NATIONAL BUREAU OF STANDARDS REPORT

7702

Output Maintenance of Sealed-Reflector Approach
and Runway Light Lamps

By
Robert T. Vaughan

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Output Maintenance of Sealed-Reflector Approach and Runway Light Lamps

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For
Ship Aeronautics Division
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Washington 25, D.C.

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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

Output Maintenance of Sealed-Reflector Approach and Runway Light Lamps

1. SCOPE

This report presents an analysis of the periodic measurements of the relative output of 6.6-ampere and 20-ampere approach-light lamps. Curves are presented showing the decrease in output with burning time for the complete lamps and for selected zones of the lamps for both vertical and horizontal positions of the seating planes.

2. MATERIALS TESTED

Six each of four types of lamps were tested:

(1) Type 20A/PAR56/1: a 500-watt, 20-ampere, PAR 56 approach-light lamp with a C-6 filament and a prismatic cover. Rated life is 50 hours. The designed burning position is with the seating plane vertical.

(2) Type 20A/PAR56/3: a 500-watt, 20-ampere, PAR 56 approach-light lamp with a CC-6 filament with a collector grid and a stippled cover. Rated life is 75 hours. The designed burning position is with the seating plane horizontal.

(3) Type 6.6A/PAR56/2: a 200-watt, 6.6-ampere, PAR 56 approach-light lamp with a C-13 filament and a prismatic cover. Rated life is 500 hours. The designed burning position is with the seating plane vertical.

(4) Type 6.6A/PAR56/3: a 200-watt, 6.6-ampere, PAR 56 approach-light lamp with a CC-6 filament and a stippled cover. Rated life is 300 hours. The designed burning position is with the seating plane horizontal.

3. PROCEDURE

The six lamps of each type were put into two groups of three lamps each and labeled:

20A/PAR56/1-V	20A/PAR56/1-H
20A/PAR56/3-V	20A/PAR56/3-H
6.6A/PAR56/2-V	6.6A/PAR56/2-H
6.6A/PAR56/3-V	6.6A/PAR56/3-H

For each type, the lamps of the "V" group were burned with their seating planes vertical, and the lamps of the "H" group were burned with their seating planes horizontal.

The lamps were seasoned, and initial lumen and intensity distribution measurements were made. The lamps were then put on life test in their respective positions, and the lumen and intensity distribution measurements were repeated at periodic intervals: every 35 hours for the 20-ampere lamps and every 100 hours for the 6.6-ampere lamps. The measurements were made for each lamp with its full surface exposed and with only one-third (upper, middle and lower thirds) of its surface area exposed. For the horizontally burned lamps, "upper and lower thirds" have little meaning except that they refer to the lamp position during the photometric measurements.

The intensity distributions were measured in the vertical plane at the horizontal angle zero degrees. In addition, measurements were made in the vertical planes at +15°H and at -15°H for the 20-ampere prismatic cover lamps, and at +5°H and -5°H for the 20-ampere stippled cover lamps. These intensity distributions at ±15°H and ±5°H were so similar to the distributions at 0°H that measurements were made only at 0°H on the 6.6-ampere lamps.

The measurements were made using a photoelectric photometer employing a color-corrected photocell at a distance of 30 meters from the test lamp. The output current of the photocell was measured and recorded by a d-c amplifier and a self-balancing recording potentiometer.

Each lamp under test was mounted in turn on a goniometer to permit rotation about a fixed horizontal axis perpendicular to the photometric axis and about a secondary axis perpendicular to the first and initially vertical, giving angles analogous to degrees of latitude and longitude respectively. In this report these angles are referred to as vertical and horizontal respectively. The test lamp was mounted in a holder which was originally alined so that the seating plane of the lamp was perpendicular to the photometric axis when the horizontal and vertical angular settings of the goniometer were 0.0 degrees.

In presenting intensity distribution data, angles are taken as positive when the photometric axis is above or to the right of, as viewed from the light, the geometric axis of the light.

4. RESULTS

The results of these measurements are given in figures 1 through 17 and tables I through IV.

As shown in tables I and II, initially all of the 20-ampere lamps had approximately the same lumen output, about 12,000 lumens. The 6.6-ampere lamps with the prismatic covers had a lumen output of about 3,000 lumens, while the lumen output of the stippled-cover type was about 3,250 lumens.

The initial peak intensities of the 20-ampere lamps were approximately 47 kilocandles for the prismatic-cover type and 410 kilocandles for the stippled-cover type. For the 6.6-ampere lamps, the initial peak intensities were approximately 14 kilocandles and 160 kilocandles for the prismatic- and stippled-cover types, respectively.

The relative peak intensities of the 20-ampere lamps, measured with full surface exposure, decrease with burning time in the following order: The 56/1-V (prismatic cover, burned with the seating plane vertical) and 56/3-H (stippled cover, burned with the seating plane horizontal) groups had the highest intensity maintenance, and the 56/3-V (stippled cover, burned with the seating plane vertical) and 56/1-H (prismatic cover, burned with the seating plane horizontal) groups followed in that order. See figures 1 and 2.

For the 6.6-ampere lamps, the 56/2-V group (prismatic cover, burned with the seating plane vertical) had the highest intensity maintenance, remaining above 100% relative intensity throughout the test.

Next in order came the 56/3-V group (stippled cover, burned with the seating plane vertical), 56/3-H group (stippled cover, burned with the seating plane horizontal), and 56/2-H group (prismatic cover, burned with the seating plane horizontal). See figure 12.

Except for the 6.6-ampere lamps with stippled covers, all of the lamp types showed better maintenance of both peak intensity and lumen output when they were burned in their design position (see figures 1, 2, 8, 12, and 16).

In general, the relative lumen output of the lamps decreased more slowly than the relative peak intensity (see Table I). Therefore, maintenance of total lumen output is not a good measure of the performance of the lamps.

Figures 1 and 2 show no significant differences in the relative intensities for measurements made at the various horizontal angles.

With only the upper one-third area of the lamps exposed, the effect of vertical burning is readily seen for both the 20-ampere and 6.6-ampere lamps in figures 3, 4, 10, and 11. In each case the decrease

in intensity for the upper zone is much greater than for the middle and lower zones. The effect of horizontal burning is similarly shown, though not as markedly, for the type 56/2 (prismatic cover) 6.6-ampere lamps in figure 10: the decrease in intensity for the middle zone is greater than for the upper and lower zones. There are no significant differences, however, among the relative peak intensity curves for the upper, lower, and middle zones of the horizontally burned (stippled cover) 6.6-ampere and both types of the horizontally burned 20-ampere lamps (see figures 3, 4, and 11).

There were no appreciable changes in the shapes of the relative intensity distribution curves for any of the four types of lamps. Tables I and II show a maximum change of about 6.6% in beam width at 50% of peak intensity for the horizontally burned 20-ampere (prismatic cover) lamps. At 25% of peak intensity the maximum change in beam width was about 4.3% for both types of the vertically burned 20-ampere lamps.

Tables I and II show a maximum shift in the location of the direction of the peak intensity of 0.6° in the upward direction for both types of the vertically burned 20-ampere lamps. The maximum shift for the 6.6-ampere lamps was 0.7° downward for the horizontally burned lamps of the prismatic-cover type.

Tables III and IV show the times during the life test when the first evidence, as determined by voltage measurements, of shorted filament turns appeared. None of the 12 6.6-ampere lamps, and only 3 of the 12 20-ampere lamps showed evidence of shorted turns during their rated life.

