AN INTERIM REPORT

ON

A STUDY OF ROADWAY LIGHTING SYSTEMS

by

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Table of Contents

INTRODUCTION

Roadway lighting is used on many urban freeways to aid the night-time driver. The high density traffic conditions normally prevailing on these facilities necessitate the provision of adequate visibility and visual comfort for safe and comfortable night-time driving.

However, in the past, too little attention has been given to the design of lighting systems for urban freeways. In most cases, the design has been merely an extension of the conventional mercury-vapor lighting systems used in the illumination of city streets. Due primarily to maintenance considerations, the 30-foot mounting height has been common practice in city street lighting. But, in order to produce an acceptable light pattern on urban freeways, conventional mercury-vapor luminaires mounted at 30-foot heights must be spaced longitudinally no greater than 160 feet. If this longitudinal spacing is exceeded, then there is a noticeable reduction in visibility caused by a significant decrease in a resultant uniformity of roadway brightness. The bright puddles of light under the luminaires and the apparent darkness between them create a "ladder" effect on the pavement. This brightness pattern often conflicts with the alignment of the roadway and leaves areas of visual uncertainty between the luminaires. Although required for adequate visibility, the close spacings make freeway lighting expensive and increase the potential hazard of collision with the lighting poles.

Even with the appropriate longitudinal spacing, the 30-foot mounting height has been found to be objectionable from the standpoint of visibility and visual comfort. When it is used in conjunction with the conventional Type III, mercury-vapor luminaires, a considerable amount of glare is experienced. Also, the level of adaptation brightness in such a system is much greater than the average roadway brightness, making objects on the roadway difficult to see. In earlier research conducted by the Texas Transportation Institute, it was found that a system of luminaires mounted at heights of 45 feet provided better visibility and visual comfort than a similar system mounted at 30 feet. (Research Report 5-9, "Intersection and Sign Illumination for Highway Safety and Efficiency", by Charles J. Keese and Donald E. Cleveland, Texas Transportation Institute, August, 1966.)

As a result of this research and a realization of the shortcomings of current freeway lighting design, the Texas Highway Department began limited application of higher mounting heights in urban freeway lighting to evaluate their suitability. The success of these experimental installations encouraged utilization of higher mounting heights. Consequently highway engineers recognized the need to investigate the effect of mounting height and spacing of luminaires on visibility and visual comfort, in order to develop design criteria for functional and economical roadway lighting.

In 1964, the Texas Transportation Institute initiated a research project, "Supplementary Studies in Highway Illumination," under the sponsorship of the Texas Highway Department in cooperation with the U. S. Bureau of Public Roads. The

ultimate goal in the research is to produce definite criteria for the design of a visual environment which is conducive to safe and comfortable night-time driving. To accomplish this goal it is necessary to determine the relationship among all of the factors within the environment. The interactions among visibility, visual comfort, brightness patterns, light distributions, and the configuration of the lighting system must be examined. The purpose of this report is to present the results of a study of the effects of system configuration on light distribution.

STUDY PROCEDURE

Test Facilities

In order to determine the light distributions of the experimental lighting systems, it was necessary to develop test facilities in which a representative section of roadway lighting could be simulated with complete flexibility in the selection of mounting height and spacing of lighting units. To facilitate this investigation, ten portable towers were designed and constructed by the Texas Highway Department and furnished to the research staff of the Texas Transportation Institute. As shown in Figure 1, these towers were made of standard triangular antenna tower sections and built on trailers to provide mobility. The frame on which the luminaires are mounted can be hoisted to any point on the tower, which is 60 feet in height. Either one or two luminaires can be mounted on this traveling frame to facilitate the study of median lighting as well as one-side lighting systems. Each of these towers is provided a 240-volt power source by means of an inter-connected system using heavy-duty, portable power cable.

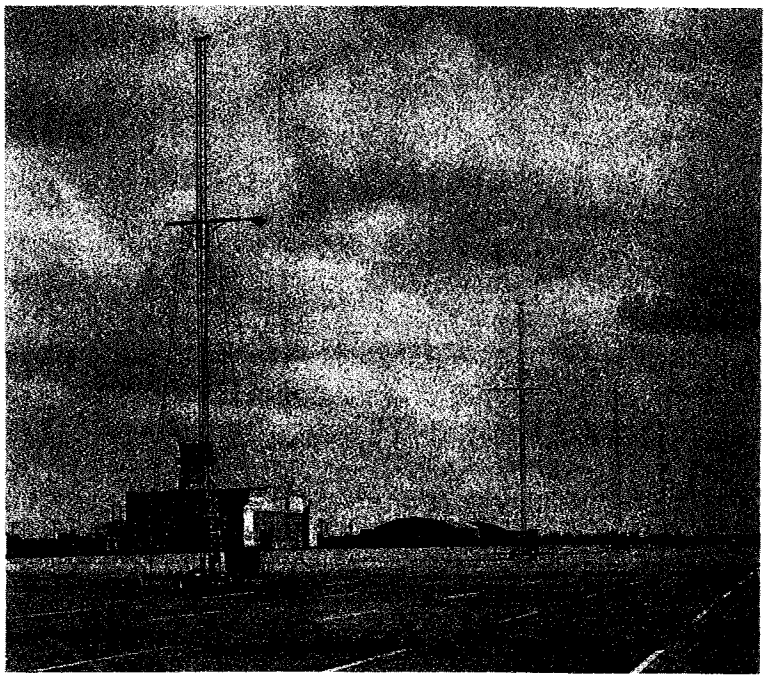
The Texas A&M University Research Annex was selected as the test site. The Annex, which was once the Bryan Air Force Base, has one large paved area approximately 600 feet wide and 3500 feet long. In addition to providing ample space for conducting the photometric studies, this area could be completely isolated from all extraneous light sources.

Collection of Photometric Data

The collection of photometric data involved measuring the illumination from the various light sources tested in terms of horizontal footcandles. For this, a Street Lighting Meter (type SL480A) was used (see Figure 2). This low-range portable illumination meter has a current-balancing circuit and self-leveling cell assembly. The photovoltaic cell has a color-correcting filter and a cosine-correcting plastic cover.

To facilitate these measurements, a grid system was established on the paved study area. The longitudinal grid interval was 10.0 feet, and the transverse grid interval was 12.5 feet. The 12.5-foot dimension was selected primarily because it was the longitudinal jointing interval in the pavement, thus making a convenient reference; also, it closely approximates the usual lane width on access-controlled facilities.

The light source to be tested was mounted at its maximum vertical adjustment on a portable tower and placed over one of the grid points. (Maximum vertical



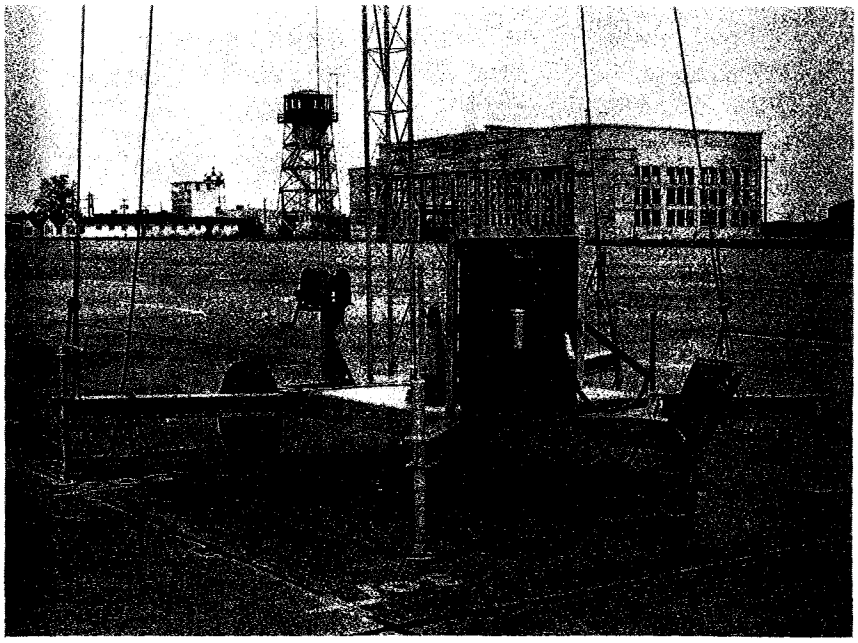


FIGURE 1 - PORTABLE LIGHTING TOWERS

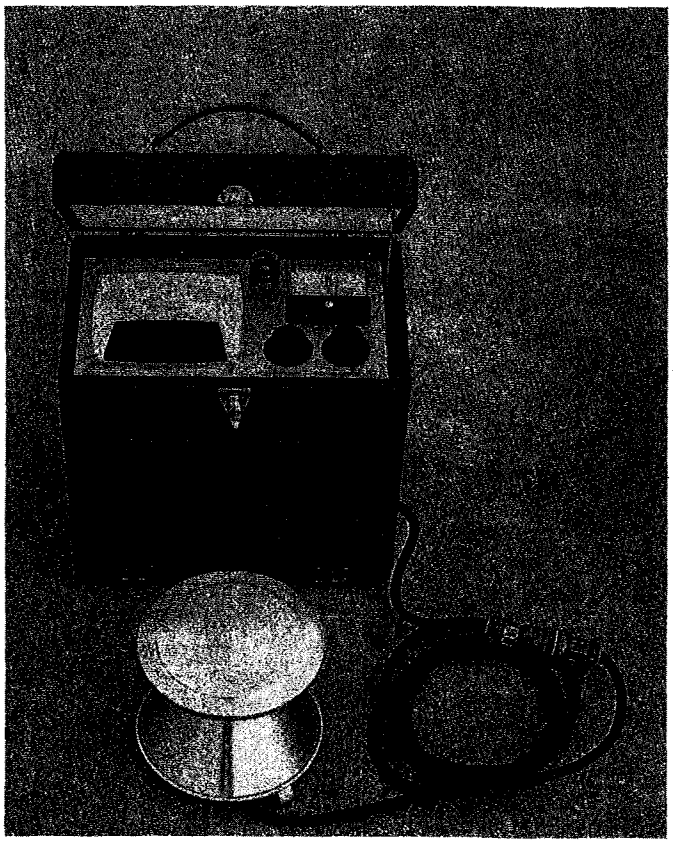


FIGURE 2- STREET LIGHTING METER

adjustment means that the luminaire is tilted upward on the street side as far as the luminaire's mounting assembly will permit when mounted on a horizontal mast arm.) Then, the light source was raised to the desired mounting height, and meter readings were taken at the grid points in all directions from it until light intensities of less than 0.05 horizontal footcandles were observed.

Experimental Procedure

It was decided to include in this phase of the research only photometric studies of 400-watt and 1000-watt, Type III, mercury-vapor luminaires which were commercially available. Three 400-watt, Type III luminaires were obtained from each of four manufacturers, and three 1000-watt, Type III luminaires were obtained from each of three manufacturers. In some cases, lamps and ballasts were furnished with the luminaires. However, to reduce the influence of the lamps on the test results, only one type of 400-watt and 1000-watt clear mercury-vapor lamps was used. These were purchased from the State Contract supplier and had outputs of 21,500 and 57,000 lumens, respectively.

In order to give adequate consideration to the various types of freeway lighting systems, the following systems were selected for the investigation.

A. System type
   1. One-side or house-side lighting
   2. Median Lighting--transverse spacings of 10, 20 and 30 feet

B. System configuration
   1. 400-watt units
      a. Mounting heights of 40, 45 and 50 feet
      b. Longitudinal spacings of 200, 210, 220, 230, 240 and 250 feet
   2. 1000-watt units
      a. Mounting heights of 50 and 60 feet
      b. Longitudinal spacings of 260, 280, 300, 320 and 340 feet.

A study of this experimental design will reveal that there are 72 combinations of 400-watt units and 48 combinations of the 1000-watt units. However, it was further necessary to consider the fact that three 400-watt lighting units from each of four manufacturers, and three 1000-watt units from each of three manufacturers, were to be used in the experiment. Since there would be inherent variability among the individual units from each of the manufacturers, it was necessary to increase the number of combinations to include all possible arrangements of three luminaires in a system. Taking these factors into consideration, 864 combinations of 400-watt units and 432 combinations of 1000-watt units would be required for a complete study. Since each combination would constitute one field study, and since each field study would require several hours to obtain photometric data, it was readily apparent that some means

must be devised to expedite the collection of data. After considering several alternatives, including various sampling techniques, a means of developing synthetic systems from basic illumination measurements was selected because it could be performed rapidly and economically by electronic computer.

The synthetic approach involved the combination of photometric data from an individual luminaire to obtain photometric data for a system of similar luminaires. Given the photometric data for a particular luminaire mounted at a certain height, the photometric data for a system of these luminaires at the same mounting height were obtained as follows:

1. The relative positions of luminaires were established.
2. The light pattern for the luminaire was superimposed on the drawing at each luminaire location in the system.
3. The light intensities at the grid points where the superimposed patterns overlapped were added together.
4. The resultant intensities at the grid points were recorded as the photometric data for the system.

The use of this technique made the amount of photometric data to be collected feasible. The only field studies required were those for each individual luminaire mounted at each of the various mounting heights. In the final experimental design, studies were conducted for each of the 400-watt units at mounting heights of 30, 40, 45 and 50 feet, and for each of 1000-watt units at mounting heights of 50 and 60 feet.

ANALYSIS OF DATA

Synthetic Lighting Systems

A computer program was prepared to perform the synthetic technique of developing photometric data for various lighting systems. The photometric measurements from each of the field studies were transferred to IBM cards. The data from the field studies of each of three luminaires of the same type and manufacturer, and the same mounting height, were read into the computer. In order to reduce the variability due to individual luminaires, these three sets of data were first averaged at each of the grid points. Since all of the luminaires tested were designed to produce a symmetrical light pattern about the transverse roadway line over which the luminaire is mounted, the photometric data were next made symmetrical about the transverse axis through the luminaire by averaging the two average light intensities at corresponding grid points on opposite sides of the axis. At the completion of these averaging operations, the computer had developed representative photometric data for a single luminaire of the given type, manufacturer, and mounting height.

With this individual light pattern in storage, the computer began to synthetize the light patterns for the various systems of this particular luminaire and the given mounting height. When this operation was completed, the values of illumination at each of the grid points in the light pattern for the single luminaire and the various synthetic systems were printed out as well as stored in the memory of the computer.

Photometric Characteristics

From the stored light patterns, the computer determined and printed out the following photometric characteristics for each of the lighting systems based on 12.5-foot lane widths:

1. Average illumination on each lane.
2. Maximum illumination on each lane.
3. Minimum illumination on each lane.
4. Ratio of maximum to minimum illumination on each lane.
5. Ratio of average to minimum illumination on each lane.

Then assuming the luminaires to be mounted over the edge of the roadway, the computer determined and printed out the values for the following characteristics for two-lane, three-lane, four-lane, and five-lane roadway widths:

1. Average illumination.
2. Maximum illumination.
3. Minimum illumination.
4. Largest of the ratios of maximum to minimum illumination on each lane.
5. Ratio of average to minimum illumination.

These characteristics were used to numerically describe the light distribution of each system.

Iso-Footcandle Charts

The final step in the analysis performed by the computer was to produce isofootcandle charts for the single luminaire and for each of the synthetic systems. In the first attempt to provide the machine plots of isofootcandle charts, a Calcomp X-Y plotter was used in conjuction with an IBM 1401 to process the photometric data prepared by the computer. However, this method required excessive run time on the computer and plotter.

As an alternative, a technique commonly known as the U-M Plot routine was used. This technique utilizes the letter spacing (10/inch) and line spacing (6/inch) of a regular IBM printing machine to provide a graphical representation of data. An example of this output is shown in Figure 3. Although the plotting accuracy of the U-M Plot was less than that of the X-Y plotter, 0.1 inch versus 0.01 inch, the U-M Plot was acceptable because the output from both methods had to be traced by hand to provide reasonably smooth curves. In addition, the cost of plotting the isolux charts by the U-M Plot technique was only a fraction of the cost of plotting by the X-Y plotter.

The entire computer analysis procedure of building the synthetic systems, determining the photometric characteristics, and plotting the isofootcandle charts was repeated for both the 400-watt and 1000-watt units from each manufacturer at each of the mounting heights tested. For this investigation, the following systems for each manufacturer were analyzed.

