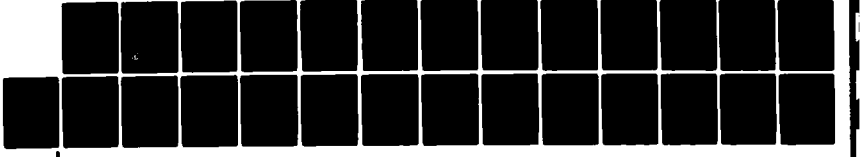
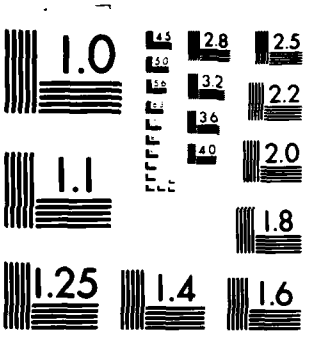
AD-A146 532 CHARACTERIZING X-RAY MACHINES(U) NAVAL SURFACE WEAPONS 1/1
CENTER SILVER SPRING MD P W BROWN JUL 84
NSWC/TR-84-146

UNCLASSIFIED F/G 20/6 NL



END
DATE FILMED
11-84
DTIC



NSWC TR 84-146

(12)

CHARACTERIZING X-RAY MACHINES

BY PAUL W. BROWN

RESEARCH AND TECHNOLOGY DEPARTMENT

JULY 1984

Approved for public release, distribution unlimited.

NAVAL SURFACE WEAPONS CENTER

Dahlgren, Virginia 22448 • Silver Spring, Maryland 20910

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NSWC TR 84-146	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CHARACTERIZING X-RAY MACHINES		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Paul W. Brown		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Surface Weapons Center (Code R34) White Oak Silver Spring, MD 20910		10. PROGRAM ELEMENT, PROJECT TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE July 1984
		13. NUMBER OF PAGES
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)

Approved for public release; distribution unlimited.

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)

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

In this report, the Philips MG 301 Constant Potential X-ray Machine was used as an example for characterizing all types of x-ray machines. The Philips MG 301 Constant Potential X-ray Machine can be used in the kilovolt range of 100 to 300 kV. This particular machine has a double focal spot capability. However, this report will only cover the 4.0mm focal spot capability. It was found through experimentation that the Philips MG 301 X-ray Machine produced 4.3 roentgens per minute (1-min) at 100 kV, and 17 mA

20. (Cont.)

with a target-to-film distance (TFD) of 4 feet. At 300 kV and 10 mA, this same machine produced 21.6 r/min with a TFD of 4 feet. It was further found through experimentation that with the Philips MG 301, the half-value layer for steel at 300 kV is 0.250 inch. This report provides technique charts for the Philips MG 301 that give the amount of time it takes to acquire a stated film density while x-raying a certain thickness of steel.

FOREWORD

X-ray machines have their own distinguishing traits or characteristics. It is well known that two x-ray machines capable of identical currents and energies may differ significantly in their output intensity and spectral content. This variation may be due to such factors as the design of the x-ray tubes, the types of target materials, or inherent filtration. Thus, it is important that the radiographer know both the capabilities and limitations of the x-ray machine he is using.

This report characterizes the Philips MG 301 Constant Potential X-ray Machine for radiographing various steel thicknesses with the 4.0mm focal spot. The following kilovolt ranges are covered in this report: 100, 150, 200, 250, and 300. The steel thicknesses covered range from .125 to 2.5 inches at .125-inch increments. The figures in this report contain vital information, and may be used as a guide in characterizing any type of x-ray machine for radiographing metals, composites, and other materials.

Approved by:

J. R. Dixon

JACK R. DIXON, Head
Materials Division

A-1

CONTENTS

ILLUSTRATIONS

TABLES

OBJECTIVE

The objective of this report is to present information in both graphical form and data sheet form for radiographers to use as a guide for characterizing any x-ray machine for any given material capable of being x-rayed. This was accomplished by characterizing the Philips MG 301 Constant Potential X-ray Machine for radiographing various steel thicknesses with a 4.0mm focal spot. The information in this report will permit users of any x-ray machine to develop exposure charts to allow them to make fast and reliable decisions when faced with the problem of developing an exposure technique for radiographing, for example, thicknesses of steel in the range of .125 to 2.5 inches. Information contained in this report provides users of the Philips MG 301 and other types of x-ray machines with guidelines for developing exposure techniques for other metals (aluminum, copper, etc.) in the thickness range stated above. This can be accomplished by using steel as a cross reference in conjunction with recorded charts of approximate radiographic equivalence factors.

PROCEDURES

The roentgen (r) outputs given at the various kilovolt energies in Table 1 were obtained with Victoreen Condenser R-Meter chambers. The output in r/min. given at a particular kV was obtained by averaging three separate readings.

The measurement procedure utilized a steel step wedge 2 inches wide by 10 inches long consisting of 20 one-half inch wide steps. The step wedge increased in thickness by .125-inch increments from the bottom step, with a thickness of .125 inch, to the top step, with a thickness of 2.5 inches. The step wedge was radiographed at 100, 150, 200, 250, and 300 kV. At each of these energy levels, the step wedge was placed on a hard cassette and radiographed for .5, 1, 2, 4, 8, and 16 minutes. Each exposure was recorded on a single Kodak 10 x 12 inch Industrex M film. The films were processed in a Kodak X-OMAT Model B automatic processor. Density readings were recorded by an X-Rite Model 301 Densitometer for those steps that appeared on the radiograph in the density range of .16 to 5.0. Due to undercut and scatter, it was necessary to mask this particular step wedge with lead bricks for the following exposure times at 300 kV: 4, 8, and 16 minutes. Data was recorded on separate data sheets for 100, 150, 200, 250, and 300 kV, and the variables listed at each energy level were noted (see Tables 2 through 6 and Figures 1 through 5). Next, this data was plotted on graphs to characterize curves for Kodak Industrex M film (see Figures 6 through 10).

Finally, the characteristic curves were used to graph the technique or exposure charts at all of the various energy levels (see Figure 5), except 100 kV. An exposure chart was not graphed for 100 kV because there were not enough data points. It should be noted that exposure data for 100 kV may be obtained from Table 2.

RESULTS

It was observed through graphical data that the steel Half-Value-Layers (HVL) associated with the Philips MG 301 X-ray machine are as follows: at 150 kV/17 mA, .137 inch; at 200 kV/14 mA, .175 inch; at 250 kV/12 mA, .237 inch; and at 300 kV/10 mA, .250 inch (see Figure 5). The HVL is the amount of material (in this case steel) that will stop half of the radiation of a given intensity. Other results, such as the time it takes to radiograph 1 inch of steel at 300 kV using the Philips MG 301 can be observed directly from the exposure charts in terms of steel thickness and exposure time relationships.