TABLE I. AVERAGE PROPERTIES OF THE 20-AMPERE LAMPS

FULL EXPOSURE

Lamp Group	Design Position of Seating Plane	Rated Life	Burning Time		Peak Intensity	Approx. Lumen Output*	Relative Peak Intensity	Relative Lumen Output	Angular Shift of Peak Intensity	Beam Width at 50% of Peak Intensity	Beam Width at 25% of Peak Intensity	Voltage
		Hours	Hours	% Rated Life	Kilocandles	Kilo-lumens	%	%	Degrees	Degrees	Degrees	volts
56/1-V	Vert.	50	Initial	-	46.3	12.10	100	100	-	12.0	16.1	25.2
20A/PAR56/1			35	70	38.7	10.27	83	85	0.4	12.0	16.5	25.6
Prismatic			70	140	30.8	8.80	66	73	0.6	12.0	16.8	26.1
			105	210	27.3	7.98	59	66	0.6	12.2	16.6	26.2
56/1-H	Vert.	50	Initial	-	48.1	12.28	100	100	-	12.0	16.1	25.5
20A/PAR56/1			35	70	33.5	8.96	69	73	0.1	11.8	16.3	25.8
Prismatic			70	140	23.9	6.80	49	55	0.2	11.5	16.2	26.4
			105	210	17.4	5.14	36	42	0.2	11.2	16.2	26.8
56/3-V	Horiz.	75	Initial	-	411	12.44	100	100	-	6.6	9.0	27.3
20A/PAR56/3			35	47	293	9.84	71	79	0.5	6.8	9.1	27.1
Stippled			70	93	223	8.28	54	67	0.6	6.7	9.1	27.6
			105	140	177	6.81	43	55	0.6	7.0	9.4	27.3
56/3-H	Horiz.	75	Initial	-	410	12.05	100	100	-	6.5	8.6	26.7
20A/PAR56/3			35	47	376	10.59	92	82	0.2	6.5	8.5	27.1
Stippled			70	93	279	9.41	68	78	0.4	6.6	8.7	27.9
			105	140	232	7.51	57	62	0.4	6.6	8.7	27.2

* The lumen output of these lamps was measured with a 60-inch integrating sphere. The accuracy of these measurements is not known, but the values are estimated to be not more than 10% low. However, since all measurements were made with the lamps in the same position, the relative lumen values are not affected by this systematic error.

TABLE II. AVERAGE PROPERTIES OF THE 6.6-AMPERE LAMPS

FULL EXPOSURE

Lamp Group	Design Position of Seating Plane	Rated Life Hours	Burning Time Hours	Burning Time % Rated Life	Peak Intensity Kilocandles	Approx. Lumen Output* Kilo-lumens	Relative Peak Intensity %	Relative Lumen Output %	Angular Shift of Peak Intensity Degrees	Beam Width at 50% of Peak Intensity Degrees	Beam Width at 25% of Peak Intensity Degrees	Voltage Volts
56/2-V	Vert.	500	Initial	-	14.0	2.98	100	100	-	11.6	15.6	27.0
6.6A/PAR56/2			100	20	15.0	3.14	107	105	-0.6	11.4	15.5	27.4
Prismatic			200	40	15.4	3.05	110	102	-0.6	11.4	15.5	27.6
			300	60	15.0	3.04	107	102	-0.6	11.4	15.5	28.0
			400	80	15.0	3.03	107	102	-0.6	11.4	15.5	28.0
			500	100	15.0	3.01	107	101	-0.6	11.4	15.5	28.5
			600	120	15.0	2.95	107	99	-0.6	11.4	15.5	28.7
56/2-H	Vert.	500	Initial	-	14.7	3.02	100	100	-	11.6	15.7	26.8
6.6A/PAR56/2			100	20	13.8	2.95	94	98	-0.4	11.6	15.5	27.0
Prismatic			200	40	13.1	2.81	89	93	-0.7	11.6	15.5	27.1
			300	60	12.4	2.70	85	89	-0.6	11.8	15.7	27.5
			400	80	11.3	2.59	77	86	-0.4	11.7	15.4	27.6
			500	100	11.0	2.55	75	84	-0.5	11.7	15.4	28.1
			600	120	10.2	2.44	70	81	-0.6	11.8	15.4	28.3
56/3-V	Horiz.	300	Initial	-	158	3.24	100	100	-	5.5	7.5	28.4
6.6A/PAR56/3			100	33	171	3.37	108	104	-0.1	5.6	7.6	28.8
Stippled			200	67	166	3.26	105	101	-0.1	5.6	7.5	29.0
			300	100	158	3.18	100	98	0.0	5.5	7.6	29.3
			400	133	152	3.18	96	98	0.1	5.7	7.6	29.6
			500	167	150	3.14	95	97	0.2	5.7	7.6	30.2
			600	200	149	3.20	94	99	0.2	5.7	7.6	30.9
56/3-H	Horiz.	300	Initial	-	161	3.28	100	100	-	5.4	7.3	28.4
6.6A/PAR56/3			100	33	170	3.18	106	97	0.1	5.2	7.1	28.7
Stippled			200	67	166	3.00	103	92	-0.1	5.1	7.1	28.9
			300	100	152	2.87	95	88	0.2	5.3	7.0	29.3
			400	133	145	2.74	91	84	0.2	5.3	7.1	29.6
			500	167	138	2.60	86	79	0.1	5.2	7.0	29.7
			600	200	2 lamps burned out							

* See footnote in Table I.

TABLE III. TIME OF FIRST EVIDENCE OF SHORTED FILAMENT TURNS

20-Ampere Lamps

Lamp No.	Rated Life Hours	Filament Type	Burning Time (Hours) 35	70	105	140
56/1-1V	50	C-6				x
-2V				(Broken)		
-3V						x
56/1-1H	50	C-6				x
-2H						x
-3H						
56/3-1V	75	CC-6	x			
-2V			x			
-3V						x
56/3-1H	75	CC-6			x	
-2H					x	(Burned out)
-3H			x			

TABLE IV. TIME OF FIRST EVIDENCE OF SHORTED FILAMENT TURNS

6.6-Ampere Lamps

Lamp No.	Rated Life Hours	Filament Type	Burning Time (Hours) 100	200	300	400	500	600
56/2-1V	500	C-13						
-2V								
-3V								
56/2-1H	500	C-13						
-2H								
-3H								
56/3-1V	300	CC-6						
-2V								
-3V								
56/3-1H	300	CC-6						
-2H								(Burned out)
-3H								x (Burned out)

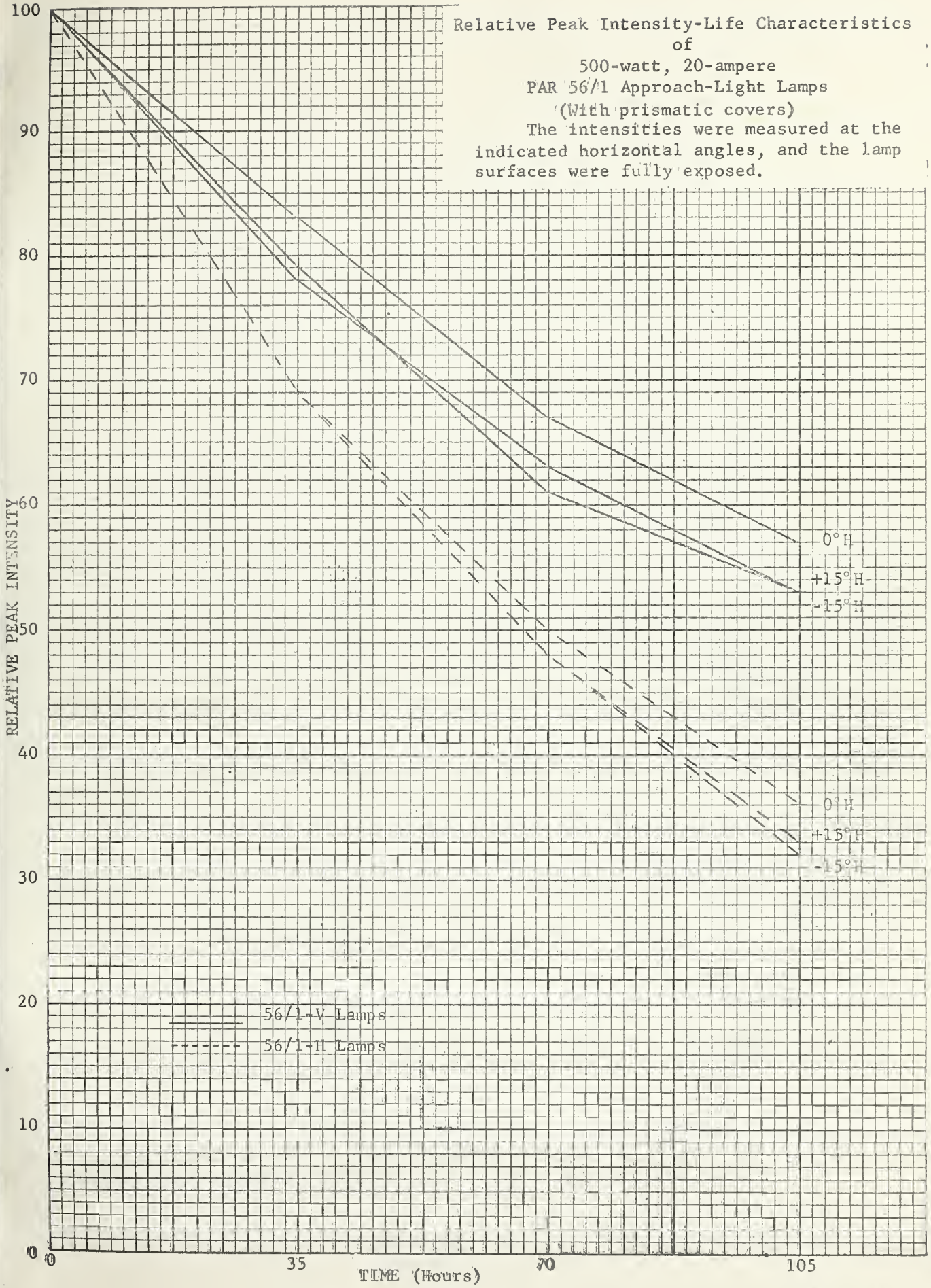
Relative Peak Intensity-Life Characteristics
of
500-watt, 20-ampere
PAR 56/1 Approach-Light Lamps
(With prismatic covers)
The intensities were measured at the indicated horizontal angles, and the lamp surfaces were fully exposed.
RELATIVE PEAK INTENSITY
100
90
80
70
60
50
40
30
20
10
0
0°H
+15°H
-15°H
0°H
+15°H
-15°H
56/1-V Lamps
56/1-H Lamps
0
35
70
105
TIME (Hours)