I. One-side lighting systems

   A. 400-watt luminaires
      1. Mounting heights - 30, 40, 45 and 50 feet
      2. Longitudinal spacings - 100, 120, 140, 160, 180, 200, 210, 220, 230, 240 and 250 feet
   B. 1000-watt luminaires
      1. Mounting heights - 50 and 60 feet
      2. Longitudinal spacings - 240, 260, 280, 300, 320, 340 and 360 feet

II. Median lighting systems

   A. 400-watt luminaires
      1. Mounting heights - same as for one-side lighting
      2. Longitudinal spacings - same as for one-side lighting
      3. Transverse spacing - 10, 20 and 30 feet
   B. 1000-watt luminaires
      1. Mounting heights - same as for one-side lighting
      2. Longitudinal spacings - same as for one-side lighting
      3. Transverse spacings - 10, 20 and 30 feet

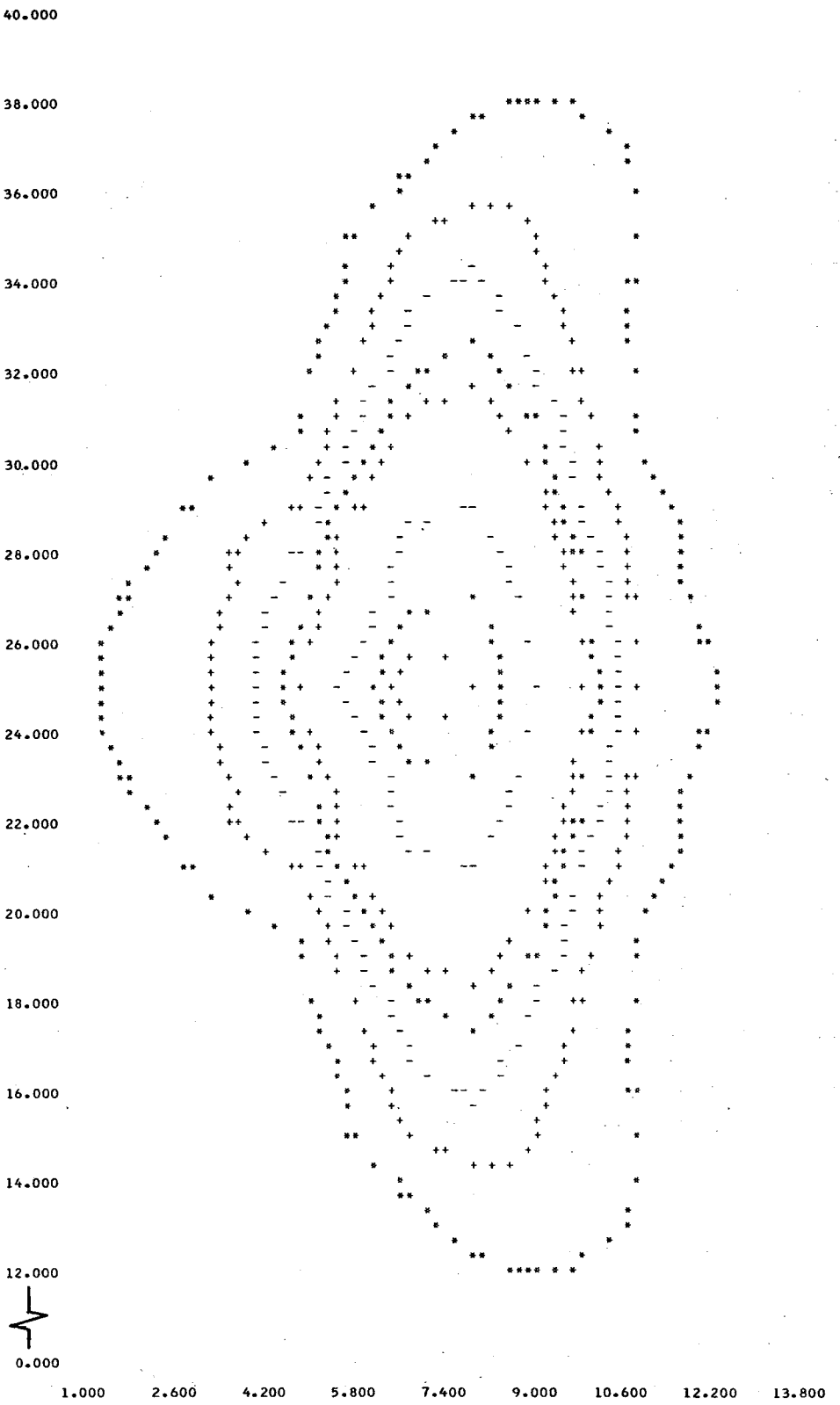


Figure 3 - Isofootcandle chart of an individual luminaire prepared by the computer and plotted by the U-M plot method.

Validation of the Synthetic Lighting Systems

Once the computer technique of building synthetic lighting systems was completed it was necessary to conduct a series of field studies to ascertain the reliability of this technique. A random sample was drawn from the synthetic systems built. Each system in this sample was set up at the test site and photometric measurements were made. These photometric data were then compared to those of the corresponding synthetic system. The differences found in comparing the actual systems with the synthetic systems were not appreciable.

Comparison Study

The photometric characteristics of the various lighting systems determined in the computer analysis were compared. The photometric characteristics were related by graphic interpretation to the configuration of the lighting system in order to illustrate the relationships between the system's confiurgation and the resultant light distribution.

RESULTS

The results of this phase of the research demonstrate the effects of luminaire placement on the light distribution of roadway lighting systems. Since the current performance specifications for roadway lighting are in terms of photometric characteristics, it is important that the relationships between the location of the luminaires within a lighting system and the resultant values of these characteristics be determined. Knowledge of these relationships will enable the engineer to design the lighting system which most efficiently satisfies the given criteria.

Amount and Uniformity of Illumination

The amount and uniformity of illumination on the roadway are influenced by each of the following lighting system geometrics:

1. Mounting height of the luminaires.
2. Longitudinal spacing between the luminaires.
3. Transverse spacing between the luminaires (for median lighting systems).
4. Roadway width.

Relationships were found between each of these factors, which locate the relative positions of the luminaires within the system, and the amount and uniformity of illumination on the roadway.

Traditionally, roadway lighting specifications have designated the amount and uniformity of illumination in terms of average illumination in horizontal footcandles and the ratio of average to minimum illumination on the roadway, respectively. Figures 4 and 5 illustrate the relationships found between initial average illumination and luminaire placement. For the roadway widths considered, the initial average illumination varied inversely with mounting height, longitudinal spacing, and transverse spacing. Also, as one of these three factors was increased within the range studied, the effects of the other two on the initial average illumination on the roadway diminished. For example, as the longitudinal spacing was increased, the rate of the reduction in initial average illumination due to an increase in either mounting height or transverse spacing became smaller.

Figure 6 shows the general relationships between uniformity of illumination and mounting height and longitudinal spacing. At most of the longitudinal spacings the ratio of average to minimum illumination was inversely proportional to the mounting height. The uniformity ratios most frequently used as design standards were reached at greater longitudinal spacings with higher mounting heights. In all cases, the most noticeable increase in uniformity was realized when the mounting height was increased from 30 to 40 feet.

The ratio of average to minimum illumination varied directly with the longitudinal spacing over most of the range of longitudinal spacings investigated. However, over the remainder of the range, the size and location of which depended upon the roadway

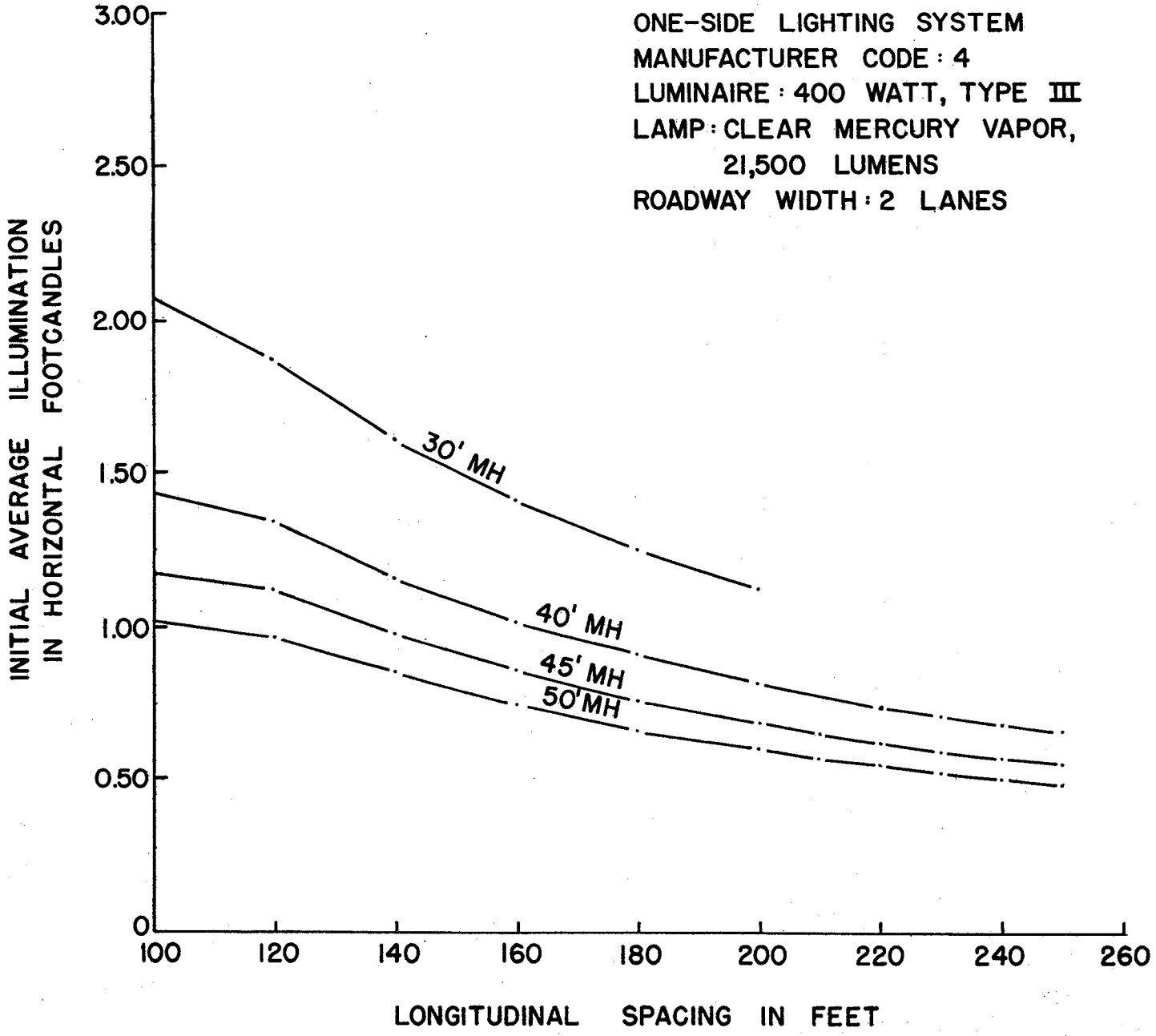


FIGURE 4–INITIAL AVERAGE ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTING HEIGHTS

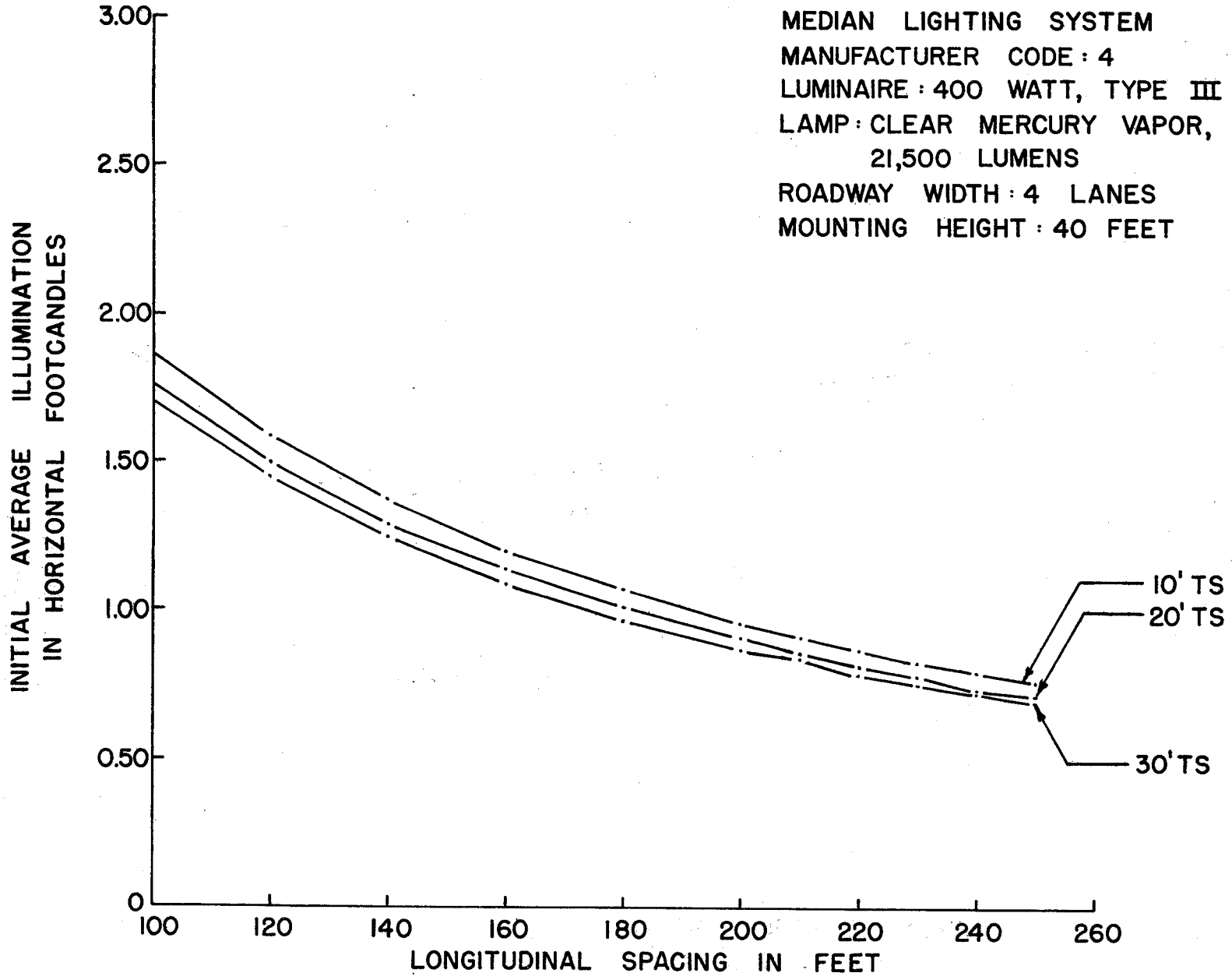


FIGURE 5-INITIAL AVERAGE ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT TRANSVERSE SPACINGS

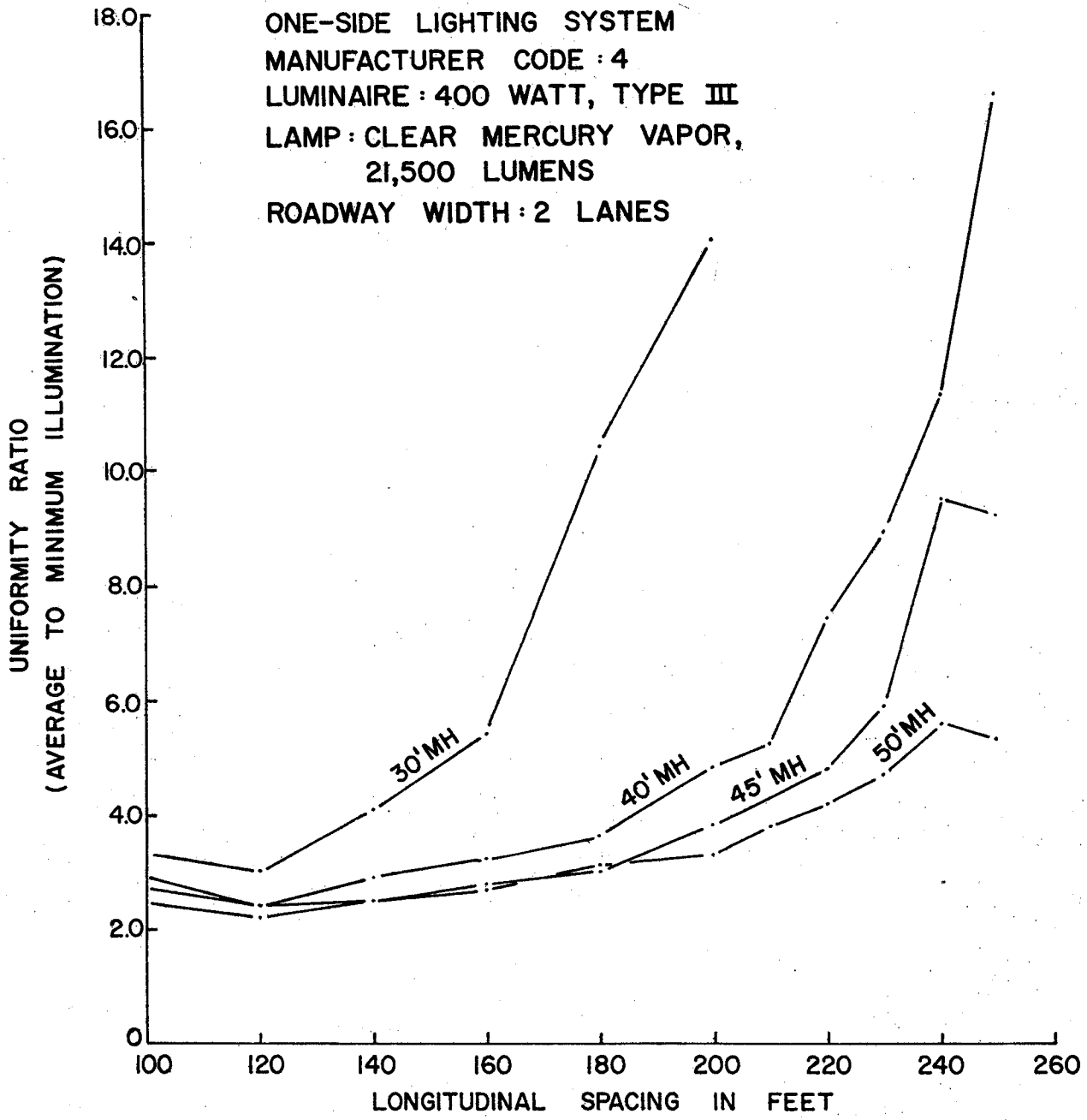


FIGURE 6- UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTING HEIGHTS

width being considered, the uniformity ratio varied inversley with the distance between luminaires, because the rate of reduction in the average illumination was greater than that in the minimum illumination as the distance was increased.