OBSERVATIONS

This report provides the radiographer with important information for radiographing steel samples in the thickness range of .125 to 2.5 inches. For example, when using the Philips MG 301 X-ray Machine, one can observe from the appropriate exposure chart that if a 1-inch steel sample were x-rayed at 300 kV, and a film density of 2.5 on Kodak Industrex M film were obtained, the exposure time would be 2 minutes while keeping all variables constant. This report can also be used by the radiographer to develop precise preliminary radiographic techniques for types of industrial x-ray films other than Kodak. These graphs produce information directly related to Kodak Industrex M film; however, through comparisons and calculations, it is possible to produce good preliminary radiographs for other types of industrial manufactured x-ray films by knowing the film speed and using Industrex M film as a standard. For example, the film speed of Kodak Industrex M film is similar to Dupont NDT-55 radiographic film.

CONCLUSIONS

The Philips MG 301 Constant Potential X-ray Machine provides kilovolt energies in the range of 100 to 300 kV. The 100 to 300 kV energy range comprises the most frequently used energies in radiographic nondestructive evaluation. Therefore, the results obtained in this report may be used to compare the results obtained from characterizing other types of x-ray machines

for the following kilovolt energies: 100, 150, 200, 250, and 300. The HVL for steel calculated from graphical data in this report were found to be within reasonable deviation ranges of published charts for steel at 200, 250, and 300 kV.

TABLE 1. OUTPUTS GIVEN AT THE VARIOUS KILOVOLT ENERGIES (PHILIPS MG 301 MACHINE)

kV	TFD	mA	r/min
100	4'	17	4.3
150	4'	17	9.7
200	4'	14	14.4
250	4'	12	18.3
300	4'	10	21.6

NOTES:
1. OBSERVED FROM VICTOREEN CONDENSER R-METER CHAMBERS
2. kV = KILOVOLTS
3. TFD = TARGET-TO-FILM DISTANCE
4. mA = MILLIAMPERES
5. r/min = ROETGENS PER MINUTE
6. 4.0mm FOCAL SPOT

TABLE 2. EXPOSURE DATA FOR PHILIPS MG 301 CONSTANT-POTENTIAL X-RAY MACHINE (100kV/17mA)

	EXPOSURE TIME, DENSITY					
THICKNESS INCHES	.5 MIN	1 MIN	2 MIN	4 MIN	8 MIN	16 MIN
2.5"	X	X	X	X	X	X
2.375"	X	X	X	X	X	X
2.25"	X	X	X	X	X	X
2.125"	X	X	X	X	X	X
2.0"	X	X	X	X	X	X
1.875"	X	X	X	X	X	X
1.75"	X	X	X	X	X	X
1.625"	X	X	X	X	X	X
1.5"	X	X	X	X	X	X
1.375"	X	X	X	X	X	X
1.25"	X	X	X	X	X	X
1.125"	X	X	X	X	X	X
1.0"	X	X	X	X	X	X
0.875"	X	X	X	X	X	X
0.75"	X	X	X	X	X	.18
0.625"	X	X	X	X	.18	.19
0.5"	.17	.17	.18	.17	.21	.27
0.375"	.18	.18	.20	.18	.38	.55
0.25"	.20	.25	.36	.26	1.04	1.74
0.125"	.52	.84	1.46	2.60	4.52	X

NOTES:
- 4.0mm FOCAL SPOT
- TFD = 4'
- HARD CASSETTE
- FRONT Pb SCREEN = 0.005"
- BACK Pb SCREEN = 0.010"
- LEAD FILTER = 0.005"
- X-OMAT DEVELOPER = 80° F
- M FILM
- STEEL

TABLE 3. EXPOSURE DATA FOR PHILIPS MG 301 CONSTANT POTENTIAL X-RAY MACHINE (150kV/17mA)

	EXPOSURE TIME, DENSITY					
THICKNESS INCHES	.5 MIN	1 MIN	2 MIN	4 MIN	8 MIN	16 MIN
2.5"	X	X	X	X	X	X
2.375"	X	X	X	X	X	X
2.25"	X	X	X	X	X	X
2.125"	X	X	X	X	X	X
2.0"	X	X	X	X	X	X
1.875"	X	X	X	X	X	X
1.75"	X	X	X	X	X	X
1.625"	X	X	X	X	X	X
1.5"	X	X	X	X	X	X
1.375"	X	X	X	.22	.24	.36
1.25"	X	X	.19	.23	.27	.42
1.125"	X	.18	.20	.25	.32	.52
1.0"	.17	.19	.21	.30	.41	.70
0.875"	.18	.21	.25	.38	.56	1.07
0.75"	.20	.24	.34	.54	.90	1.74
0.625"	.24	.33	.50	.86	1.52	2.85
0.5"	.32	.50	.80	1.48	2.65	4.55
0.375"	.49	.84	1.45	2.70	4.45	X
0.25"	.90	1.64	2.87	4.78	X	X
0.125"	2.27	3.90	X	X	X	X

NOTES:
- 4.0mm FOCAL SPOT
- TFD = 4'
- HARD CASSETTE
- FRONT Pb SCREEN = 0.005"
- BACK Pb SCREEN = 0.010"
- LEAD FILTER = 0.005"
- X-OMAT DEVELOPER = 80° F
- M FILM
- STEEL

TABLE 4. EXPOSURE DATA FOR PHILIPS MG 301 CONSTANT POTENTIAL X-RAY MACHINE (200kV/14mA)

	EXPOSURE TIME, DENSITY					
THICKNESS INCHES	.5 MIN	1 MIN	2 MIN	4 MIN	8 MIN	16 MIN
2.5"	X	X	X	X	X	X
2.375"	X	X	X	X	X	X
2.25"	X	X	X	X	X	X
2.125"	X	X	X	X	X	.58
2.0"	X	X	X	X	X	.61
1.875"	X	X	X	X	X	.68
1.75"	X	X	X	.31	.45	.76
1.625"	X	X	.25	.34	.51	.87
1.5"	X	X	.27	.38	.60	1.04
1.375"	X	.23	.31	.54	.74	1.30
1.25"	.20	.25	.36	.56	.95	1.68
1.125"	.23	.30	.44	.72	1.28	2.22
1.0"	.26	.36	.56	.96	1.78	3.04
0.875"	.32	.46	.75	1.34	2.46	4.08
0.75"	.40	.62	1.07	1.93	3.47	X
0.625"	.53	.87	1.54	2.78	4.80	X
0.5"	.74	1.28	2.27	3.92	X	X
0.375"	1.10	1.95	3.34	X	X	X
0.25"	1.76	3.08	4.92	X	X	X
0.125"	3.27	X	X	X	X	X

NOTES:
- 4.0mm FOCAL SPOT
- TFD = 4'
- HARD CASSETTE
- FRONT Pb SCREEN = 0.005"
- BACK Pb SCREEN = 0.010"
- LEAD FILTER = 0.005"
- X-OMAT DEVELOPER = 80° F
- M FILM
- STEEL

TABLE 5. EXPOSURE DATA FOR PHILIPS MG 301 CONSTANT POTENTIAL X-RAY MACHINE (250kV/12mA)

