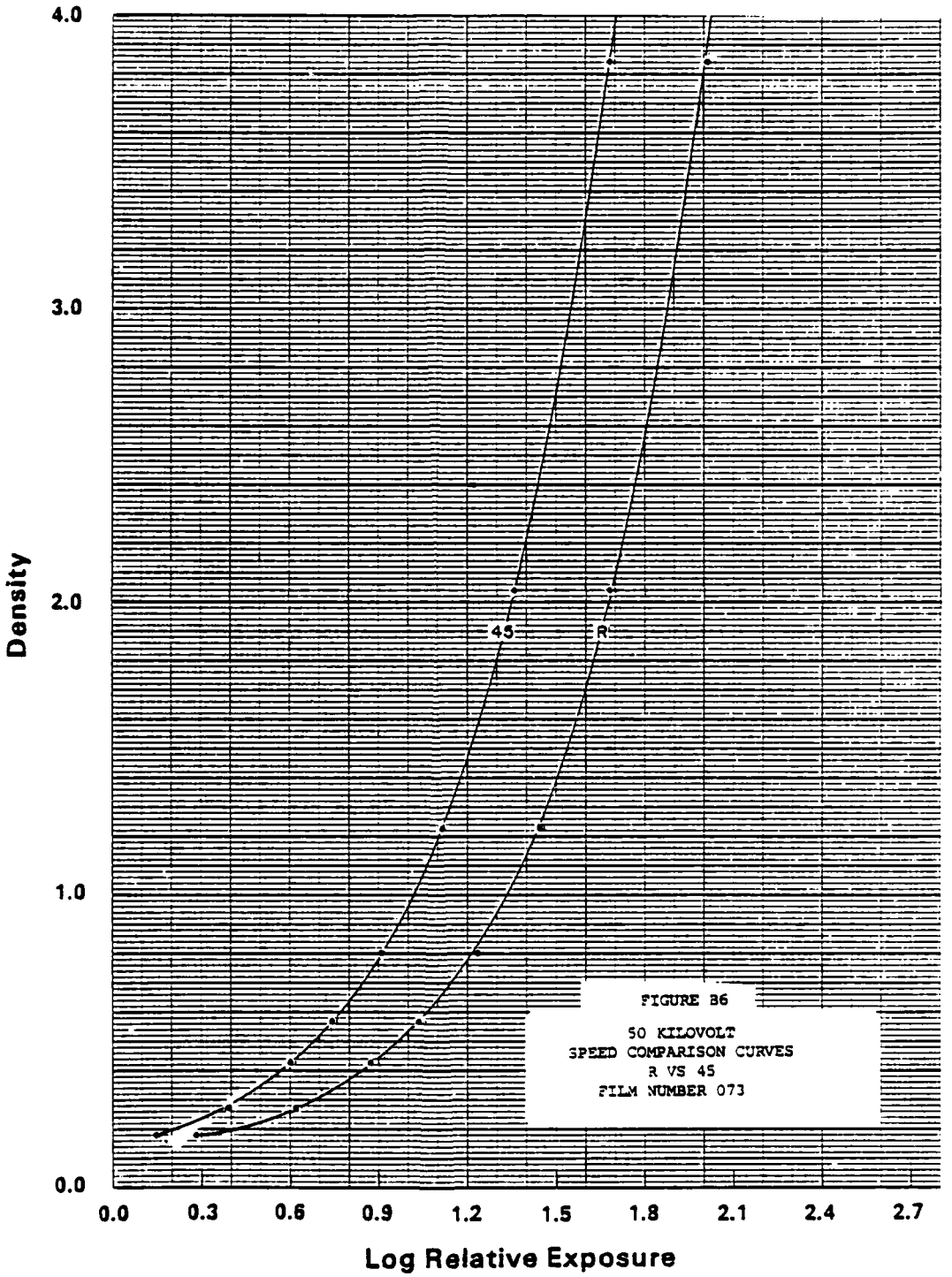


FIGURE B6

50 KILOVOLT
SPEED COMPARISON CURVES
R VS 45
FILM NUMBER 073

50 KV

FILM TYPE

R VS. 45 FILM NO. 073

STEP NO.	D avg. 45	LRE 45	LRE R	DIFF.	LRE 45 ± DIFF.
1	.140	.03			
2	.146				
3	.152	.09	0.0	- .09	.18
4	.159				
5	.168	.15	.02	- .13	.28
6	.182				
7	.203	.255	,09	- .165	.42
8	.234				
9	.274	.39	.165	- .225	.615
10	.334	.48	.255	- .225	.705
11	.427	.60	.33	- .27	.87
12	.566	.735	.44	- .295	1.03
13	.803	.905	.58	- .325	1.23
14	1.228	1.11	.78	- .33	1.44
15	2.038	1.355	1.035	- .32	1.675
16	3.842	1.68	1.35	- .33	2.01

TABLE B6

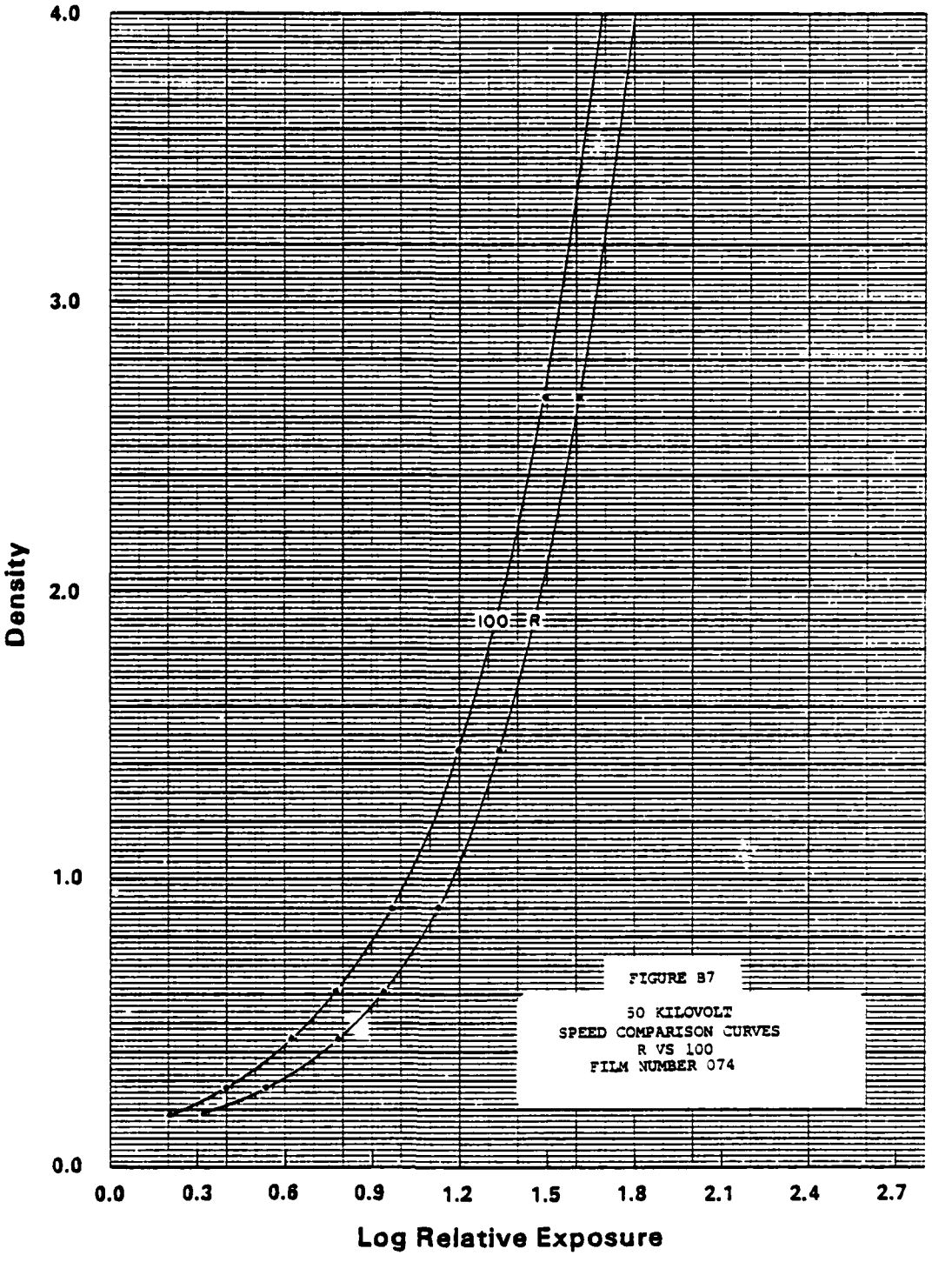


FIGURE B7

50 KILOVOLT
SPEED COMPARISON CURVES
R VS 100
FILM NUMBER 074

50 KV

FILM TYPE

R VS. 100 FILM NO. 074

STEP NO.	D avg. 100	LRE 100	LRE R	DIFF.	LRE 100 ⊕ DIFF.
1	.142	.045			
2	.143				
3	.145	.05			
4	.154				
5	.161	.135	0.0	- .135	.27
6	.171				
7	.184	.205	.095	- .11	.315
8	.207				
9	.236	.315	.18	- .135	.45
10	.278	.395	.26	- .135	.53
11	.342	.50	.34	- .16	.66
12	.441	.615	.45	- .165	.78
13	.607	.77	.6	- .17	.94
14	.898	.96	.795	- .165	1.124
15	1.447	1.185	1.045	- .14	1.325
16	2.672	1.485	1.36	- .125	1.61

TABLE B7

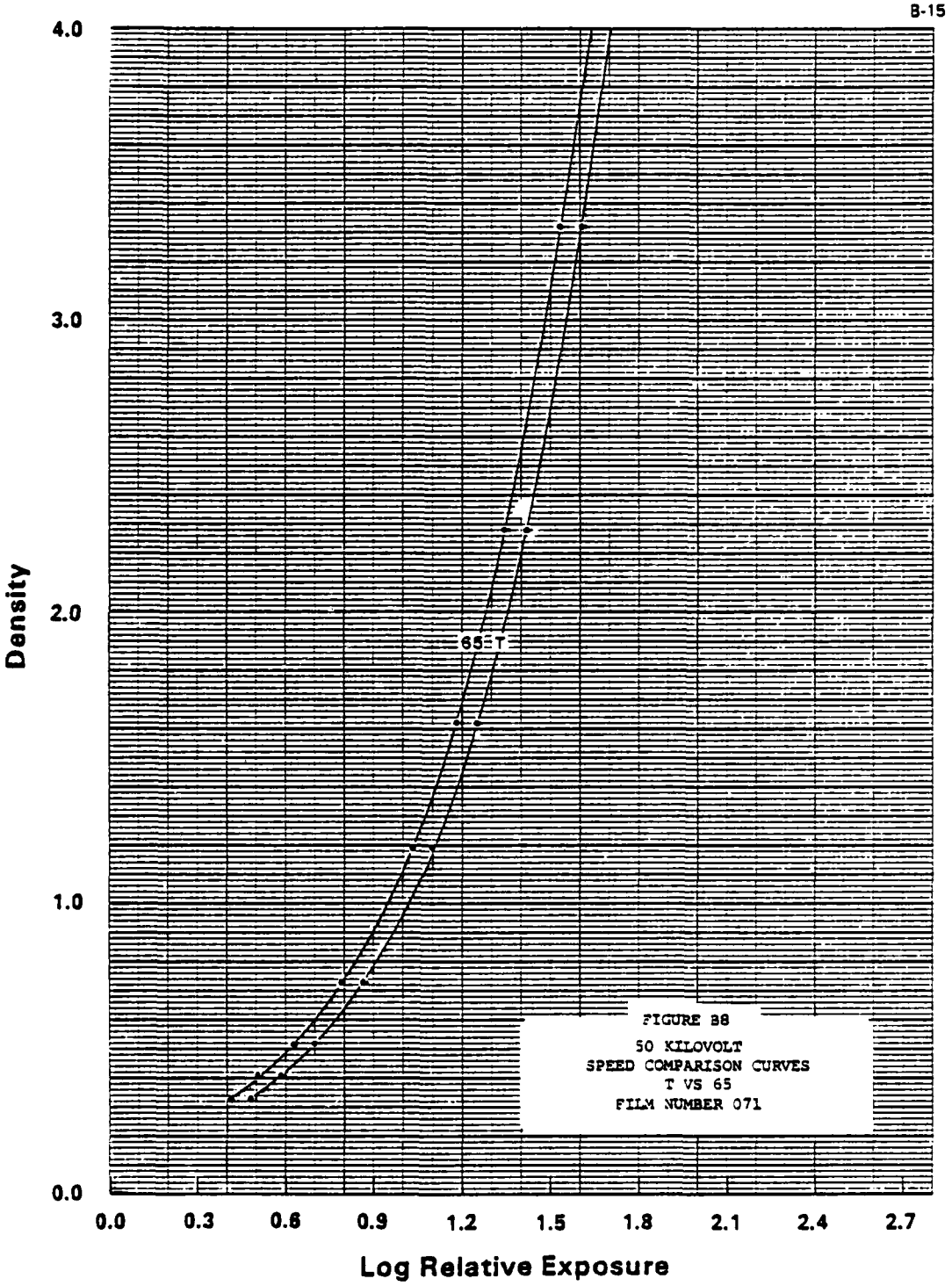


FIGURE B8
50 KILOVOLT
SPEED COMPARISON CURVES
T VS 65
FILM NUMBER 071

50 KV

FILM TYPE

T VS. 65 FILM NO. 071

STEP NO.	D avg. T	LRE T	LRE 65	DIFF.	LRE T ± DIFF.
1	.332	.48	.55	+ .07	.41
2	.342				
3	.361	.52	.59	+ .07	.45
4	.377				
5	.407	.58	.66	+ .08	.50
6	.454				
7	.518	.695	.765	+ .07	.625
8	.604				
9	.730	.86	.953	+ .075	.785
10	.916	.965	1.04	+ .075	.89
11	1.192	1.095	1.165	+ .07	1.025
12	1.619	1.245	1.315	+ .07	1.175
13	2.284	1.415	1.49	+ .075	1.34
14	3.328	1.605	1.68	+ .075	1.53
15	4.582				
16	4.818				

TABLE B8

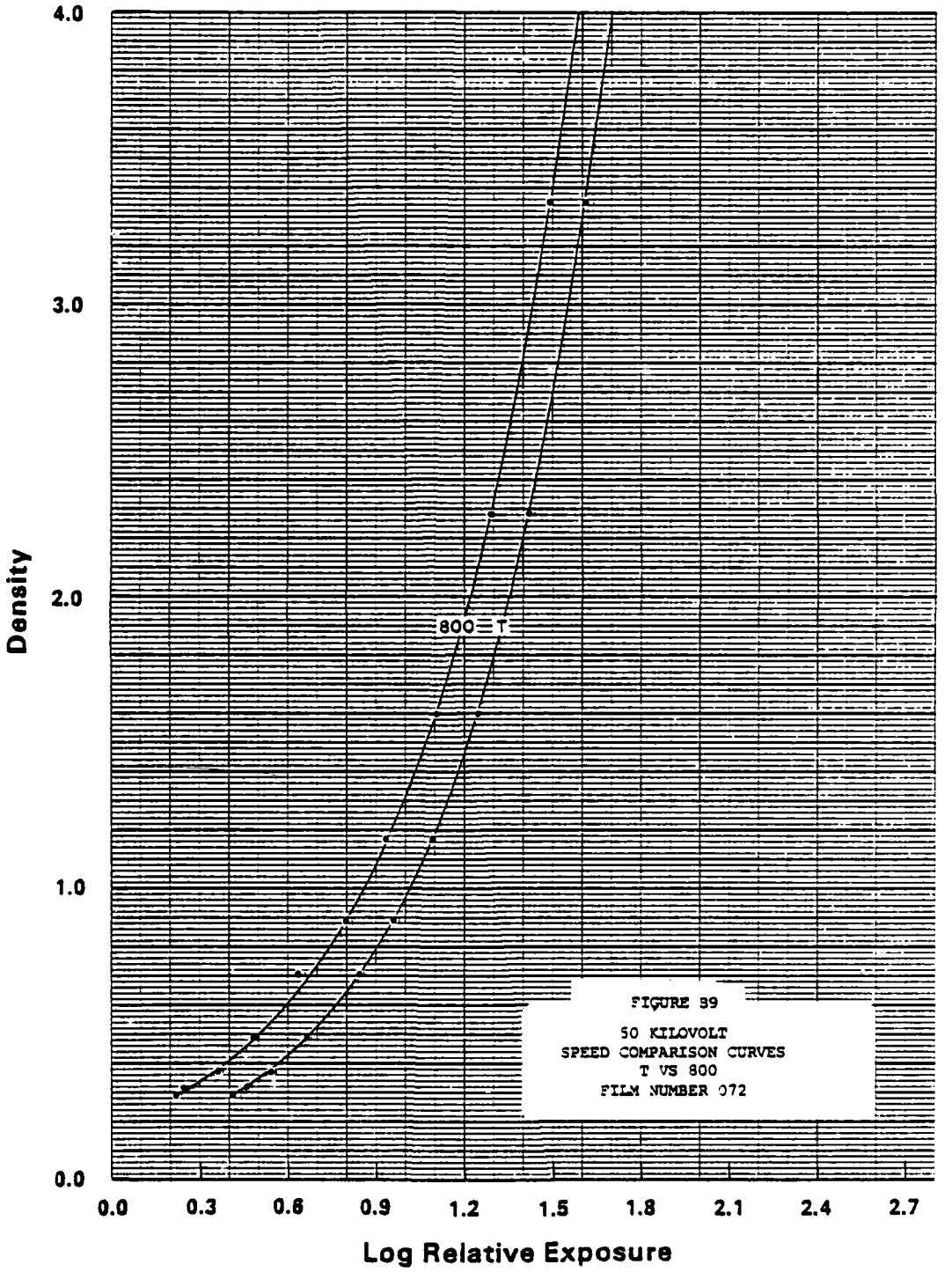


FIGURE 39

50 KILOVOLT
SPEED COMPARISON CURVES
T VS 800
FILM NUMBER 072

50 KV

FILM TYPE

T VS. 800 FILM NO. 072

STEP NO.	D avg. T	LRE T	LRE 800	DIFF.	LRE T ± DIFF.
1	.289	.415	.61	+ .195	.22
2	.296				
3	.314	.455	.67	+ .215	.24
4	.344				
5	.373	.54	.72	+ .18	.36
6	.419				
7	.489	.66	.84	+ .18	.48
8	.574				
9	.706	.84	1.05	+ .21	.63
10	.890	.955	1.115	+ .16	.795
11	1.169	1.085	1.24	+ .155	.93
12	1.598	1.24	1.38	+ .14	1.10
13	2.283	1.415	1.545	+ .13	1.285
14	3.347	1.605	1.73	+ .125	1.48
15	4.743				
16	5.075				

TABLE B9

APPENDIX C

80 KILOVOLT FILM SPEED COMPARISONS

TABLE OF CONTENTS

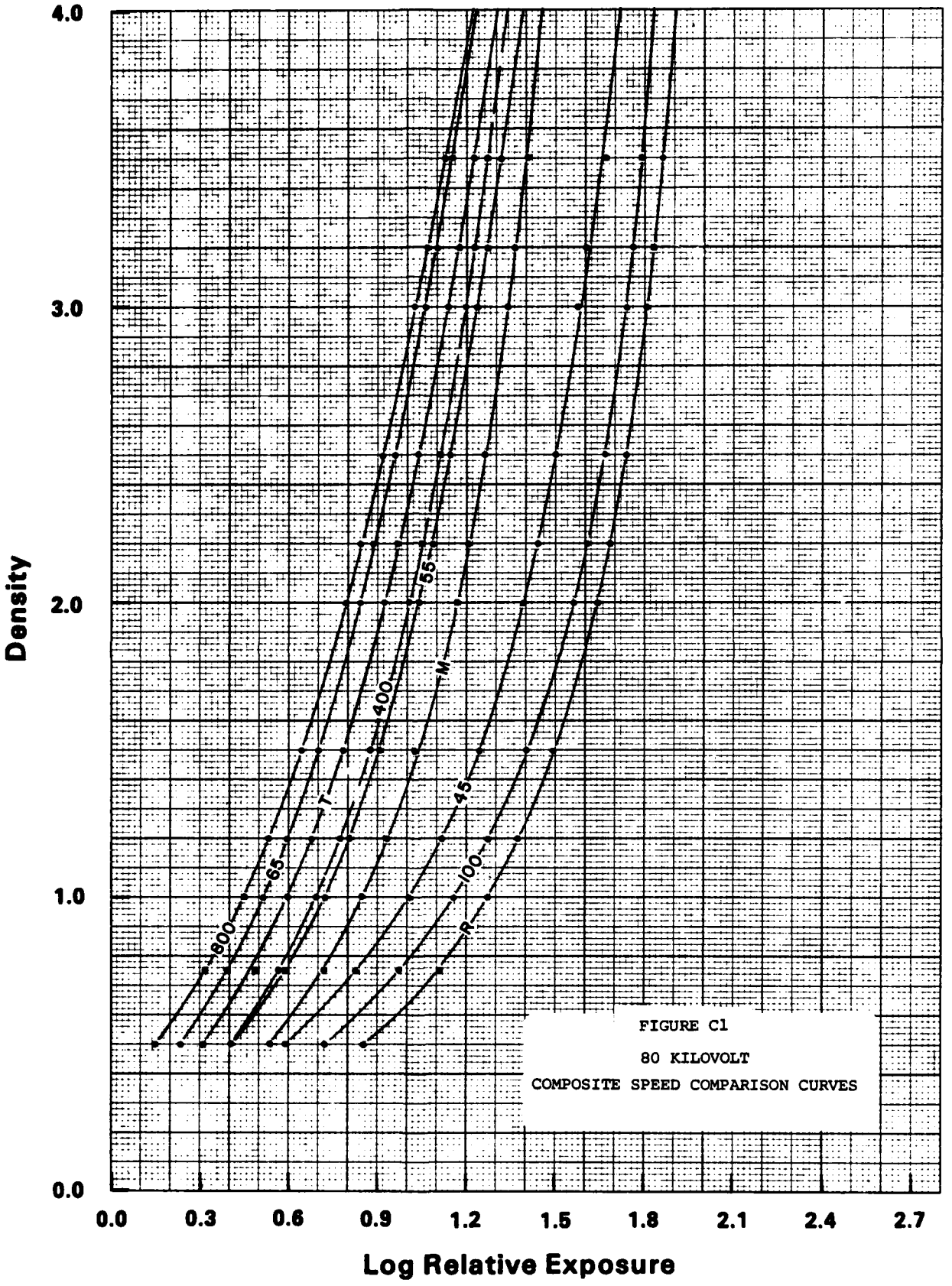


FIGURE C1

80 KILOVOLT

COMPOSITE SPEED COMPARISON CURVES

80 KV LRE Values For Speed Comparison Curves

Density	M	R	T	55	400	45	100	65	800
0.5	.54	.855	.31	.405	.405	.265 / .59	.135 / .72	.08 / .23	.165 / .145
0.75	.72	1.10	.475	.585	.575	.28 / .82	.13 / .97	.085 / .39	.16 / .315
1.0	.845	1.27	.595	.72	.70	.265 / 1.005	.11 / 1.16	.085 / .51	.15 / .445
1.2	.93	1.375	.675	.80	.775	.26 / 1.115	.105 / 1.27	.08 / .595	.145 / .53
1.5	1.03	1.495	.78	.905	.875	.255 / 1.24	.09 / 1.405	.08 / .70	.14 / .64
2.0	1.165	1.64	.92	1.04	1.005	.25 / 1.39	.08 / 1.56	.08 / .84	.13 / .79
2.2	1.205	1.685	.965	1.085	1.05	.245 / 1.44	.08 / 1.605	.08 / .885	.125 / .84
2.5	1.26	1.74	1.035	1.145	1.11	.24 / 1.5	.075 / 1.665	.08 / .955	.12 / .915
3.0	1.34	1.81	1.135	1.235	1.195	.235 / 1.575	.07 / 1.74	.075 / 1.06	.11 / 1.025
3.2	1.365	1.835	1.175	1.27	1.225	.23 / 1.605	.07 / 1.765	.075 / 1.1	.105 / 1.07
3.5	1.405	1.86	1.225	1.315	1.27	.19 / 1.67	.07 / 1.79	.08 / 1.145	.095 / 1.13