The effect of the transverse spacing between luminaires in median lighting systems on the uniformity of illumination is shown in Figure 7. Generally, the greater the transverse spacing, the higher the uniformity ratio. But at some longitudinal spacings the 20-foot transverse spacing produced less uniformity than the 30-foot transverse spacing, because even though the 30-foot configuration had a lower average illumination, it had the same minimum illumination as the corresponding 30-foot system (Figure 38).

The isofootcandle charts shown in Figures 8 through 21 also illustrate the effects of mounting heights, longitudinal spacings, and transverse spacing on the amount and uniformity of illumination. These charts show an appreciable reduction of the maximum intensity and more uniform distribution of light as a result of increased mounting height. The tendency of the intensity contours to run parallel to the roadway is indicative of relatively uniform light distribution along the driver's path of travel through the system. The shorter the longitudinal spacing and the higher the mounting height, the greater is this tendency.

The effects of luminaire wattage and manufacturer on the initial average illumination and the uniformity ratio are shown in Figures 22, 23, 24, and 25. For a given system geometry, the 1000-watt luminaires provided higher initial average illumination and lower uniformity ratios than did the 400-watt units. This means that a system of 1000-watt luminaries would satisfy performance specifications based on these photometric characteristics at greater longitudinal spacings than would a similar system of 400-watt luminaires; thus, requiring fewer units to do the job.

Although all of the luminaires tested were Type III, a comparison showed that luminaires of the same wattage but different manufacturers produced light patterns which differed with respect to amount and uniformity of illumination. These differences among the luminaires were found to vary with the system studied, indicating that for a given set of design criteria the optimum system geometrics are dependent on the luminaire used (Figures 22, 23, 24 and 25). However, the relationships discussed above between the amount and uniformity of illumination and system geometrics apply to all the luminaires.

The width of the roadway to be lighted was found to affect the amount and uniformity of illumination on it from a given lighting system. The relationship between initial average illumination and roadway width is shown in Figures 26 and 27. Regardless of the mounting height, the initial average illumination decreased as the roadway width was increased. Figures 28 through 33 illustrate the effect of roadway width on the uniformity of the light patterns from several lighting systems. At the shorter longitudinal spacings the narrower roadways usually had lower uniformity ratios than the wider roadways, but at the longer spacings the wider

roadways usually had the lower uniformity ratios. This effect was caused by the greater percentage decrease in minimum illumination relative to the average illumination on the narrower roadways as the longitudinal spacing was increased. It can also be noted that the higher the mounting height, the less the effect of roadway width on the uniformity of illumination.

Minimum Illumination

The amount of illumination on the roadway can also be considered from the standpoint of minimum illumination. Figures 34, 35, 36, 37 and 38 illustrate the relationships between initial minimum illumination and system geometrics. Generally, initial minimum illumination was inversely proportional to longitudinal spacing, transverse spacing, and roadway width. Also, the rate of reduction in the initial minimum illumination due to either an increase in longitudinal spacing or roadway width was inversely proportional to mounting height. As shown in Figure 34, each mounting height had a range of longitudinal spacing over which it had a higher initial minimum illumination than the other mounting heights. As the longitudinal spacing was increased, the lower mounting height gave way to the next higher mounting. However, as the roadway width was increased, the lower mounting height ranges became smaller until the minimum illumination was directly proportional to the mounting height at almost every longitudinal spacing studied (Figure 37).

Comparisons of uniformity of illumination produced by several systems are shown in Figures 39 and 40. The relationships between uniformity of illumination in terms of the largest maximum to minimum illumination ratio along the lane lines and system configuration were similar to those between the uniformity ratio (average to minimum illumination) and system configuration. However, comparisons of maximum-to-minimum illumination ratios indicated a greater increase in uniformity due to higher mounting heights than did the conventional uniformity ratio.

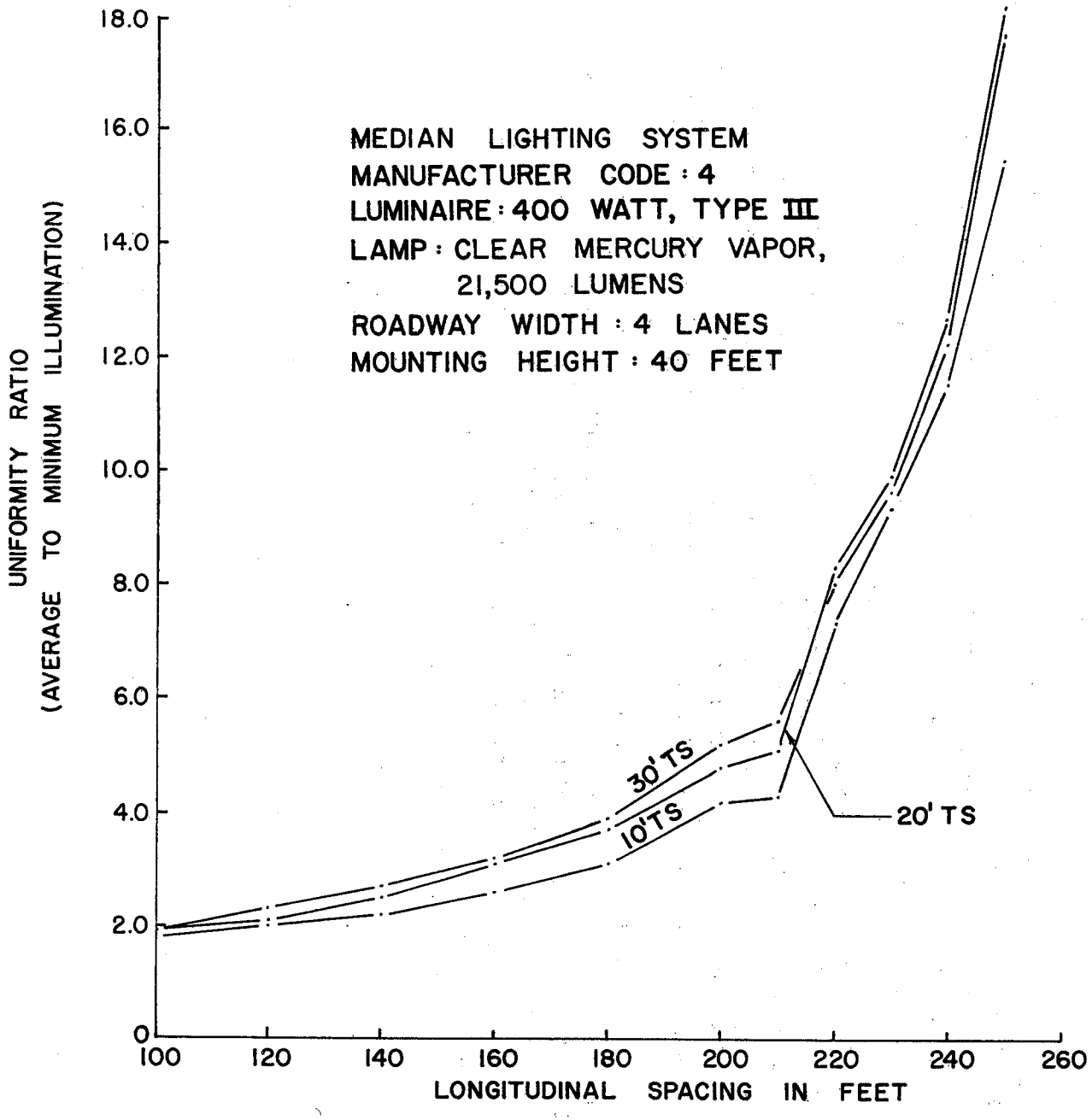
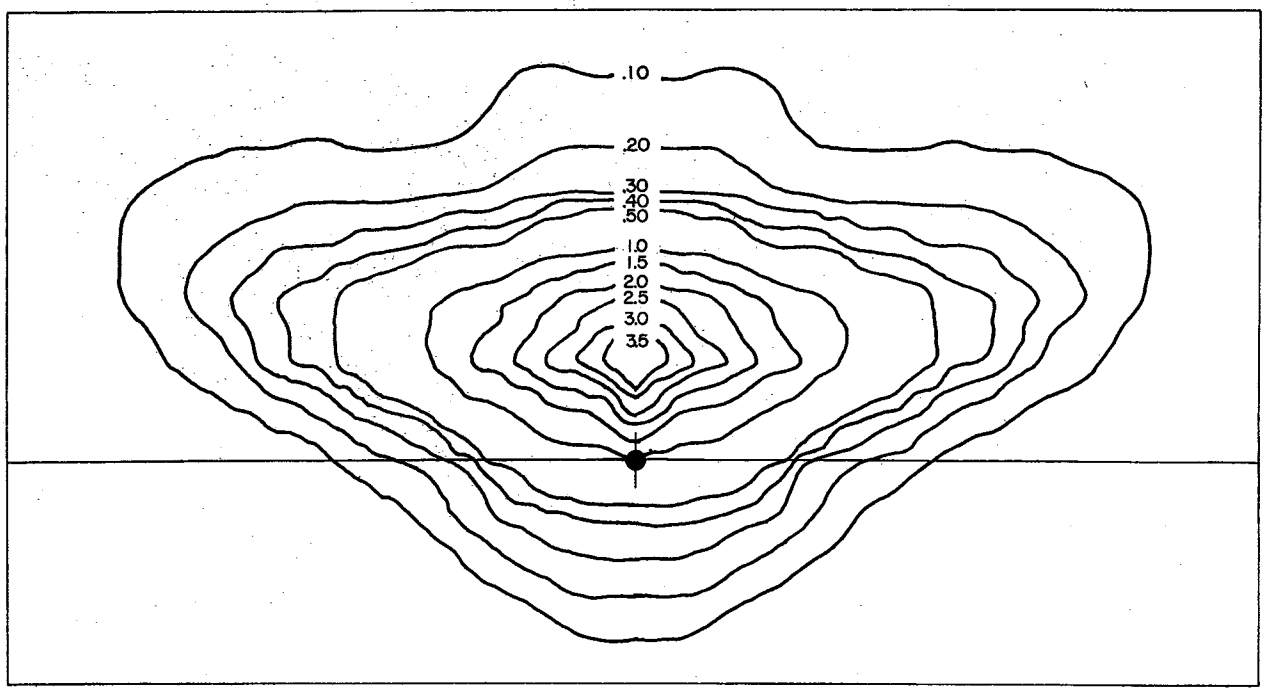
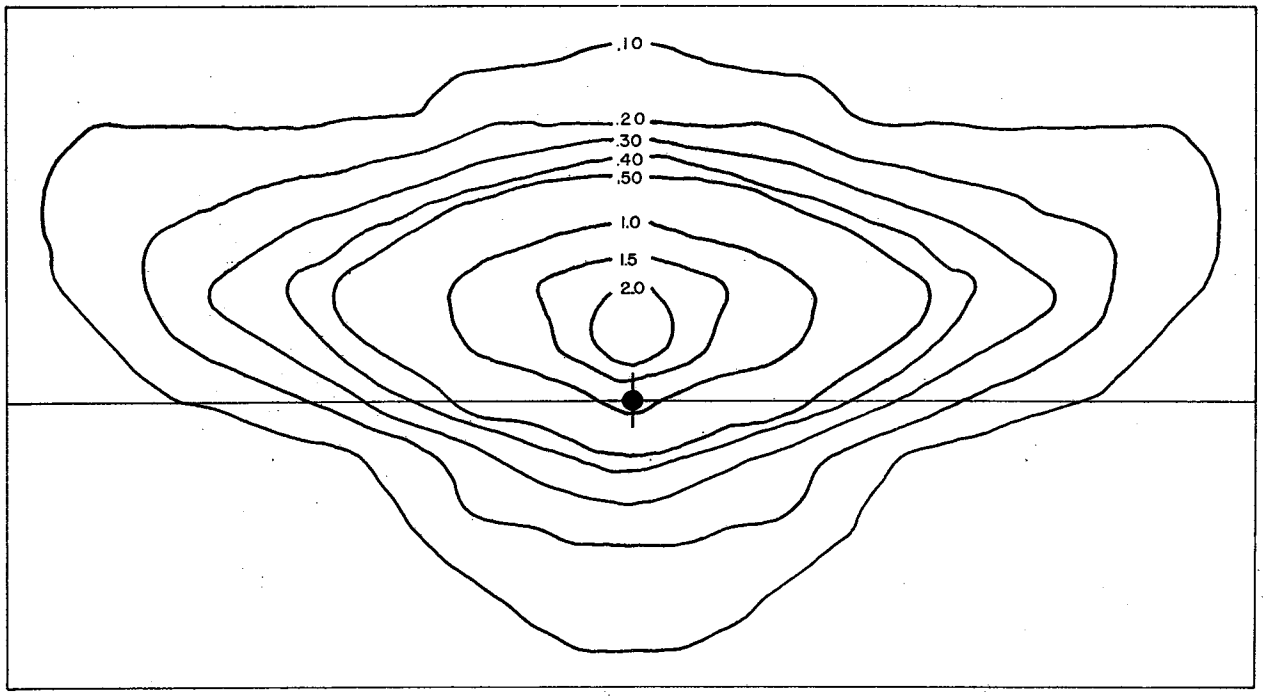


FIGURE 7 - UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT TRANSVERSE SPACINGS



ISO-FOOTCANDLE CURVE
SINGLE LUMINAIRE

LUMINAIRE: 400 WATT, TYPE III$_4$
MOUNTING HEIGHT: 30'

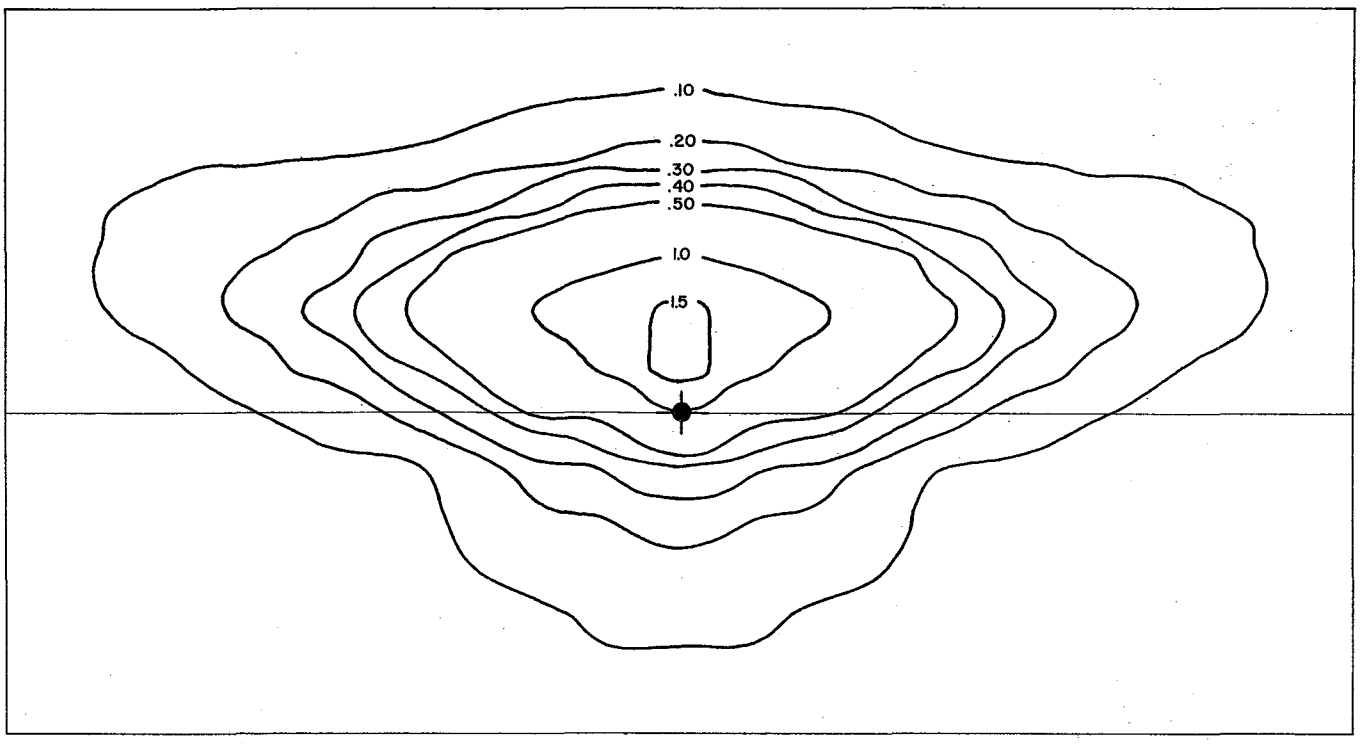


ISO-FOOTCANDLE CURVE
SINGLE LUMINAIRE

LUMINAIRE: 400 WATT, TYPE III$_4$
MOUNTING HEIGHT: 40'