	EXPOSURE TIME, DENSITY					
THICKNESS INCHES	.5 MIN	1 MIN	2 MIN	4 MIN	8 MIN	16 MIN
2.5"	X	X	X	X	X	X
2.375"	X	X	X	X	X	X
2.25"	X	X	X	.39	.79	1.16
2.125"	X	X	X	.40	.80	1.17
2.0"	X	.23	.33	.43	.86	1.33
1.875"	.20	.24	.36	.50	.97	1.55
1.75"	.21	.26	.40	.58	1.12	1.87
1.625"	.23	.29	.46	.69	1.33	2.30
1.5"	.25	.33	.54	.87	1.66	2.86
1.375"	.28	.39	.66	1.09	2.09	3.55
1.25"	.32	.47	.82	1.41	2.70	4.38
1.125"	.38	.59	1.06	1.86	3.43	X
1.0"	.47	.77	1.41	2.49	4.33	X
0.875"	.59	1.01	1.91	3.30	X	X
0.75"	.78	1.37	2.57	4.25	X	X
0.625"	1.03	1.85	3.38	X	X	X
0.5"	1.44	2.57	4.43	X	X	X
0.375"	2.03	3.50	X	X	X	X
0.25"	2.94	4.79	X	X	X	X
0.125"	X	X	X	X	X	X

NOTES:
- 4.0mm FOCAL SPOT
- TFD = 4'
- HARD CASSETTE
- FRONT Pb SCREEN = 0.005"
- BACK Pb SCREEN = 0.010"
- LEAD FILTER = 0.005"
- X-OMAT DEVELOPER = 80° F
- M FILM
- STEEL

TABLE 6. EXPOSURE DATA FOR PHILIPS MG 301 CONSTANT POTENTIAL X-RAY MACHINE (300kV/10mA)

	EXPOSURE TIME, DENSITY					
THICKNESS INCHES	.5 MIN	1 MIN	2 MIN	4 MIN	8 MIN	16 MIN
2.5"	X	X	X	.28	.40	.62
2.375"	X	X	X	.33	.50	.84
2.25"	X	X	.55	.40	.63	1.11
2.125"	X	.30	.57	.47	.79	1.42
2.0"	X	.32	.62	.59	1.01	1.84
1.875"	.29	.35	.68	.73	1.29	2.40
1.75"	.31	.40	.77	.92	1.69	3.11
1.625"	.34	.47	.90	1.21	2.21	3.86
1.5"	.38	.56	1.07	1.54	2.87	X
1.375"	.44	.67	1.29	2.02	3.63	X
1.25"	.53	.83	1.61	2.61	X	X
1.125"	.64	1.05	1.99	3.34	X	X
1.0"	.79	1.35	2.53	X	X	X
0.875"	1.01	1.78	3.19	X	X	X
0.75"	1.30	2.32	3.95	X	X	X
0.625"	1.71	3.01	4.88	X	X	X
0.5"	2.25	3.85	X	X	X	X
0.375"	2.99	4.85	X	X	X	X
0.25"	3.96	X	X	X	X	X
0.125"	X	X	X	X	X	X

NOTES:
- 4.0mm FOCAL SPOT
- TFD = 4'
- HARD CASSETTE
- FRONT Pb SCREEN = 0.005"
- BACK Pb SCREEN = 0.010"
- LEAD FILTER = 0.005"
- X-OMAT DEVELOPER = 80° F
- M FILM
- STEEL

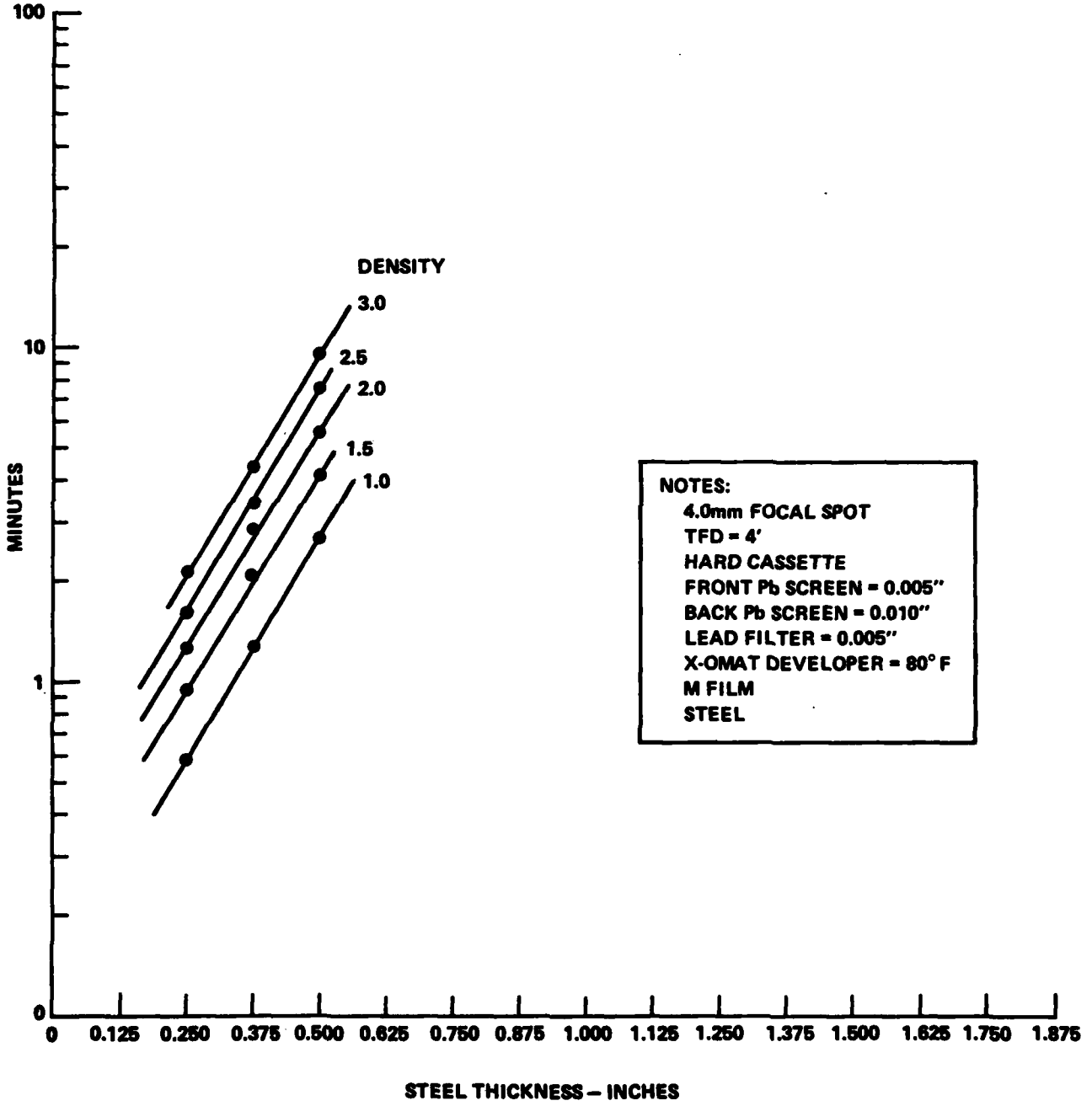


FIGURE 1. EXPOSURE CHART FOR PHILIPS MG 301 (150kV/17mA)