Figure 1

Relative Peak Intensity-Life Characteristics
of
500-watt, 20-ampere
PAR 56/3 Approach-Light Lamps
(With stippled covers)

The intensities were measured at the indicated horizontal angles, and the lamp surfaces were fully exposed.

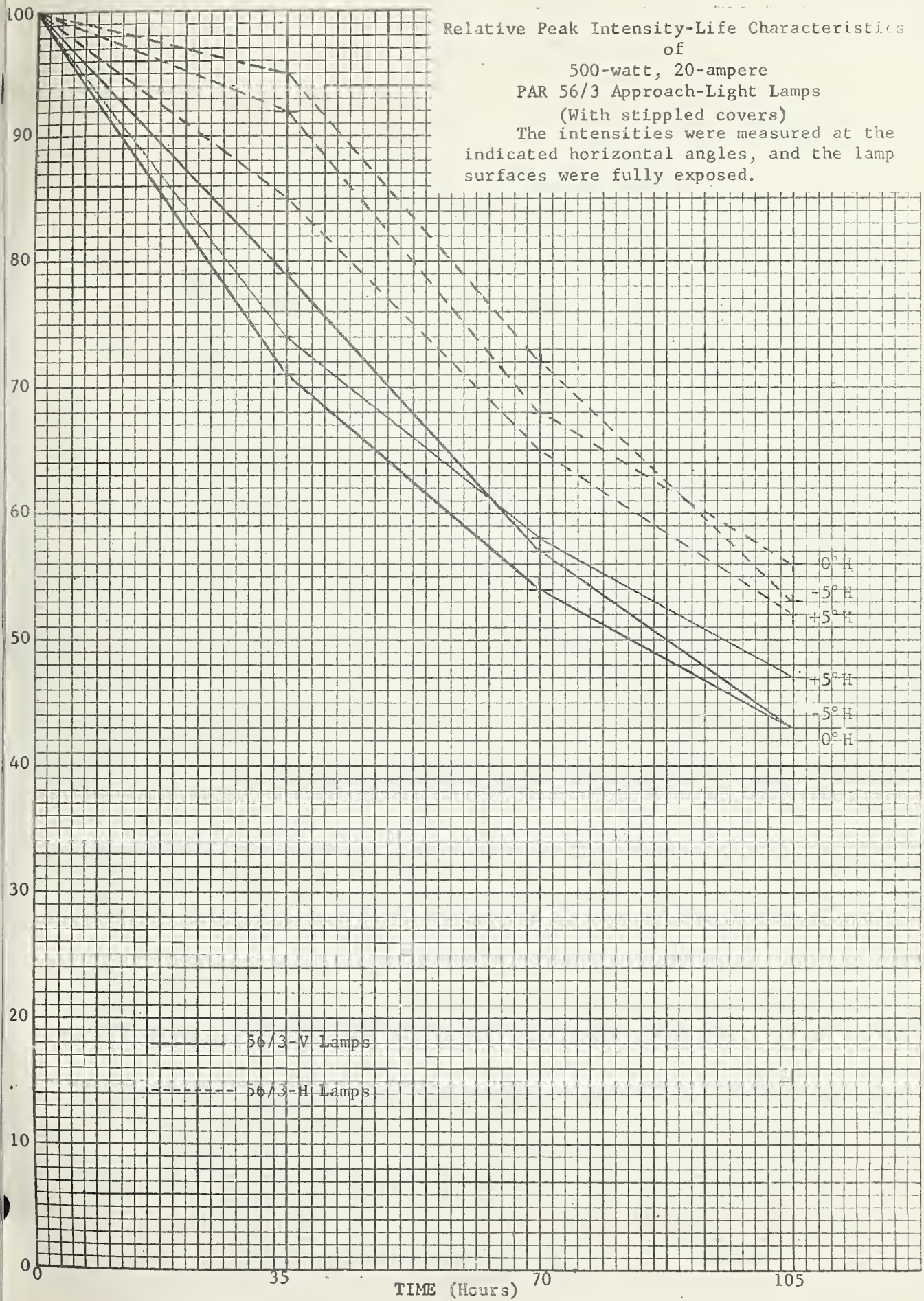

Figure 2

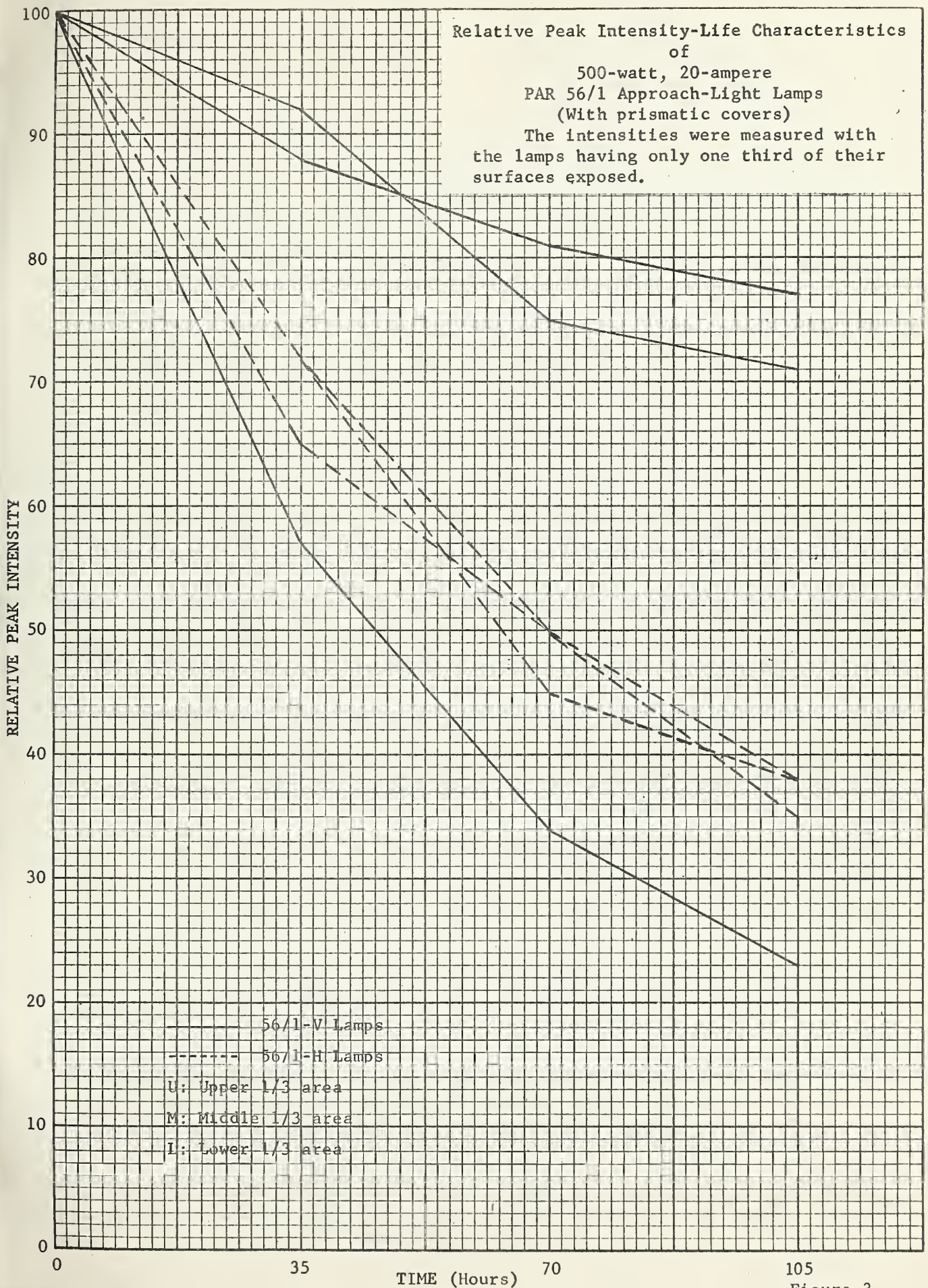
Relative Peak Intensity-Life Characteristics
of
500-watt, 20-ampere
PAR 56/1 Approach-Light Lamps
(With prismatic covers)
The intensities were measured with the lamps having only one third of their surfaces exposed.
RELATIVE PEAK INTENSITY
100
90
80
70
60
50
40
30
20
10
0
0
35
70
105
TIME (Hours)
56/1-V Lamps
56/1-H Lamps
U: Upper 1/3 area
M: Middle 1/3 area
L: Lower 1/3 area