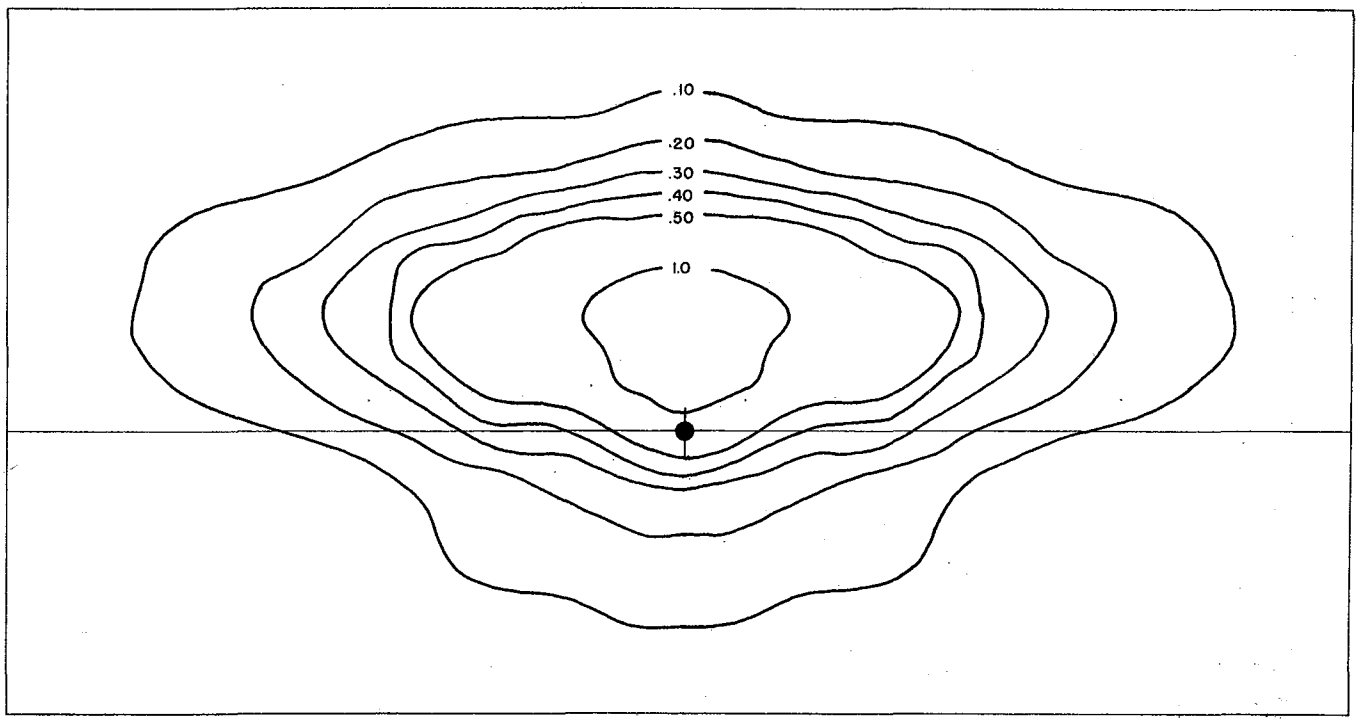
SCALE: 0 10 20 30 40 50
FEET

FIGURE 8 - ISOLUX CHARTS OF INDIVIDUAL LUMINAIRES



ISO-FOOTCANDLE CURVE
SINGLE LUMINAIRE

LUMINAIRE: 400 WATT, TYPE III 4
MOUNTING HEIGHT 45'

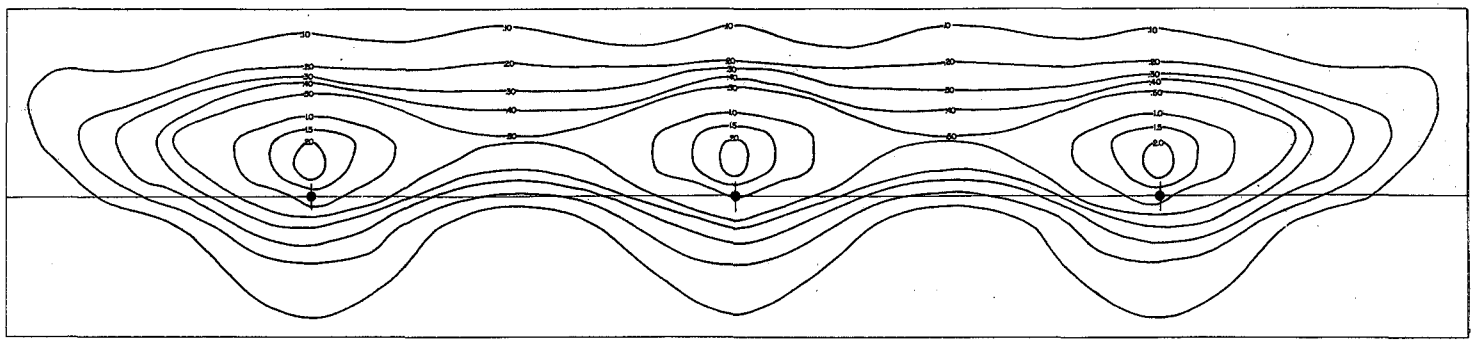


ISO-FOOTCANDLE CURVE
SINGLE LUMINAIRE

LUMINAIRE: 400 WATT, TYPE III 4
MOUNTING HEIGHT: 50'

SCALE: 0 10 20 30 40 50
FEET

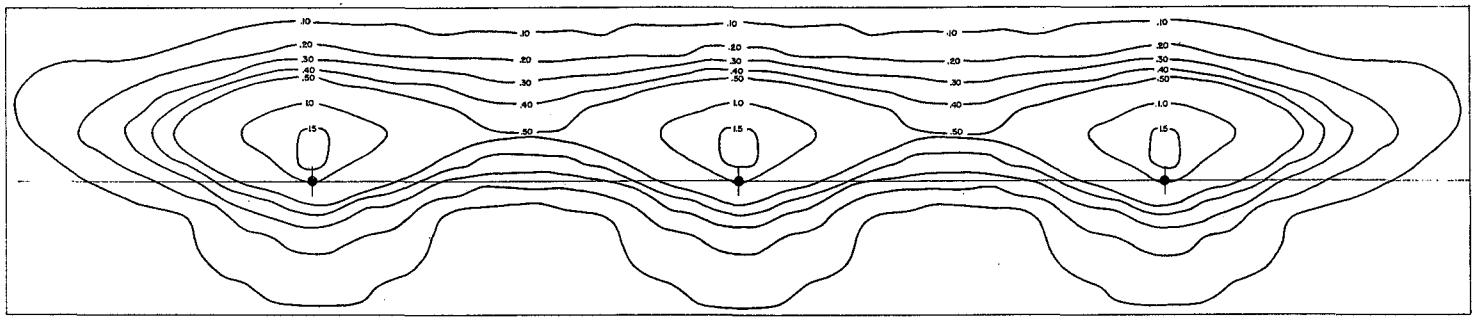
FIGURE 9 - ISOLUX CHARTS OF INDIVIDUAL LUMINAIRES



LUMINAIRE: 400 WATT, TYPE III.
MOUNTING HEIGHT: 40'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

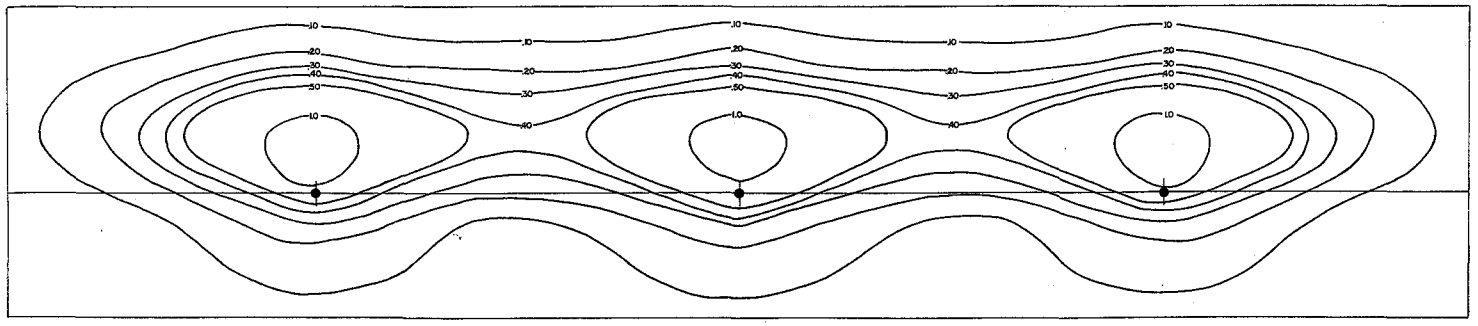
LONGITUDINAL SPACING: 200'



LUMINAIRE: 400 WATT, TYPE III.
MOUNTING HEIGHT: 45'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 200'

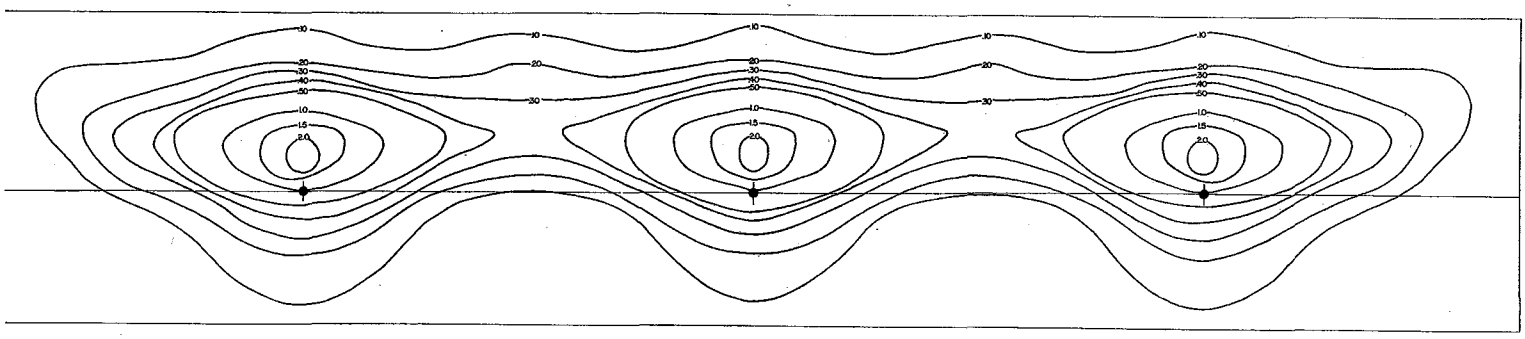


LUMINAIRE: 400 WATT, TYPE III.
MOUNTING HEIGHT: 50'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 200'
SCALE: 0 20 40 60 80 100 FEET

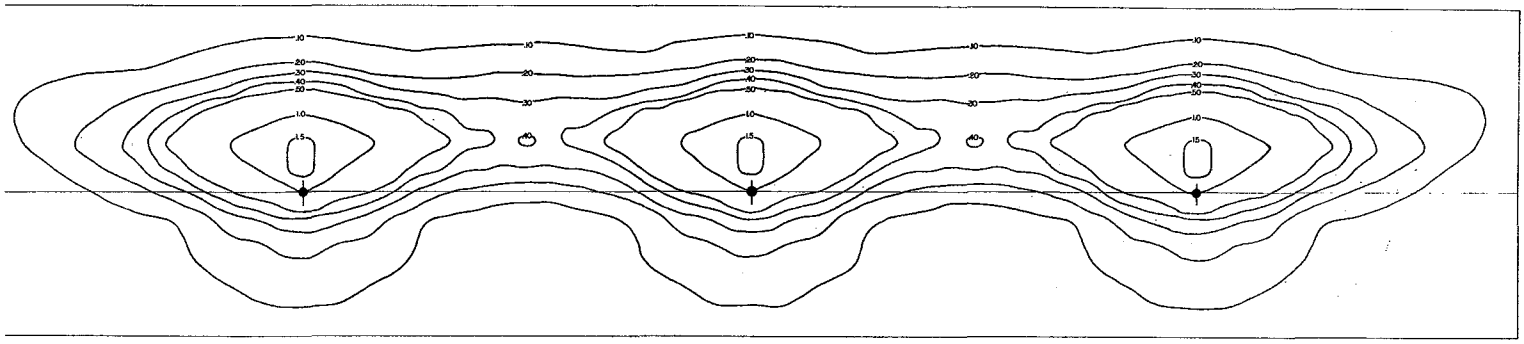
FIGURE 10- ISOLUX CHARTS OF ONE-SIDE LIGHTING SYSTEMS



LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 40'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

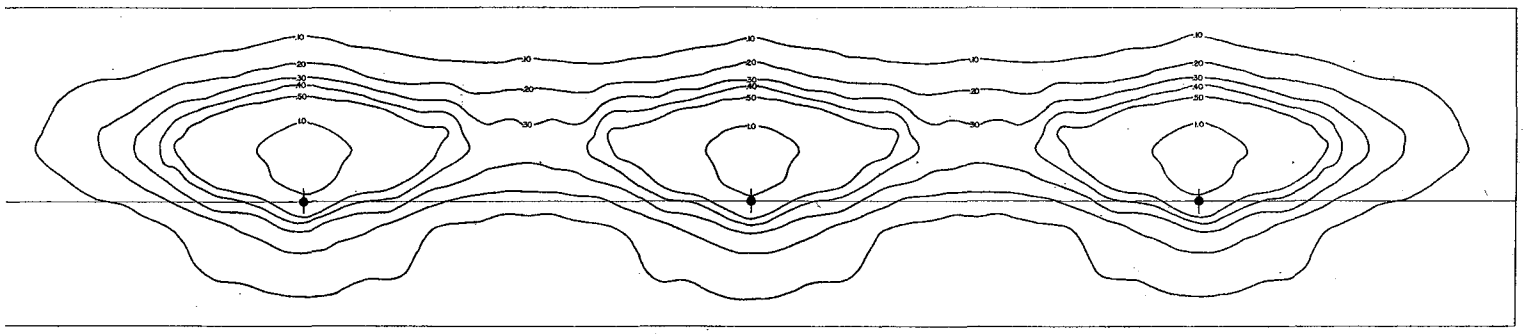
LONGITUDINAL SPACING : 220'



MINAIRE : 400 WATT, TYPE III.
)UNTING HEIGHT : 45'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING : 220'

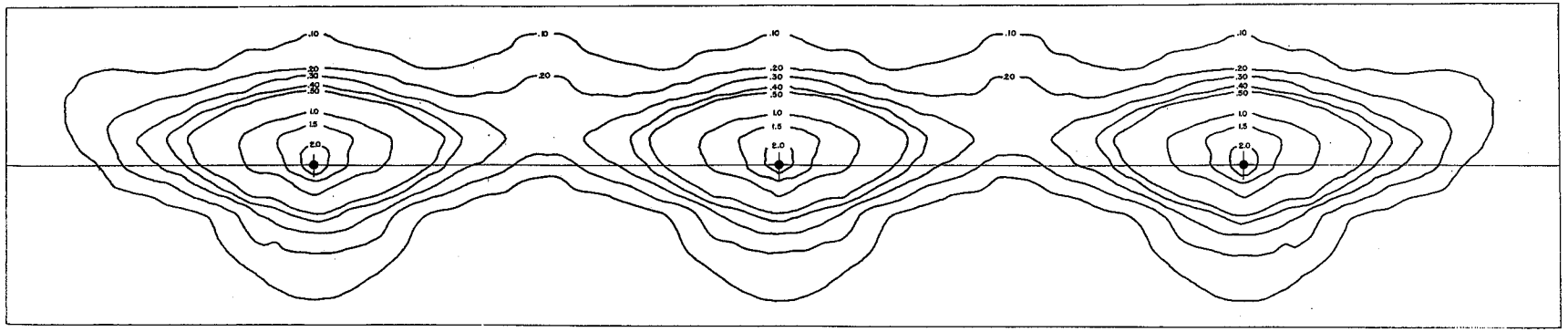


LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 50'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING : 220'
SCALE : 0 20 40 60 80 100 FEET

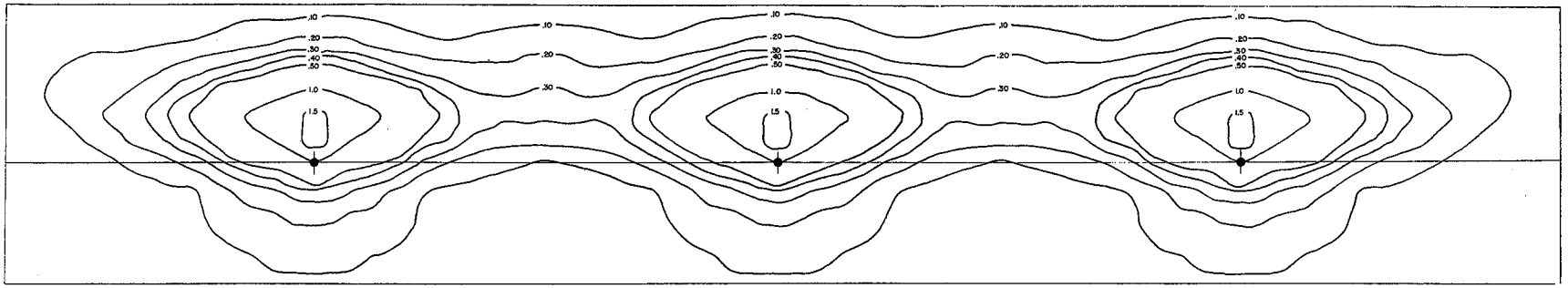
FIGURE 11 - ISOLUX CHARTS OF ONE-SIDE LIGHTING SYSTEMS



LUMINAIRE: 400 WATT, TYPE III,
MOUNTING HEIGHT: 40'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