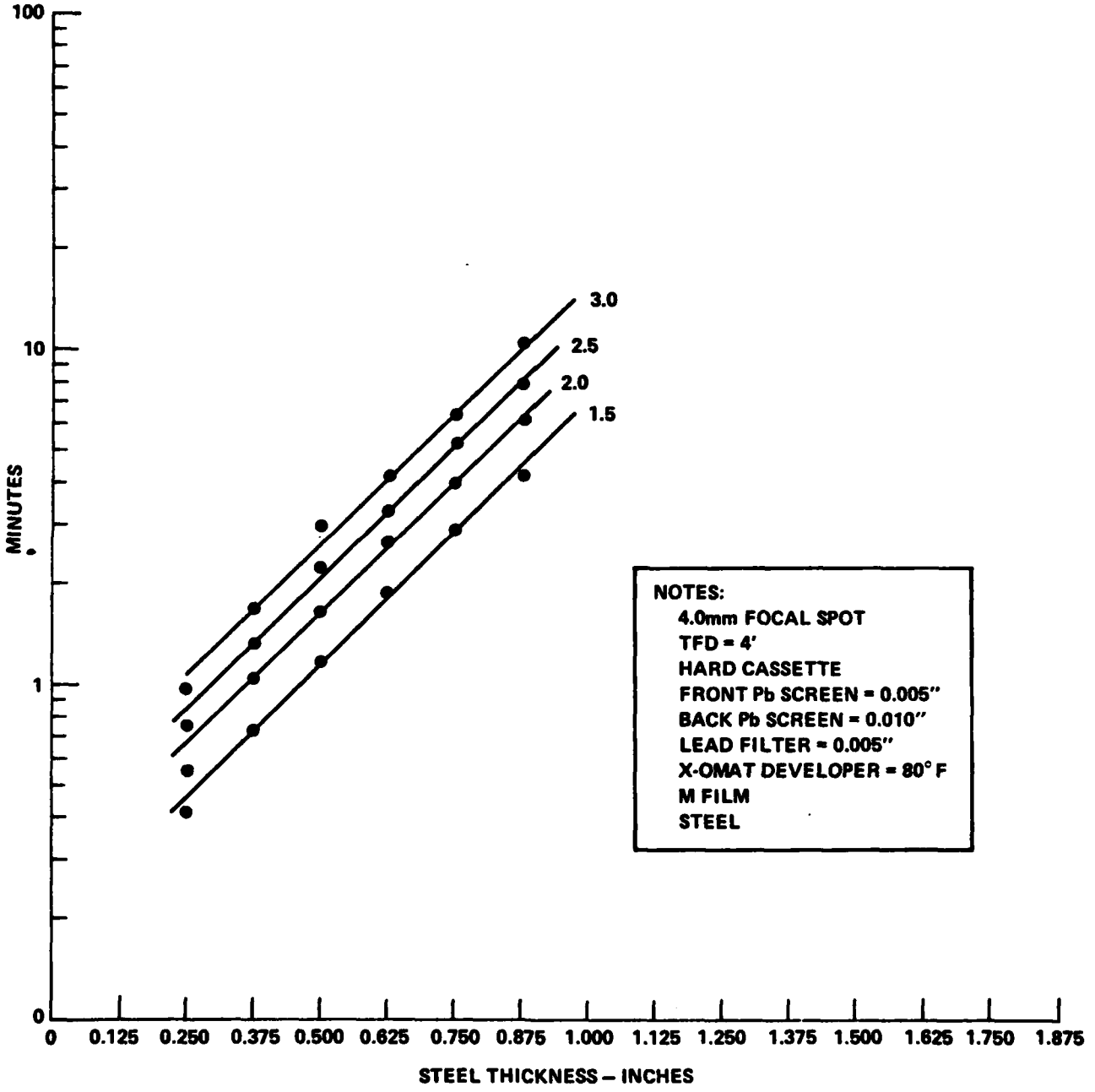


FIGURE 2. EXPOSURE CHART FOR PHILIPS MG 301 (200kV/14mA)

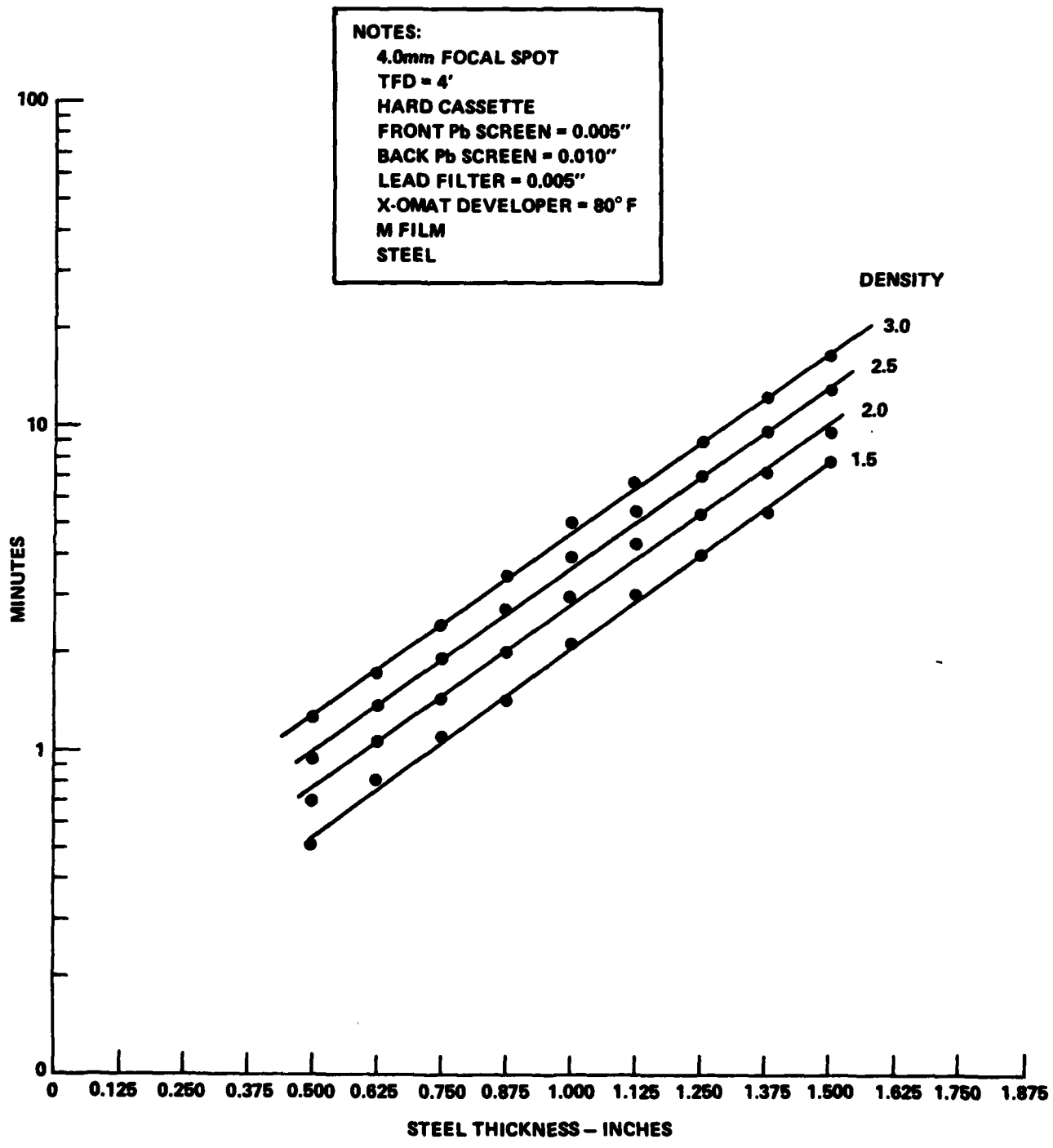


FIGURE 3. EXPOSURE CHART FOR PHILIPS MG 301 (250kV/12mA)