Figure 3

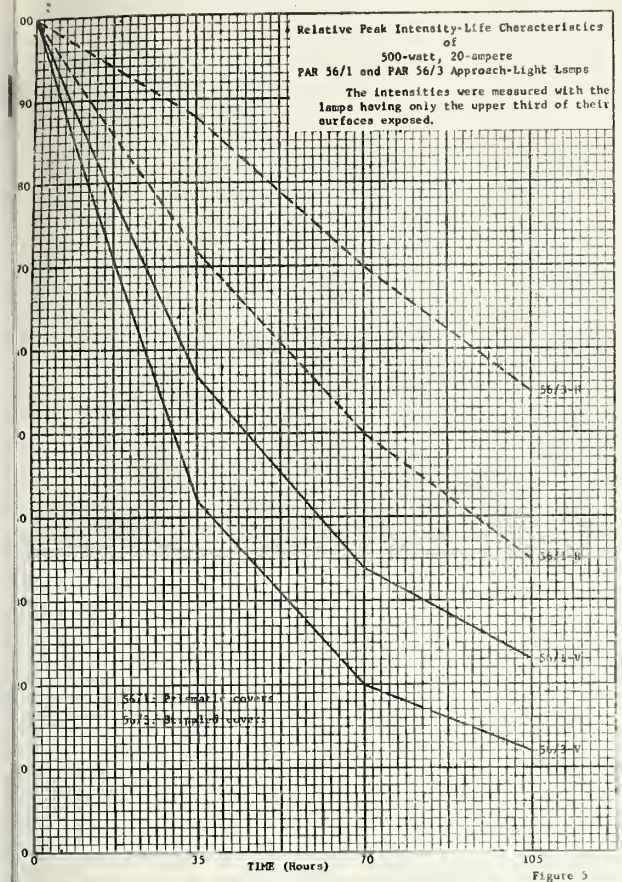

Figure 5

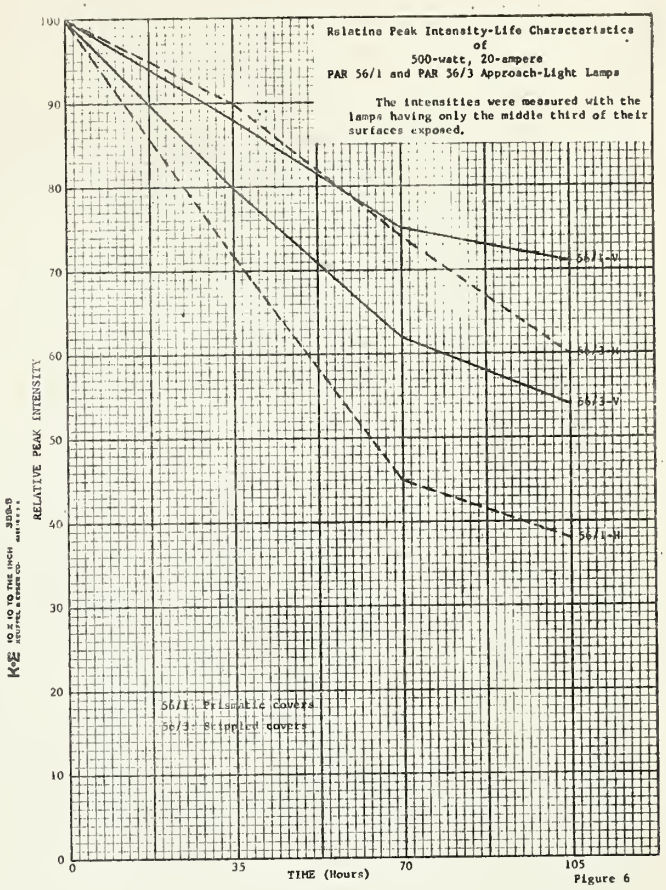

Figure 6

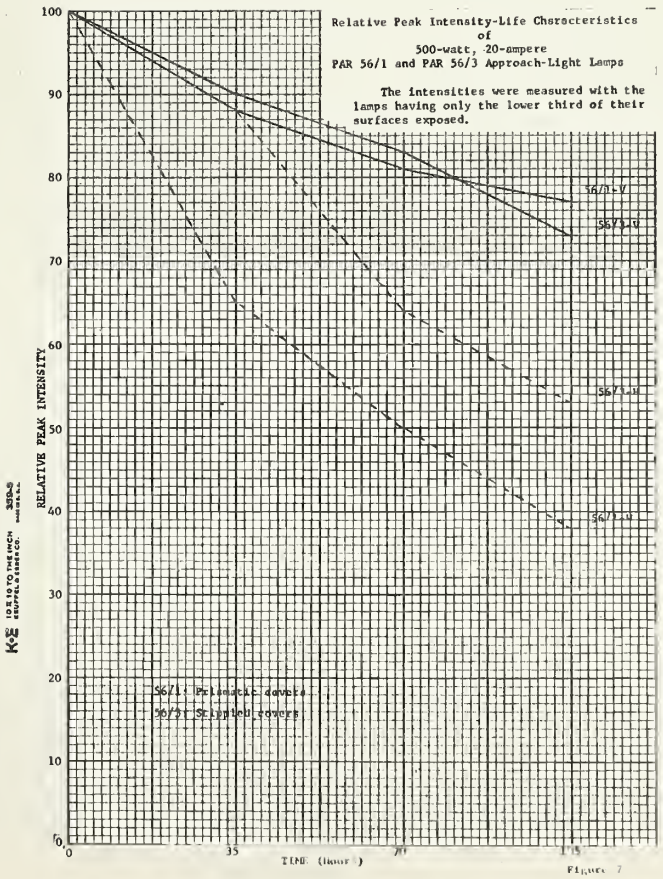

Figure 7

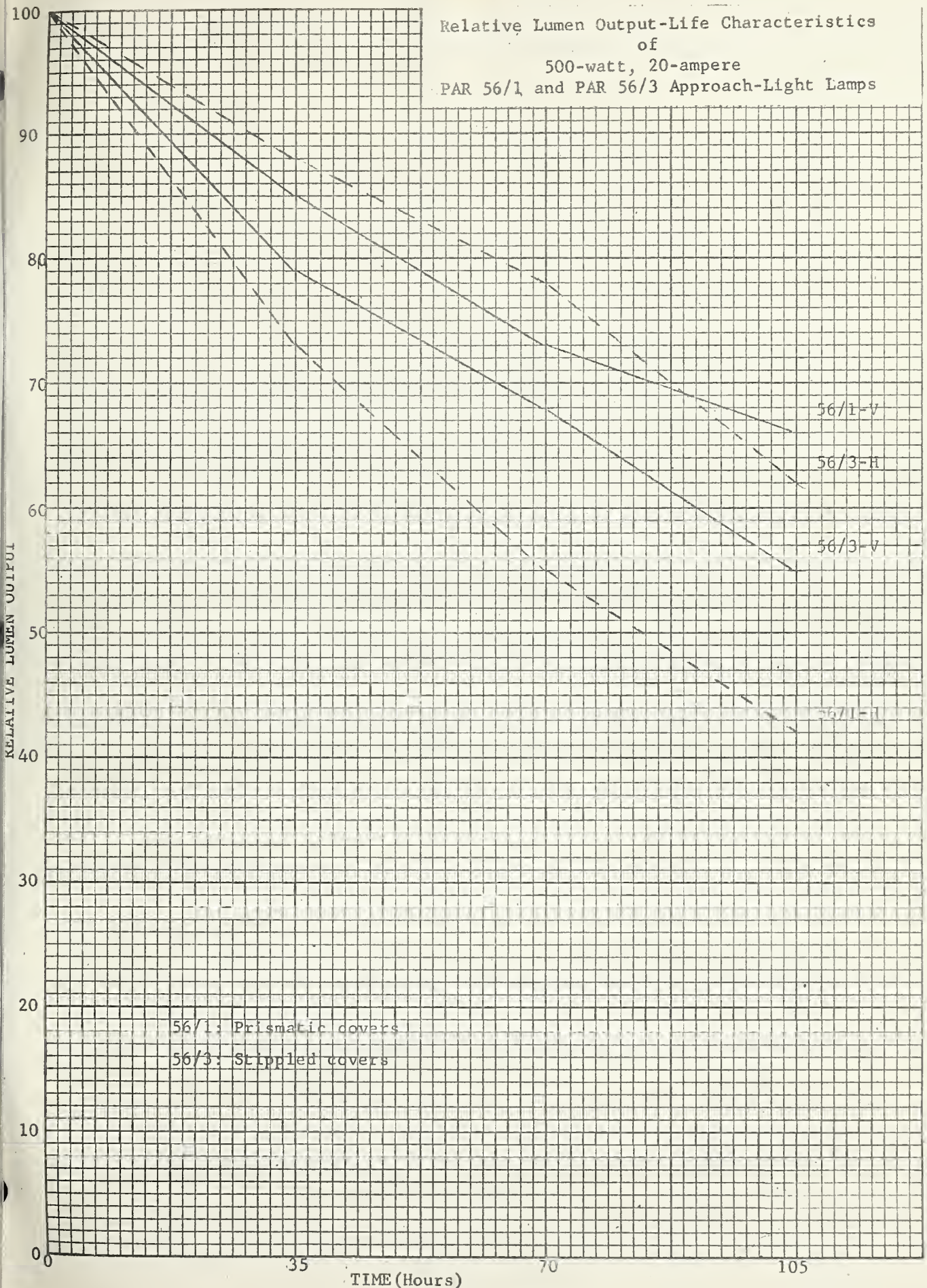
Relative Lumen Output-Life Characteristics
of
500-watt, 20-ampere
PAR 56/1 and PAR 56/3 Approach-Light Lamps
RELATIVE LUMEN OUTPUT
100
90
80
70
60
50
40
30
20
10
0
0
35
70
105
TIME (Hours)
56/1-V