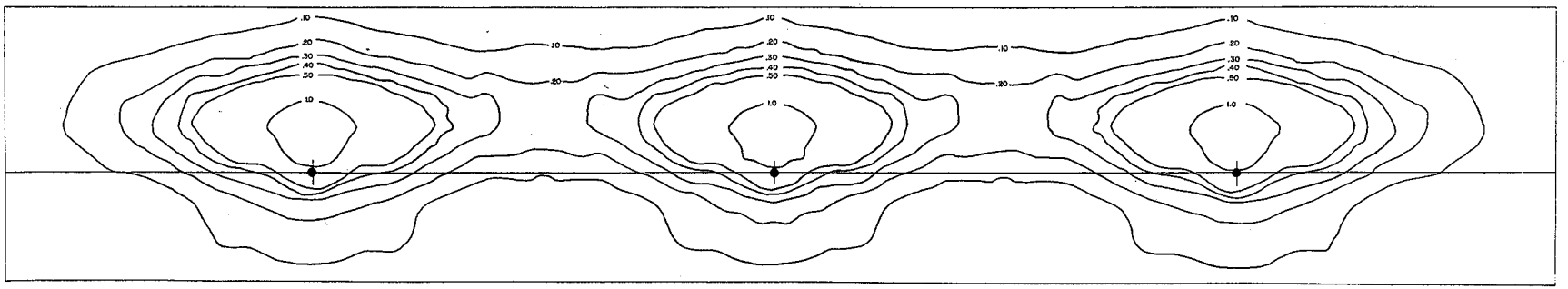
LONGITUDINAL SPACING: 240'



LUMINAIRE: 400 WATT, TYPE III,
MOUNTING HEIGHT: 45'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 240'

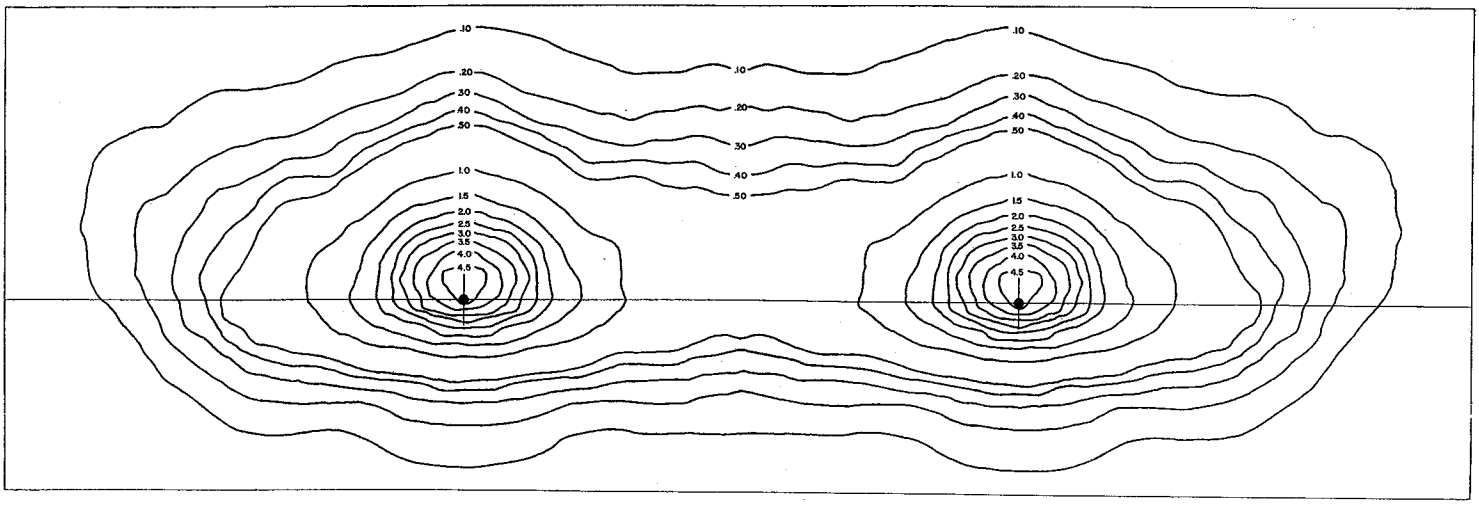


LUMINAIRE: 400 WATT, TYPE III,
MOUNTING HEIGHT: 50'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 240'
SCALE 0 20 40 60 80 100 FEET

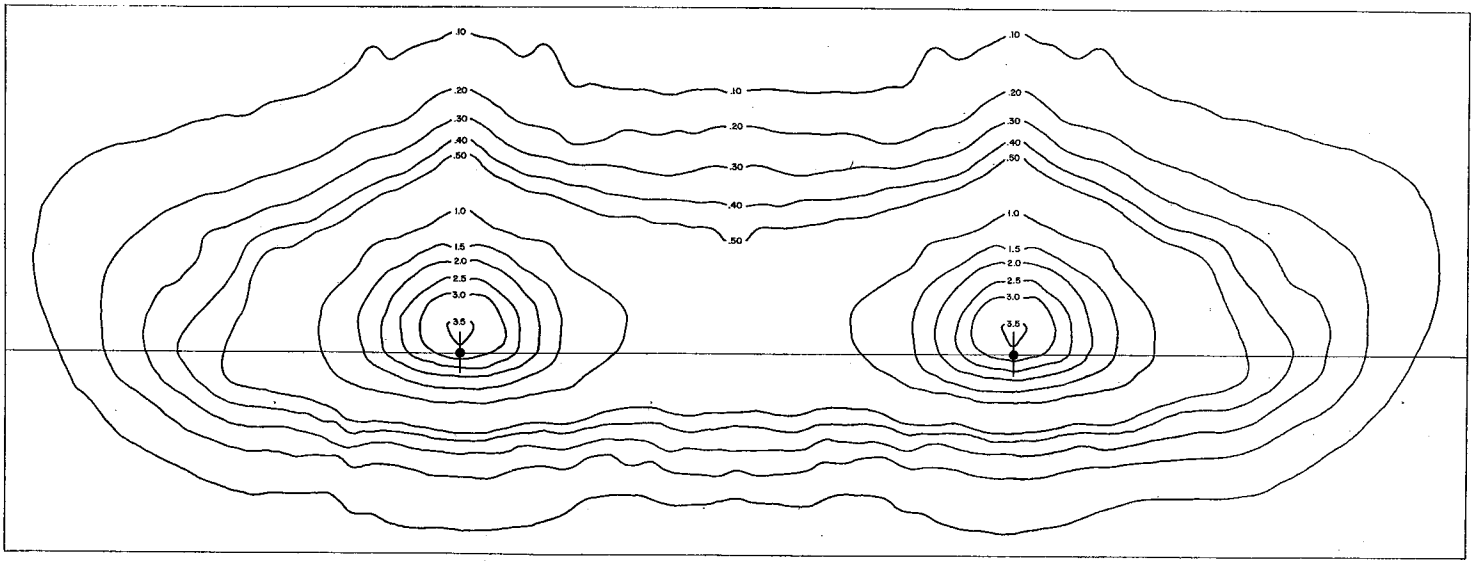
FIGURE 12 – ISOLUX CHARTS OF ONE-SIDE LIGHTING SYSTEMS



LUMINAIRE: 1000 WATT, TYPE III,
MOUNTING HEIGHT: 50'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 260'

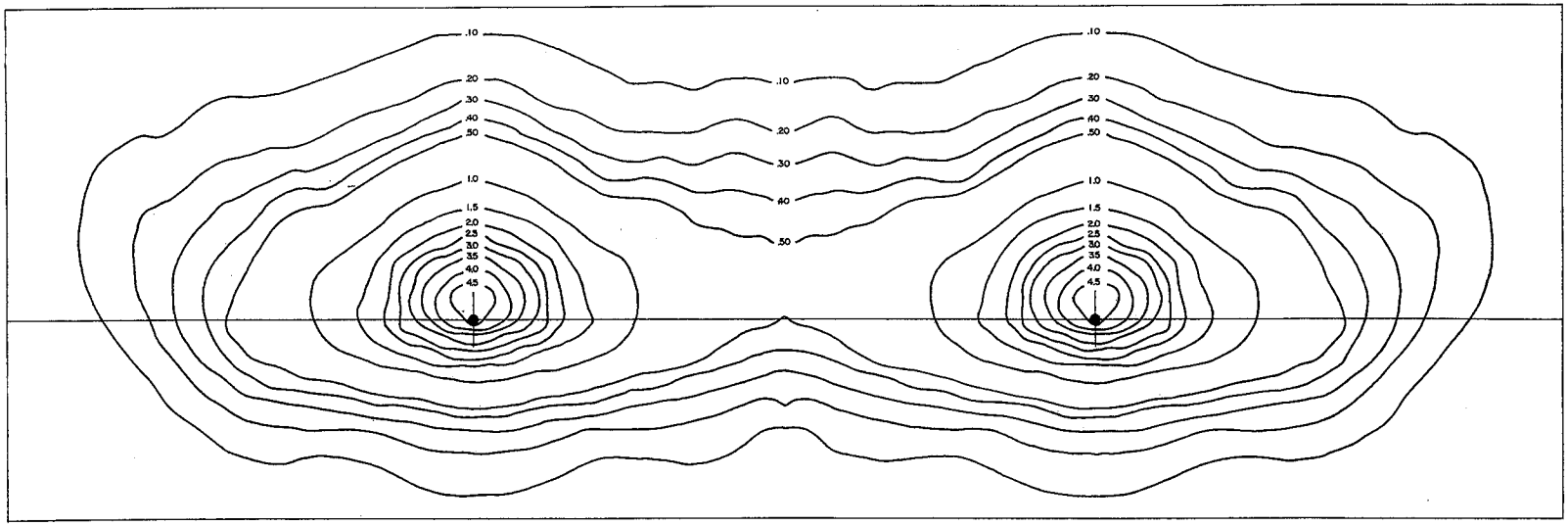


LUMINAIRE: 1000 WATT, TYPE III,
MOUNTING HEIGHT: 60'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 260'
SCALE:

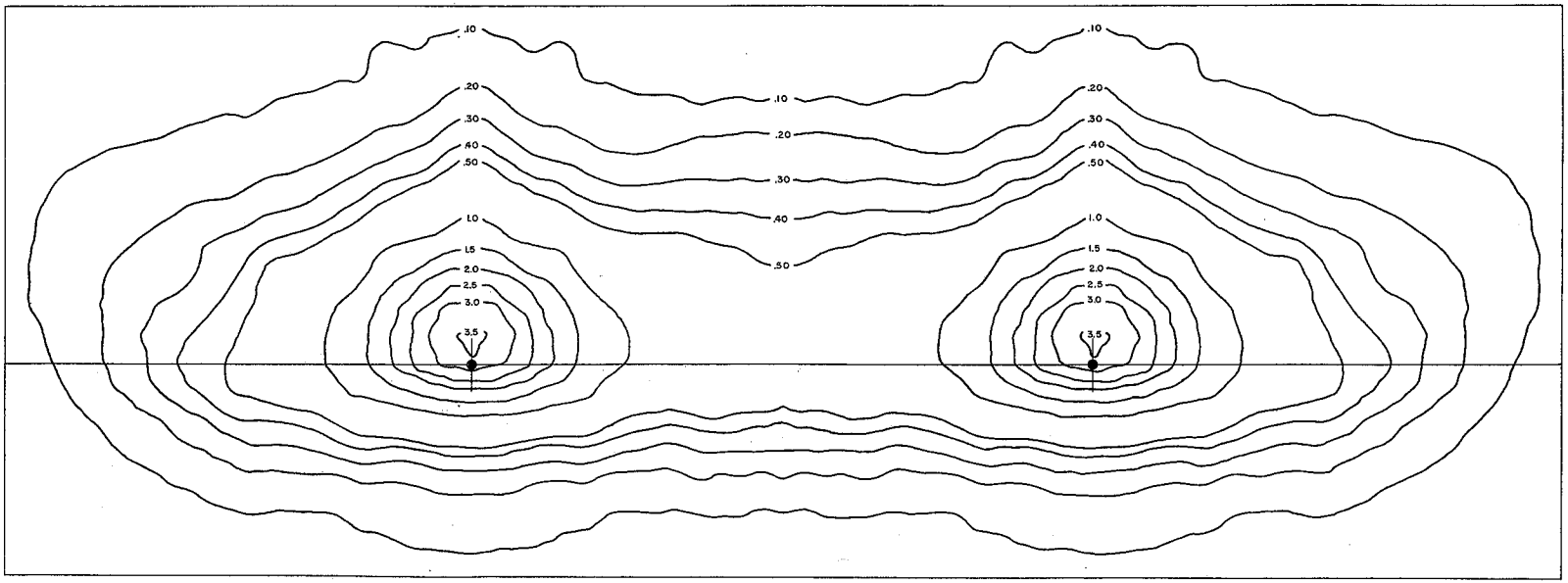
FIGURE 13 - ISOLUX CHARTS OF ONE-SIDE LIGHTING SYSTEMS



LUMINAIRE: 1000 WATT, TYPE III,
MOUNTING HEIGHT : 50'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING : 280'



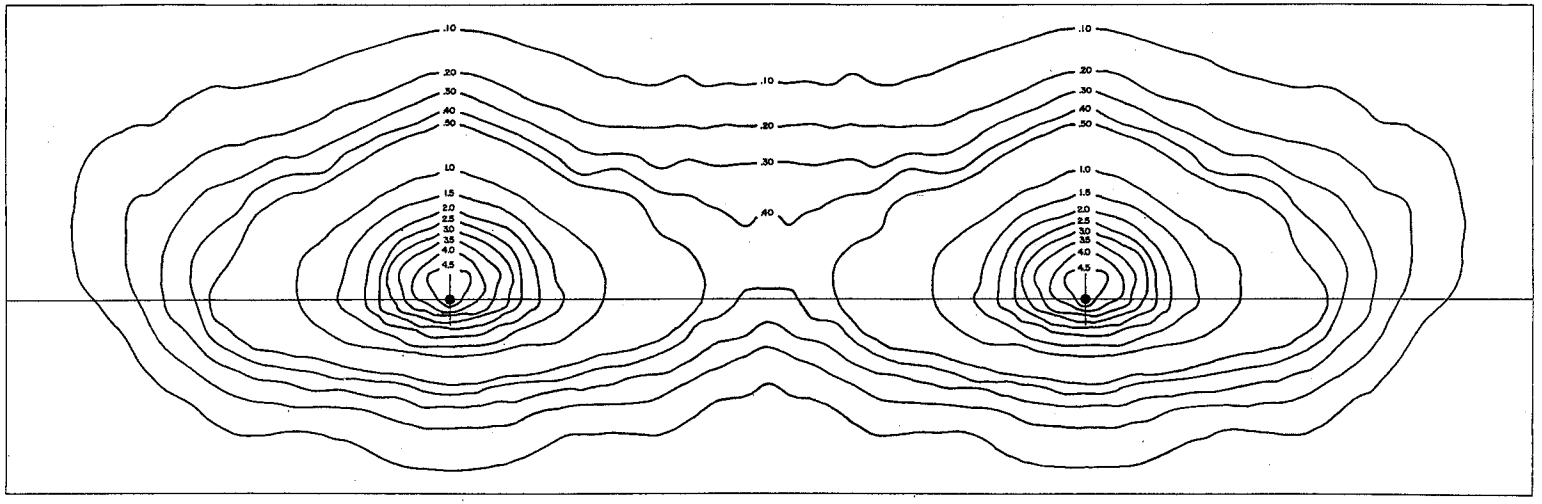
LUMINAIRE: 1000 WATT, TYPE III,
MOUNTING HEIGHT : 60'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING : 280'

SCALE: 0 20 40 60 80 100 FEET

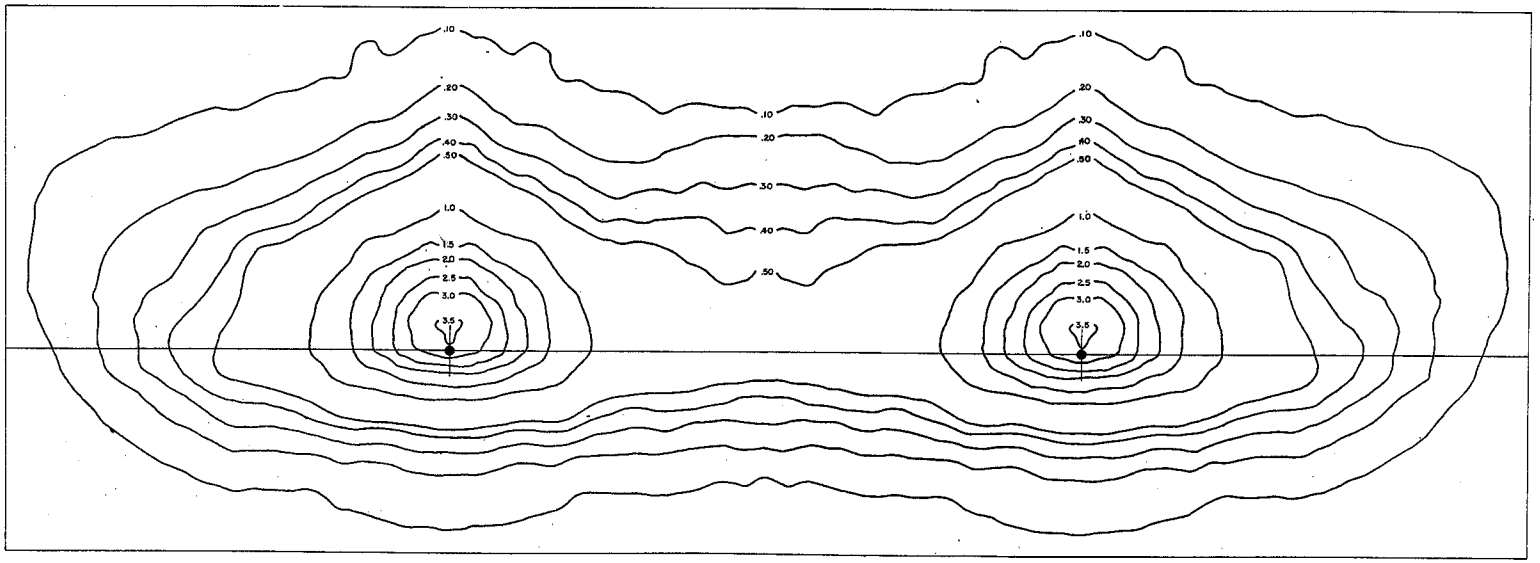
FIGURE 14 - ISOLUX CHARTS OF ONE-SIDE LIGHTING SYSTEMS



LUMINAIRE: 1000 WATT, TYPE III,
MOUNTING HEIGHT: 50'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 300'