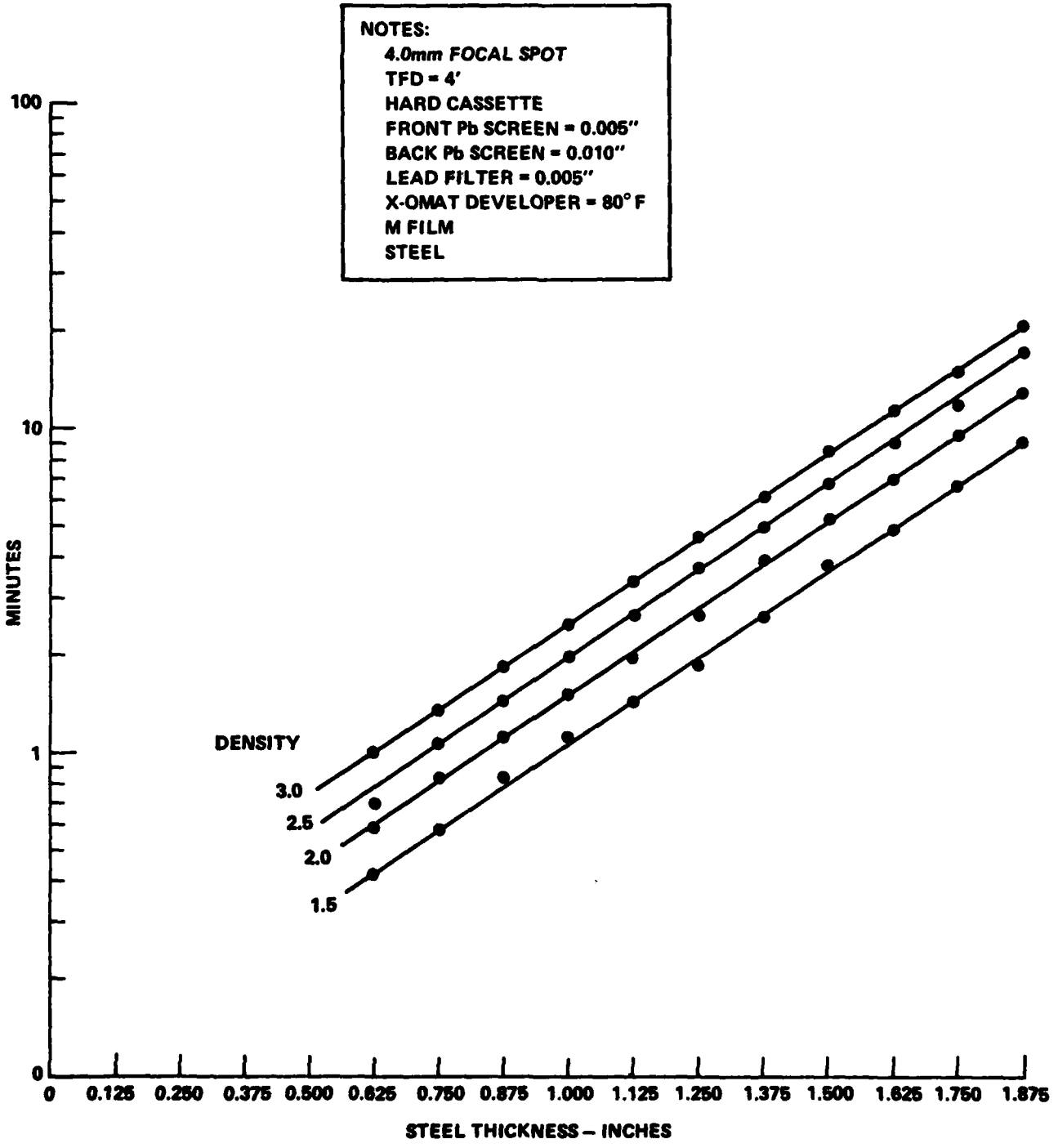


FIGURE 4. EXPOSURE CHART FOR PHILIPS MG 301 (300kV/10mA)