Speed Relative To M in Percent

Density	M	R	T	55	400	45	100	65	800
0.5	100	48.4	169.8	136.5	136.5	89.1	66.1	204.2	248.3
1.0	100	37.6	177.8	133.4	139.6	69.2	48.4	216.3	251.2
1.5	100	34.3	177.8	133.4	142.9	61.7	42.2	213.8	245.5
2.0	100	33.5	175.8	133.4	144.5	59.6	40.3	211.3	237.1
2.5	100	33.1	167.9	130.3	141.3	57.5	39.4	201.8	221.3
3.0	100	33.9	160.3	127.4	139.6	58.2	39.8	190.5	206.5
3.5	100	35.1	151.4	123.0	136.5	54.3	41.2	182.0	188.4

Contrast Numbers

Density	M	R	T	55	400	45	100	65	800
1.0-3.0	4.04	3.70	3.70	3.88	4.04	3.51	3.45	3.64	3.45
1.0-1.2	2.35	1.90	2.5	2.5	2.67	1.82	1.82	2.35	2.35
2.0-2.2	5.0	4.44	4.44	4.44	4.44	4.0	4.44	4.44	4.0
3.0-3.2	8.0	8.0	5.0	5.71	6.67	6.67	8.0	5.0	4.44
1.5-2.5	4.35	4.08	3.92	4.17	4.26	3.85	3.85	3.92	3.64
2.0-3.0	5.71	5.88	4.65	5.13	5.26	5.41	5.56	4.56	4.26
2.5-3.5	6.90	8.33	5.26	5.88	6.25	5.88	8.0	5.26	4.65

TABLE C1

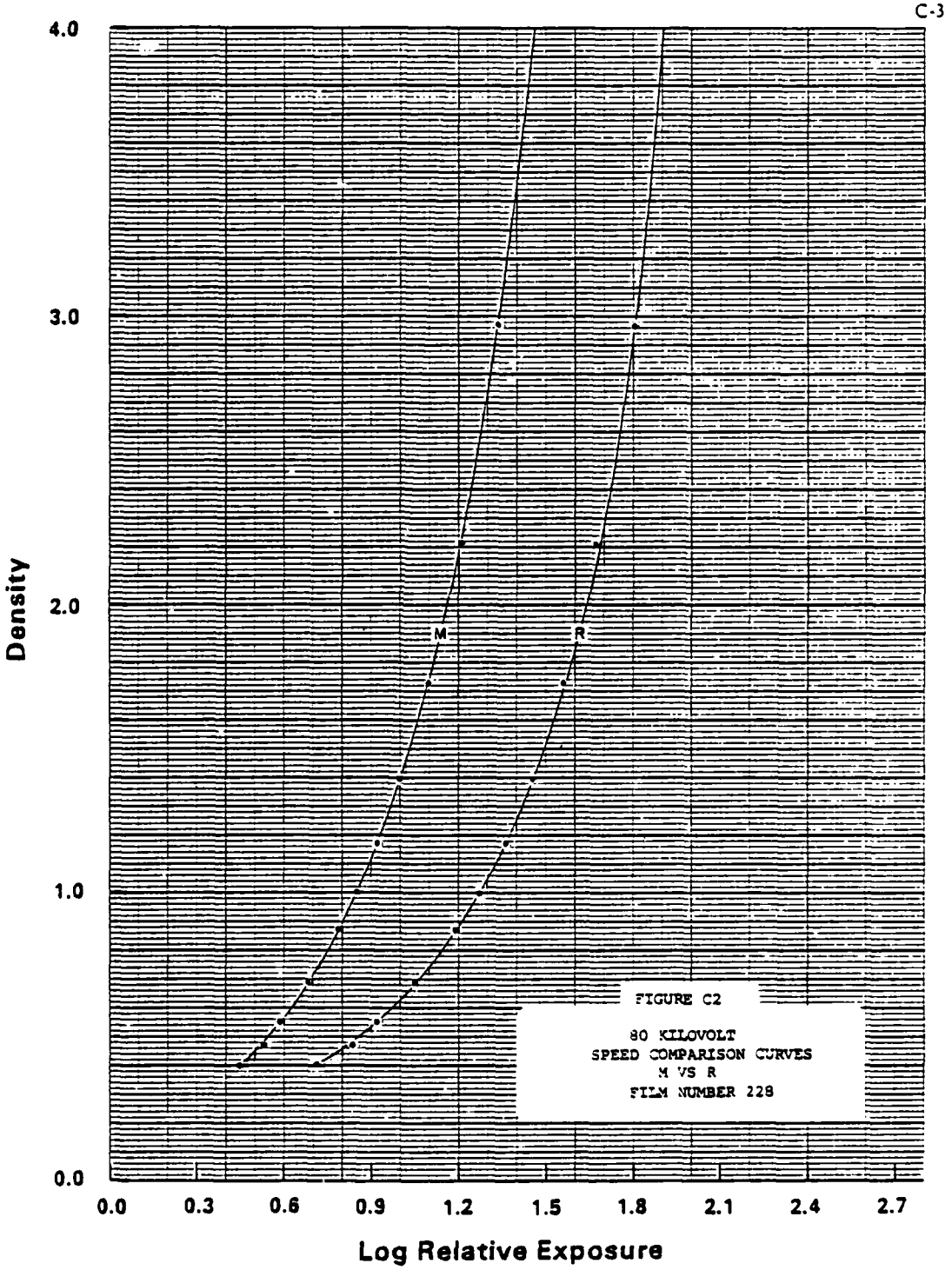


FIGURE C2

80 KILOVOLT
SPEED COMPARISON CURVES
M VS R
FILM NUMBER 228

80 KV

FILM TYPE

M vs. R FILM NO. 228

STEP NO.	D avg. M	LRE M	LRE R	DIFF. -	LRE M ⊕ -DIFF.
1	.408	.45	.19	.26	.71
2	.438	---	---	---	---
3	.471	.53	.225	.305	.835
4	.509	---	---	---	---
5	.556	.585	.255	.33	.915
6	.615	---	---	---	---
7	.685	.68	.315	.365	1.045
8	.769	---	---	---	---
9	.870	.785	.38	.405	1.19
10	1.005	.85	.425	.425	1.275
11	1.172	.92	.475	.445	1.365
12	1.399	1.00	.545	.455	1.455
13	1.726	1.095	.63	.465	1.56
14	2.212	1.205	.74	.465	1.67
15	2.963	1.338	.87	.468	1.806
16	4.228	1.515	1.11	.405	1.92

TABLE C2

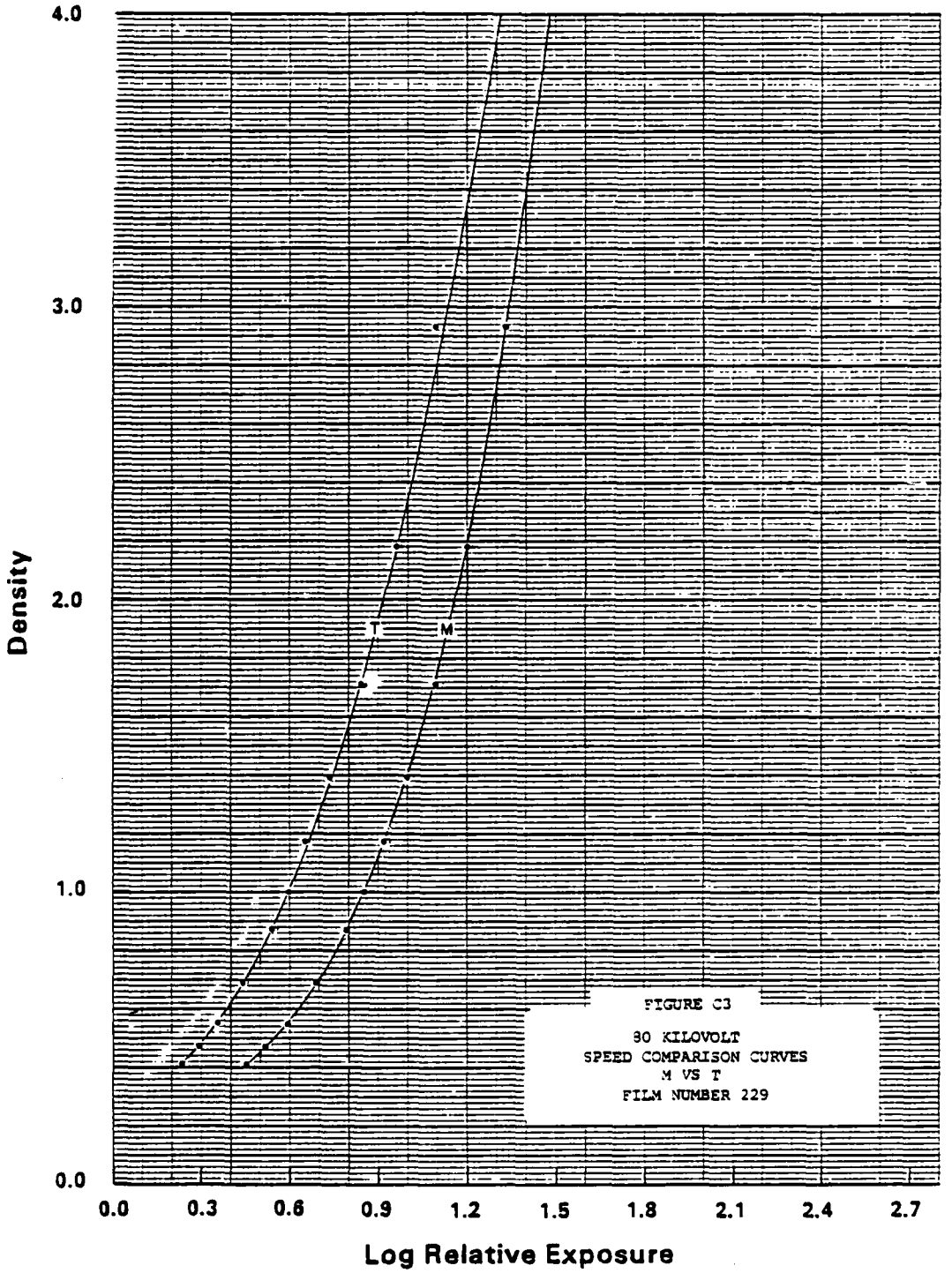


FIGURE C3

80 KILOVOLT
SPEED COMPARISON CURVES
M VS T
FILM NUMBER 229

80 KV

FILM TYPE

M VS. T FILM NO. 229

STEP NO.	D avg. M	LRE M	LRE T	DIFF. +	LRE M ± DIFF.
1	.410	.45	.665	.215	.235
2	.436	---	---	---	---
3	.470	.515	.74	.225	.29
4	.510	---	---	---	---
5	.558	.59	.825	.235	.355
6	.614	---	---	---	---
7	.685	.68	.925	.245	.435
8	.768	---	---	---	---
9	.872	.79	1.045	.255	.535
10	1.000	.85	1.11	.26	.59
11	1.168	.915	1.18	.265	.65
12	1.392	.995	1.255	.26	.735
13	1.708	1.09	1.34	.25	.84
14	2.184	1.20	1.44	.24	.96
15	2.931	1.33	---	---	---
16	4.200	---	---	---	---

TABLE C3

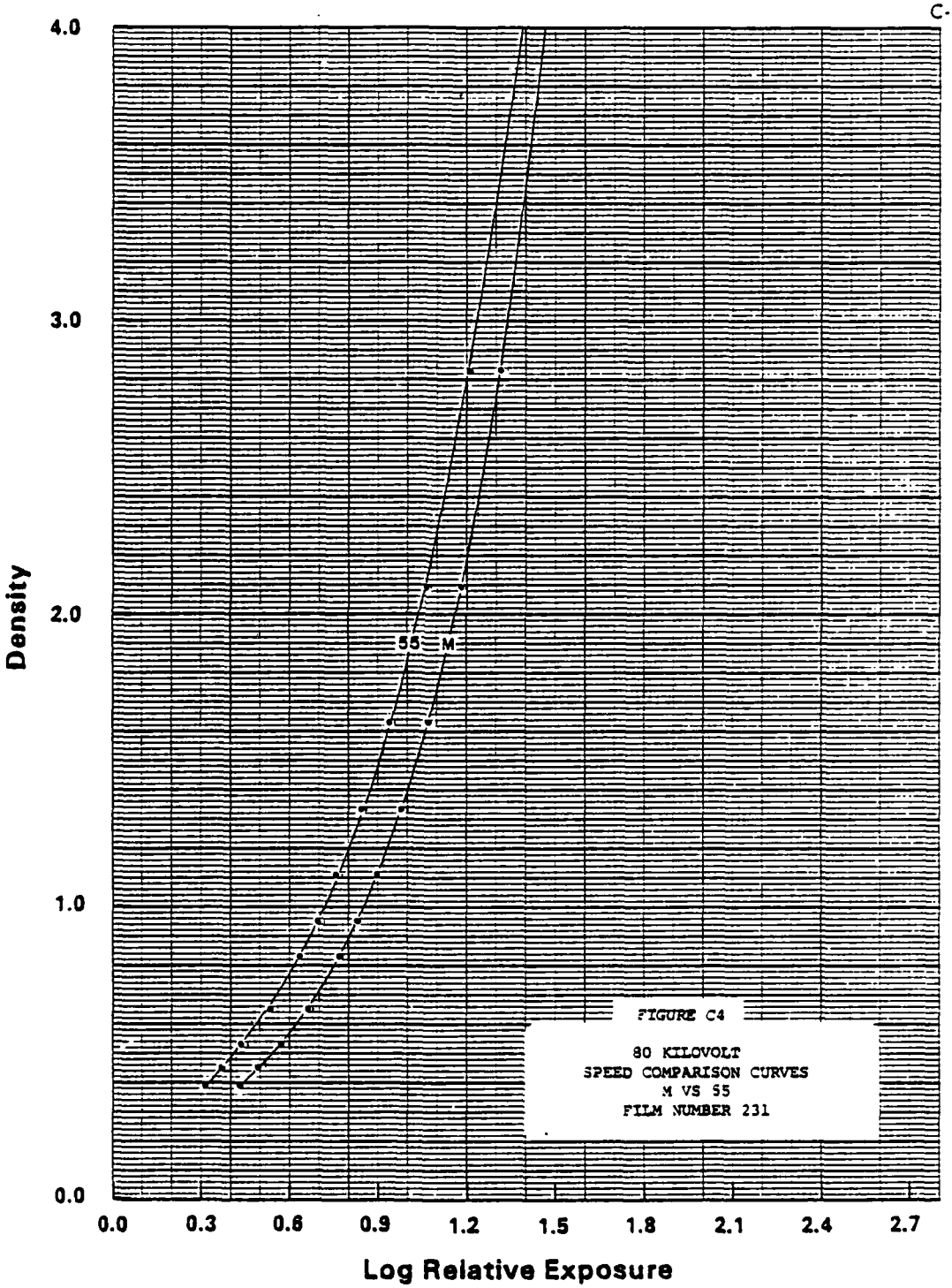


FIGURE C4

80 KILOVOLT
SPEED COMPARISON CURVES
M VS 55
FILM NUMBER 231

80 KV

FILM TYPE

M VS. 55 FILM NO. 231

STEP NO.	D avg. M	LRE M	LRE 55	DIFF. +	LRE M ± DIFF.
1	.390	.43	.55	.12	.31
2	.417	---	---	---	---
3	.447	.49	.615	.125	.365
4	.485	---	---	---	---
5	.527	.565	.70	.135	.43
6	.583	---	---	---	---
7	.651	.66	.79	.13	.53
8	.725	---	---	---	---
9	.828	.765	.90	.135	.63
10	.952	.83	.965	.135	.695
11	1.113	.895	1.035	.14	.755
12	1.329	.975	1.11	.135	.84
13	1.631	1.07	1.20	.13	.94
14	2.093	1.18	1.30	.12	1.06
15	2.823	1.315	1.425	.11	1.205
16	4.094	---	---	---	---

TABLE C4

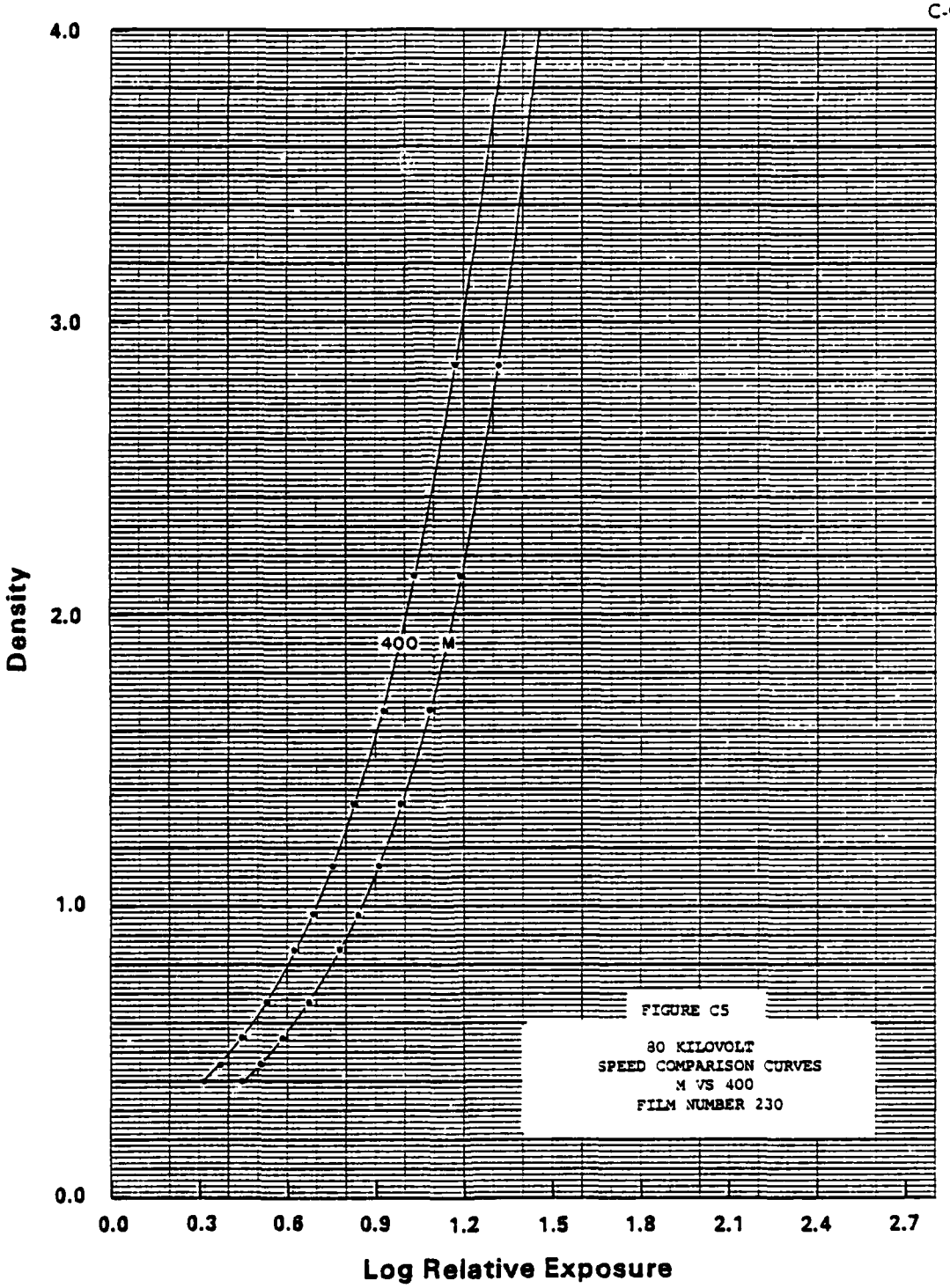


FIGURE C5

80 KILOVOLT
SPEED COMPARISON CURVES
M VS 400
FILM NUMBER 230

80 KV

FILM TYPE

M VS. 400 FILM NO. 230

STEP NO.	D avg. M	LRE M	LRE 400	DIFF. +	LRE M ⊖ DIFF.
1	.399	.445	.575	.13	.315
2	.426	---	---	---	---
3	.459	.505	.64	.135	.37
4	.498	---	---	---	---
5	.544	.58	.72	.14	.44
6	.600	---	---	---	---
7	.664	.67	.815	.145	.525
8	.747	---	---	---	---
9	.848	.775	.93	.155	.62
10	.973	.84	.995	.155	.685
11	1.137	.905	1.06	.155	.75
12	1.354	.985	1.145	.16	.825
13	1.665	1.08	1.235	.155	.925
14	2.128	1.185	1.34	.155	1.03
15	2.857	1.32	1.47	.15	1.17
16	4.121	---	---	---	---

TABLE C5

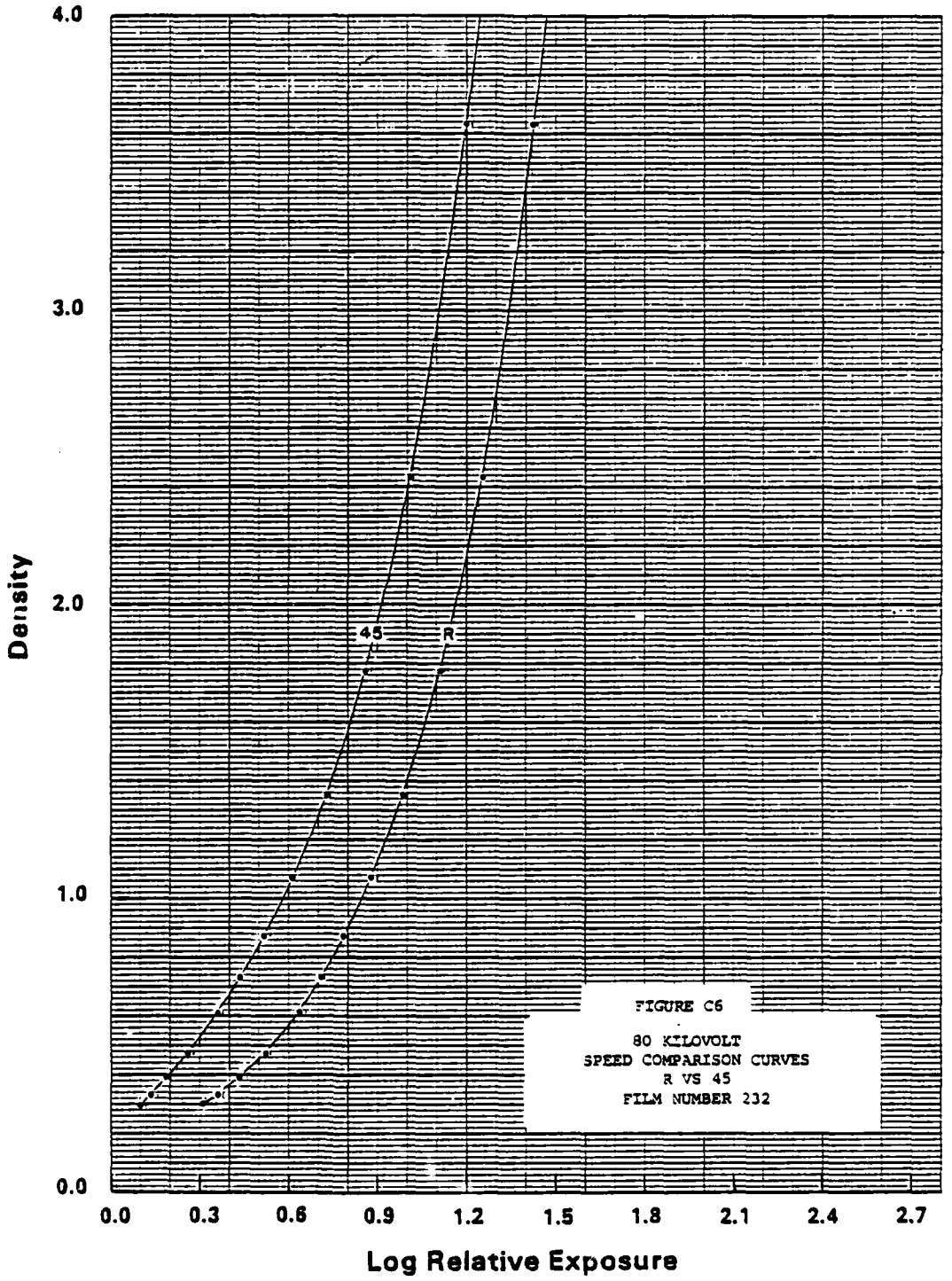


FIGURE C6

80 KILOVOLT
SPEED COMPARISON CURVES
R VS 45
FILM NUMBER 232

80 KV

FILM TYPE

R VS. 45 FILM NO. 232

STEP NO.	D avg. R	LRE R	LRE 45	DIFF. +	LRE R ⊖ DIFF.
1	.300	.31	.52	.21	.10
2	.315	---	---	---	---
3	.332	.36	.59	.23	.13
4	.359	---	---	---	---
5	.389	.43	.68	.25	.18
6	.428	---	---	---	---
7	.475	.52	.785	.265	.255
8	.536	---	---	---	---
9	.618	.635	.91	.275	.36
10	.724	.705	.98	.275	.43
11	.867	.785	1.055	.27	.515
12	1.063	.875	1.145	.27	.605
13	1.353	.985	1.245	.26	.725
14	1.778	1.11	1.36	.25	.86
15	2.434	1.25	1.495	.245	1.005
16	3.623	1.43	---	---	---