56/3-H
56/3-V
56/1-H
56/1: Prismatic covers
56/3: Stippled covers

Figure 8

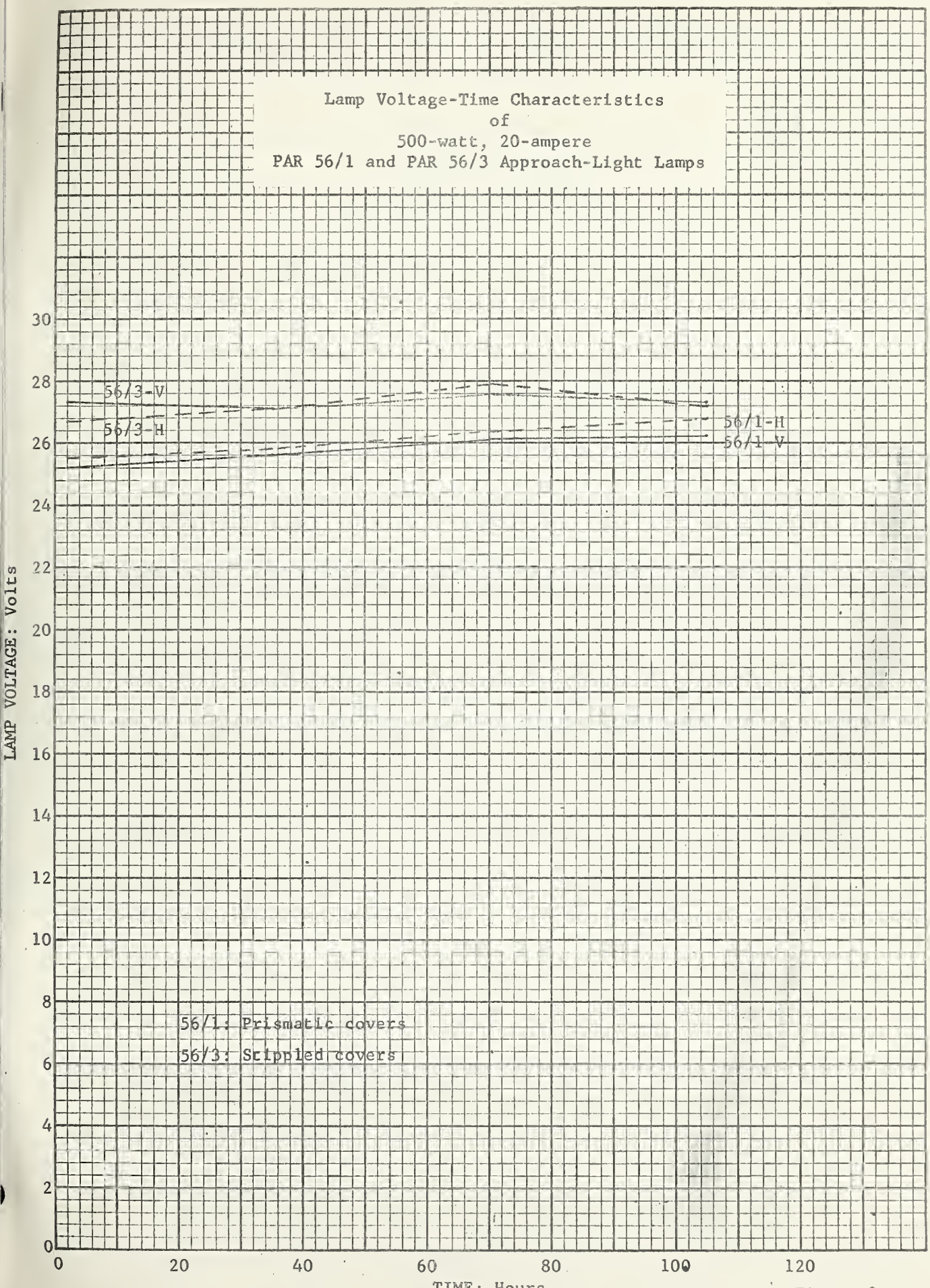
Lamp Voltage-Time Characteristics
of
500-watt, 20-ampere
PAR 56/1 and PAR 56/3 Approach-Light Lamps
LAMP VOLTAGE: Volts
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
56/3-V
56/3-H
56/1-H
56/1-V
56/1: Prismatic covers
56/3: Stippled covers
0
20
40
60
80
100
120
TIME: Hours