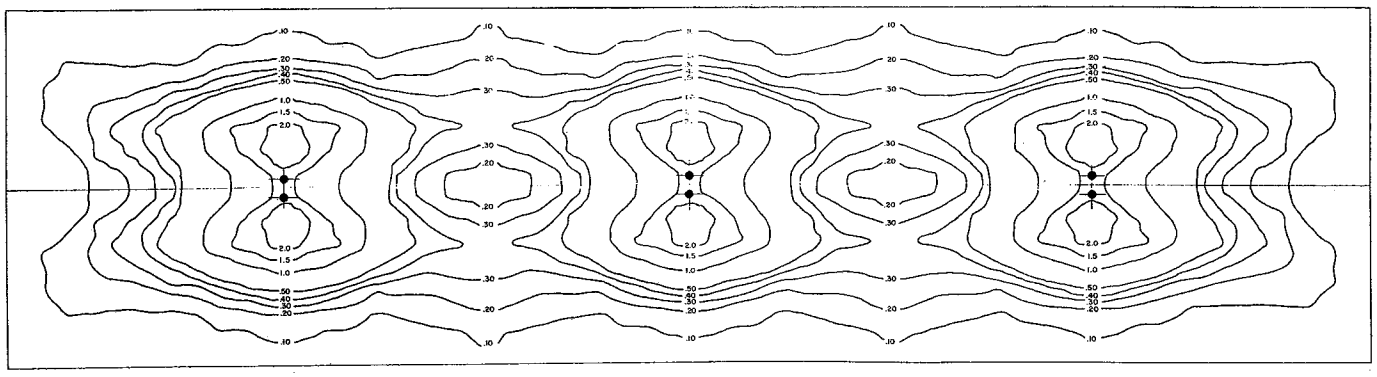


LUMINAIRE: 1000 WATT, TYPE III,
MOUNTING HEIGHT: 60'

ISO-FOOTCANDLE CURVE
ONE-SIDE LIGHTING

LONGITUDINAL SPACING: 300'
SCALE: 0 20 40 60 80 100 FEET

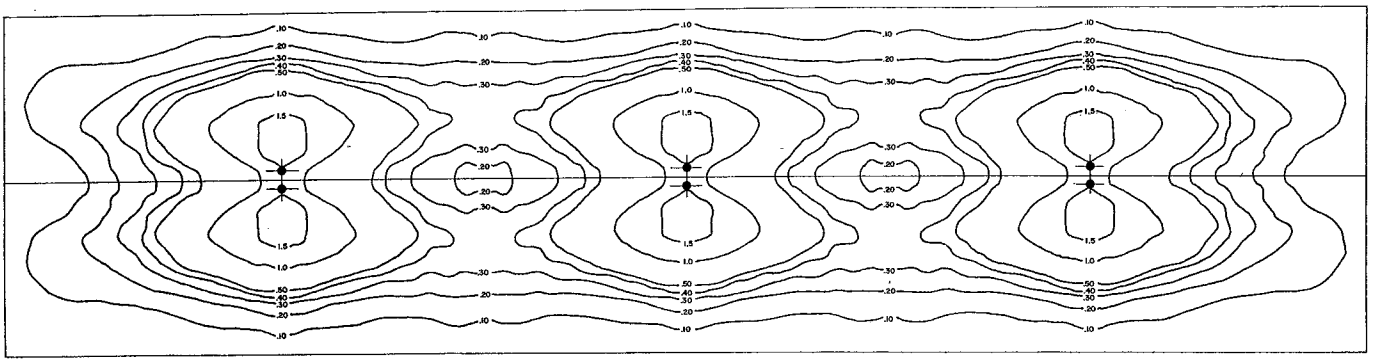
FIGURE 15– ISOLUX CHARTS OF ONE-SIDE LIGHTING SYSTEMS



LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 40'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

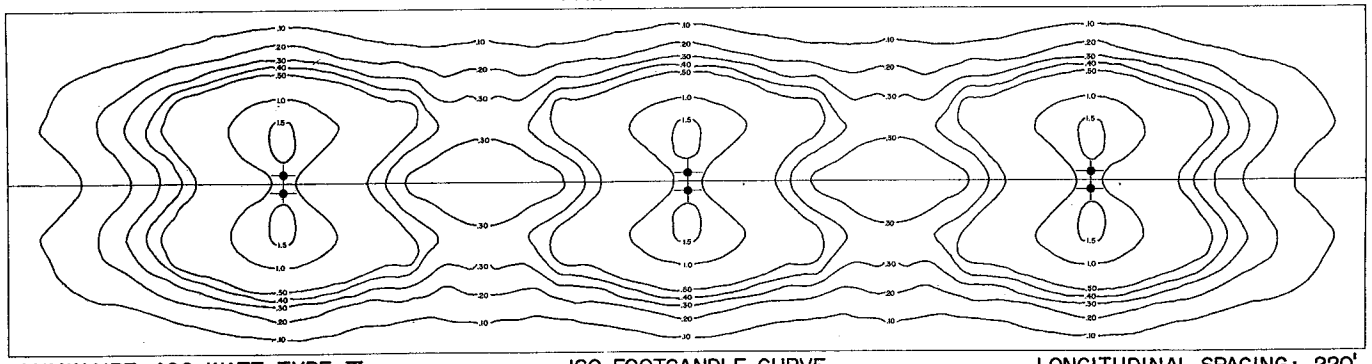
LONGITUDINAL SPACING : 220'
TRANSVERSE SPACING : 10'



LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 45'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 220'
TRANSVERSE SPACING : 10'



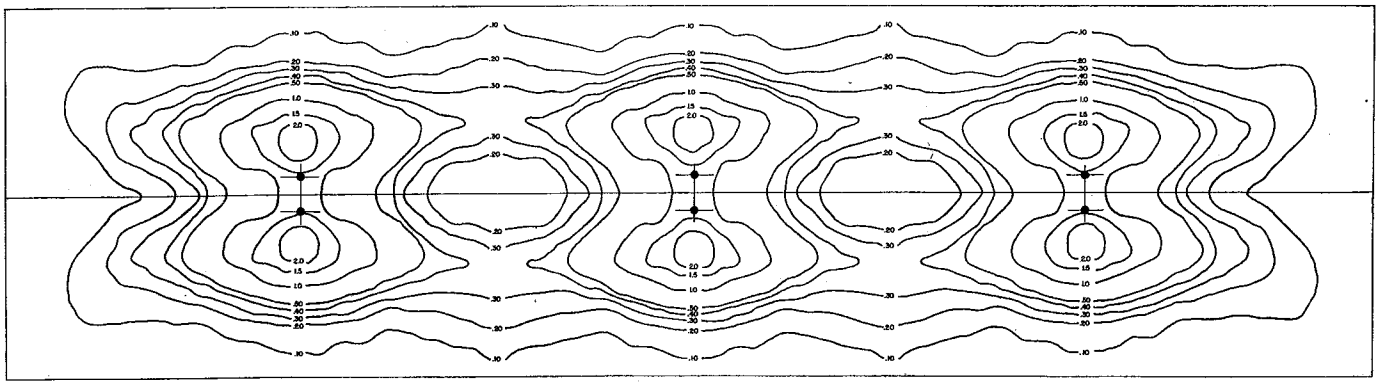
LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 50'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 220'
TRANSVERSE SPACING : 10'

SCALE : 0 20 40 60 80 100 FEET

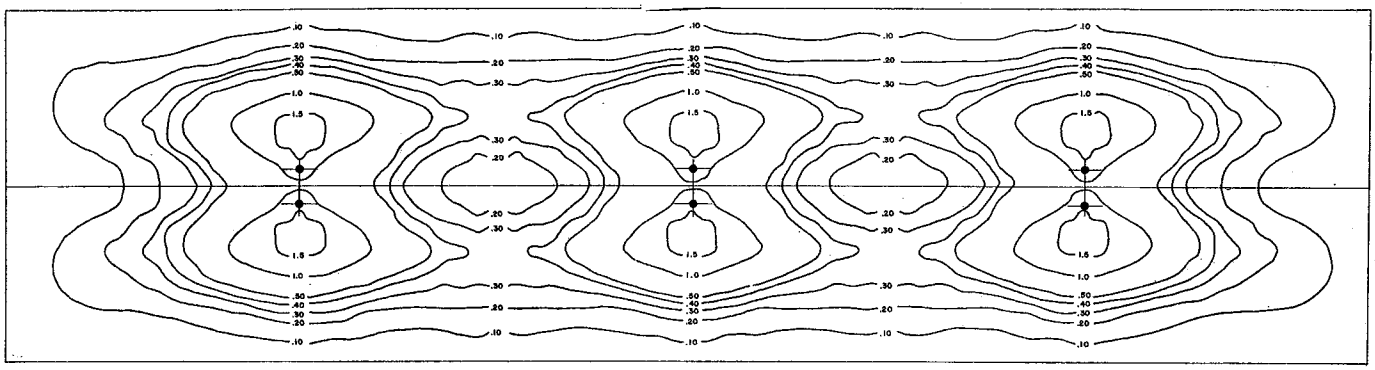
FIGURE 16 - ISOLUX CHARTS OF MEDIAN LIGHTING SYSTEMS



LUMINAIRE: 400 WATT, TYPE III.
MOUNTING HEIGHT: 40'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

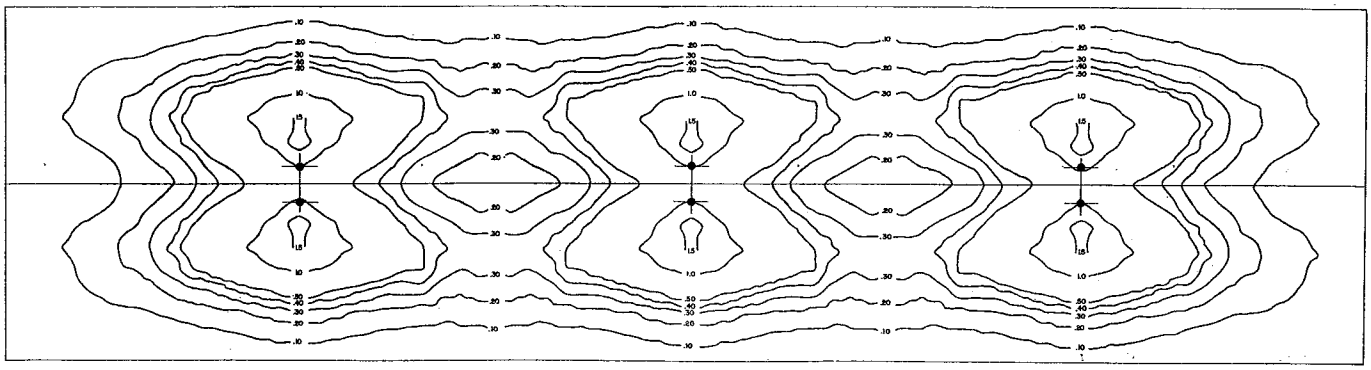
LONGITUDINAL SPACING: 220'
TRANSVERSE SPACING: 20'



LUMINAIRE: 400 WATT, TYPE III.
MOUNTING HEIGHT: 45'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING: 220'
TRANSVERSE SPACING: 20'



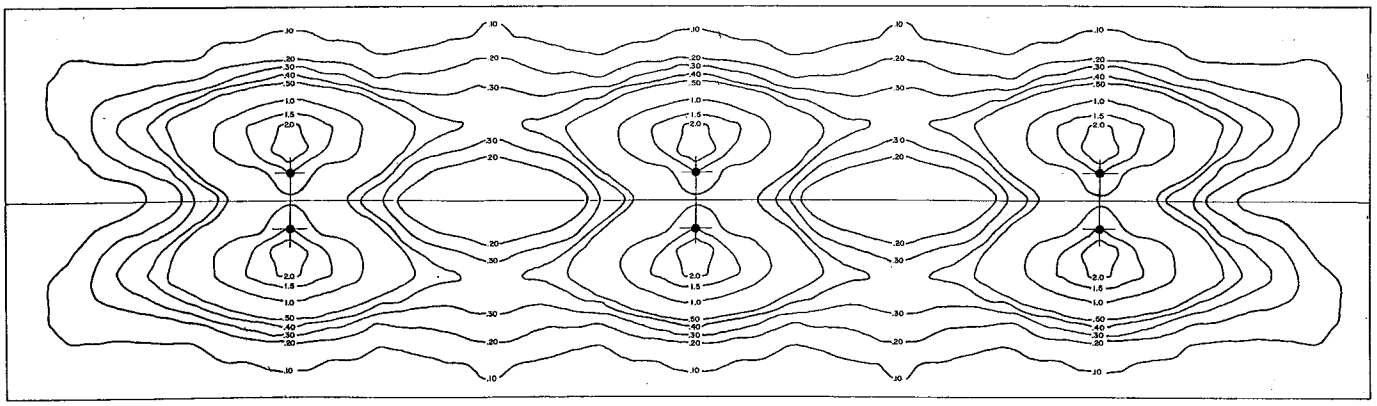
LUMINAIRE: 400 WATT, TYPE III.
MOUNTING HEIGHT: 50'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING: 220'
TRANSVERSE SPACING: 20'

SCALE: 0 20 40 60 80 100 FEET

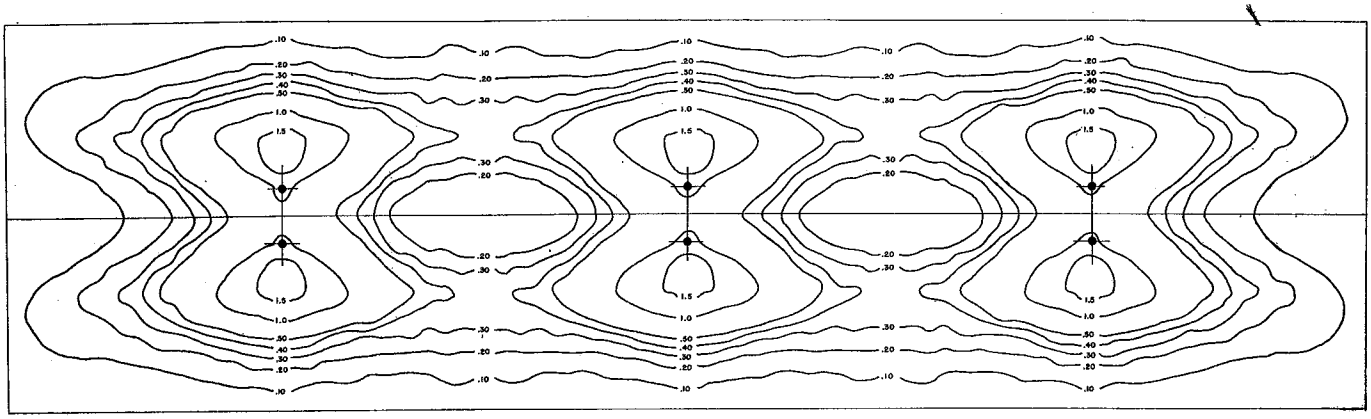
FIGURE 17-ISOLUX CHARTS OF MEDIAN LIGHTING SYSTEMS



LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 40'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

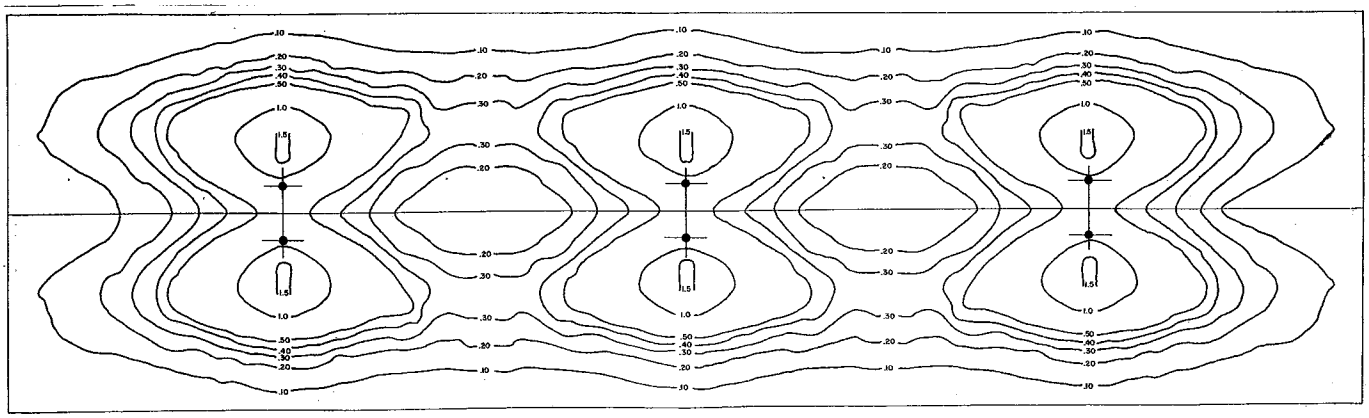
LONGITUDINAL SPACING : 220'
TRANSVERSE SPACING : 30'



LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 45'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING: 220'
TRANSVERSE SPACING : 30'



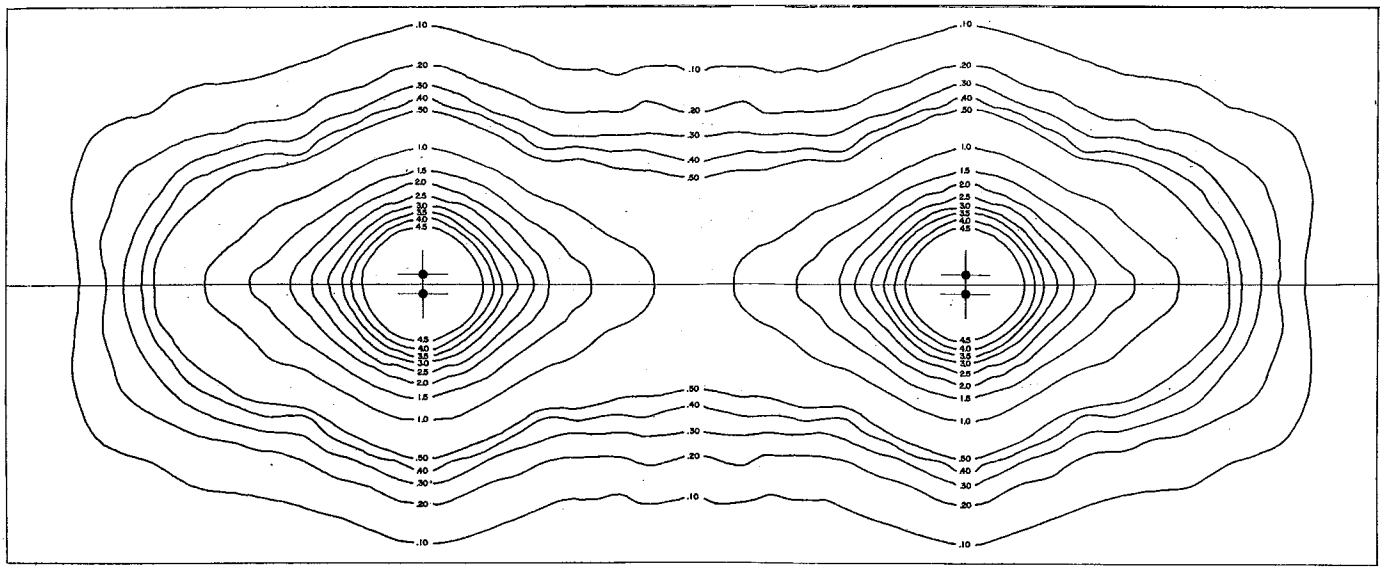
LUMINAIRE : 400 WATT, TYPE III.
MOUNTING HEIGHT : 50'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 220'
TRANSVERSE SPACING : 30'

SCALE : 0 20 40 60 80 100 FEET

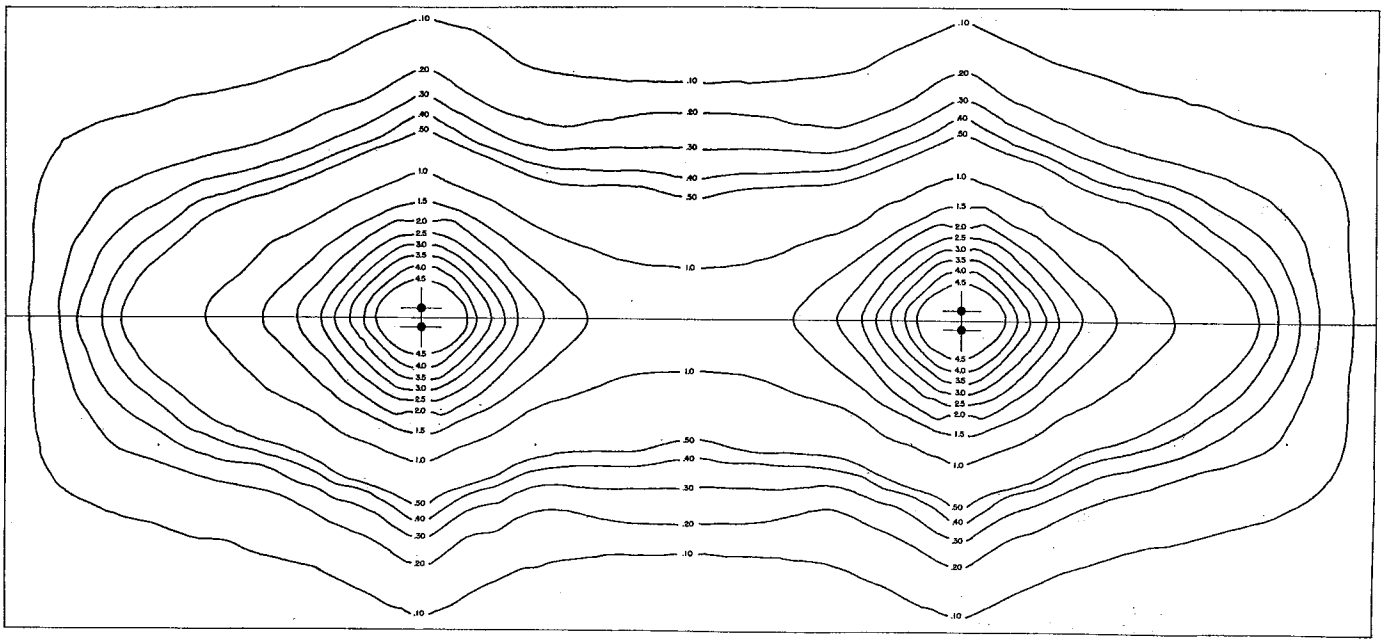
FIGURE 18 - ISOLUX CHARTS OF MEDIAN LIGHTING SYSTEMS



LUMINAIRE : 1000 WATT, TYPE III.
MOUNTING HEIGHT : 50'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 280'
TRANSVERSE SPACING : 10'



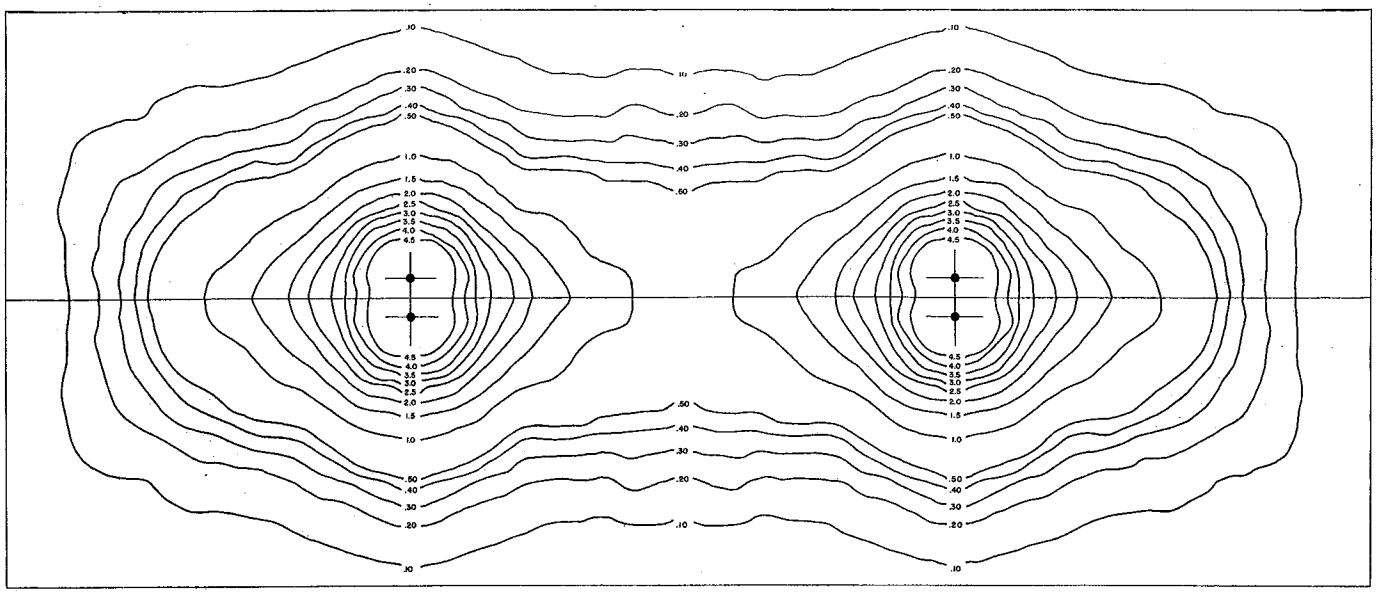
LUMINAIRE : 1000 WATT, TYPE III.
MOUNTING HEIGHT : 60'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 280'
TRANSVERSE SPACING : 10'

SCALE : 0 20 40 60 80 100 FEET

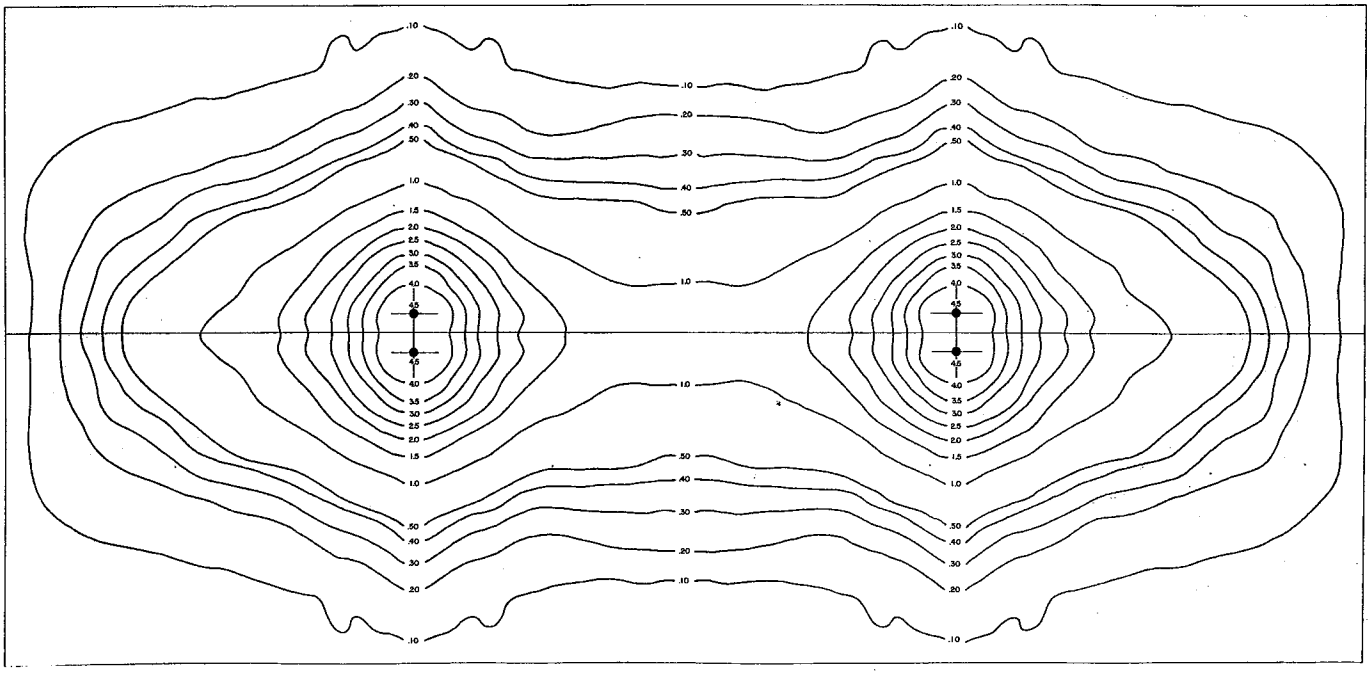
FIGURE 19 - ISOLUX CHARTS OF MEDIAN LIGHTING SYSTEMS



LUMINAIRE: 1000 WATT, TYPE III.
MOUNTING HEIGHT: 50'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING: 280'
TRANSVERSE SPACING: 20'



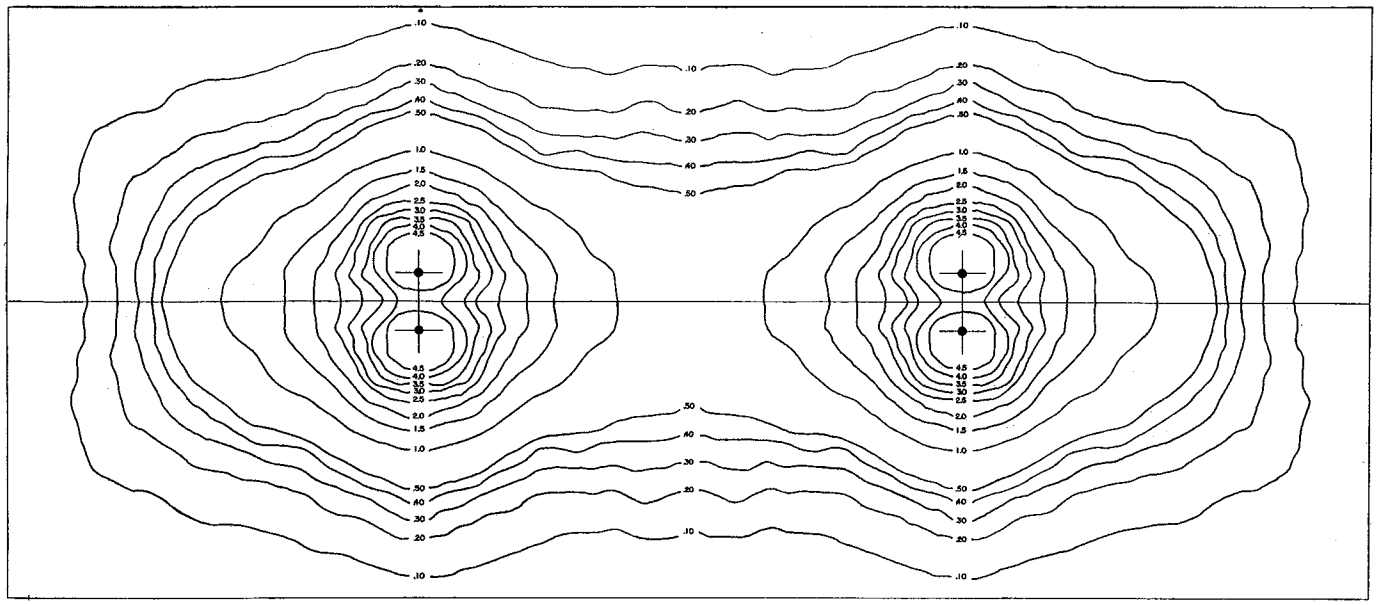
LUMINAIRE : 1000 WATT , TYPE III.
MOUNTING HEIGHT : 60'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 280'
TRANSVERSE SPACING : 20'

SCALE: 0 20 40 60 80 100 FEET

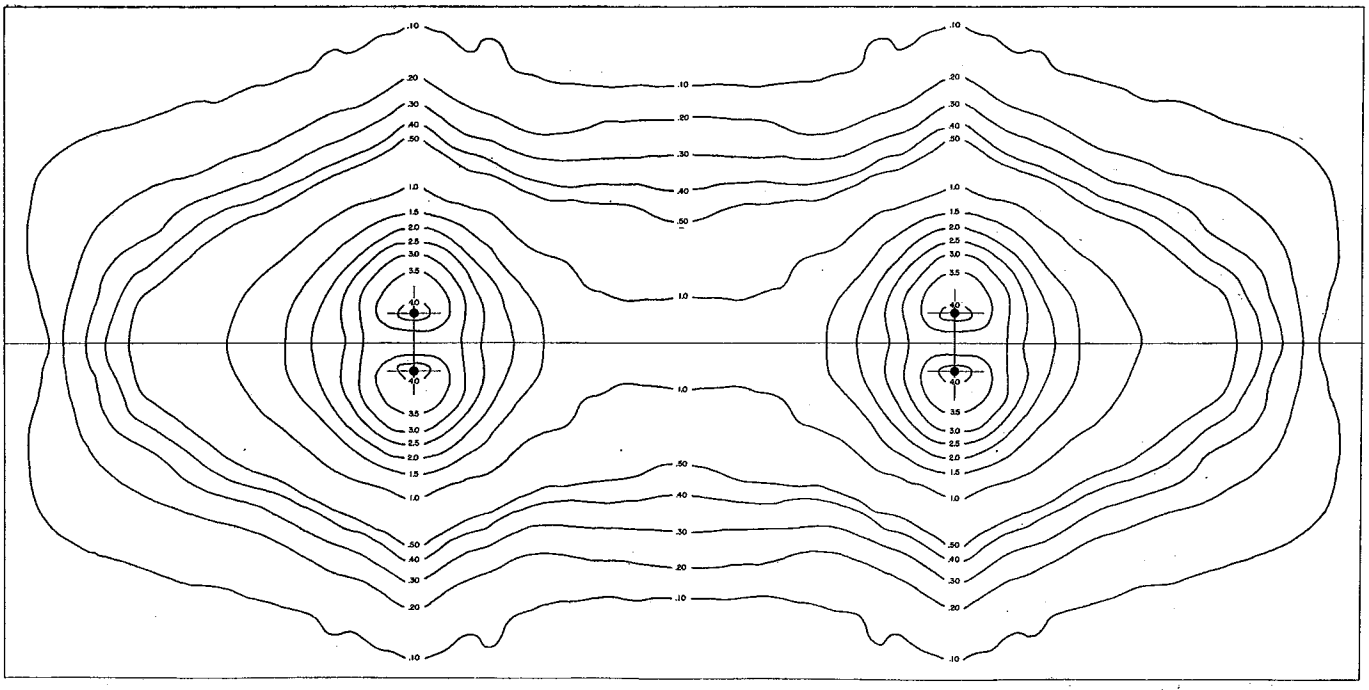
FIGURE 20- ISOLUX CHARTS OF MEDIAN LIGHTING SYSTEMS



LUMINAIRE : 1000 WATT, TYPE III.
MOUNTING HEIGHT : 50'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 280'
TRANSVERSE SPACING : 30'