TABLE C6

80 KV

FILM TYPE

R VS. 100 FILM NO. 233

STEP NO.	D avg. R	LRE R	LRE 100	DIFF.	LRE R ± DIFF.
1	.293	.30	.42	.12	.18
2	.308	---	---	---	---
3	.325	.35	.50	.15	.20
4	.353	---	---	---	---
5	.382	.42	.555	.135	.285
6	.421	---	---	---	---
7	.464	.51	.65	.14	.37
8	.523	---	---	---	---
9	.600	.625	.755	.13	.495
10	.702	.695	.82	.125	.57
11	.839	.77	.89	.12	.65
12	1.024	.86	.97	.11	.75
13	1.295	.965	1.065	.10	.865
14	1.699	1.085	1.18	.095	.99
15	2.326	1.23	1.305	.075	1.155
16	3.459	1.41	1.48	.07	1.34

TABLE C7

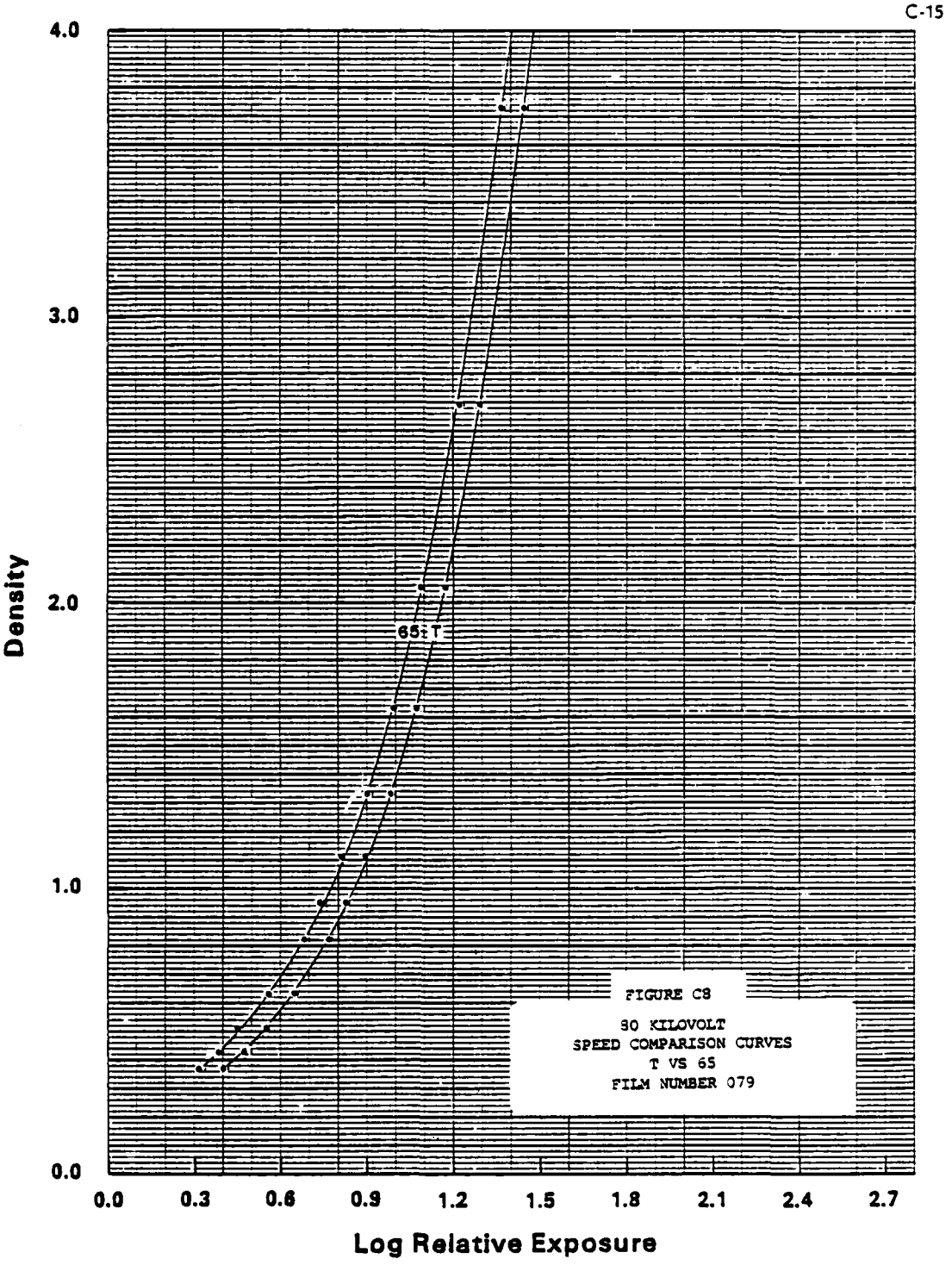


FIGURE C8

80 KILOVOLT
SPEED COMPARISON CURVES
T VS 65
FILM NUMBER 079

80 KV

FILM TYPE

T VS. 65 FILM NO. 079

STEP NO.	D avg. T	LRE T	LRE 65	DIFF.	LRE T ± DIFF.
1	.362	.40	.49	.09	.31
2	.390	---	---	---	---
3	.426	.47	.56	.09	.38
4	.463	---	---	---	---
5	.510	.55	.65	.10	.45
6	.568	---	---	---	---
7	.637	.65	.74	.09	.56
8	.723	---	---	---	---
9	.823	.765	.85	.085	.68
10	.949	.825	.915	.09	.735
11	1.114	.895	.98	.085	.81
12	1.331	.98	1.06	.08	.90
13	1.633	1.07	1.15	.08	.99
14	2.058	1.17	1.255	.085	1.085
15	2.691	1.295	1.37	.075	1.22
16	3.730	1.445	1.515	.07	1.375

TABLE C8

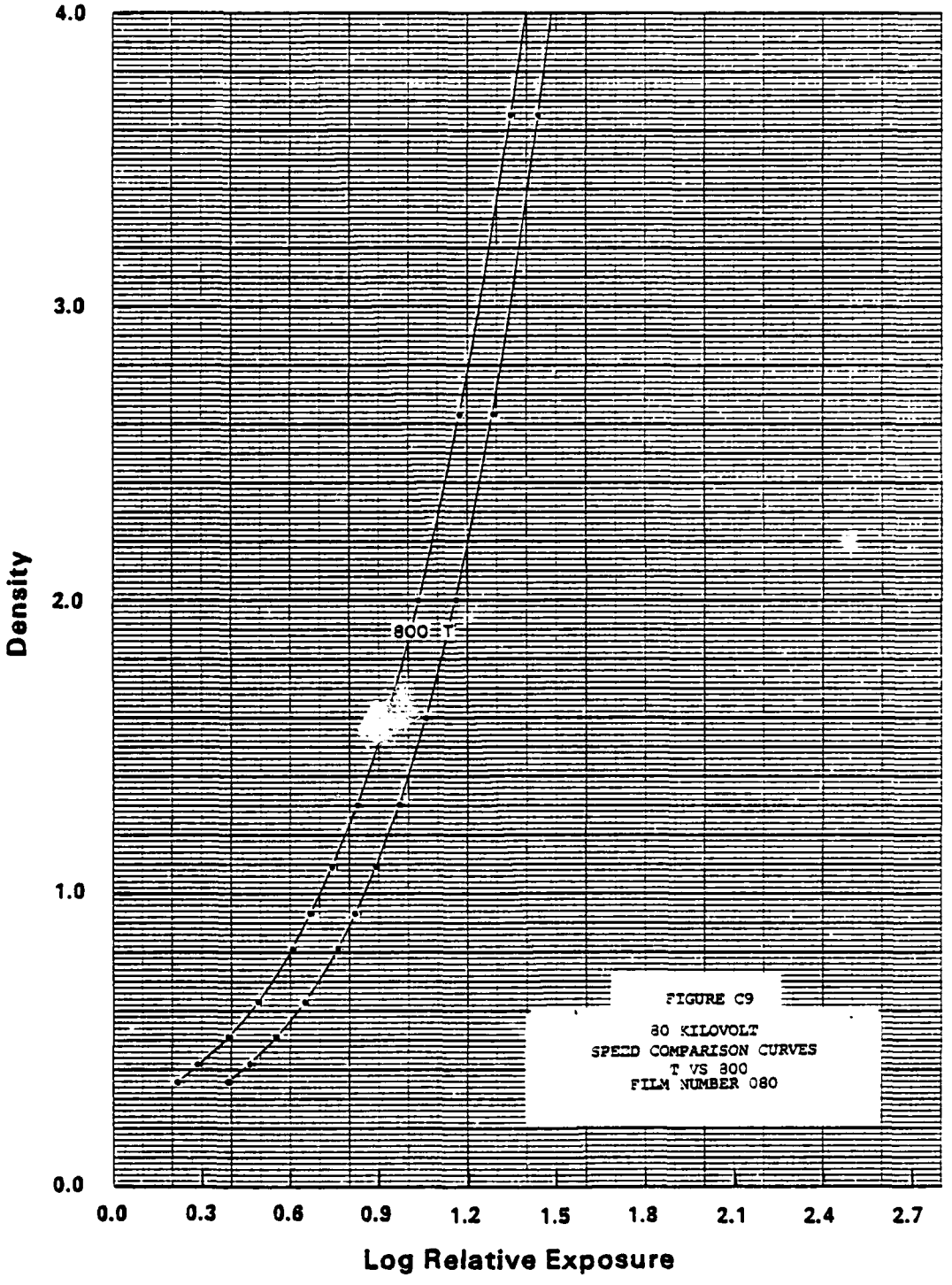


FIGURE C9

80 KILOVOLT
SPEED COMPARISON CURVES
T VS 800
FILM NUMBER 080

80 KV

FILM TYPE

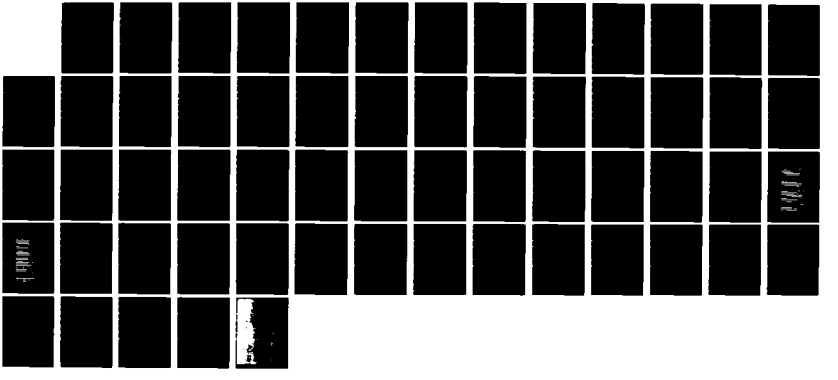
T VS. 800 FILM NO. 080 .

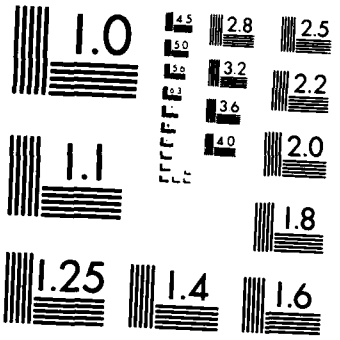
STEP NO.	D avg. T	LRE T	LRE 800	DIFF.	LRE T ± DIFF.
1	.359	.39	.565	.175	.215
2	.383	---	---	---	---
3	.419	.46	.635	.175	.285
4	.459	---	---	---	---
5	.508	.55	.715	.165	.385
6	.560	---	---	---	---
7	.631	.65	.81	.16	.49
8	.710	---	---	---	---
9	.812	.76	.915	.155	.605
10	.973	.82	.975	.155	.665
11	1.097	.89	1.04	.15	.74
12	1.308	.97	1.115	.145	.825
13	1.601	1.06	1.20	.14	.92
14	2.020	1.165	1.295	.13	1.035
15	2.634	1.285	1.40	.115	1.17
16	3.658	1.435	---	---	---

TABLE C9

AD-A128 731 EVALUATION AND COMPARISON OF INDUSTRIAL RADIOGRAPHIC FILM CHARACTERISTICS..(U) SOUTHWEST RESEARCH INST SAN ANTONIO TX R D WILLIAMS ET AL. 25 SEP 80 2/2

UNCLASSIFIED SWRI-15-5607-803 DLA900-79-C-1266 F/G 14/5 NL





APPENDIX D

110 KILOVOLT FILM SPEED COMPARISONS

TABLE OF CONTENTS

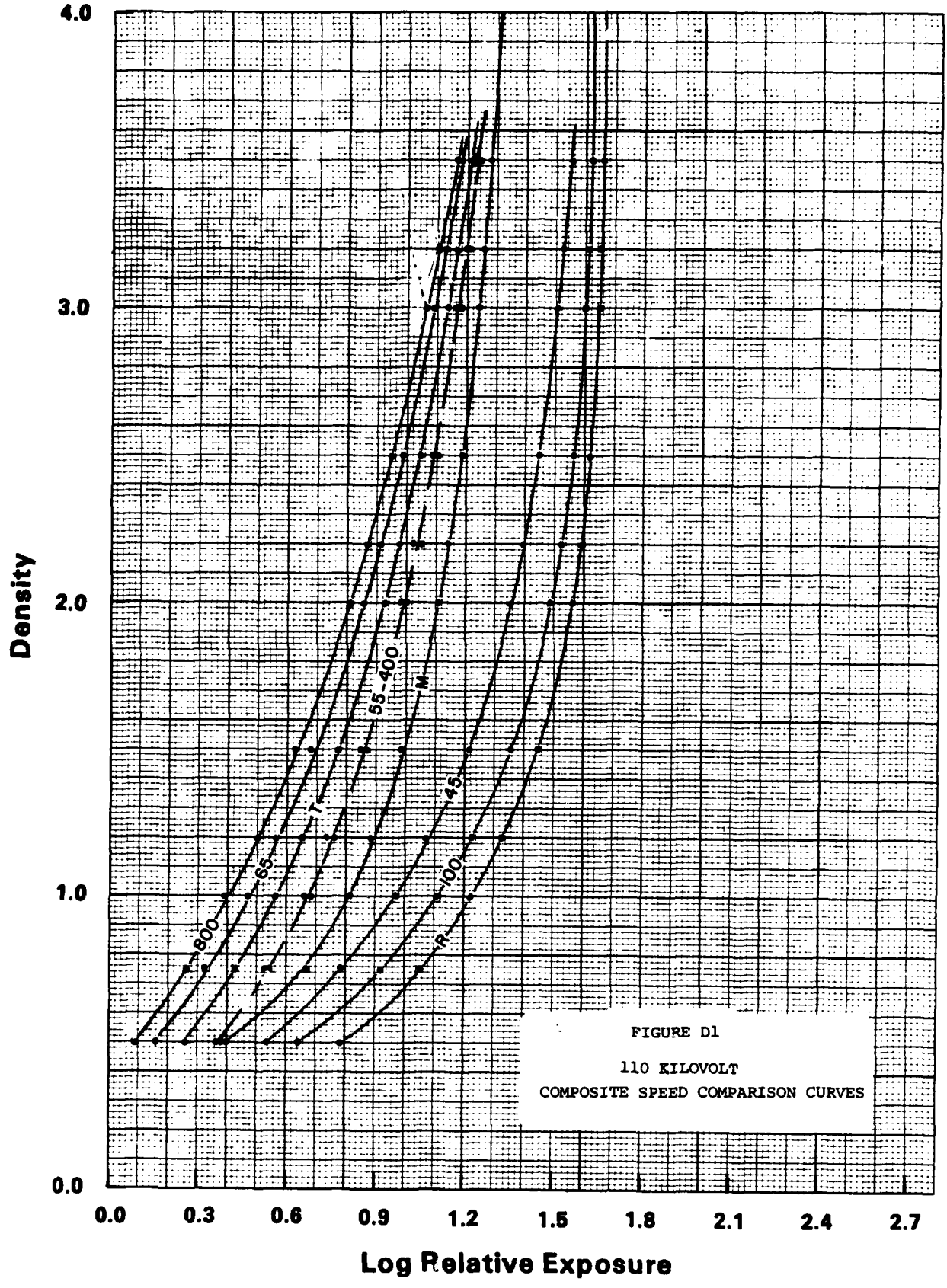


FIGURE D1

110 KILOVOLT

COMPOSITE SPEED COMPARISON CURVES

110 KV LRE Values For Speed Comparison Curves

Density	M	R	T	55	400	45	100	65	800
0.5	.40	.785	.26	.375	.36	.25 / .535	.14 / .645	.10 / .16	.17 / .09
0.75	.67	1.05	.425	.54	.53	.26 / .79	.13 / .92	.10 / .325	.165 / .26
1.0	.81	1.22	.56	.675	.66	.25 / .97	.11 / 1.11	.09 / .47	.165 / .395
1.2	.89	1.325	.65	.76	.74	.25 / 1.075	.10 / 1.225	.09 / .56	.15 / .50
1.5	.99	1.445	.77	.86	.85	.23 / 1.215	.09 / 1.355	.09 / .68	.14 / .63
2.0	1.11	1.56	.925	1.00	.98	.205 / 1.355	.07 / 1.49	.07 / .855	.12 / .805
2.2	1.14	1.59	.98	1.045	1.025	.195 / 1.395	.065 / 1.525	.065 / .915	.115 / .865
2.5	1.185	1.62	1.05	1.10	1.085	.175 / 1.445	.055 / 1.565	.06 / .99	.10 / .95
3.0	1.24	1.645	1.14	1.175	1.165	.14 / 1.505	.04 / 1.605	.05 / 1.09	.075 / 1.065
3.2	1.255	1.65	1.175	1.20	1.19	.125 / 1.525	.038 / 1.612	.045 / 1.13	.06 / 1.115
3.5	1.28	1.66	1.22	1.235	1.23	.10 / 1.56	.032 / 1.628	.04 / 1.18	.05 / 1.17

Speed Relative To M in Percent

Density	M	R	T	55	400	45	100	65	800
0.5	100	41.2	138.0	105.9	109.6	73.3	56.9	173.8	204.2
1.0	100	38.9	177.8	136.5	141.3	69.2	50.1	218.8	260.0
1.5	100	35.1	166.0	134.9	138.0	59.6	43.2	204.2	229.1
2.0	100	35.5	153.1	128.8	134.9	56.9	41.7	179.9	201.8
2.5	100	36.7	136.5	121.6	125.9	55.0	41.7	156.7	171.8
3.0	100	39.4	125.9	116.1	118.9	54.3	43.2	141.3	149.6
3.5	100	41.7	114.8	110.9	112.2	52.5	44.9	125.9	128.8

Contrast Numbers

Density	M	R	T	55	400	45	100	65	800
1.0-3.0	4.65	4.71	3.45	4.0	3.96	3.74	4.04	3.23	2.98
1.0-1.2	2.5	1.90	2.22	2.35	2.5	1.90	1.74	2.22	1.90
2.0-2.2	6.67	6.67	3.64	4.44	4.44	5.0	5.71	3.33	3.33
3.0-3.2	13.3	40.0	5.71	8.0	8.0	10.0	28.6	5.0	4.0
1.5-2.5	5.13	5.71	3.57	4.17	4.26	4.35	4.76	3.23	3.12
2.0-3.0	7.69	11.76	4.65	5.71	5.41	6.67	8.70	4.26	3.85
2.5-3.5	10.52	25.0	5.88	7.41	6.90	8.70	15.87	5.26	4.55

TABLE D1

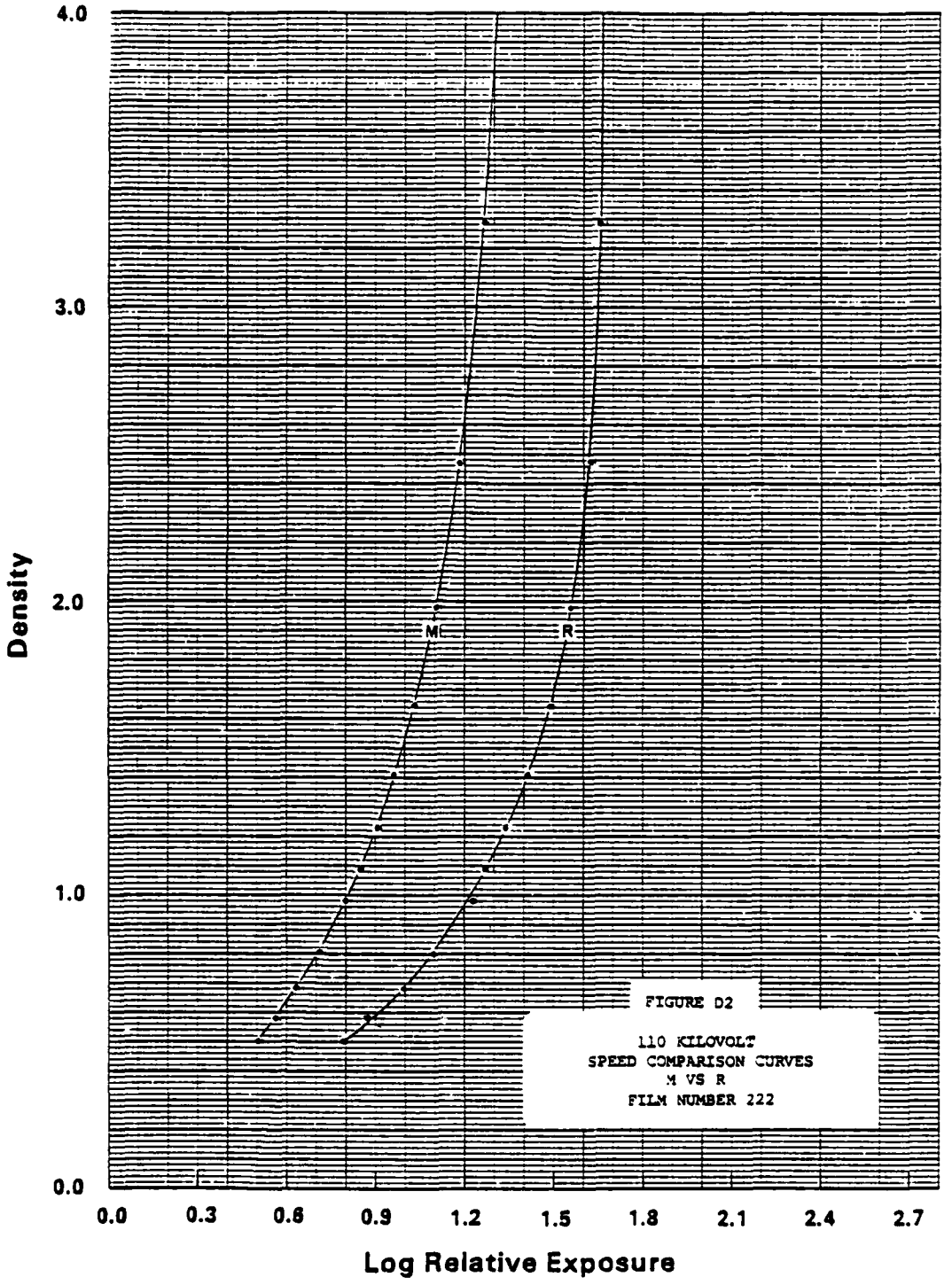


FIGURE D2

110 KILOVOLT
SPEED COMPARISON CURVES
M VS R
FILM NUMBER 222

110 KV

FILM TYPE

M vs. R FILM NO. 222

STEP NO.	D avg. M	LRE M	LRE R	DIFF. -	LRE M +-DIFF.
1	.505	.50	.21	.29	.79
2	.540	---	---	---	---
3	.582	.56	.25	.31	.87
4	.627	---	---	---	---
5	.681	.635	.275	.36	.995
6	.738	---	---	---	---
7	.809	.71	.33	.38	1.09
8	.885	---	---	---	---
9	.982	.80	.375	.425	1.225
10	1.094	.84	.415	.425	1.265
11	1.229	.895	.455	.44	1.335
12	1.412	.955	.50	.455	1.41
13	1.648	1.025	.565	.46	1.485
14	1.980	1.10	.645	.455	1.555
15	2.472	1.18	.74	.44	1.62
16	3.296	1.265	.88	.385	1.65