Figure 9

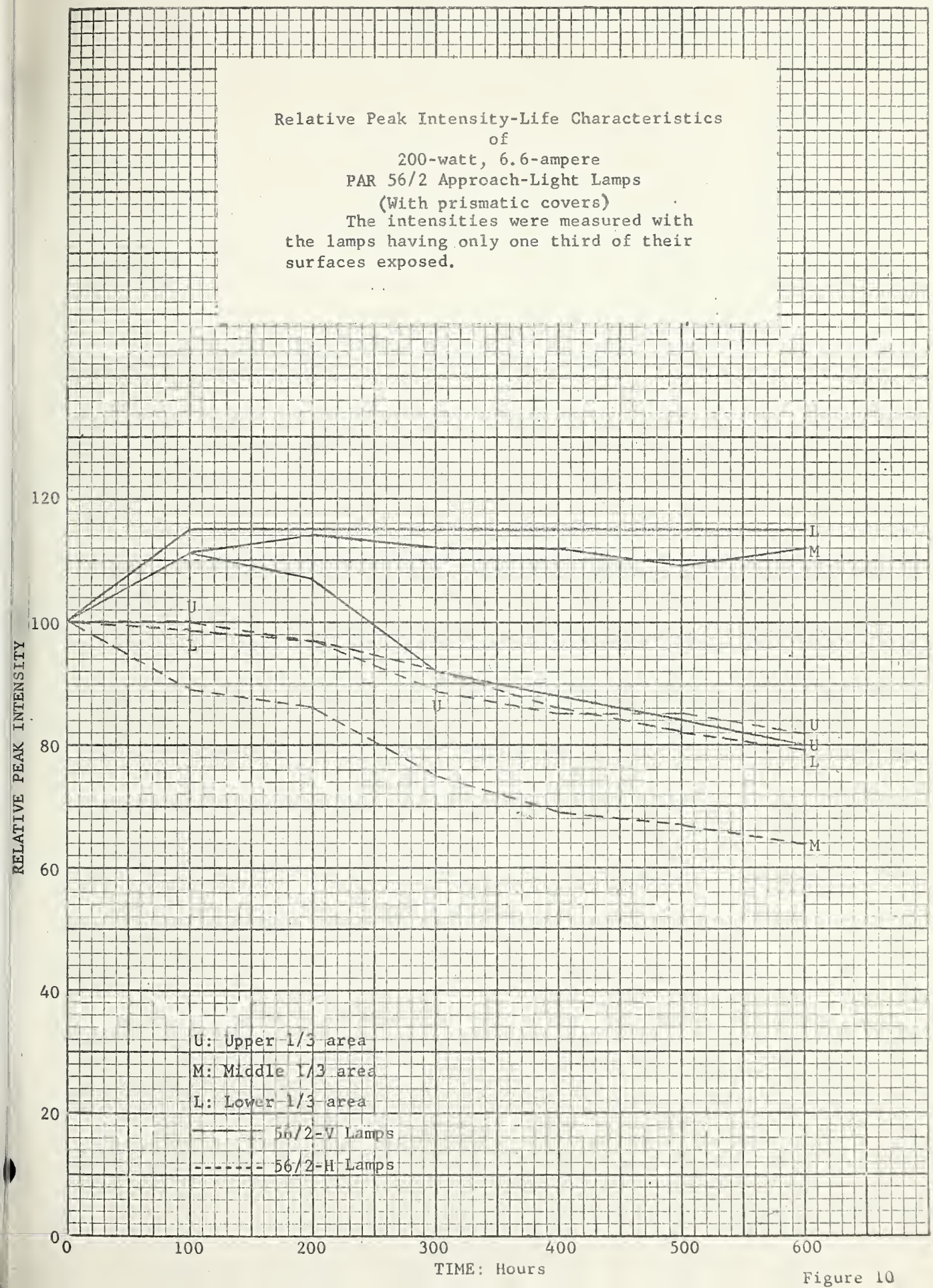
Relative Peak Intensity-Life Characteristics
of
200-watt, 6.6-ampere
PAR 56/2 Approach-Light Lamps
(With prismatic covers)
The intensities were measured with the lamps having only one third of their surfaces exposed.
RELATIVE PEAK INTENSITY
120
100
80
60
40
20
0
0
100
200
300
400
500
600
TIME: Hours
L
M
U
L
U
U
L
U
L
M
U: Upper 1/3 area
M: Middle 1/3 area
L: Lower 1/3 area
56/2-V Lamps
56/2-H Lamps

Figure 10

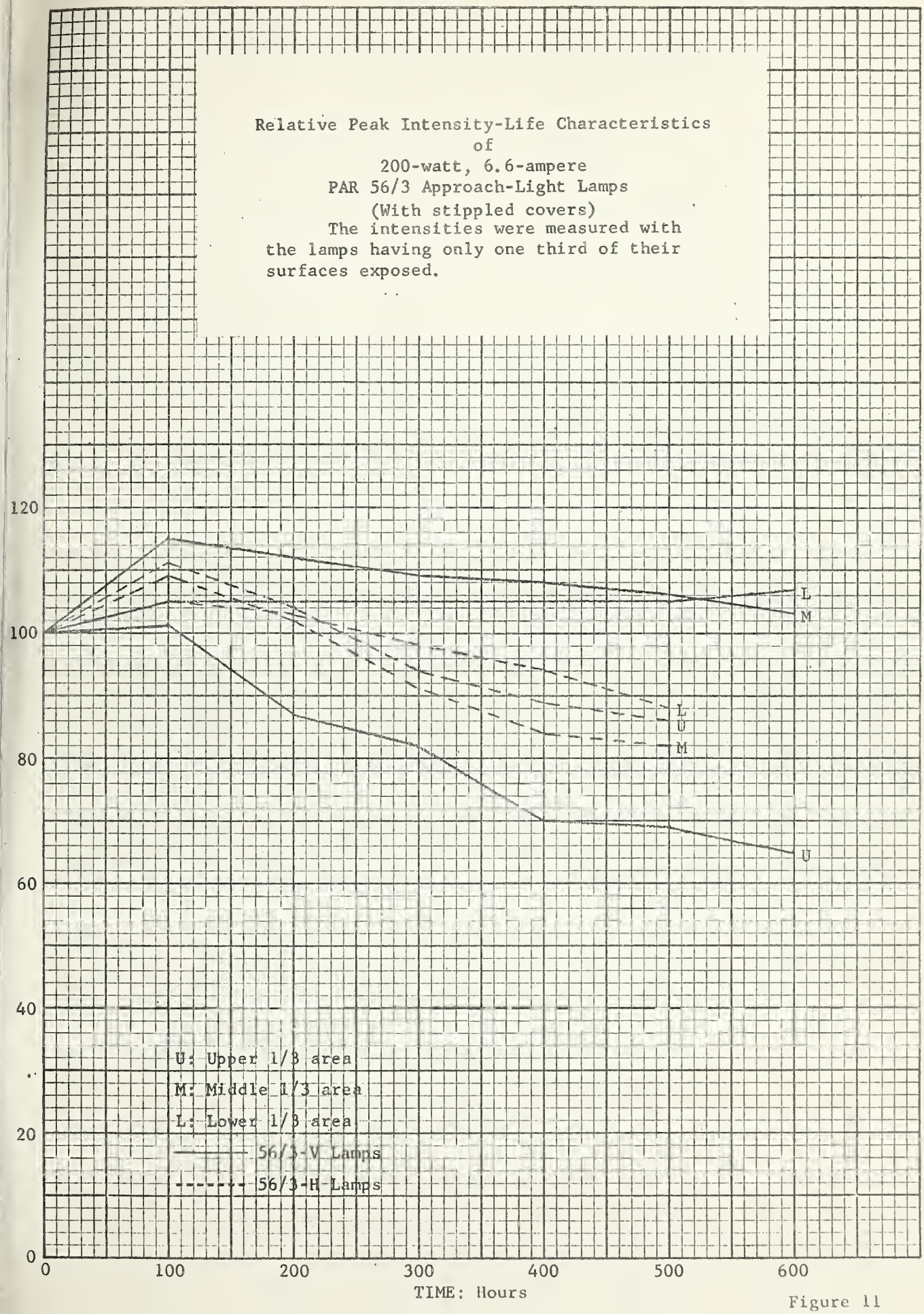
Relative Peak Intensity-Life Characteristics
of
200-watt, 6.6-ampere
PAR 56/3 Approach-Light Lamps
(With stippled covers)
The intensities were measured with the lamps having only one third of their surfaces exposed.
120
100
80
60
40
20
0
0
100
200
300
400
500
600
TIME: Hours
L
M
L
U
M
U
U: Upper 1/3 area
M: Middle 1/3 area
L: Lower 1/3 area
56/3-V Lamps
56/3-H Lamps

Figure 11

Relative Peak Intensity-Life Characteristics
of
200-watt, 6.6-ampere
PAR 56/2 and PAR 56/3 Approach-Light Lamps

The intensities were measured with the lamps having their full surfaces exposed.