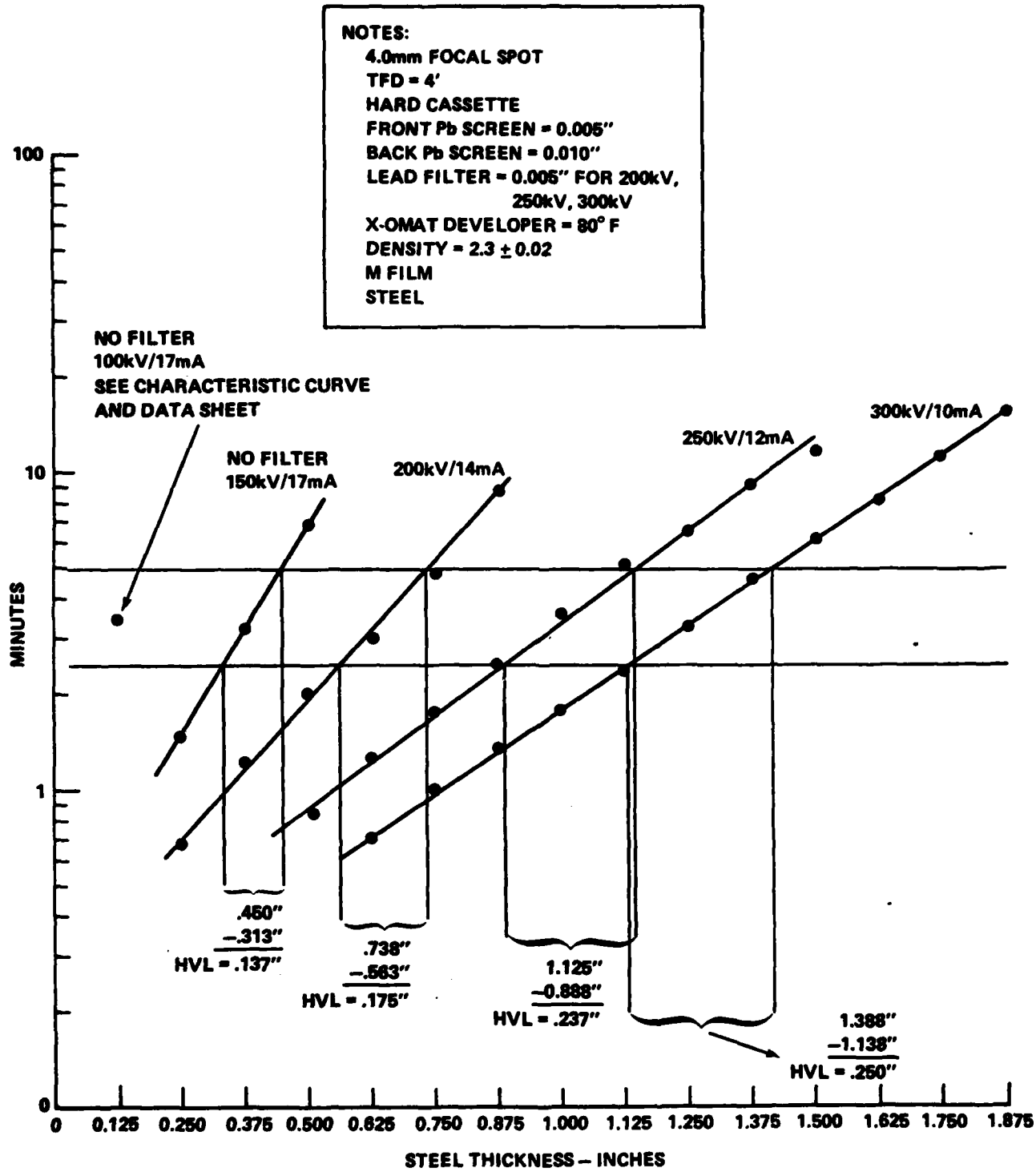


FIGURE 5. EXPOSURE CHART FOR PHILIPS MG 301

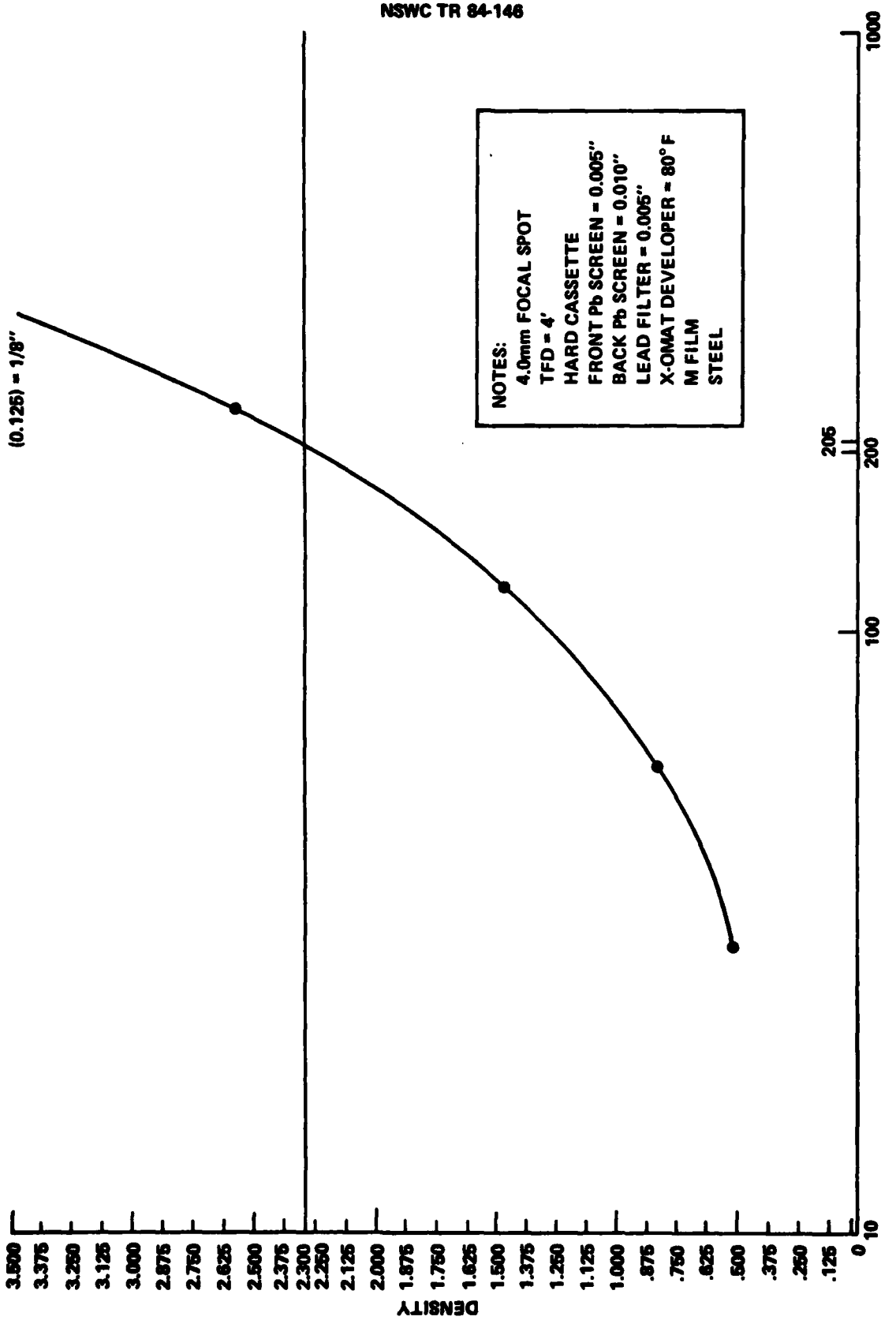


FIGURE 6. CHARACTERISTIC CURVE FOR PHILIPS MG 301 (100kV/17mA)