TABLE D2

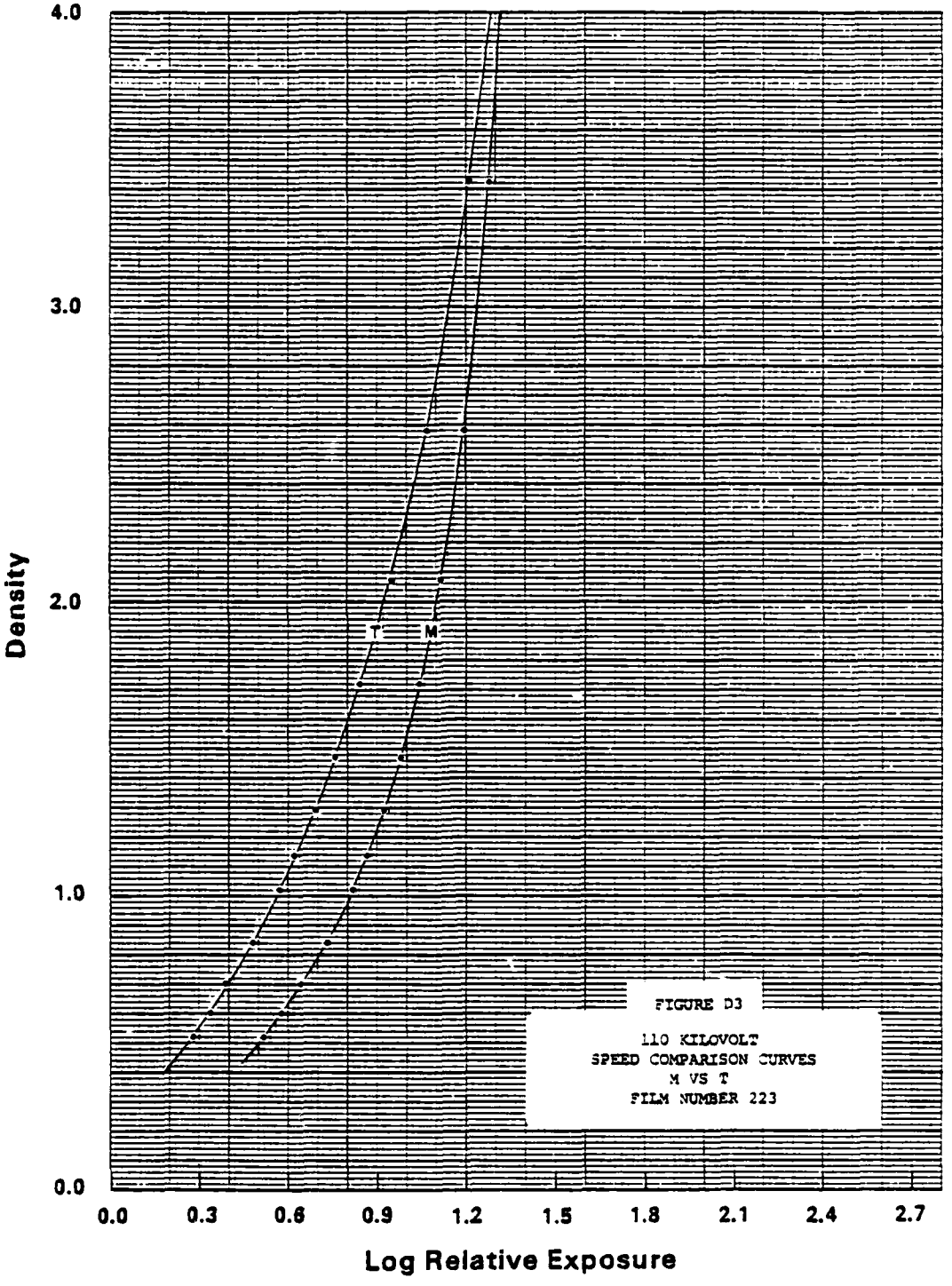


FIGURE D3

110 KILOVOLT
SPEED COMPARISON CURVES
M VS T
FILM NUMBER 223

110 KV

FILM TYPE

M VS. T FILM NO. 223

STEP NO.	D avg. M	LRE M	LRE T	DIFF. +	LRE M + DIFF.
1	.526	.515	.755	.24	.275
2	.561	---	---	---	---
3	.603	.58	.82	.24	.34
4	.651	---	---	---	---
5	.706	.645	.90	.255	.39
6	.769	---	---	---	---
7	.842	.73	.98	.25	.48
8	.927	---	---	---	---
9	1.024	.815	1.06	.245	.57
10	1.140	.865	1.11	.245	.62
11	1.289	.92	1.15	.23	.69
12	1.476	.975	1.195	.22	.755
13	1.724	1.04	1.24	.20	.84
14	2.077	1.115	1.28	.165	.95
15	2.582	1.195	1.325	.13	1.065
16	3.428	1.275	---	---	---

TABLE D3

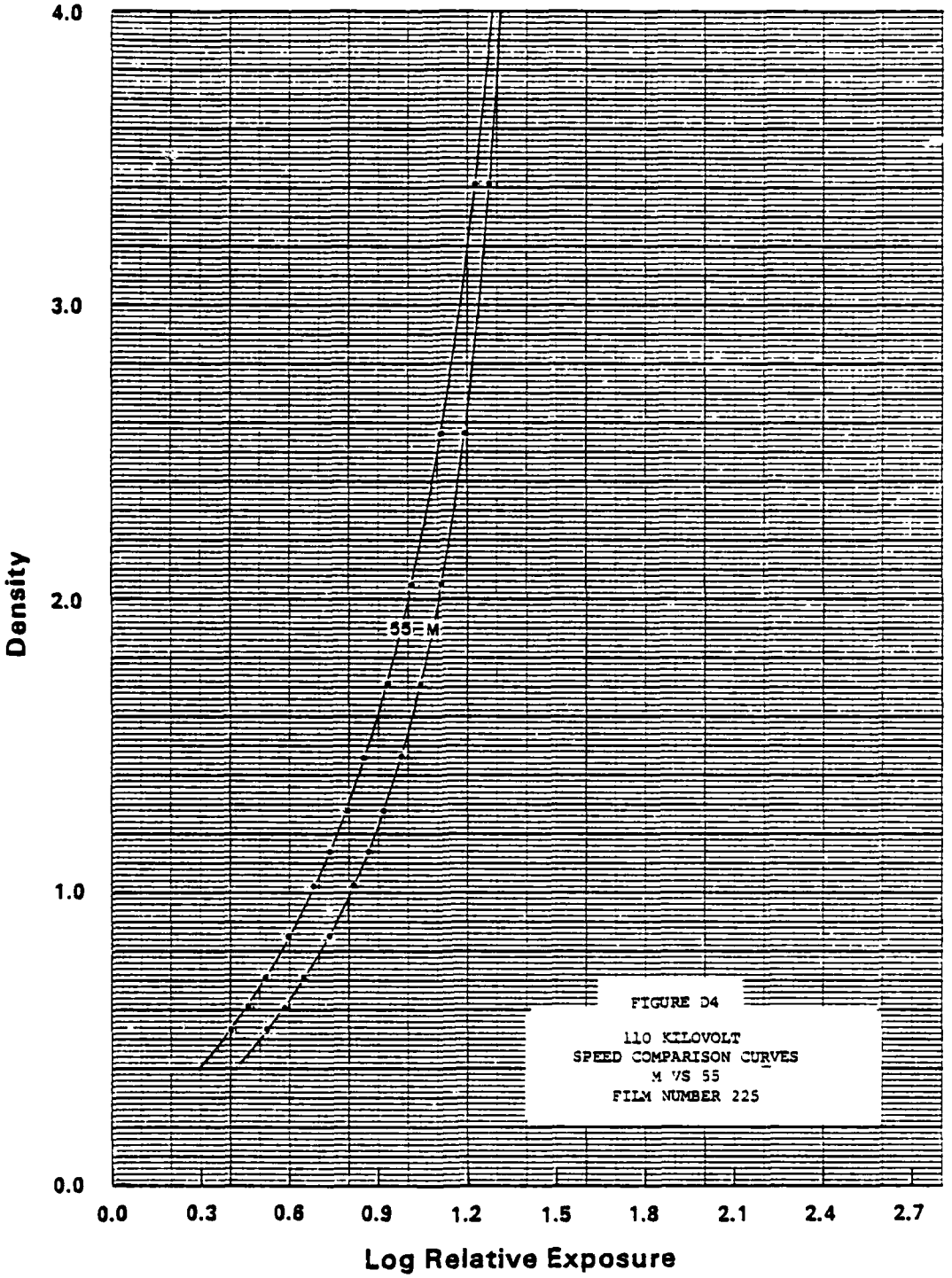


FIGURE D4

110 KILOVOLT
SPEED COMPARISON CURVES
M VS 55
FILM NUMBER 225

110 KV

FILM TYPE

M VS. 55 FILM NO. 225

STEP NO.	D avg. M	LRE M	LRE 55	DIFF. +	LRE M +/− DIFF.
1	.533	.525	.65	.125	.40
2	.565	---	---	---	---
3	.609	.585	.71	.125	.46
4	.653	---	---	---	---
5	.709	.65	.785	.135	.515
6	.772	---	---	---	---
7	.845	.73	.865	.135	.595
8	.927	---	---	---	---
9	1.026	.815	.95	.135	.68
10	1.140	.865	.995	.13	.735
11	1.282	.915	1.045	.13	.785
12	1.464	.975	1.10	.125	.85
13	1.708	1.04	1.155	.115	.925
14	2.057	1.11	1.21	.10	1.01
15	2.562	1.19	1.27	.08	1.11
16	3.409	1.275	1.325	.05	1.225

TABLE D4

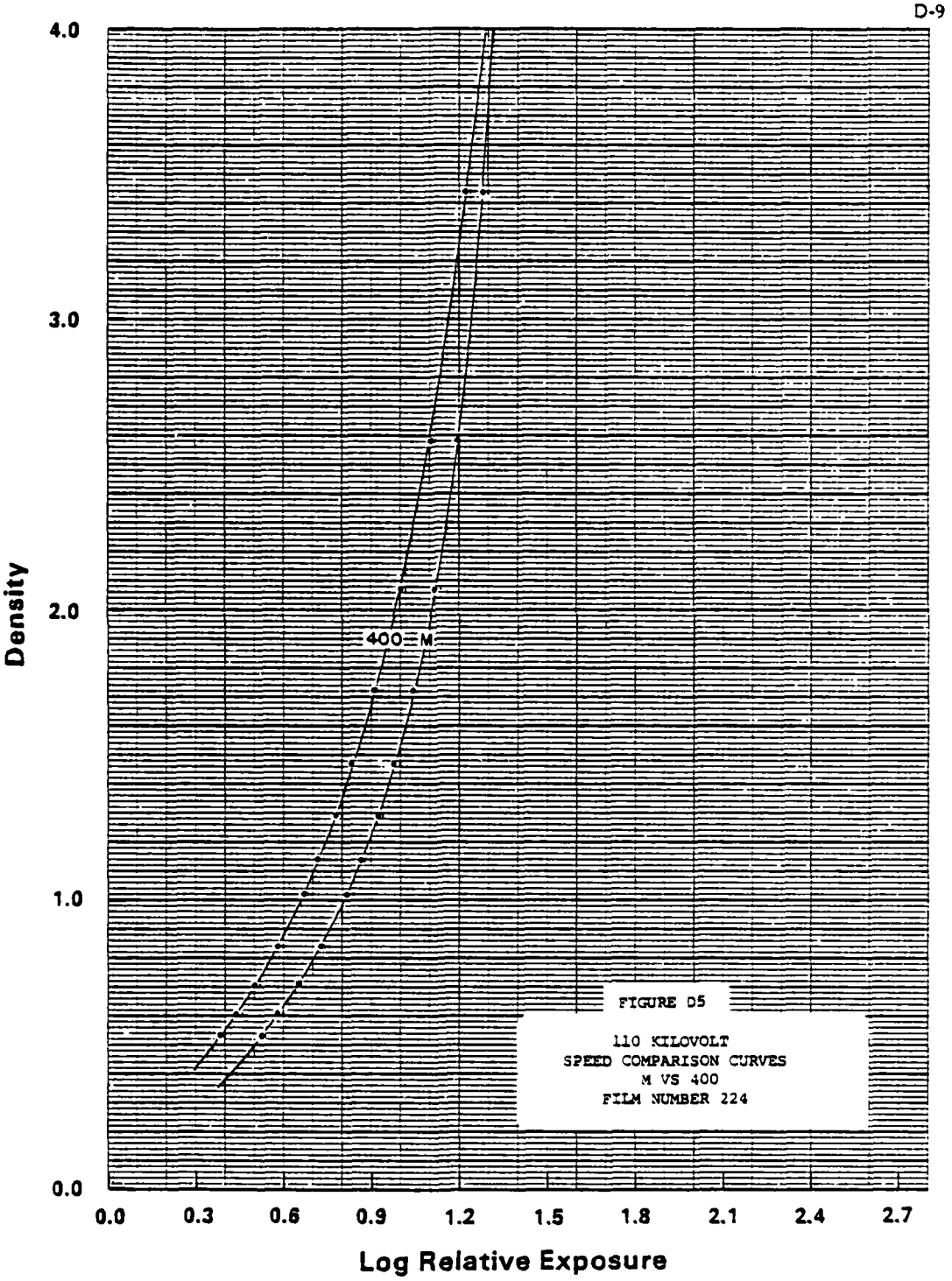


FIGURE D5

110 KILOVOLT
SPEED COMPARISON CURVES
M VS 400
FILM NUMBER 224

110 KV

FILM TYPE

M VS. 400 FILM NO. 224 .

STEP NO.	D avg. M	LRE M	LRE 400	DIFF. +	LR. + −DIFF.
1	.531	.525	.665	.14	.385
2	.563	---	---	---	---
3	.604	.58	.73	.15	.43
4	.653	---	---	---	---
5	.708	.65	.80	.15	.50
6	.770	---	---	---	---
7	.844	.73	.88	.15	.58
8	.927	---	---	---	---
9	1.023	.815	.965	.15	.665
10	1.140	.865	1.015	.15	.715
11	1.288	.92	1.065	.145	.775
12	1.472	.975	1.12	.145	.83
13	1.724	1.04	1.17	.13	.91
14	2.078	1.115	1.23	.115	1.00
15	2.587	1.195	1.285	.09	1.105
16	3.439	1.28	---	---	---

TABLE D5

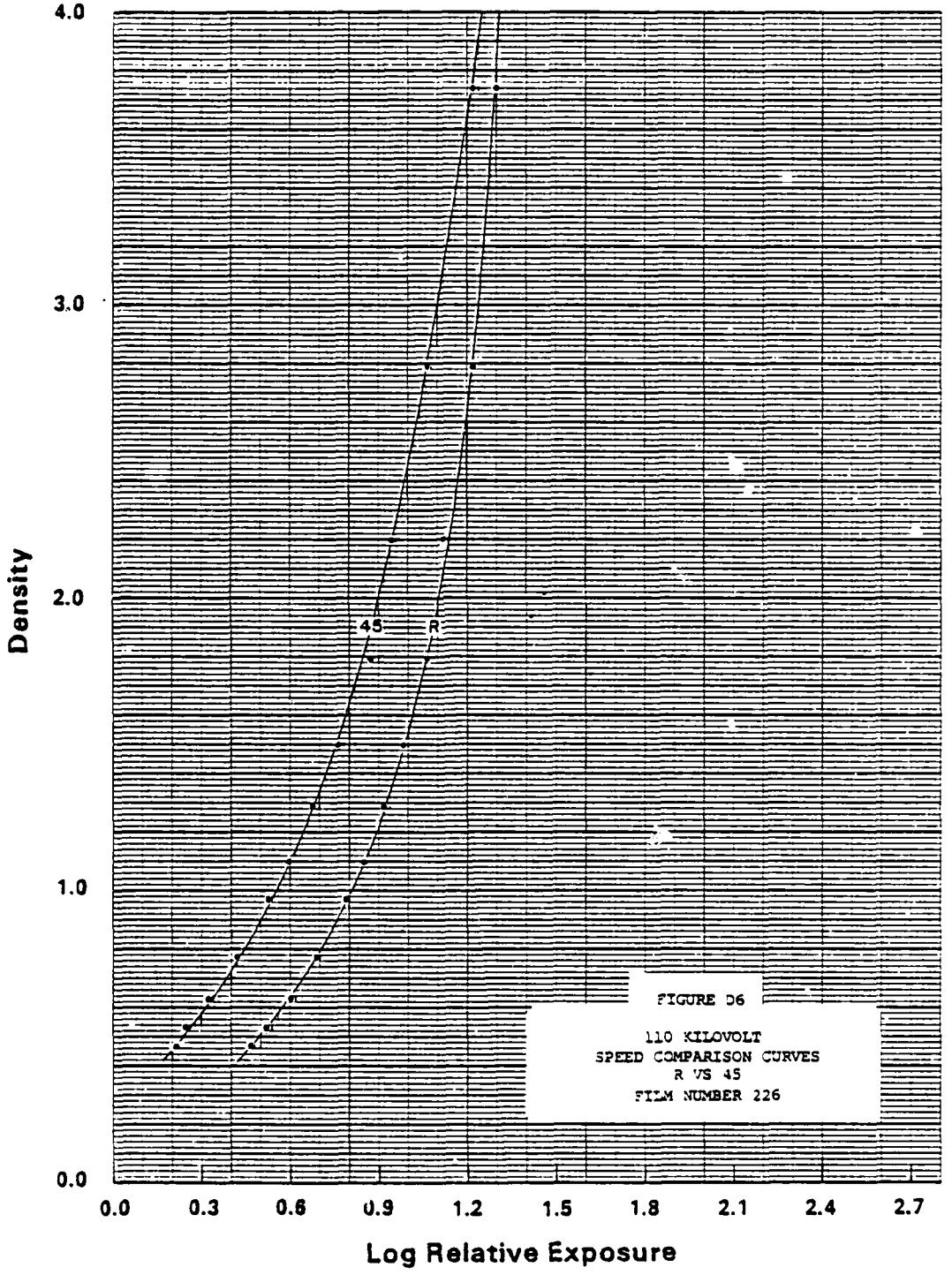


FIGURE D6

110 KILOVOLT
SPEED COMPARISON CURVES
R VS 45
FILM NUMBER 226

110 KV

FILM TYPE

R VS. 45 FILM NO. 226

STEP NO.	D avg. R	LRE R	LRE 45	DIFF. +	LRE R +/− DIFF.
1	.463	.465	.72	.255	.21
2	.492	---	---	---	---
3	.530	.52	.795	.275	.245
4	.578	---	---	---	---
5	.631	.60	.875	.275	.325
6	.696	---	---	---	---
7	.774	.69	.96	.27	.42
8	.865	---	---	---	---
9	.978	.79	1.055	.265	.525
10	1.111	.85	1.105	.255	.595
11	1.284	.915	1.155	.24	.675
12	1.498	.98	1.20	.22	.76
13	1.794	1.06	1.25	.19	.87
14	2.202	1.12	1.295	.175	.945
15	2.790	1.22	---	---	---
16	3.739	1.30	---	---	---

TABLE D6

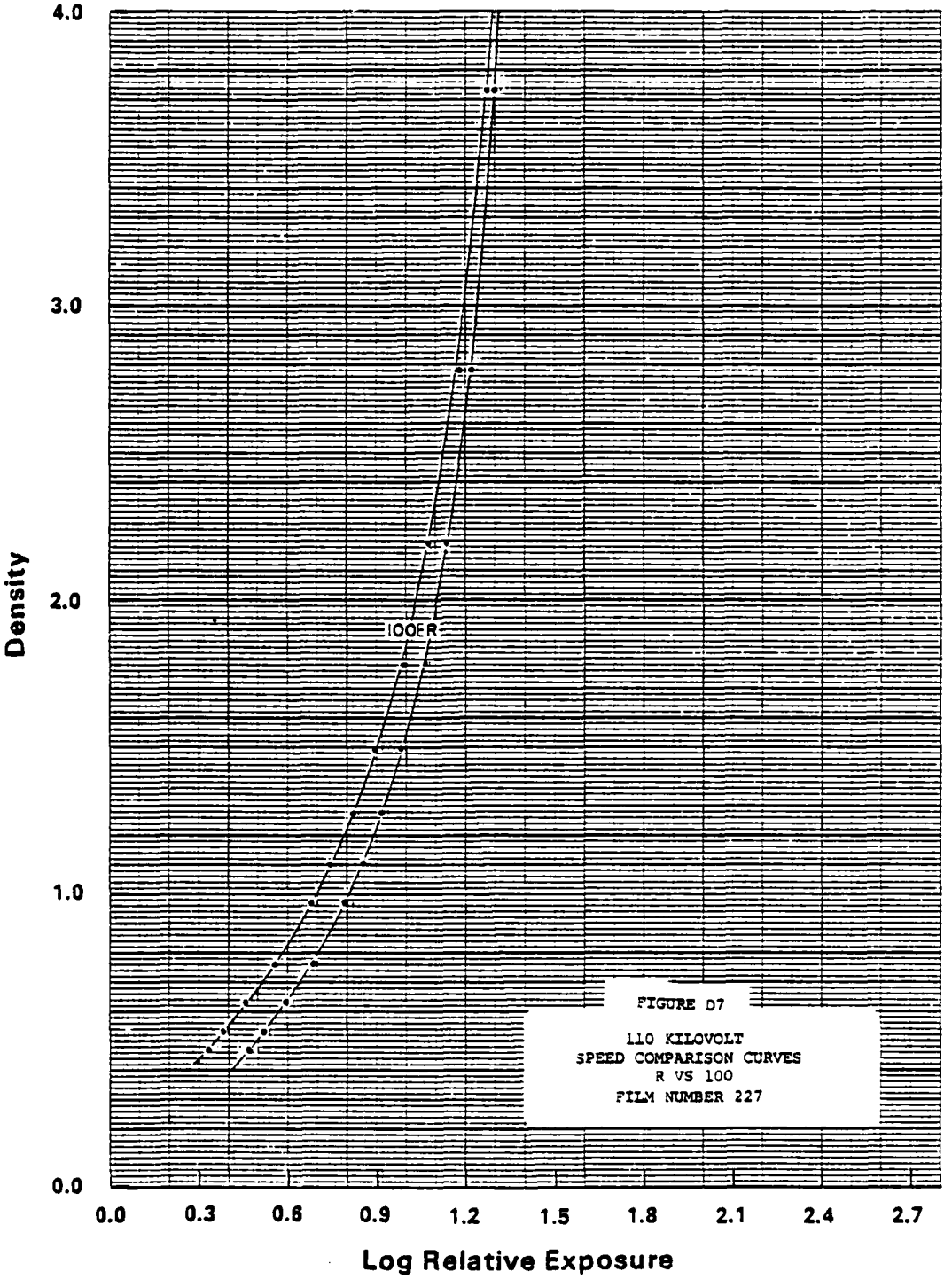


FIGURE D7

110 KILOVOLT
SPEED COMPARISON CURVES
R VS 100
FILM NUMBER 227

110 KV

FILM TYPE

R VS. 100 FILM NO. 227

STEP NO.	D avg. R	LRE R	LRE 100	DIFF. +	LRE R +/- DIFF.
1	.462	.465	.60	.135	.33
2	.489	---	---	---	---
3	.527	.52	.66	.14	.38
4	.573	---	---	---	---
5	.628	.595	.735	.14	.455
6	.689	---	---	---	---
7	.766	.685	.815	.13	.555
8	.858	---	---	---	---
9	.969	.79	.905	.115	.675
10	1.106	.85	.955	.105	.745
11	1.275	.915	1.01	.095	.82
12	1.497	.98	1.07	.09	.89
13	1.787	1.06	1.13	.07	.99
14	2.195	1.135	1.195	.06	1.075
15	2.779	1.22	1.26	.04	1.18
16	3.732	1.30	1.325	.025	1.275