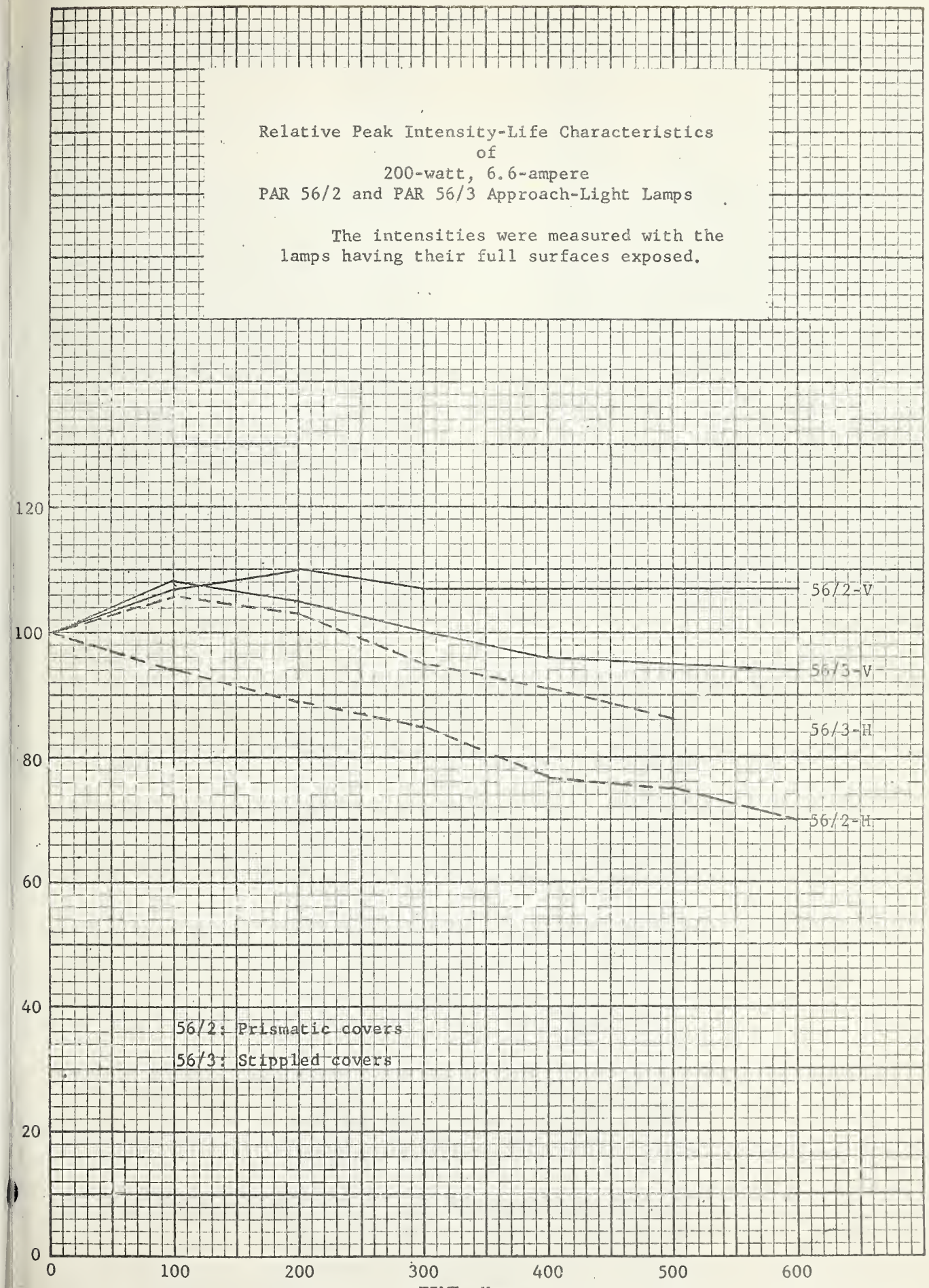

Figure 12

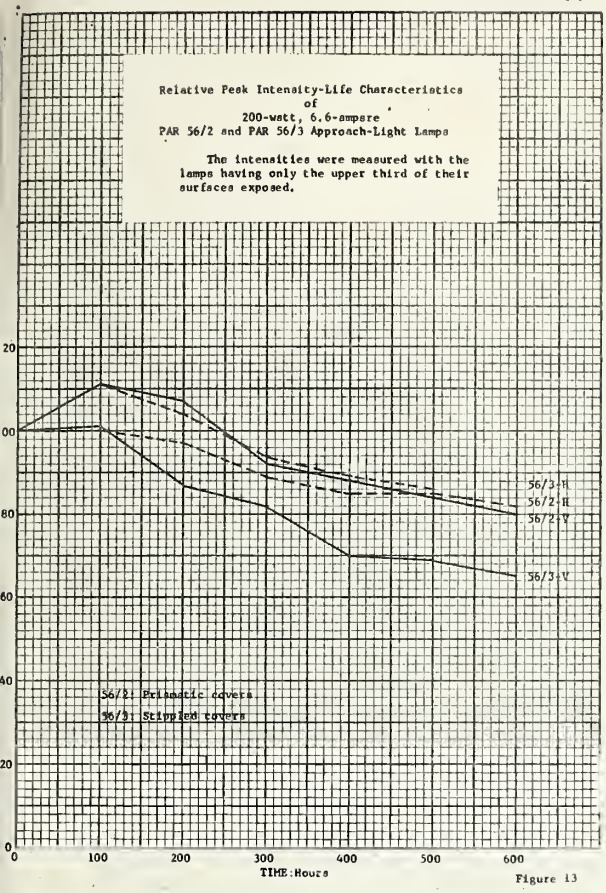

Figure 13

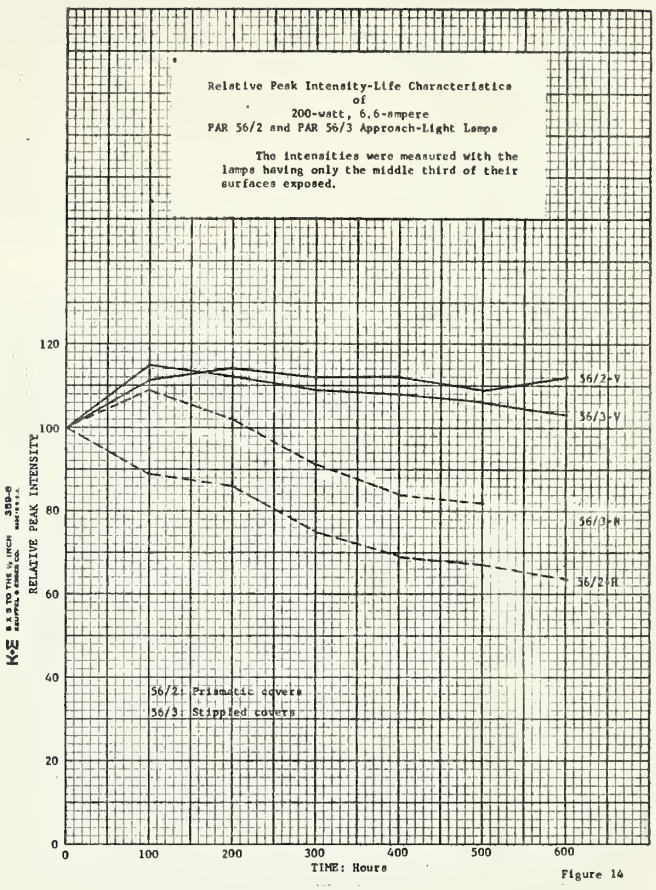

Figure 14

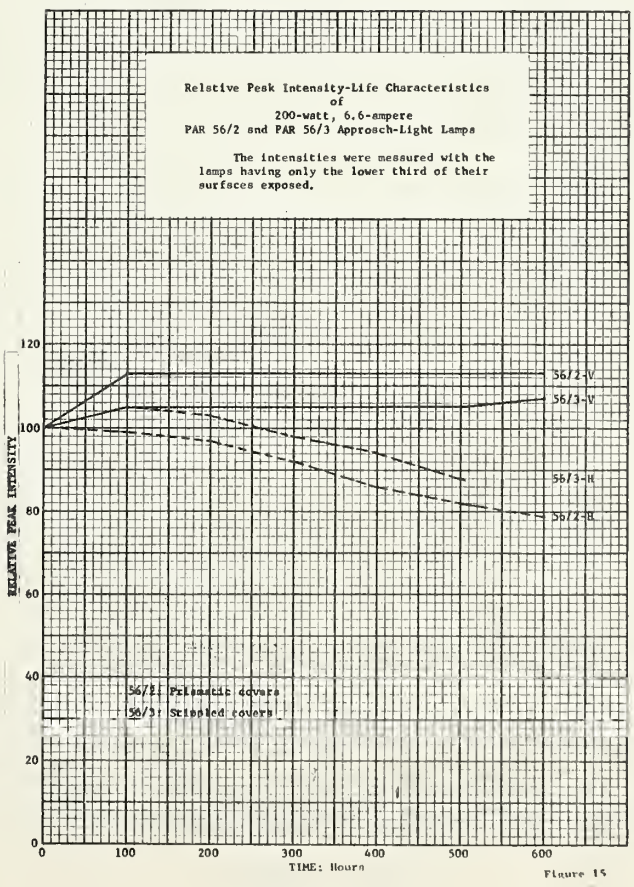

Figure 15

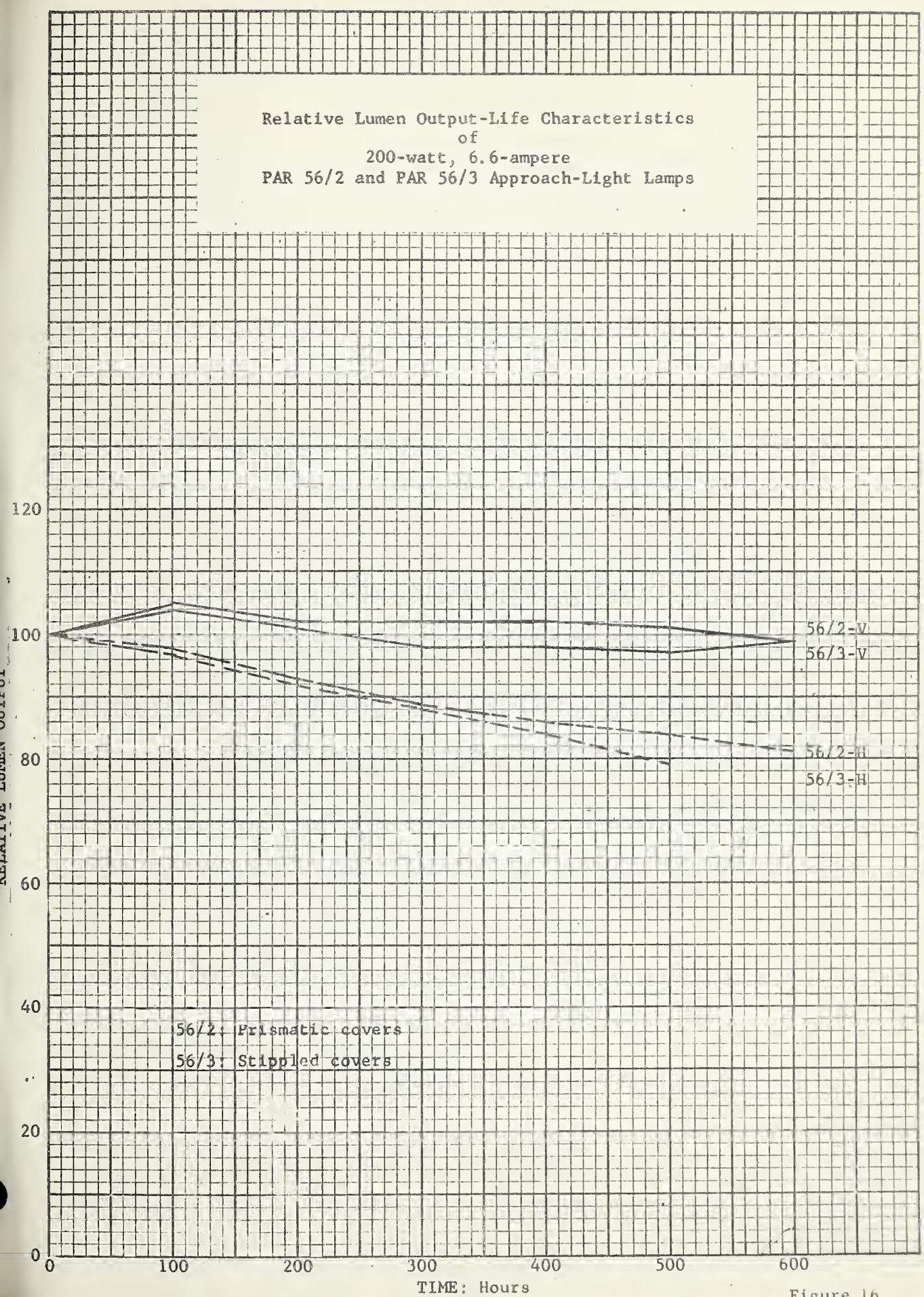
Relative Lumen Output-Life Characteristics
of
200-watt, 6.6-ampere
PAR 56/2 and PAR 56/3 Approach-Light Lamps
RELATIVE LUMEN OUTPUT
120
100
80
60
40
20
0
0
100
200
300
400
500
600
TIME: Hours
56/2-V
56/3-V
56/2-H