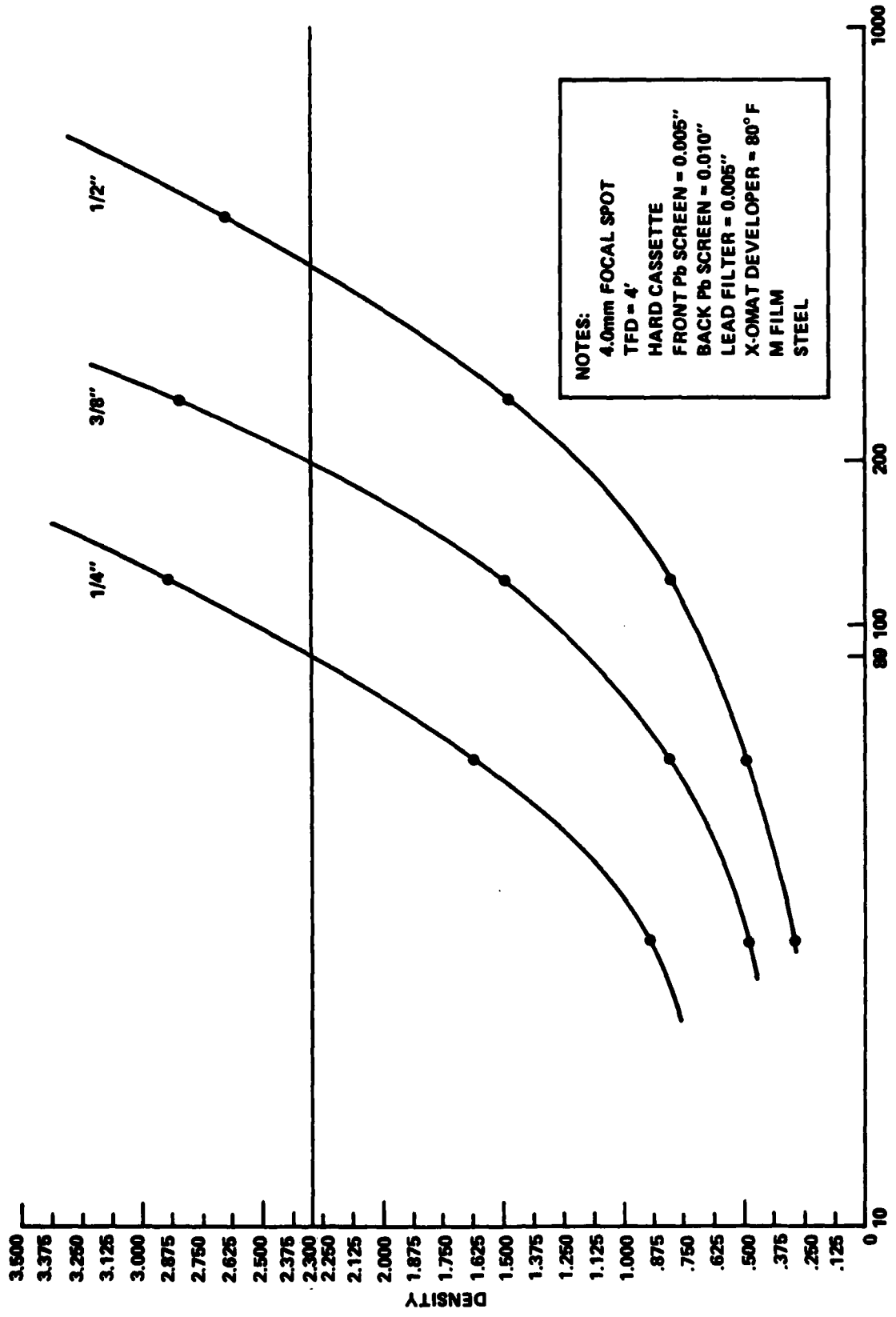


FIGURE 7. CHARACTERISTIC CURVES FOR PHILIPS MG 301 (150kV/17mA)

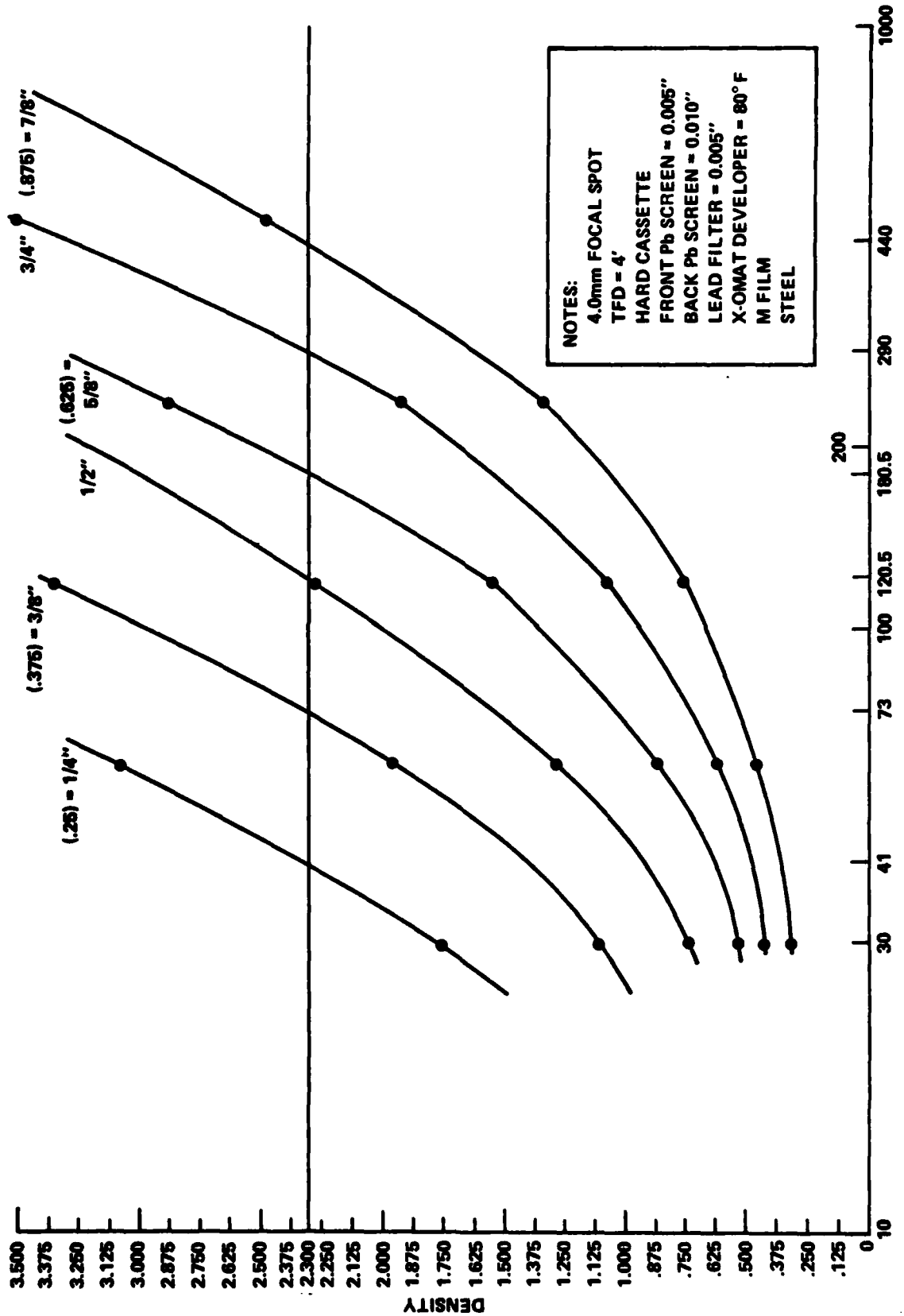
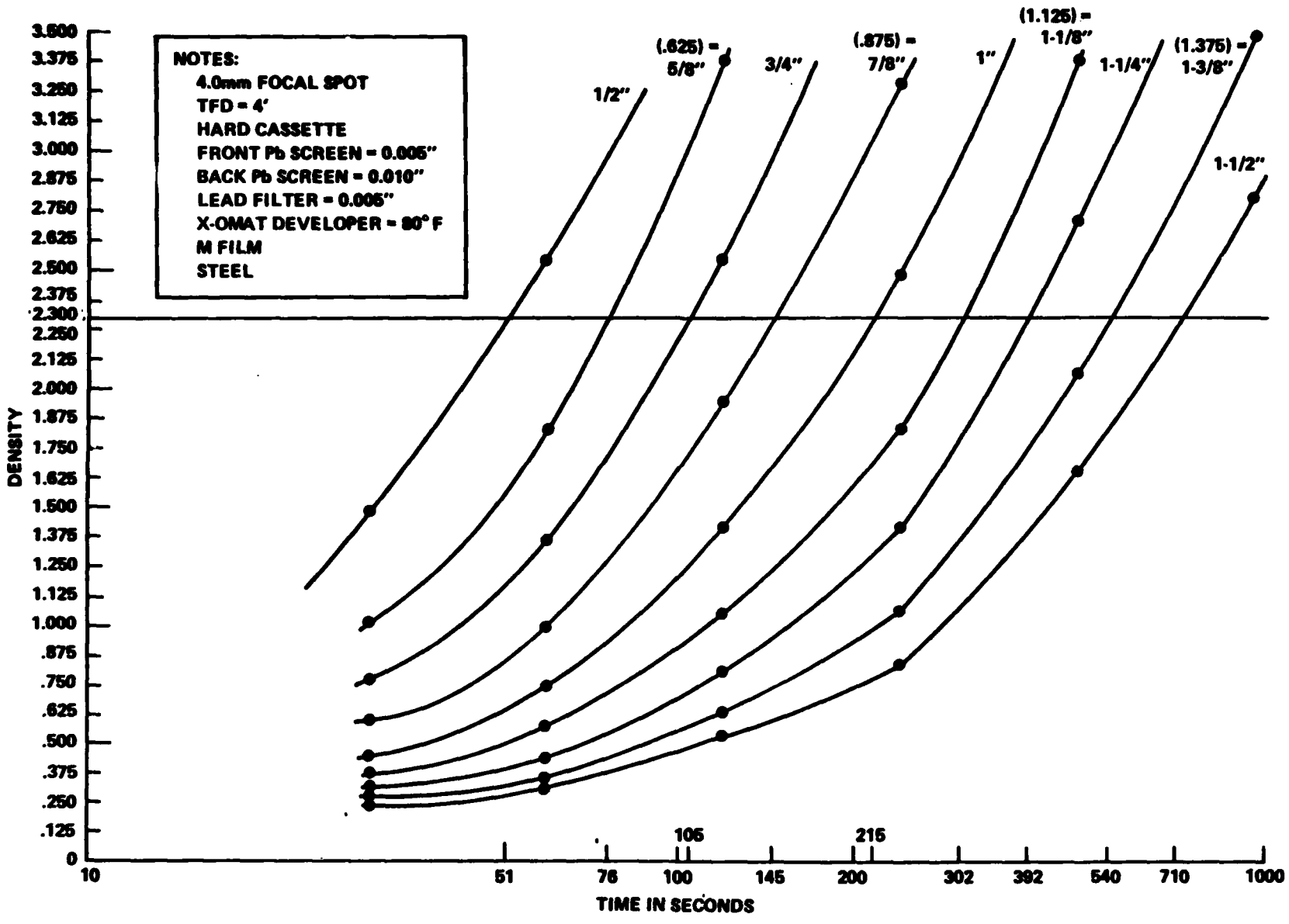