TABLE D7

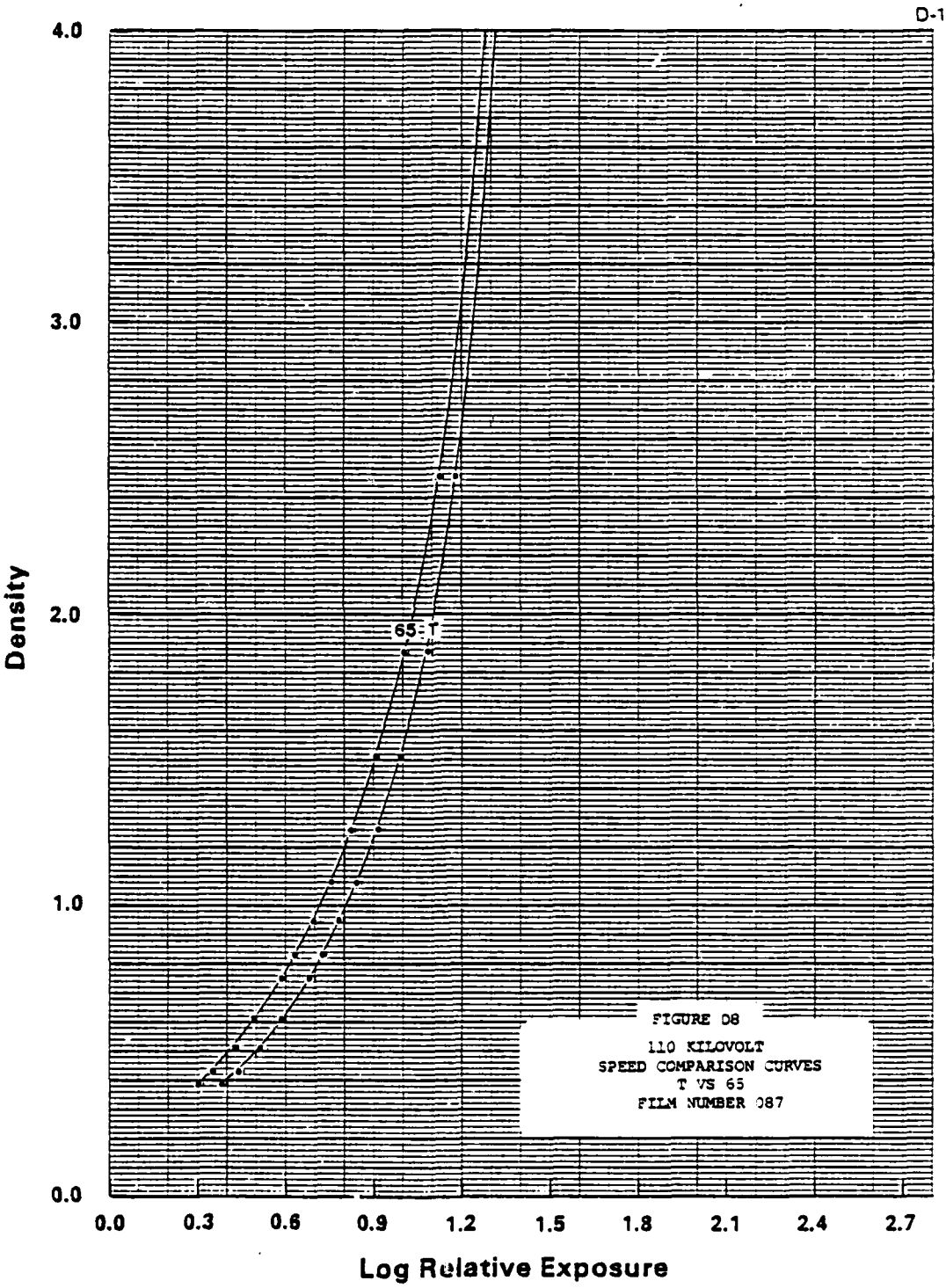


FIGURE D8

110 KILOVOLT
SPEED COMPARISON CURVES
T VS 65
FILM NUMBER 087

110 KV

FILM TYPE

T VS. 65 FILM NO. 087

STEP NO.	D avg. T	LRE T	LRE 65	DIFF. +	LRE T +/− DIFF.
1	.380	.385	.47	.085	.30
2	.407	---	---	---	---
3	.437	.44	.53	.09	.35
4	.469	---	---	---	---
5	.509	.51	.595	.085	.425
6	.557	---	---	---	---
7	.612	.585	.68	.095	.49
8	.673	---	---	---	---
9	.748	.675	.77	.095	.58
10	.835	.725	.82	.095	.63
11	.945	.78	.87	.09	.69
12	1.081	.84	.93	.09	.75
13	1.263	.91	1.00	.09	.82
14	1.512	.985	1.07	.085	.90
15	1.873	1.075	1.155	.08	.995
16	2.473	1.18	1.24	.06	1.12

TABLE D8

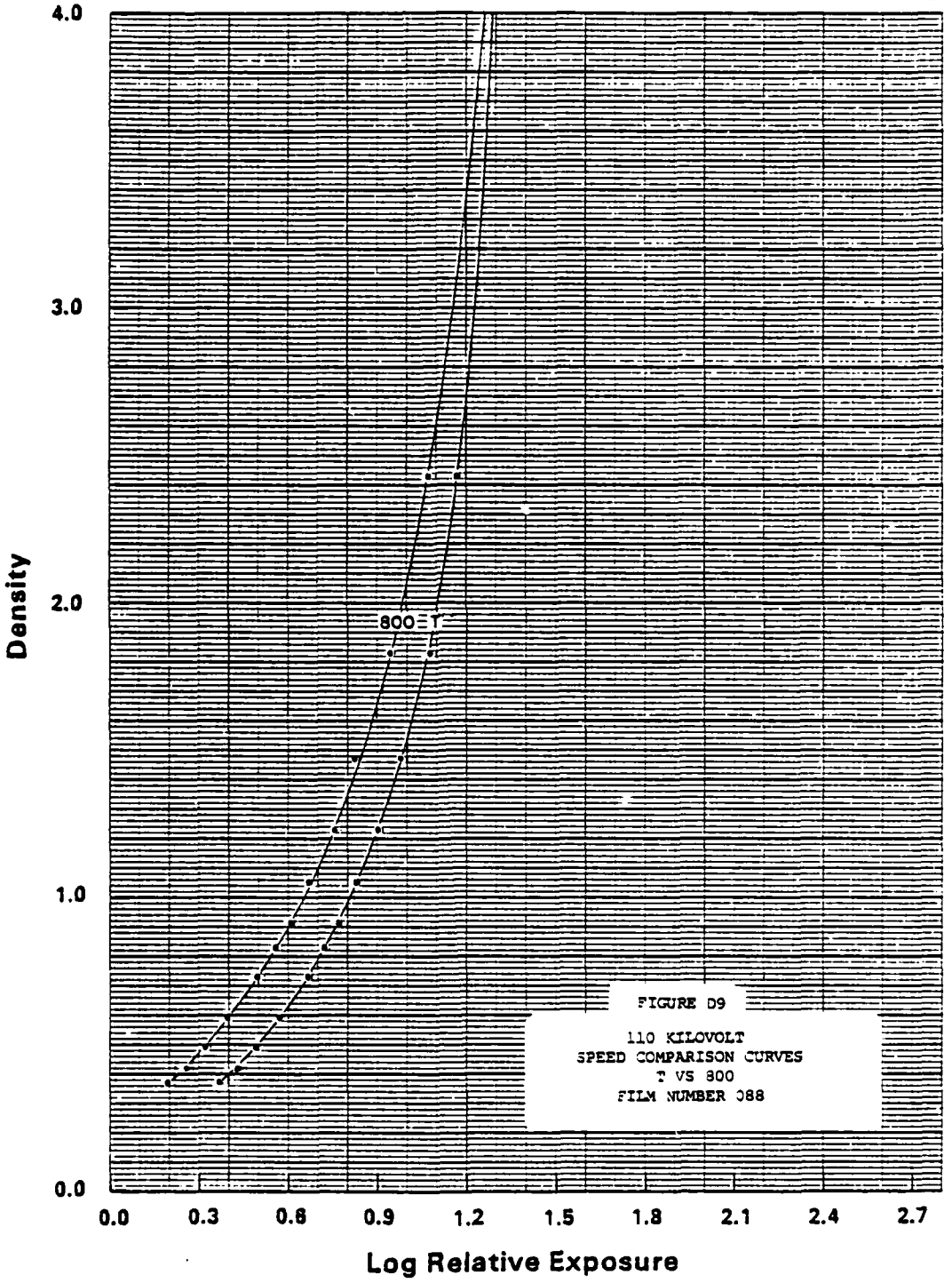


FIGURE D9

110 KILOVOLT
SPEED COMPARISON CURVES
T VS 800
FILM NUMBER 088

110 KV

FILM TYPE

T VS. 800 FILM NO. 088

STEP NO.	D avg. T	LRE T	LRE 800	DIFF. +	LRE T +-DIFF.
1	.370	.37	.545	.175	.195
2	.394	---	---	---	---
3	.421	.43	.60	.17	.26
4	.457	---	---	---	---
5	.494	.495	.67	.175	.32
6	.543	---	---	---	---
7	.594	.57	.75	.18	.39
8	.654	---	---	---	---
9	.727	.66	.835	.175	.485
10	.813	.715	.88	.165	.55
11	.918	.77	.935	.165	.605
12	1.047	.825	.985	.16	.665
13	1.230	.90	1.05	.15	.75
14	1.472	.975	1.13	.155	.82
15	1.827	1.065	1.19	.125	.94
16	2.424	1.17	1.27	.10	1.07

TABLE D9

APPENDIX E

140 KILOVOLT FILM SPEED COMPARISONS

TABLE OF CONTENTS

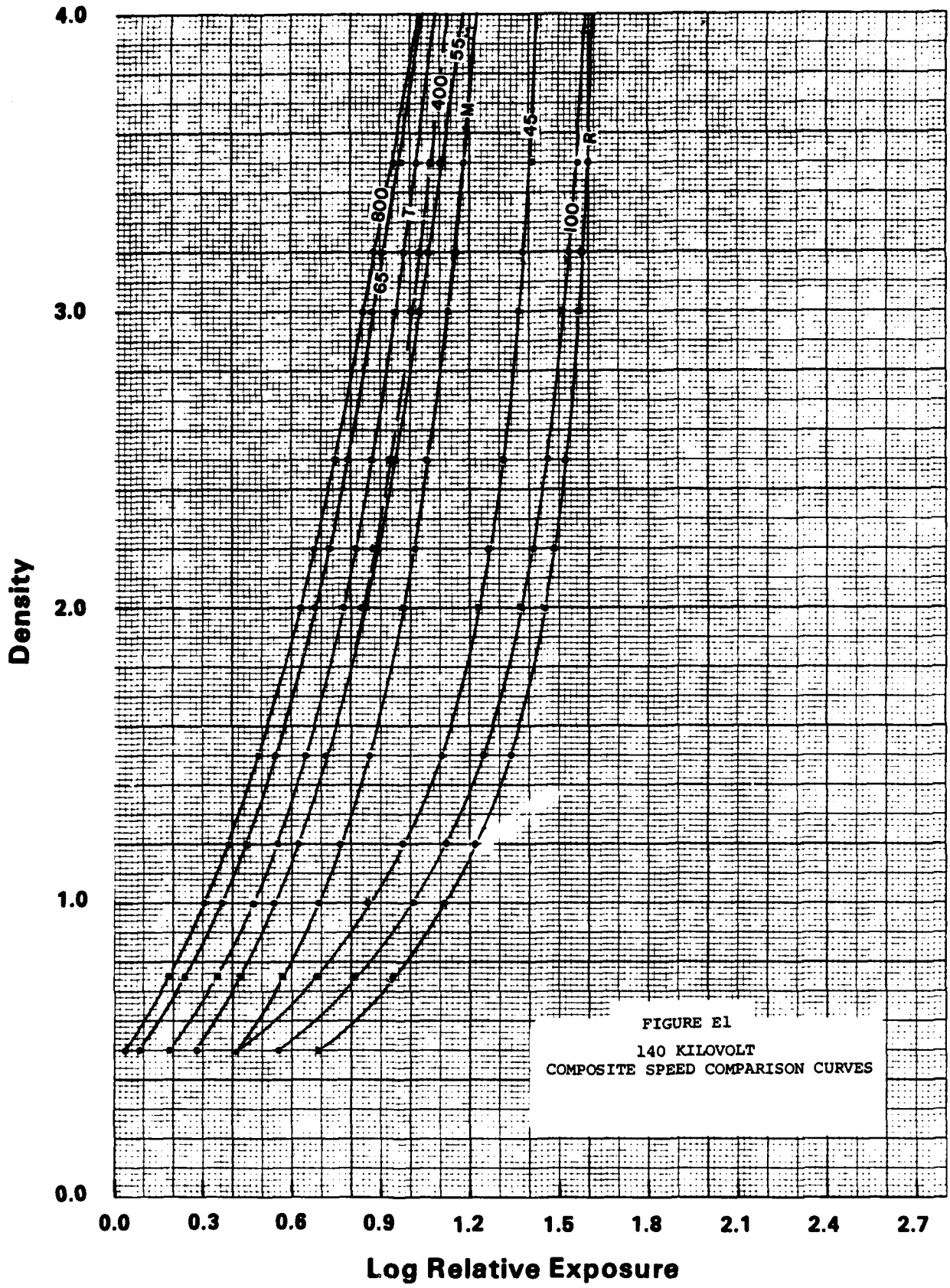


FIGURE E1

140 KILOVOLT
COMPOSITE SPEED COMPARISON CURVES

140 KV LRE Values For Speed Comparison Curves

Density	M	R	T	55	400	45	100	65	800
0.5	.41	.69	.19	.28	.285	.28 / .41	.135 / .555	.11 / .09	.15 / .04
0.75	.57	.94	.345	.425	.43	.26 / .68	.13 / .81	.11 / .235	.16 / .185
1.0	.69	1.115	.47	.54	.545	.26 / .855	.11 / 1.005	.105 / .365	.165 / .305
1.2	.76	1.22	.55	.62	.62	.245 / .975	.10 / 1.12	.10 / .45	.16 / .39
1.5	.86	1.34	.645	.715	.715	.235 / 1.105	.095 / 1.245	.10 / .545	.16 / .485
2.0	.975	1.45	.775	.845	.835	.225 / 1.225	.08 / 1.37	.10 / .675	.145 / .63
2.2	1.015	1.485	.815	.89	.875	.22 / 1.265	.075 / 1.41	.09 / .725	.14 / .675
2.5	1.06	1.525	.875	.945	.93	.21 / 1.315	.065 / 1.46	.08 / .795	.125 / .75
3.0	1.13	1.57	.95	1.03	1.005	.20 / 1.37	.06 / 1.51	.075 / .875	.11 / .84
3.2	1.16	1.58	.98	1.06	1.035	.20 / 1.38	.05 / 1.53	.075 / .905	.10 / .88
3.5	1.19	1.60	1.02	1.105	1.07	.19 / 1.41	.04 / 1.56	.07 / .97	.09 / .95

Speed Relative To M in Percent

Density	M	R	T	55	400	45	100	65	800
0.5	100	52.5	166.0	134.9	133.4	100	71.6	208.9	234.4
1.0	100	37.6	166.0	141.3	139.6	68.4	48.4	211.3	242.7
1.5	100	33.1	164.1	139.6	139.6	56.9	41.2	206.5	237.1
2.0	100	33.5	158.5	134.9	136.5	56.2	40.3	199.5	221.3
2.5	100	34.3	153.1	130.3	134.9	55.6	39.8	184.1	204.2
3.0	100	36.3	151.4	125.9	133.4	57.5	41.7	179.9	195.0
3.5	100	38.9	147.9	121.6	131.8	60.3	42.7	166.0	173.8

Contrast Numbers

Density	M	R	T	55	400	45	100	65	800
1.0-3.0	4.55	4.4	4.17	4.08	4.35	3.88	3.96	3.92	3.74
1.0-1.2	2.86	1.9	2.5	2.5	2.67	1.67	1.74	2.35	2.35
2.0-2.2	5.0	5.71	5.0	4.44	5.0	5.0	5.0	4.0	4.44
3.0-3.2	6.67	20.0	6.67	6.67	6.67	20.0	10.0	6.67	5.0
1.5-2.5	5.0	5.41	4.35	4.35	4.65	4.76	4.65	4.0	3.77
2.0-3.0	6.45	8.33	5.71	5.41	5.88	6.90	7.14	5.0	4.76
2.5-3.5	7.69	13.33	6.90	6.25	7.14	10.53	10.0	5.71	5.0

TABLE E1

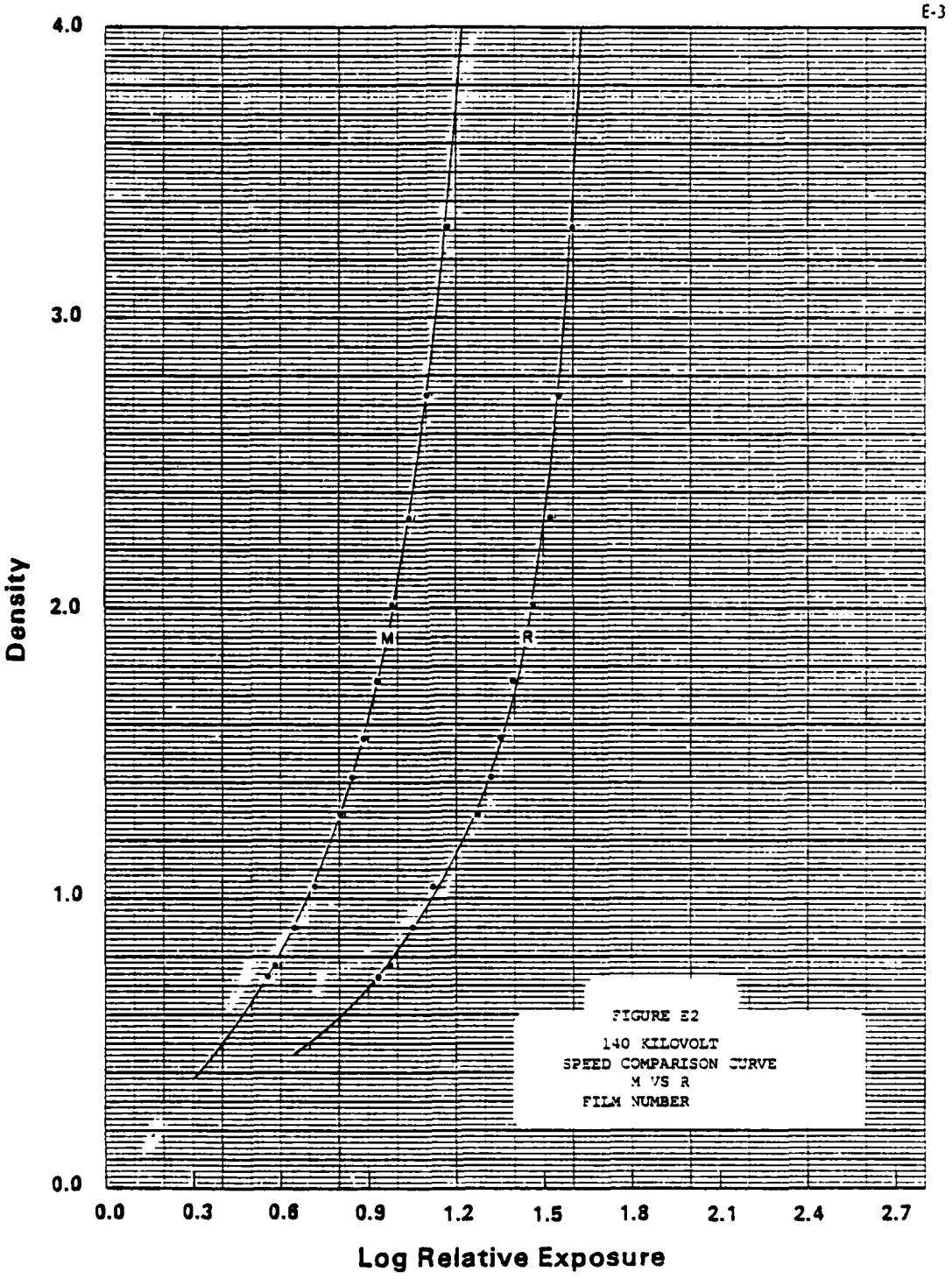


FIGURE E2

140 KILOVOLT
SPEED COMPARISON CURVE
M VS R
FILM NUMBER

140 KV

FILM TYPE

M vs. R FILM NO. 213

STEP NO.	D avg. M	LRE M	LRE R	DIFF. -	LRE M +/- DIFF.
1	.730	.555	.180	.375	.930
2	.778	.580	.185	.395	.975
3	.835	.615	.210	.405	1.020
4	.905	.645	.240	.405	1.050
5	.984	.680	.250	.430	1.110
6	1.043	.710	.280	.430	1.140
7	1.172	.750	.305	.445	1.195
8	1.288	.800	.330	.470	1.270
9	1.419	.840	.365	.475	1.315
10	1.565	.880	.410	.470	1.350
11	1.753	.920	.450	.470	1.390
12	2.016	.980	.500	.480	1.460
13	2.309	1.040	.560	.480	1.520
14	2.734	1.100	.640	.450	1.550
15	3.314	1.165	.735	.430	1.595
16	4.173	---	---	---	---

TABLE E2

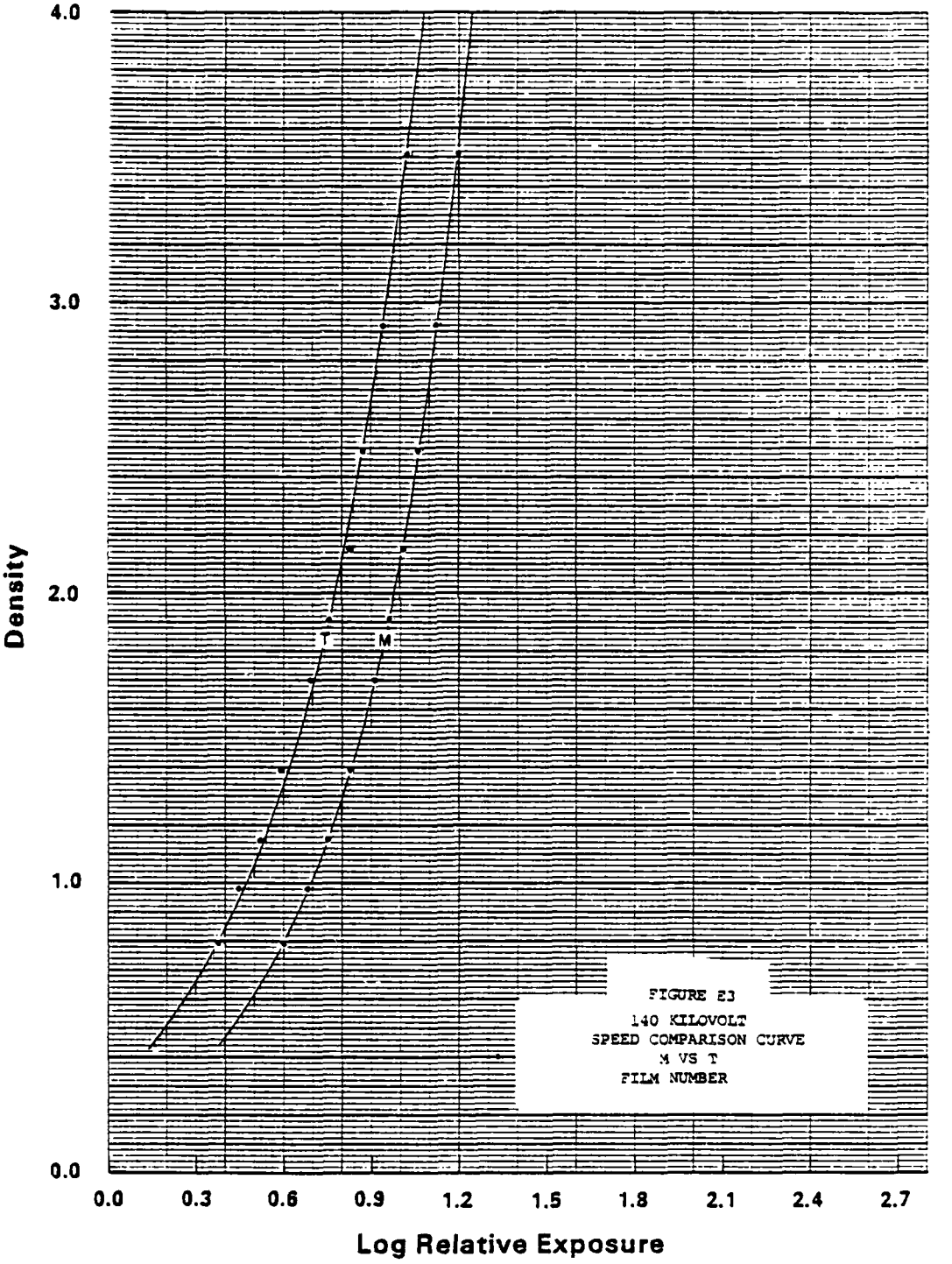


FIGURE E3
140 KILOVOLT
SPEED COMPARISON CURVE
M VS T
FILM NUMBER

140 KV

FILM TYPE

M VS. T FILM NO. 215

STEP NO.	D avg. M	LRE M	LRE T	DIFF. +	LRE M +DIFF.
1	.794	.600	.825	.225	.375
2	.844	.620	.850	.230	.390
3	.907	.650	.885	.235	.415
4	.982	.680	.915	.235	.445
5	1.062	.710	.950	.240	.470
6	1.154	.750	.985	.235	.515
7	1.264	.785	1.010	.225	.560
8	1.389	.825	1.060	.235	.590
9	1.532	.870	1.090	.220	.650
10	1.699	.910	1.125	.215	.695
11	1.906	.960	1.165	.205	.755
12	2.156	1.010	1.205	.185	.825
13	2.490	1.060	1.250	.190	.870
14	2.922	1.120	---	---	---
15	3.512	1.195	---	---	---
16	4.316	---	---	---	---