56/3-H
56/2: Prismatic covers
56/3: Stippled covers

Figure 16

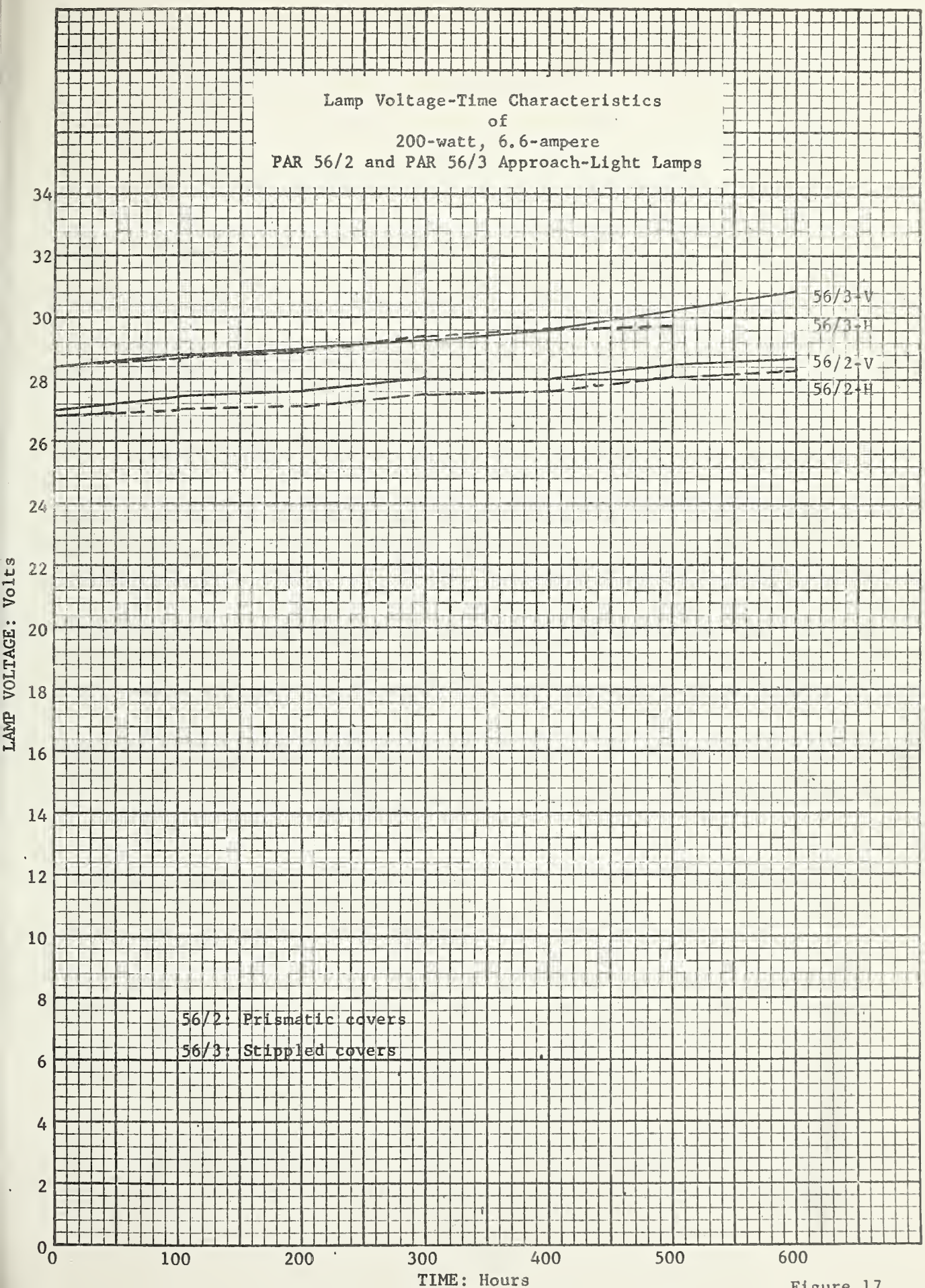
Lamp Voltage-Time Characteristics
of
200-watt, 6.6-ampere
PAR 56/2 and PAR 56/3 Approach-Light Lamps
LAMP VOLTAGE: Volts
TIME: Hours
56/3-V
56/3-H
56/2-V
56/2-H
56/2: Prismatic covers
56/3: Stippled covers
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
0
100
200
300
400
500
600

Figure 17

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.


NBS