FIGURE 8. CHARACTERISTIC CURVES FOR PHILIPS MG 301 (200kV/14mA)



NSWC TR 84-146

FIGURE 9. CHARACTERISTIC CURVES FOR PHILIPS MG 301 (250kV/12mA)

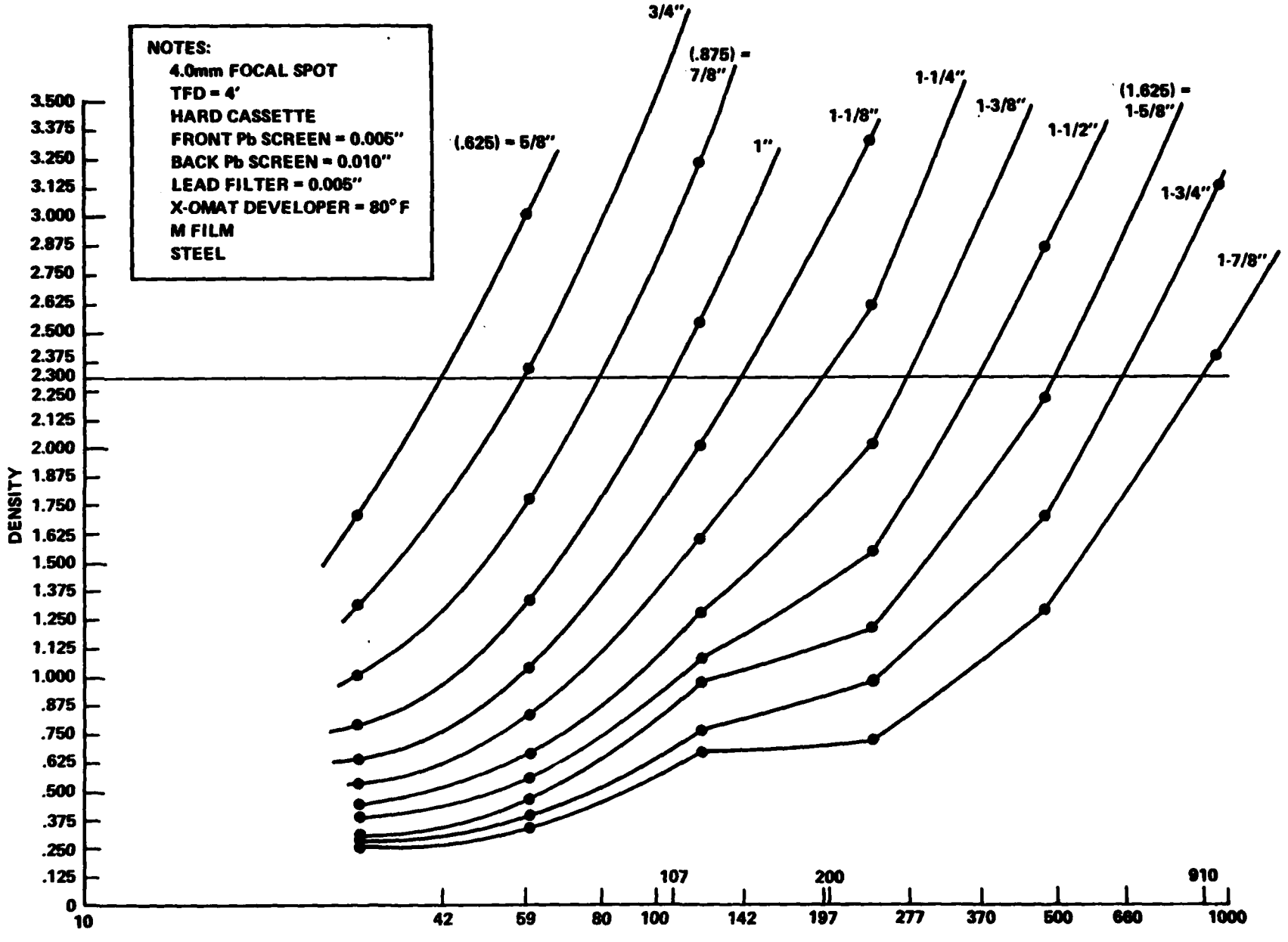


FIGURE 10. CHARACTERISTIC CURVES FOR PHILIPS MG 301 (300kV/10mA)

DISTRIBUTION

	Copies
Defense Technical Information Center Cameron Station Alexandria, VA 22314	12

Internal Distribution:	Copies
E431	9
E432	3
R34	1
R34 (Paul Brown)	1
R30	2