TABLE E3

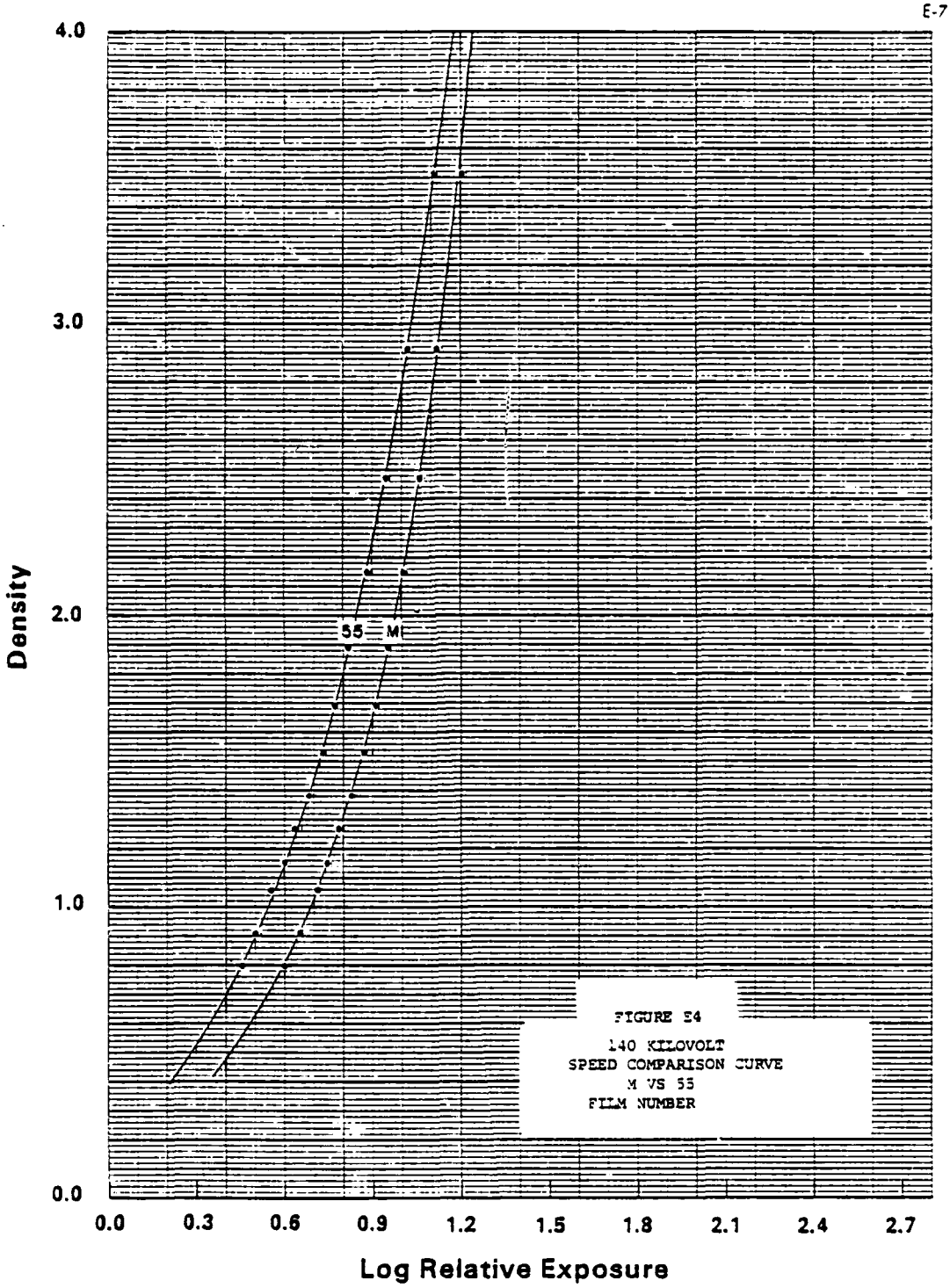


FIGURE 54

140 KILOVOLT
SPEED COMPARISON CURVE
M VS 55
FILM NUMBER

140 KV

FILM TYPE

M VS. 55 FILM NO. 217

STEP NO.	D avg. M	LRE M	LRE 55	DIFF. +	LRE M +-DIFF.
1	.798	.600	.745	.145	.455
2	.850	.620	.770	.150	.470
3	.910	.650	.800	.150	.500
4	.983	.680	.840	.160	.520
5	1.062	.710	.870	.160	.550
6	1.158	.750	.900	.150	.600
7	1.264	.785	.940	.155	.630
8	1.384	.825	.970	.145	.680
9	1.532	.870	1.010	.140	.730
10	1.695	.910	1.050	.140	.770
11	1.890	.950	1.085	.135	.815
12	2.142	1.005	1.130	.125	.880
13	2.473	1.060	1.175	.115	.945
14	2.913	1.120	1.220	.100	1.020
15	3.518	1.205	---	---	---
16	4.308	---	---	---	---

TABLE E4

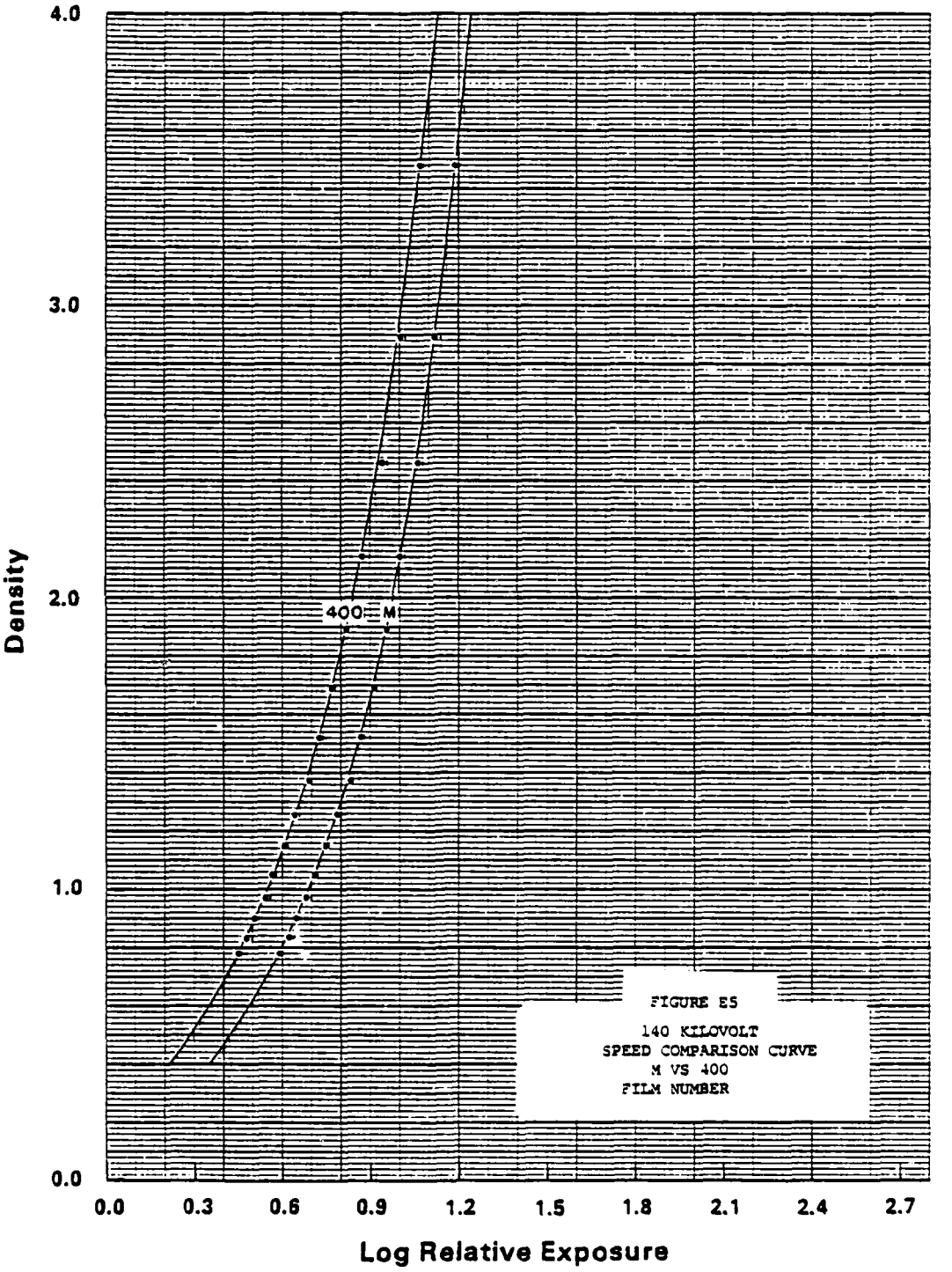


FIGURE E5

140 KILOVOLT
SPEED COMPARISON CURVE
M VS 400
FILM NUMBER

140 KV

FILM TYPE

M VS. 400 FILM NO. 216

STEP NO.	D avg. M	LRE M	LRE 400	DIFF. +	LRE M +/- DIFF.
1	.783	.590	.730	.140	.450
2	.838	.620	.760	.140	.480
3	.902	.645	.790	.145	.500
4	.974	.680	.820	.140	.540
5	1.057	.710	.860	.150	.560
6	1.153	.750	.895	.145	.605
7	1.259	.785	.930	.145	.640
8	1.378	.830	.970	.140	.690
9	1.525	.865	1.005	.140	.725
10	1.692	.910	1.045	.135	.775
11	1.889	.955	1.090	.135	.820
12	2.145	1.005	1.130	.125	.870
13	2.463	1.060	1.180	.120	.940
14	2.889	1.120	1.240	.120	1.000
15	3.480	1.190	---	---	---
16	4.278 ---	---	---	---	---

TABLE E5

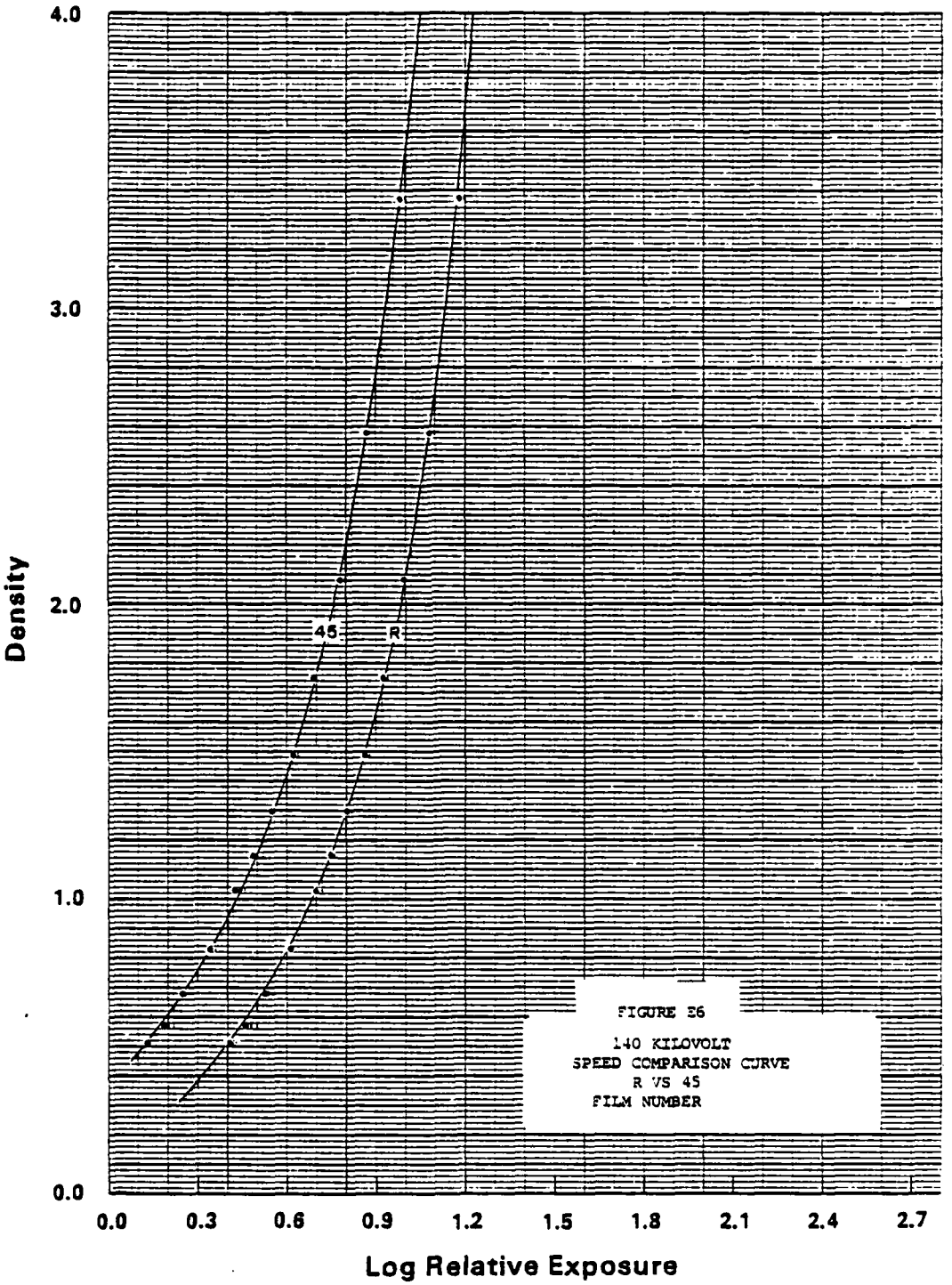


FIGURE E6

140 KILOVOLT
SPEED COMPARISON CURVE
R VS 45
FILM NUMBER

140 KV

FILM TYPE

R VS. 45 FILM NO. 218

STEP NO.	D avg. R	LRE R	LRE 45	DIFF. +	LRE R +/- DIFF.
1	.505	.405	.680	.275	.130
2	.535	.430	.705	.275	.155
3	.574	.460	.735	.275	.185
4	.620	.490	.770	.280	.210
5	.681	.530	.810	.280	.250
6	.744	.565	.850	.285	.280
7	.818	.610	.880	.270	.340
8	.908	.650	.920	.270	.380
9	1.015	.695	.965	.270	.425
10	1.146	.745	1.005	.260	.485
11	1.298	.800	1.050	.250	.550
12	1.488	.750	1.100	.240	.620
13	1.744	.920	1.150	.230	.690
14	2.086	.995	1.205	.210	.785
15	2.579	1.080	---	---	---
16	3.377	1.180	---	---	---

TABLE E6

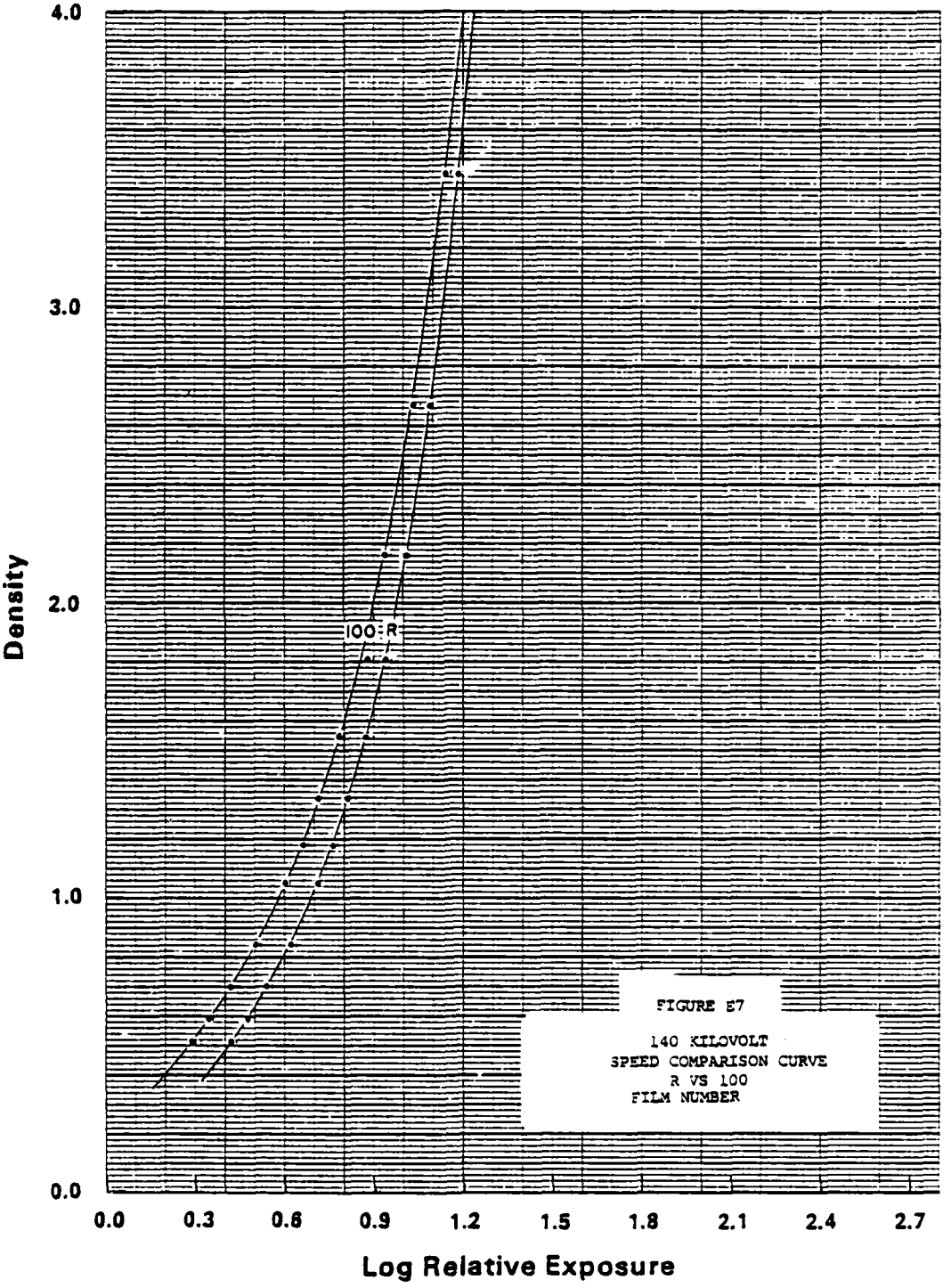


FIGURE E7

140 KILOVOLT
SPEED COMPARISON CURVE
R VS 100
FILM NUMBER

140 KV

FILM TYPE

R vs. 100 FILM NO. 219

STEP NO.	D avg. R	LRE R	LRE 100	DIFF. +	LRE R +DIFF.
1	.517	.420	.550	.130	.290
2	.554	.440	.580	.140	.300
3	.597	.475	.605	.130	.345
4	.643	.505	.635	.130	.375
5	.703	.540	.665	.125	.415
6	.769	.580	.700	.120	.460
7	.847	.620	.740	.120	.500
8	.941	.660	.775	.115	.545
9	1.050	.710	.820	.110	.600
10	1.179	.760	.860	.100	.660
11	1.339	.810	.910	.100	.710
12	1.543	.870	.960	.090	.780
13	1.807	.940	1.005	.065	.875
14	2.164	1.005	1.075	.070	.935
15	2.662	1.090	1.145	.055	1.035
16	3.445	1.185	1.230	.045	1.140

TABLE E7

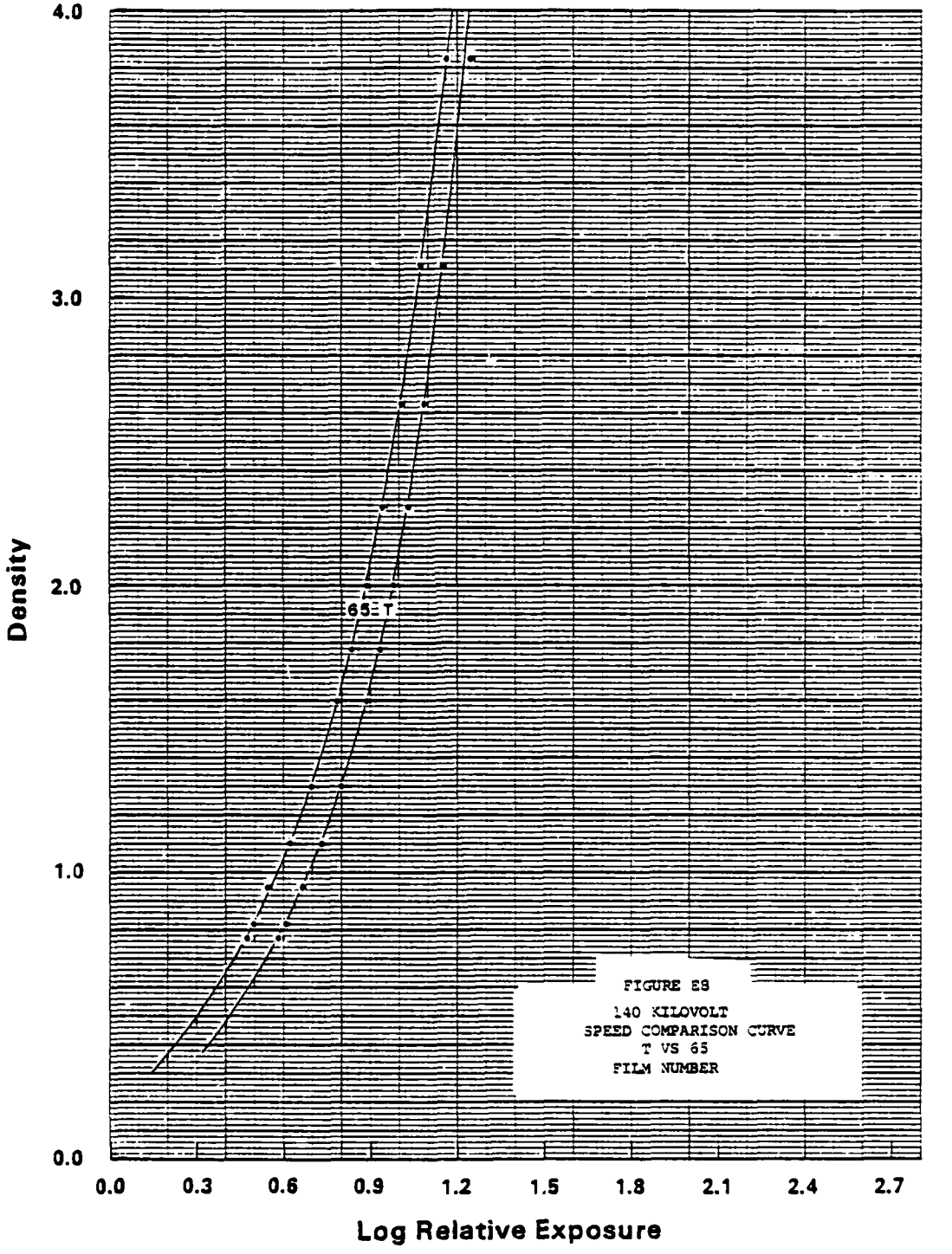


FIGURE E8

140 KILOVOLT
SPEED COMPARISON CURVE
T VS 65
FILM NUMBER

140 KV

FILM TYPE

T VS. 65 FILM NO. 220

STEP NO.	D avg. T	LRE T	LRE 65	DIFF. +	LRE T + −DIFF.
1	.773	.580	.690	.110	.470
2	.822	.605	.720	.115	.490
3	.877	.635	.740	.105	.530
4	.944	.660	.780	.120	.540
5	1.018	.700	.805	.105	.595
6	1.104	.730	.840	.110	.620
7	1.201	.765	.875	.110	.655
8	1.308	.800	.905	.105	.695
9	1.442	.840	.945	.105	.735
10	1.596	.885	.985	.100	.785
11	1.779	.930	1.025	.095	.835
12	2.001	.980	1.070	.090	.890
13	2.275	1.030	1.120	.090	.940
14	2.626	1.085	1.165	.080	1.005
15	3.113	1.145	1.220	.075	1.070
16	3.833	1.225	---	---	---

TABLE E8

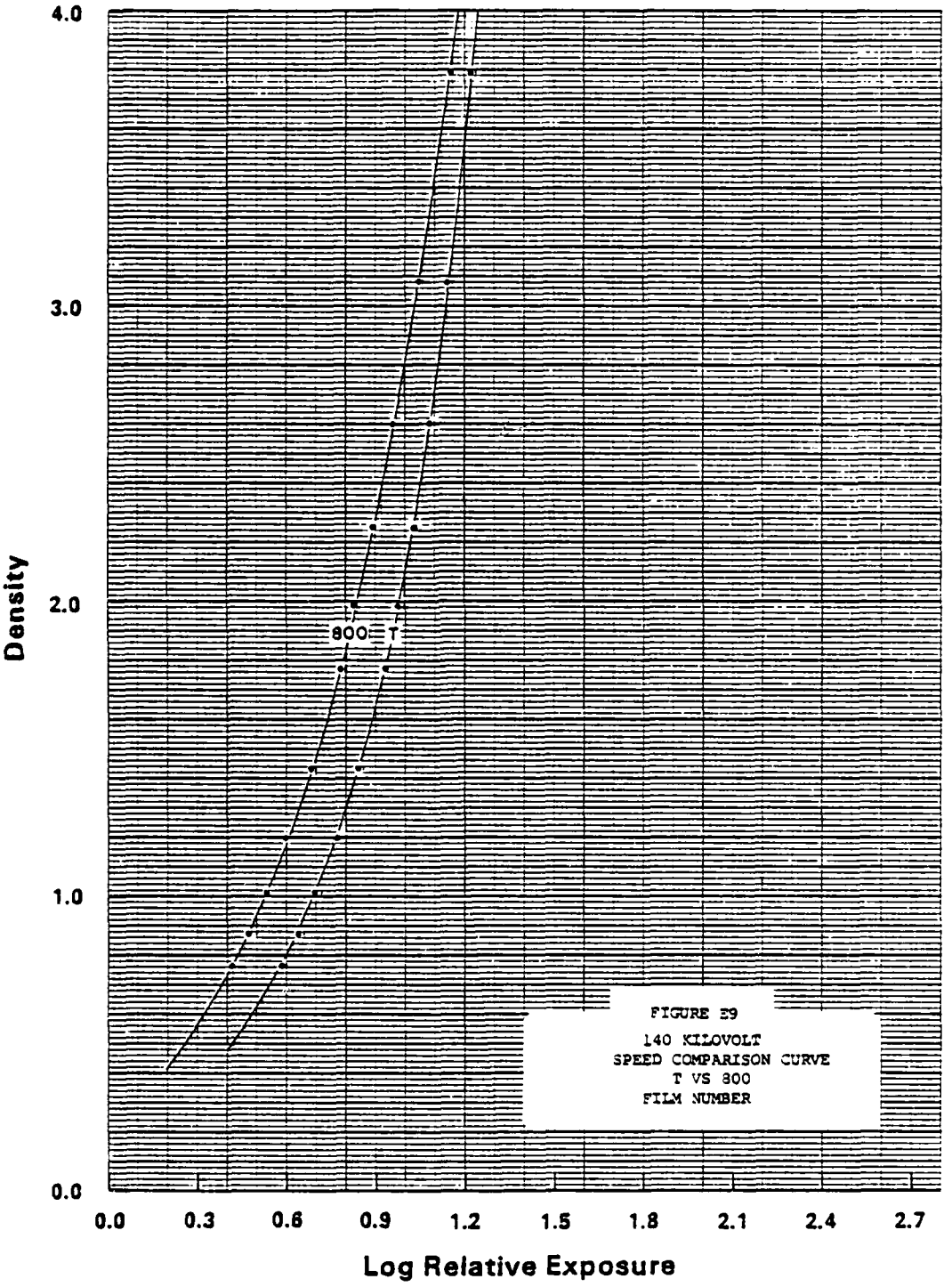


FIGURE 29

140 KILOVOLT
SPEED COMPARISON CURVE
T VS 800
FILM NUMBER

140 KV

FILM TYPE

T VS. 800 FILM NO. 221

STEP NO.	D avg. T	LRE T	LRE 800	DIFF. +	LRE T +/− DIFF.
1	.767	.580	.750	.17	.41
2	.817	.605	.78	.175	.43
3	.875	.635	.805	.17	.465
4	.940	.660	.835	.175	.485
5	1.013	.695	.86	.165	.53
6	1.098	.730	.90	.17	.56
7	1.196	.765	.935	.17	.595
8	1.306	.800	.965	.165	.635
9	1.434	.840	1.00	.16	.68
10	1.589	.885	1.04	.155	.73
11	1.766	.930	1.075	.145	.785
12	1.982	.975	1.12	.145	.83
13	2.252	1.025	1.16	.135	.89
14	2.603	1.080	1.205	.125	.955
15	3.083	1.140	---	---	---
16	3.793	1.220	---	---	---

TABLE E9

APPENDIX F

CONTRAST BAR GRAPHS

TABLE OF CONTENTS

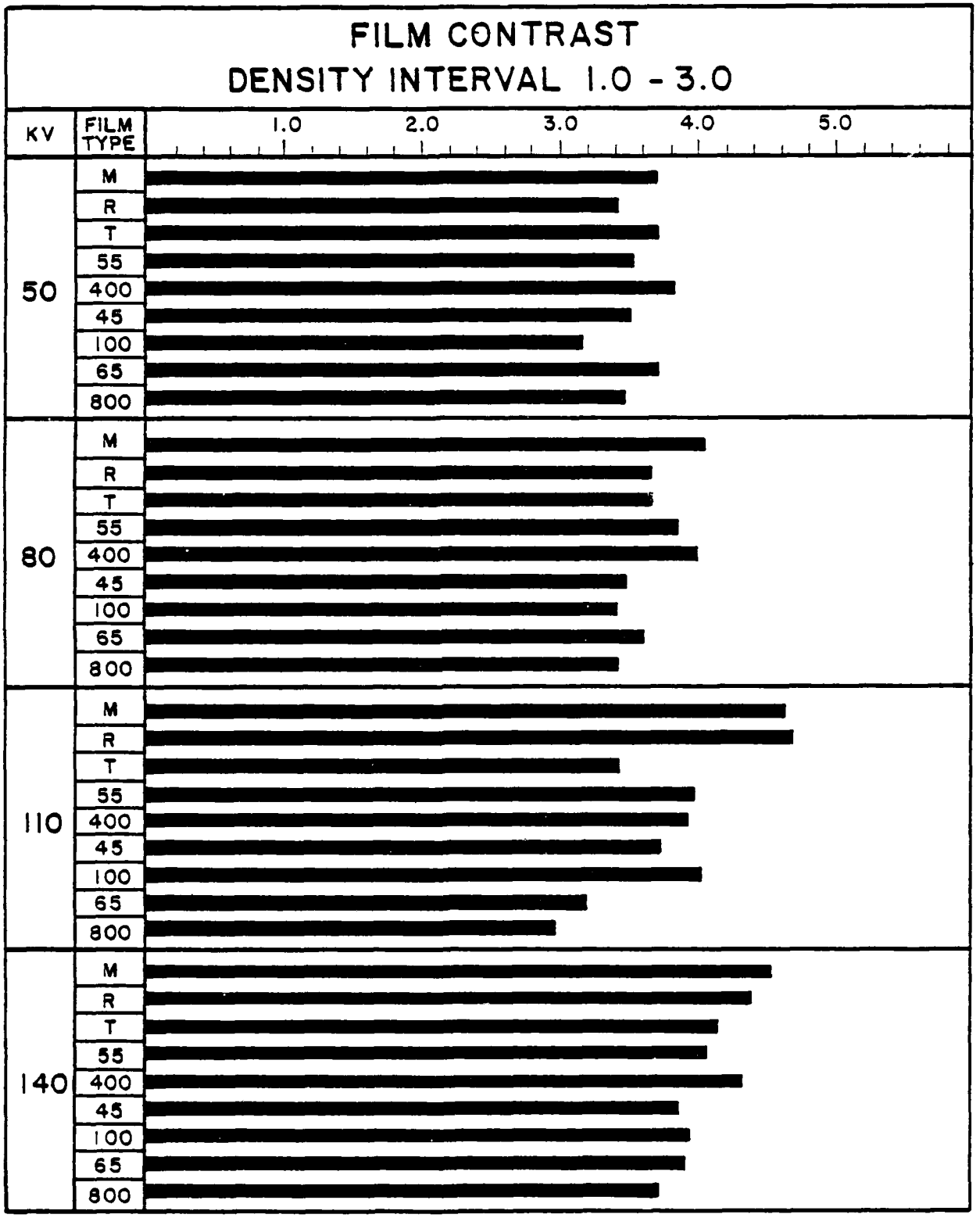

FILM CONTRAST
DENSITY INTERVAL 1.0 - 3.0
KV
FILM TYPE
1.0
2.0
3.0
4.0
5.0
50
M
R
T
55
400
45
100
65
800
80
M
R
T
55
400
45
100
65
800
110
M
R
T
55
400
45
100
65
800
140
M
R
T
55
400
45
100
65
800

FIGURE F1

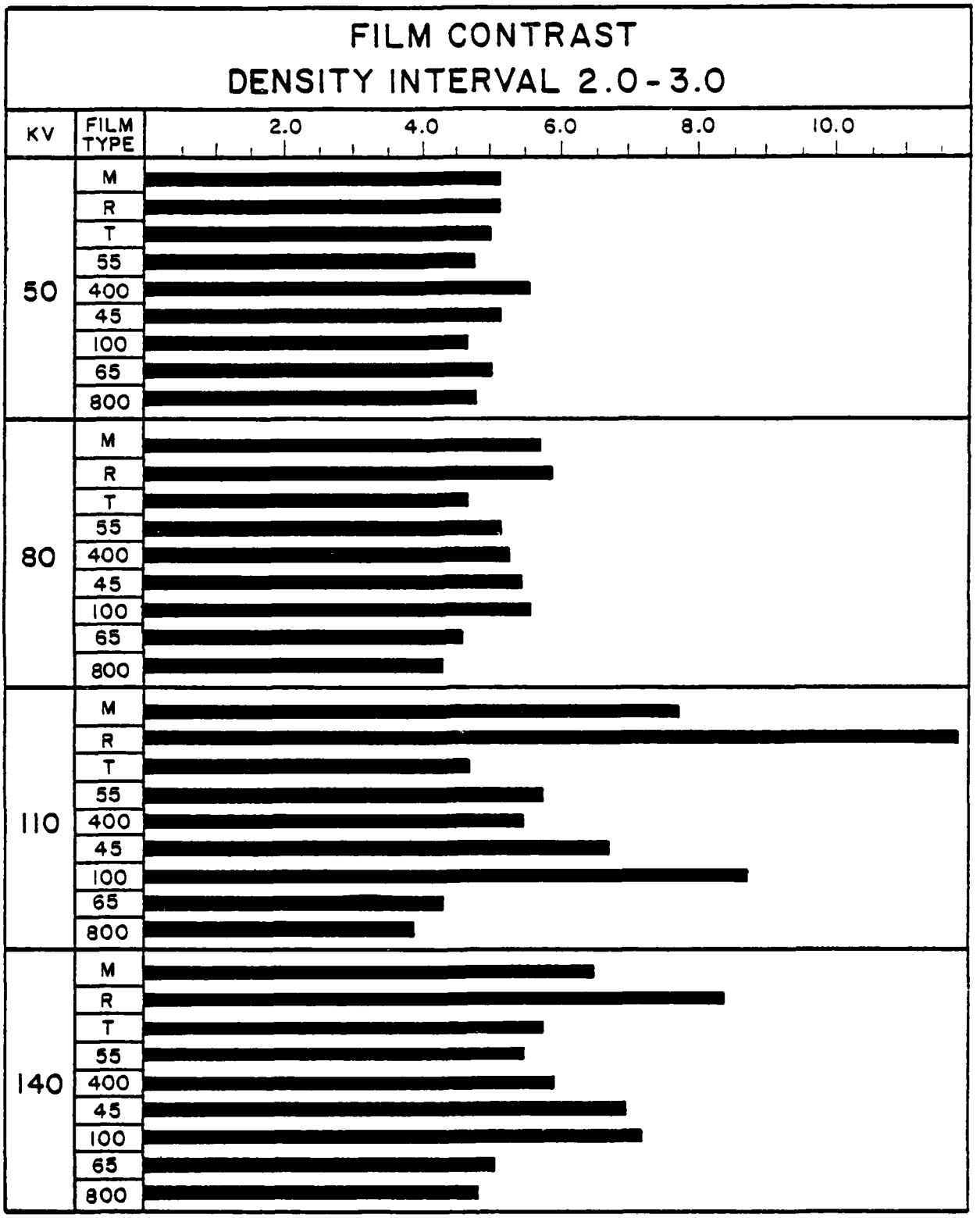

FILM CONTRAST
DENSITY INTERVAL 2.0-3.0
KV
FILM TYPE
2.0
4.0
6.0
8.0
10.0
50
M
R
T
55
400
45
100
65
800
80
M
R
T
55
400
45
100
65
800
110
M
R
T
55
400
45
100
65
800
140
M
R
T
55
400
45
100
65
800

FIGURE F2

APPENDIX G

TEST PLAN

TEST PLAN

EVALUATION/COMPARISON OF INDUSTRIAL RADIOGRAPHIC FILM CHARACTERISTICS

1.0 PURPOSE: This test plan defines the laboratory procedures to be followed in accomplishing the project.

2.0 EQUIPMENT REQUIRED:

2.1 X-Ray Machine: The standard x-ray units used by the Air Force are the Sperry 160 KVP or the Magnaflux 150 KVP. Either of these units will provide data suitable for Air Force field use. However, once the project is started, the same machine must be used for all the exposures for the comparison data to be valid.

2.2 Aluminum Step Tablet: The step tablet shall be constructed of 15 steps, each step to be 1/16 inch thickness change in such a manner as to have both ascending and descending steps on the same tablet. Material to be either 2024 or 7075 aluminum alloy. A border of lead marking tape, 1/4 inch wide and two layers thick (approx 0.005 inch), shall be placed on both long edges to reduce internal scatter. Figure 1 is a sketch of the required tablet.

2.3 Densitometer: Any direct reading, transmission densitometer capable of indicating to 3 decimal places (third place may be estimated) and having a minimum density range of 0.00 to 4.00 Hurter and Driffield (H&D) units may be used. A calibrated film density strip to be used in checking/standardizing the densitometer is also required.

2.4 Cassettes: The preferred cassettes for sheet film are the flexible (plastic) type. However, if the flexible type is not available, rigid cassettes may be used.

2.5 X-Ray Film: Fresh film in unopened boxes shall be procured for the project. Effort should be made to obtain film with latest possible expiration dates. Films to be evaluated are: Kodak Types R, M, and T; DuPont Types NDT 45, 55, and 65; and GAF Types 100, 200, and 400. The types of packaging to be included are: interleaved or sheet; daylight or ready pack; and lead pack or lead oxide screens (NOTE: Lead oxide screens may not be available from all of the manufacturers). Each of the various types of film used in the evaluation should be from the same batch or emulsion number, e.g., all Type M interleaved of one emulsion; all Type R interleaved of one emulsion, etc.

2.6 Processing: Both hand (tank) processing facilities and an automatic industrial processor will be required. Either method may be used for the major portion with the alternate used only to process the nine comparison films. Automatic processing cycle shall be 11 minutes and hand processing shall be 6 minutes in the developer for optimum contrast. Industrial x-ray

film processing chemicals must be used with Kodak chemical preferred.

3.0 PROCEDURES:

3.1 General.

3.1.1 The project will require x-ray exposures and film processing over an extended period of time. Care must be taken to assure uniformity throughout the project. Minor changes that normally have no significant effect can produce wide variations in comparison results if rigid controls are not exercised. Examples of some of the procedures requiring special attention are:

a. Exposure - Warmup of machines, strict adherence to exposure details, power supply variations.

b. Setup - Consistent conditions including the use of a lead exposure surface, identical cassettes or film holders, positioning of film and tubehead.

c. Processing - (Hand) Uniform time, temperature, agitation and replenishment, use of "hot" or fresh solutions, (Automatic) uniform temperature, increase or decrease in developer activity due to replenishment rate, do not change or dump solutions during the project, do not process evaluation films until cleanup films have been run during daily startup.

d. Density Measurement: Clean light and lens daily, check calibration each day prior to starting and at 30 minute intervals during sustained operation using the standard density strip.

3.1.2 The project is a comparison of one film's properties versus anothers. While all three film manufacturer's products are used by field and depot labs, the predominant film is Kodak Type M. Due to the extensive use of Kodak Type M, it shall be used as the comparison standard in the project.

3.1.3 Film emulsion response varies with radiation wave form which is a function of kilovoltage. This makes it necessary to run film speed/contrast curves and calibrate the step tablet response over a range of kilovoltages. Comparison exposures shall be made at 50, 80, 110, and 140 kilovolts.

3.2 Fog Density Determination:

3.2.1 Laboratory work on the project should not be started until all films to be evaluated are available. Fog density determination should be the first task and should be accomplished shortly after opening the package. This is intended to reduce potential fog accumulation due to dark room handling.

3.2.2 Fog density is determined by subjecting fresh, unexposed film to a complete processing cycle (development, fixation, rinsing, and drying). All films should be processed on the same day, using the necessary

replenishment additions to minimize processing variations.

3.2.3 Densities are to be measured in 12 locations on each film sheet and recorded. Densitometer calibration is especially important at these lower densities. Density measurement locations should: (a) be evenly spaced across and down the sheet, (b) be in approximately the same location for each film, and (c) be at least one inch from each film edge.

3.3 Film Speed Determination:

3.3.1 General - Film speed determination is somewhat complicated and involves the use of the aluminum step tablet. Procedures and precautionary statements are detailed and explicit in the early paragraphs and are shortened in later paragraphs, however, they still apply. Special emphasis must be devoted to maintaining constant and uniform conditions throughout the project to provide valid comparison data.

3.3.2 Calibration of Step Tablet:

3.3.2.1 The first step in the procedure of determining comparison speed values is to calibrate the step tablet. Radiation absorption varies with wavelength and the calibration must be accomplished for each kilovoltage range. The procedure is identical in each case except for change of the exposure technique (kilovoltage and time).

3.3.2.2 To calibrate the step tablet at any kilovoltage, two exposures are made on two of the standard films (Kodak Type M). The first exposure should be selected to produce a density of 0.15 to 0.20 on the number one step. The second exposure must be exactly twice the first exposure. Consistent with good practice, this should be done by doubling the time rather than adjusting the milliamperage. Exact timing is essential as the calibration calculation is dependent upon this two-to-one relationship. The second exposure shall consist of two exposures each being identical to the first exposure. This procedure is necessary to compensate for any possible error due to exposure buildup.

3.3.2.2 Both films should be processed in an identical manner, either together if hand processing is used or one following the other in an automatic processor. Densities shall be read on a calibrated densitometer and recorded. A minimum of 4 densities will be measured on each step numbers 2 through 15 and 8 densities on step number 1. This provides eight density measurements for each thickness which will be used to determine the average density per step.

3.3.3 Film Speed Comparison

3.3.3.1 Once the step tablet has been calibrated for a specific kilovoltage, it is for all practical purposes independent of make or type of film. To obtain the speed relationship between two different films of approximately the same speed type, it is only necessary to expose the two films side by side (split film technique) using the step tablet as the subject at the

kilovoltage for which the step tablet was calibrated.

3.3.3.2 Comparison exposures are to be accomplished by inserting the standard film and the comparison film side by side in the same cassette or film holder. This is done by using either 7 X 17 or by shearing 14 X 17 inch film in half. All exposures should be made on top of a lead surface to minimize back scatter. The step tablet must be carefully centered with equal portions covering both films and the long dimension (15 inch) parallel to the long edge of the film (17 inch). A slightly longer than normal focal spot to film distance (48 inches) shall be used and the long axis of the tubehead shall be parallel with the long dimension of the step tablet.

3.3.3.3 The aiming point is the center of the number 1 step on the tablet. Emphasis shall be placed on maintaining consistent setups throughout the project. Suitable exposure values (time-milliamperage) shall be selected and used for each of the kilovoltages at which the step tablet was calibrated.

3.3.3.4 Both films shall be processed at the same time. Following processing, at least 3 density measurements shall be made on each of steps numbers 2 through 15 and 6 measurements on step number 1 on each film. This will provide a total of 6 densities for each thickness on each film.

3.3.3.5 Exposures will be made on: M vs NDT 55; M vs GAF 200; M vs T; M vs R; T vs NDT 65; T vs GAF 400; R vs NDT 45; and R vs GAF 100. This will be 8 exposures at each of the four kilovoltages and at each available packaging. Speed comparison standard data will be obtained by exposures on: Sheet film M vs Ready Pak M; Sheet film M vs Lead Pak M; and Ready Pak M vs Lead Pak M.

3.4 Film Contrast Comparison. Film contrast comparison will be obtained from data generated by paragraph 3.3.

3.5 Emulsion Consistency: The test for emulsion consistency is relatively simple and consists merely of exposing the film to be evaluated to a relatively light density (0.75 to 1.0 H&D). The film is exposed without an absorber or step tablet, processed and evaluated for streaks, mottling or other emulsion artifacts using both reflected and transmitted light. One of each type film should be evaluated, i.e., R, M, T, NDT-45, NDT-55, NDT-65, GAF-100, GAF-200, and GAF-400. Only one kilovoltage and one type of packaging is required.

3.6 Pre-and Post-Exposure Pressure Sensitivity. The following test is very crude and the contractor may propose an improved alternate approach. The suggested approach is to use a ballpoint pen and writing on a piece of paper placed on the film before and after exposure. Exposure should be just slightly more dense than in paragraph 3.5 (1.0 to 1.25).

3.7 Pre- and Post-Exposure Kink Sensitivity. Again the test proposed may be improved with better control over the mechanics of producing a kink.

Suggested approach is to loosely fasten a 1/4 inch diameter steel bar to a board. The film is inserted under the bar to approximately its mid-point, the film ends folded together and pulled taut. The desired effect is to control the bending of the film to a 1/4 inch diameter. Film shall be "kinked" prior to and after exposure similar to para 3.5. The bending or kink before and after exposure shall be at 90 degrees to each other.

3.8 Hand Vs Automatic Processing. Processing variables are generally independent of energy level (kilovoltage) and packaging. Comparison is required at only one kilovoltage (suggest 80 or 110 KVP) and for only one type of packaging. Comparison is to be made using the split film technique described in paragraph 3.3.3 except both films will be the same type and manufacturer. One of the films will be processed by hand while the other film from the same exposure will be processed through the automatic processor. One of each type film should be evaluated (i.e., R, M, T, NDT-45, NDT-55, NDT-65, GAF-100, GAF-200, and GAF-400). Following exposure and processing, three density measurements will be made on each step, numbers 2 through 15 and 6 density measurements on step No. 1. This will provide a total of 6 density measurements for each thickness and each processing method. The measurements are to be recorded and will be used in determining the average density per thickness.

4.0 EVALUATION:

4.1 General - The type of graph paper most convenient and generally used to plot film characteristic or sensitometric curves is 20 X 20 divisions to the inch (K&E Nos 46-1240 or 46-1242). Other types of graph paper may be used; however, the 20 X 20 divisions provide a display that is easy to interpret and to use.

4.2 Fog Density. The 12 density measurements should be recorded in table form of each type/mfgr/packaging film vs density readings plus one addition column of the arithmetic average.

4.3 Film Speed

4.3.1 General - There are several possible ways to compare film speeds. This paragraph details the procedures to develop "Log Relative Exposure" curves and also a percentage speed comparison chart.

4.3.2 Calibration of the Step TAblet.

4.3.2.1 The eight density measurements on each step number or thickness (from paragraph 3.3.2.2) should be arranged in tabular form for each exposure with a ninth column of average density. The table is used to plot two curves on a single sheet of graph paper with the ordinate as the density (0.00 to 4.00) and the abscissa as the step number (1 to 15). Curve I is the single exposure while Curve II being exactly twice the exposure of Curve I. These curves are then used to plot a calibration curve (Curve III) of density versus log relative exposure for the step tablet at a specific kilovoltage. This is done by designating the lowest discernable density reading on Curve I as Point 1. A second sheet of graph paper is prepared

for Curve III by ruling the ordinate into 0.2 density units at every 10th line and the abscissa into 0.1 log relative exposure units at every 5th line. The density of Point 1 is plotted on this new Curve III at a log relative exposure of zero (0). Point 2 is located by drawing a vertical line from Point 1 to Curve II. This location (Point 2) is the same thickness or step number as Point 1 and is exactly twice the exposure. The density of Point 2 is plotted on Curve III at log relative exposure 0.3 (mathematically, log 2 equals 0.3). Next, draw a horizontal line from Point 2 to Curve I and designate this as Point 3 which is the same density as Point 2. Locate Point 4 by drawing a vertical line from Point 3 to Curve II. Again, Point 4 is the same step number or thickness as Point 3 but is exactly twice the exposure. Plot the density of Point 4 on Curve III at log relative exposure 0.6 (mathematically, log 2 plus log 2 equals 0.6). Continue this process through Points 6, 8, etc., increasing the log relative exposure by 0.3 each time.

4.3.2.2 The number of points plotted in the above paragraph are not sufficient for an accurate and extended calibration curve. Additional points are determined in the following manner: Draw a smooth hyperbolic pencil curve through the few points plotted on Curve III. On this preliminary curve, find the density at log relative exposure 0.15 (this is one-half the distance between 0.0 and 0.30). This point, labeled Point 1A, provides a density which can be located on Curve I. Next, locate Point 2A by drawing a vertical line from Curve I - Point 1A to Curve II. Plot the density of Point 2A at a log relative exposure of 0.45 (0.15 plus 0.30) on Curve III. Then proceed to locate points 3A, 4A, 5A, etc., plotting the densities at log relative exposures of 0.75, 1.05, 1.35, etc., on Curve III. If, in the calibration, the second set of points 1A, 2A, 3A, etc., is offset either side of the preliminary curve, this is caused by inaccuracies in locating Point 1A. To eliminate this difficulty, each point in this set should be shifted equal amounts along the log relative exposure axis to give the best match with the preliminary curve. (NOTE: Do not shift the points along the density axis.)

4.3.2.3 Curves I, II, and III are used to determine the average log relative exposure per step of the tablet. First, find the highest density of one of the curves and the lowest density in the normal visual range (about density 1.0) in the same curve. Convert these densities into log relative exposure values using Curve III. The difference between the two log relative exposure values divided by the difference between the two steps is the average difference log relative exposure per step.

Example: Step #12 - density = 3.72 - Log Relative Exposure = 0.93
Step #1 - density = 1.18 - Log Relative Exposure = 0.30
Difference - 11 steps - Difference Log Relative Exposure - 0.6

Average difference log relative exposure per step = 0.63 divided by 11= 0.058
To determine the percent speed difference per step, merely convert 0.58 to its antilog of 1.14 or 14% speed difference between steps.

4.3.2.4 The accuracy of Curve III will impact speed comparison calculations and should be determined using Curves I and II. Select a given density and determine the corresponding step numbers in Curves I and II. Since Curve II

is exactly twice the exposure of Curve I, the difference in step numbers converted to log relative exposure using the average log relative exposure value calculated in Curve II should equal 0.300. Any variation from 0.300 is due to inaccuracy. This variation can be expressed in percentage through its antilog.

Example: Density of 1.5 H&D equals log relative exposure of 0.203 (Step 3.5 times 0.058) on Curve I and 0.505 (Step 8.71 times 0.058) on Curve II. This is a log relative exposure differnce of 0.302. Since the actual log relative exposure difference is 0.300 (twice the exposure), the inaccuracy of Curve III log relative exposure is 0.002 or converting to antilog and expressing in percentage 0.5%.

4.3.3 Film Speed Calculations:

4.3.3.1 The density readings obtained in paragraph 3.3.3.4 should be arranged in tabular form for each pair of films exposed. Columns are to contain step number, conversion to log relative exposure, the 6 measured densities, and the average density. The tables are to be used in plotting the comparison curves (standard vs comparison film). The two curves for each exposure in paragraph 3.3.3.5 shall be plotted.

4.3.3.2 Traditionally, film speed comparison is also given in percentage terms. The curves plotted in paragraph 4.3.3.1 show film speed differences vary with both kilovoltage and density. Comparisons are to be developed from the curves and will be provided as tables listing the percentage differences at densities of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, and 3.5, wherever possible. The curves also include the effect of fog density which must be accounted when developing percentage differences.

4.3.3.3 Percentage speed comparisons are derived by arbitrarily assigning the standard film, Kodak Type M, a value of 100. All other films will have some value relating to Kodak Type M, i.e., Type R films will be in the 50's range while Type T films will be in the 200's range. The actual percentage is determined by adding the applicable fog density, from paragraph 4.2, to the density for which the comparison is being made. The log relative exposure difference between the standard and film being evaluated is determined from the speed comparison curves, paragraph 4.3.3.1. When the curve of the film being evaluated is displaced to the right of the standard film, it indicates a slower speed film while a shift to left indicates a faster speed film. If the film being evaluated is slower than the standard, the percentage speed comparison is calculated by dividing 100 by the antilog of the log relative exposure difference. If the film being evaluated is faster than the standard, multiply the antilog of the log relative exposure difference by 100.

4.4 Film Contrast Calculation:

4.4.1 By definition, film contrast is the slope of the characteristic film curve at a given density. Practically, however, the film contrast is determined as the "average" contrast over the ordinary usable range of densities as from a density of 1.0 to a density of 3.0, i.e., the slope

of a line drawn between the two densities on the curve. Mathematically, it is the difference between a density of 3.0 plus fog and a density of 1.0 plus fog divided by the difference in log relative exposure of these two points.

4.4.2 Characteristic film curves are noted for the continually changing slope along the entire curve. The average film contrast number calculated in paragraph 4.4.1 does not reflect this changing slope. Also, a small error in judgement of position or placement of a point can make a relatively large error in the contrast calculation. For these reasons, contrast calculations must also be presented as a range of values along with the specific average number. The calculations are performed similar to those in paragraph 4.4.1 except for the density ranges. To reflect slope changes, contrast values shall be calculated for densities of: 1.0 to 1.20; 2.0 to 2.20; and 3.0 to 3.20 (Note: Fog densities must be incorporated due to their significant effect upon contrast). The results are to be reported as horizontal bar graphs with lines at the 1.0, 2.0, and 3.0 density values.

4.5 Emulsion Consistency Calculation. The approach to grading emulsion consistency is subjective depending on the evaluator's judgement rather than a numeric grade derived from laboratory tests. The films to be evaluated, paragraph 3.5, should be examined in subdued light with a variable intensity illuminator. The films are to be graded on the basis of evenness of density, mottling, streaking, or other emulsion artifacts under transmitted and reflected light. The evaluator should arrange the films in descending order based on his judgement of emulsion consistency. This is accomplished simply by comparing two films, one versus the other, and selecting the best. This process is continued until all 9 films are graded. Once the films have been placed in relative order, they can be assigned a numerical rating of 1 to 9, with 9 being the most consistent or highest rated film (Note: If, in the evaluator's judgement, two films are identical in quality, they should be given the same number. The best film will still have a value of 9, but the bottom film may be higher than 1). Some objectivity can be introduced by having three or more independent evaluations performed by different individuals. Personnel performing the evaluation should be experienced in viewing radiographs. The assigned numerical ratings of the independent evaluation should be totaled and new relative ratings or positions assigned.

4.6 Pressure and Kink Sensitivity: Evaluation and assessment of films for pre-exposure pressure sensitivity; post exposure pressure sensitivity; pre-exposure kink sensitivity; and post exposure kink are to be accomplished in the same manner detailed in paragraph 4.5. The evaluation results on each of the characteristics will be reported in separate tables giving the assigned rating by each evaluator, total of the assigned numerical ratings, and relative overall position of the film based upon the total ratings. In addition, a summary table will be provided comparing the relative overall ratings for each of the characteristics.

APPENDIX H

ALTERNATE METHOD FOR DEVELOPMENT OF

FILM SPEED COMPARISON CURVES

TABLE OF CONTENTS

I. DEVELOPMENT OF FILM SPEED COMPARISON CURVES

BY THE ALTERNATE METHOD

The basic premise on which this alternate method of speed comparison is based is that over the range of practical radiographic densities all industrial type radiographic films exhibit a linear relationship of Density vs Exposure response for a fixed quality of radiation incident at the film face. Since the quality of radiation incident upon the film is modified both by the voltage applied to the X-Ray Tube and by the thickness and material properties of any absorber placed between the tube head and the film, density comparisons for any pair of films should only be made for discrete thicknesses of the step tablet at a specific kilovoltage.

For the film comparison exposures of this project the tube head voltages were fixed at 50, 80, 110 and 140 kilovolts and the absorbers used were the previously calibrated step tablets. For exposure of the speed comparison films 7 inch by 17 inch strips of the standard film, Kodak Type M, and the comparison film were placed side by side in a single 14 inch by 17 inch cassette. One of the step tablets was placed over the standard film and the other over the comparison film during the exposure. These step tablets are radiographically equivalent. Both films were processed simultaneously to avoid differences in processing history.

In the tabular listings of Table I, Density vs Step Number, each density listed is an average of 16 data points/per step/ per film. Although fog density for each film is noted in each column heading, it is not subtracted from the average data which is used in developing the film speed comparison curves.

Since the density differences observed between the standard and comparison films at any discrete step of the step tablet are a direct result of the speed difference between these two films (i.e.; exposure time and radiation quality are identical), these two densities can be converted directly to log relative exposure using the calibration curve for the kilovoltage used during exposure. The antilog of the difference in LRE times 100 is equal to the percentage speed difference between these two films.

Figures 1 & 2 show graphically the operations required to determine speed difference between two films. First enter Figure 1 at Step 14 and obtain densities of 2.21 for Type M film and 0.71 for Type R film. With these densities now enter the 50 KV calibration curve, Figure 2, and obtain LRE = 1.40 for Type M film and LRE = 0.855 for Type R. The difference then is 0.545 LRE units and since LRE (R) < LRE (M), ΔLRE = -0.545.

The antilog (i.e.; Log) of =-.545 is 0.2851. Rounding to 0.29 and multiplying by 100, we find that the speed of Type R film relative to Type M is approximately 29%. The practical meaning of this is that to achieve a density of 2.21 with Type R film under Step 14 the exposure must be increased 0.545 LRE units. Thus the LRE for Type R film at a density of 2.21 relative to Type M should be 1.40 + 0.545 = 1.945. This is now a valid data point in plotting a curve of Density vs Log Relative Exposure for Type R film vs Type M film. If this same procedure is carried out for each of the density pairs for every step of the step tablet, characteristic curves may be plotted which accurately reflect the speed and contrast characteristics of Type R vs Type M film.

It is not necessary to generate the curves of Figure 1 since the data of Table I may be used directly to enter the calibration curve in obtaining LRE values. Table II illustrates the method of organizing data prior to plotting of the curves. Data from Steps 2 through 6 of the step tablet are omitted since they are not needed to produce a smooth curve.

Figures 3 and 4 illustrate the differences between curves plotted by the test plan method and by this alternate method.

FIGURE H1

50 KV SPEED COMPARISON EXPOSURES

KODAK TYPE M VS R

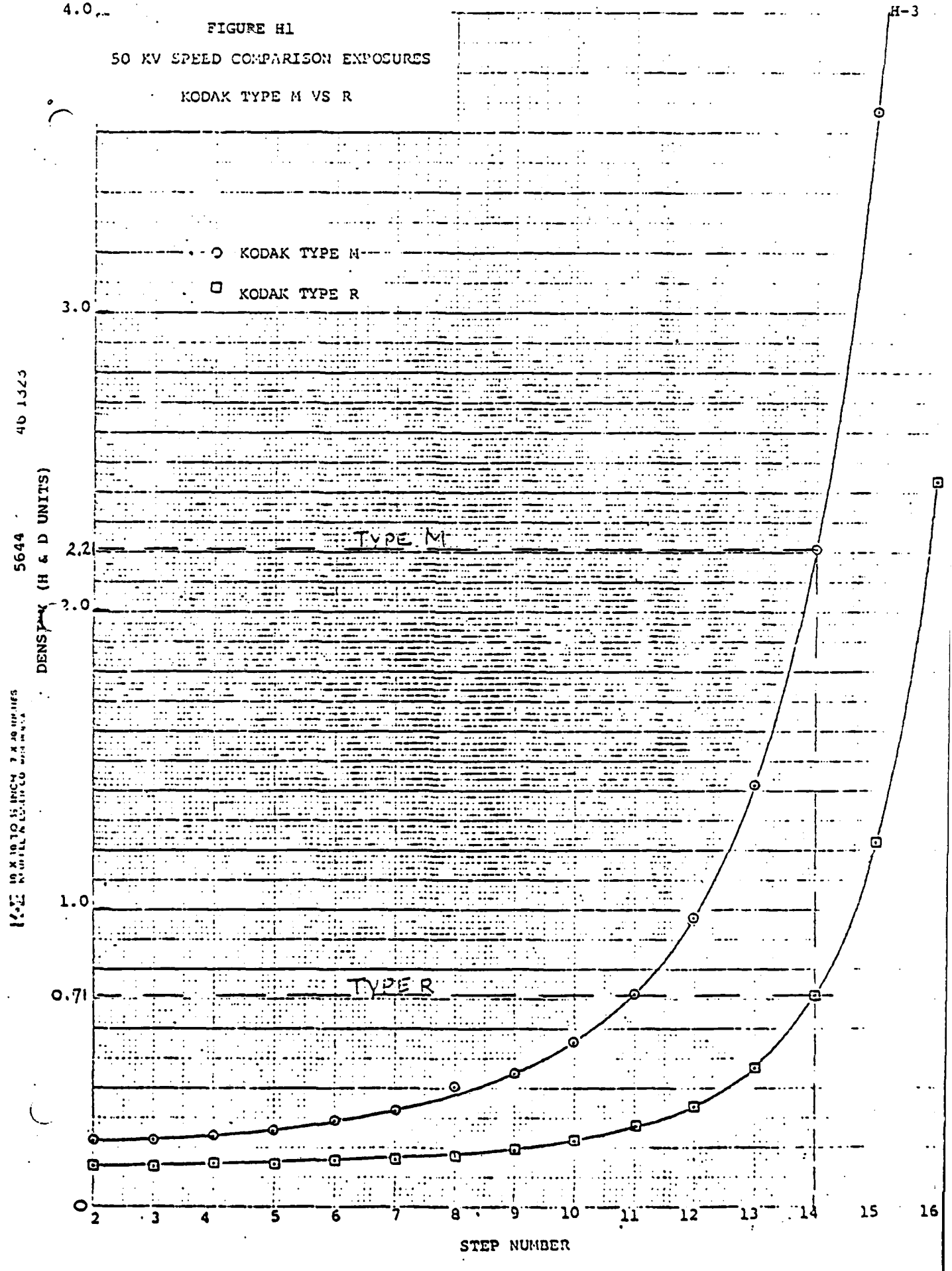


FIGURE H2
50 KV
CALIBRATION CURVE

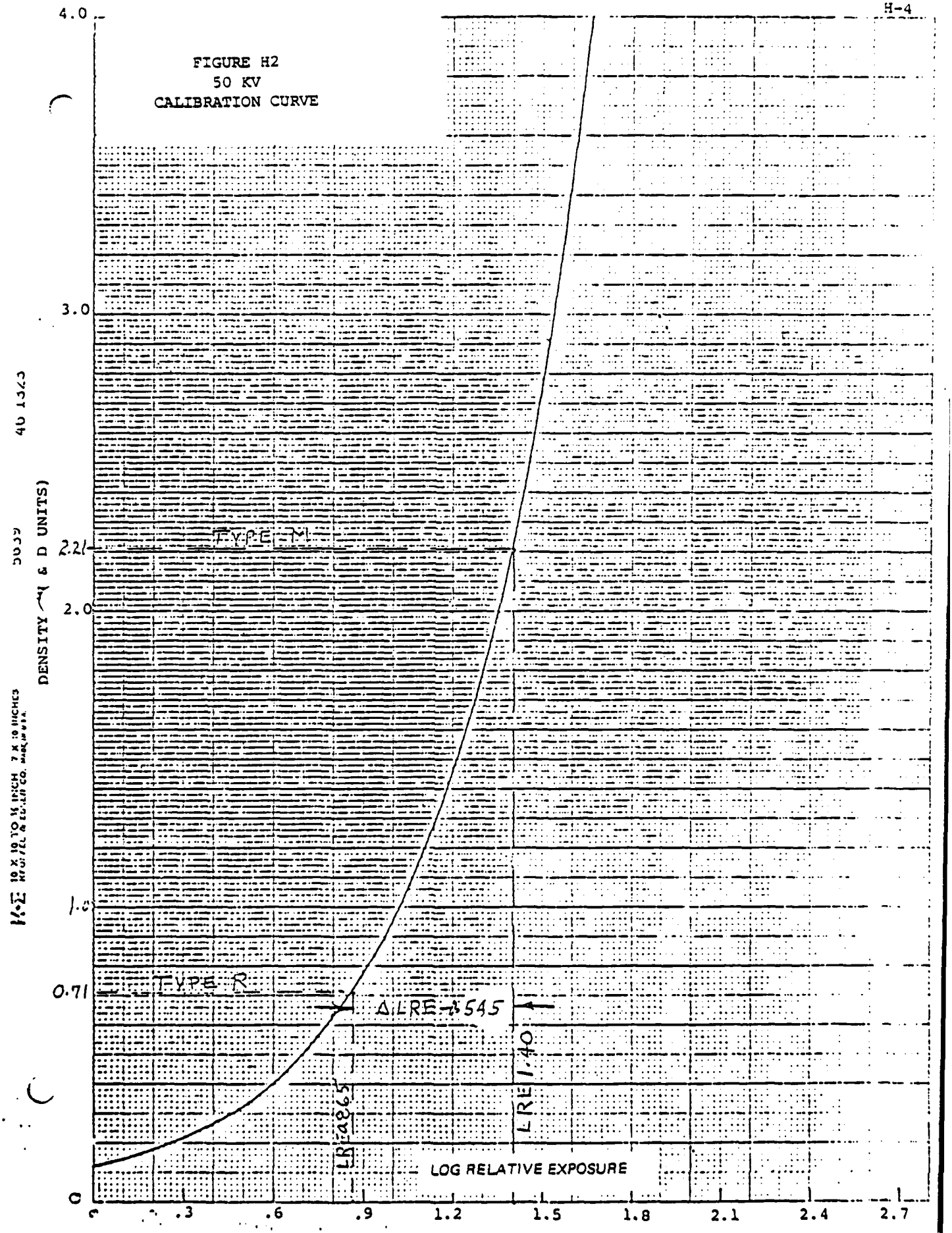


TABLE H1 FILM SPEED COMPARISON DATA

Project: 15-5607-803

50 KV	M	R	M	T	M	55	M	400	
Dev Ho	.100	.112	.100	.110	.100	.114	.100	.124	Avg
D	200 D								LOG M
1	0.210	0.135	0.204	0.342	0.199	0.284	0.202	0.273	
2	0.218	0.135	0.214	0.342	0.203	0.293	0.206	0.287	.340
3	0.226	0.135	0.222	0.358	0.214	0.297	0.215	0.293	.510
4	0.239	0.145	0.235	0.382	0.227	0.310	0.229	0.310	.680
5	0.257	0.145	0.256	0.420	0.244	0.336	0.243	0.344	.85
6	0.289	0.153	0.275	0.477	0.267	0.364	0.267	0.364	1.02
7	0.321	0.160	0.310	0.539	0.302	0.411	0.298	0.412	1.19
8	0.404	0.170	0.357	0.633	0.347	0.472	0.344	0.474	1.36
9	0.444	0.190	0.425	0.763	0.409	0.571	0.412	0.566	1.53
10	0.553	0.222	0.528	0.958	0.503	0.698	0.506	0.704	1.70
11	0.717	0.268	0.681	1.237	0.646	0.902	0.652	0.906	1.87
12	0.977	0.339	0.924	1.689	0.873	1.224	0.880	1.231	2.04
13	1.418	0.465	1.329	2.407	1.244	1.755	1.269	1.771	2.21
14	2.212	0.713	2.067	3.551	1.933	2.653	1.964	2.712	2.38
15	3.674	1.228	3.453	4.757	3.223	4.086	3.251	4.263	2.55
16	4.995	2.439	4.867	4.660	4.897	4.837	4.815	4.830	2.72

Film Type	D	LRE	LRE diff		% M		NOTES		
M R	2.0	2.35 / 2.68	-.33		46.77				
M R	1.5	2.245 / 2.61	-.365		43.15				
M R	1.0	2.05 / 2.48	-.43		37.15				
M R	0.5	1.62 / 2.225	-.605		24.83				
M T	3.5	2.56 / 2.38	+.18		151.36				
	3.0	2.515 / 2.315	+.2		158.49				
	2.5	2.45 / 2.23	+.22		165.96				
	2.0	2.365 / 2.125	+.24		173.73				
	1.5	2.255 / 1.975	+.28		190.55				
	1.0	2.08 / 1.73	+.35		223.87				
	0.5	1.65 / 1.11	+.54		346.74				
M 55	3.5	2.575 / 2.48	.095		124.45				
	3.0	2.53 / 2.435	.095		124.45				
	2.5	2.47 / 2.36	.11		128.82				
	2.0	2.39 / 2.27	.12		131.83				
	1.5	2.28 / 2.14	.14		138.04				
	1.0	2.12 / 1.92	0.2		158.49				
	0.5	1.69 / 1.41	.28		190.55				

TABLE H2 FILM SPEED COMPARISONS ALTERNATE METHOD

Project: _____

		TYPE M VS TYPE R							
Step No	D avg M	LRE - M	LRE - R	LRE diff	LRE -M+				% Speed Diff.
1	.210	.28	.04	-.24	.52				58%
7	.321	.49	.14	-.35	.84				45%
8	.404	.60	.17	-.43	1.03				37%
9	.444	.645	.23	-.415	1.06				38%
10	.553	.74	.31	-.43	1.17				37%
11	.717	.855	.40	-.455	1.31				35%
12	.977	1.05	.52	-.53	1.58				30%
13	1.418	1.185	.66	-.525	1.71				30%
14	2.212	1.40	.855	-.545	1.945				29%
15	3.674	1.625	1.12	-0.505	2.13				31%
		TYPE M VS TYPE T							
	D avg M	LRE - M	LRE - T	LRE Diff	LRE - M-				
1	.204	.26	.52	+.26	0				182%
7	.310	.48	.725	+.245	.235				176%
8	.357	.54	.80	+.26	.28				182%
9	.425	.625	.89	+.265	.36				184%
10	.528	.71	1.0	+.29	.42				195%
11	.681	.835	1.12	+.285	.55				193%
12	.924	.985	1.27	+.285	.7				193%
13	1.329	1.155	1.435	+.28	.875				191%
14	2.067	1.37	1.61	+.24	1.13				174%
14.35	2.44	1.445	1.66	+.215	1.23				164%
15	3.453	1.60	--	--	--				
		SPEED COMPARISONS							
	WORK PLAN		METHOD			ALTERNATE METHOD			
Density	ΔLRE-R	ΔLRE-T	R% M	T% M	ΔLRE - R	ΔLRE T	R% M	T% M	
3.5	---	+ .18	---	151%	- .52	+ .16	30%	145%	
3.0	- .255	.195	56%	157%	- .53	.185	30%	153%	
2.5	- .29	.22	51%	166%	- .54	.22	29%	166%	
2.0	- .335	.245	46%	176%	- .545	.25	29%	178%	
1.5	- .38	.285	42%	193%	- .535	.27	29%	186%	
1.0	- .435	.345	37%	221%	- .50	.28	32%	191%	
0.5	- .62	.575	24%	376%	- .42	.26	38%	182%	

Date: _____ Signature: _____

(SwR 17) Rev 6/75

FIGURE H4
50KV CHARACTERISTIC CURVES
KODAK TYPES M VS T
□ TEST PLAN METHOD
○ ALTERNATE METHOD
NOTE: DENSITIES AS PLOTTED INCLUDE BASE DENSITY PLUS FOG