LUMINAIRE : 1000 WATT, TYPE III.
MOUNTING HEIGHT : 60'

ISO-FOOTCANDLE CURVE
MEDIAN LIGHTING

LONGITUDINAL SPACING : 280'
TRANSVERSE SPACING : 30'

SCALE : 0 20 40 60 80 100 FEET

FIGURE 21— ISOLUX CHARTS OF MEDIAN LIGHTING SYSTEMS

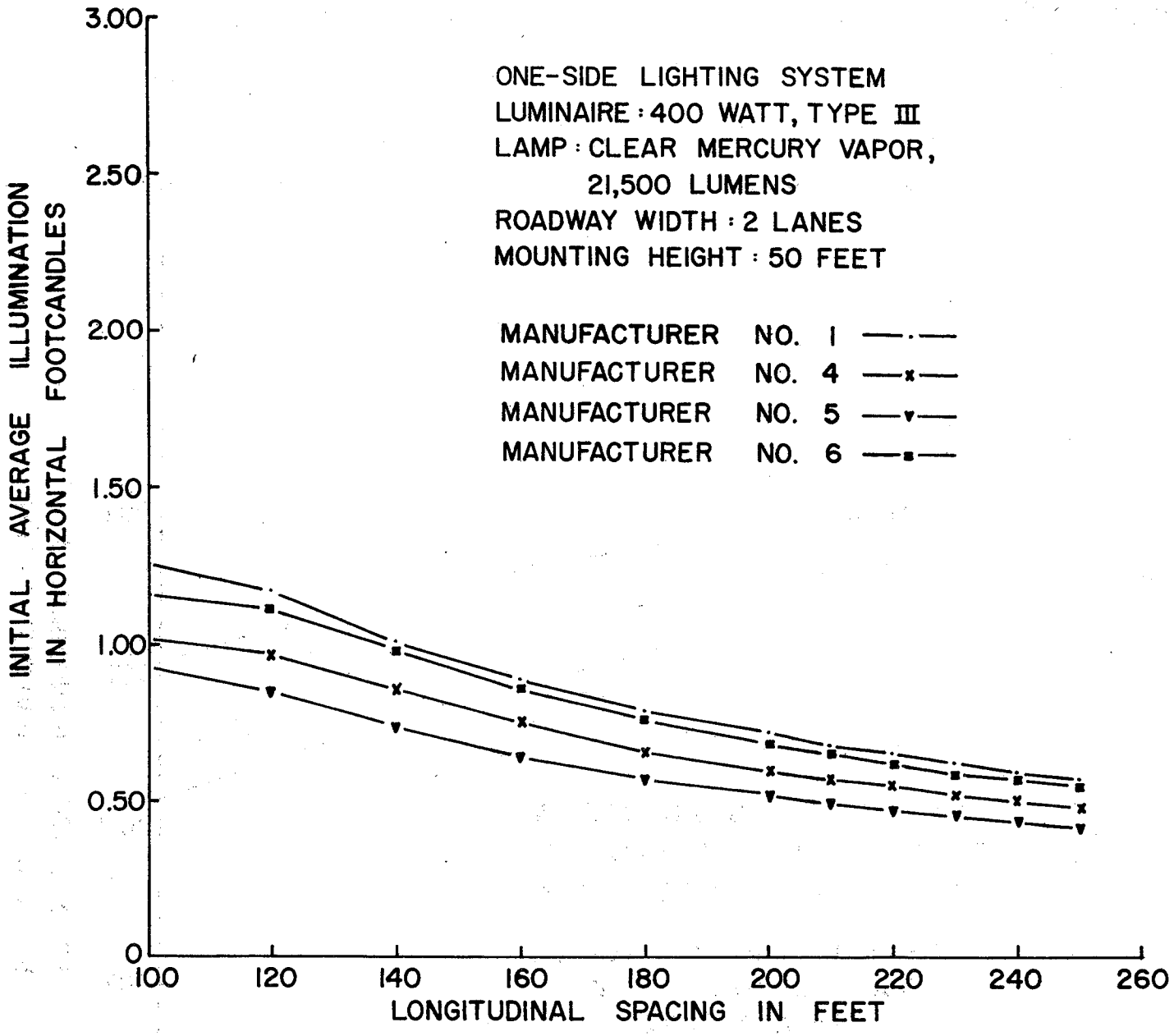


FIGURE 22- INITIAL AVERAGE ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MANUFACTURERS

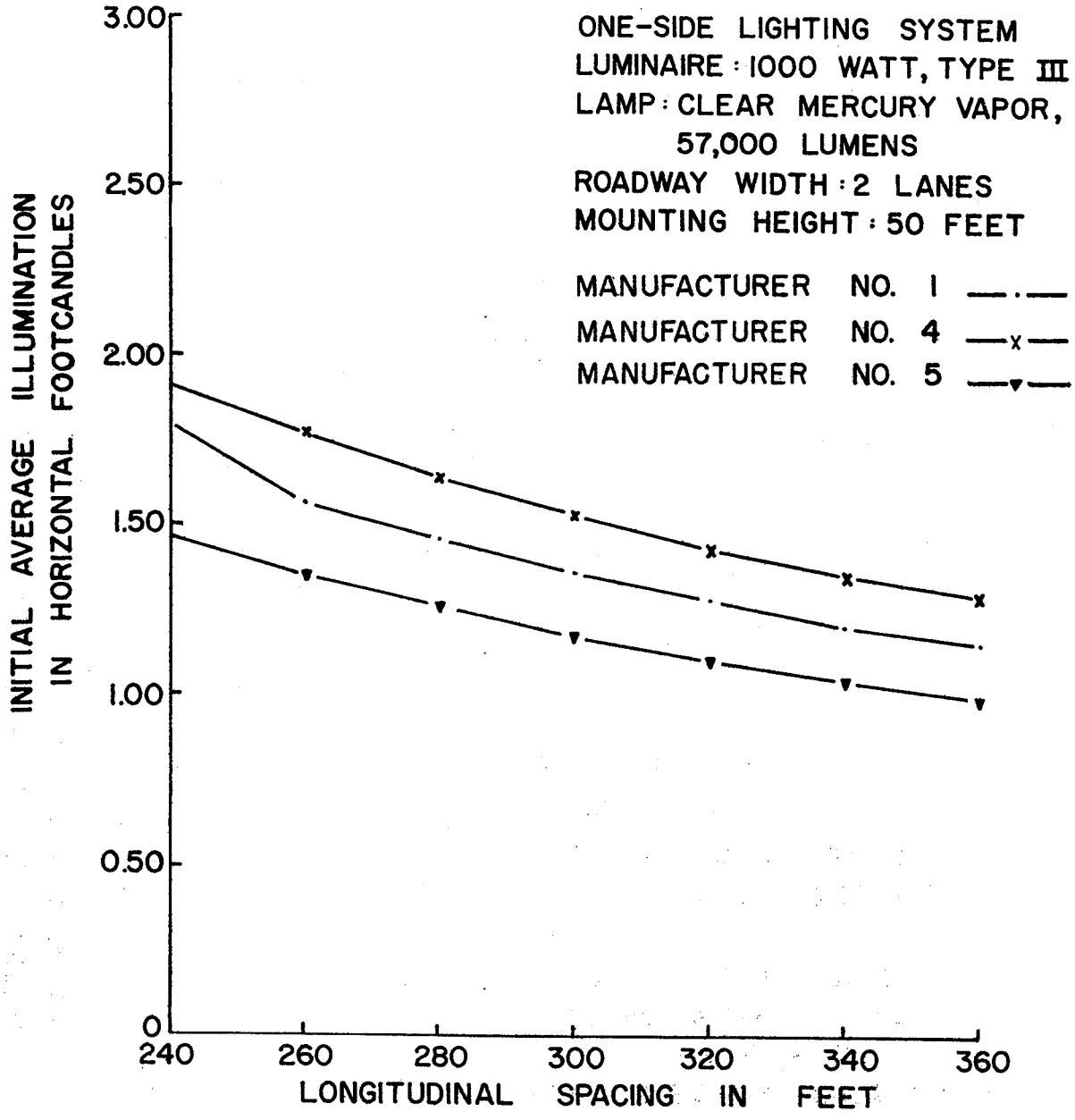


FIGURE 23– INITIAL AVERAGE ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MANUFACTURERS

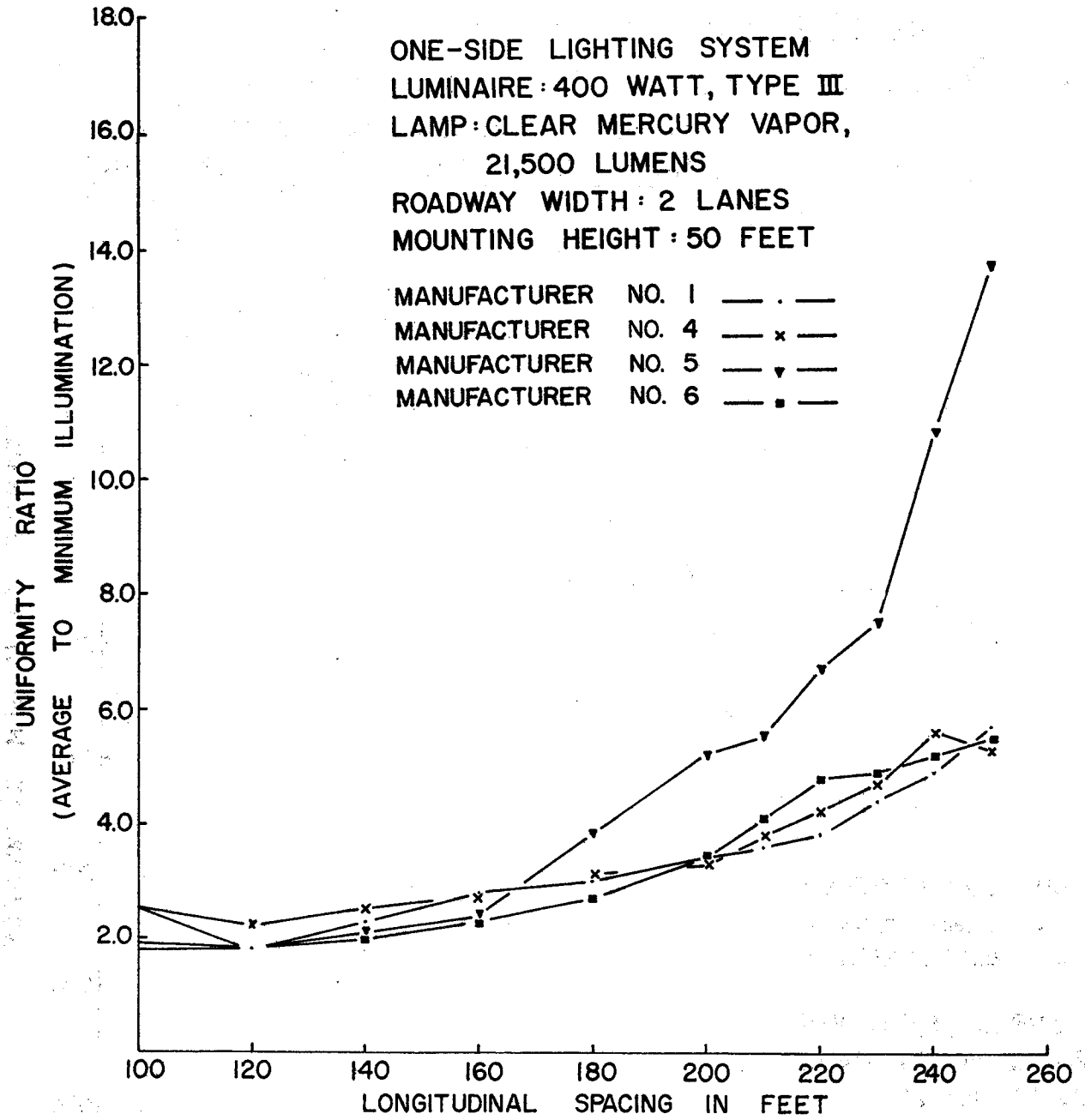


FIGURE 24 – UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT MANUFACTURERS

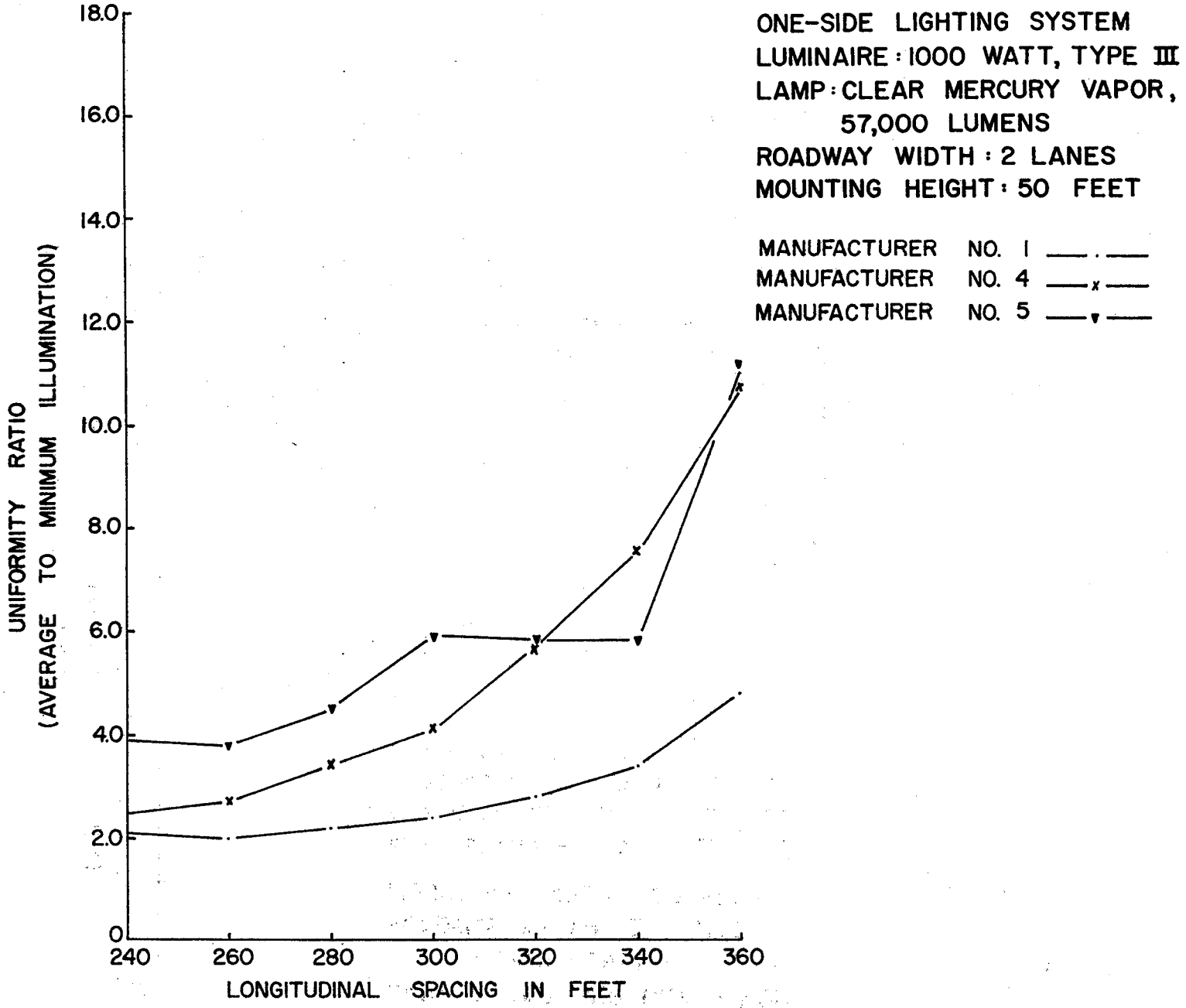


FIGURE 25–UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT MANUFACTURERS

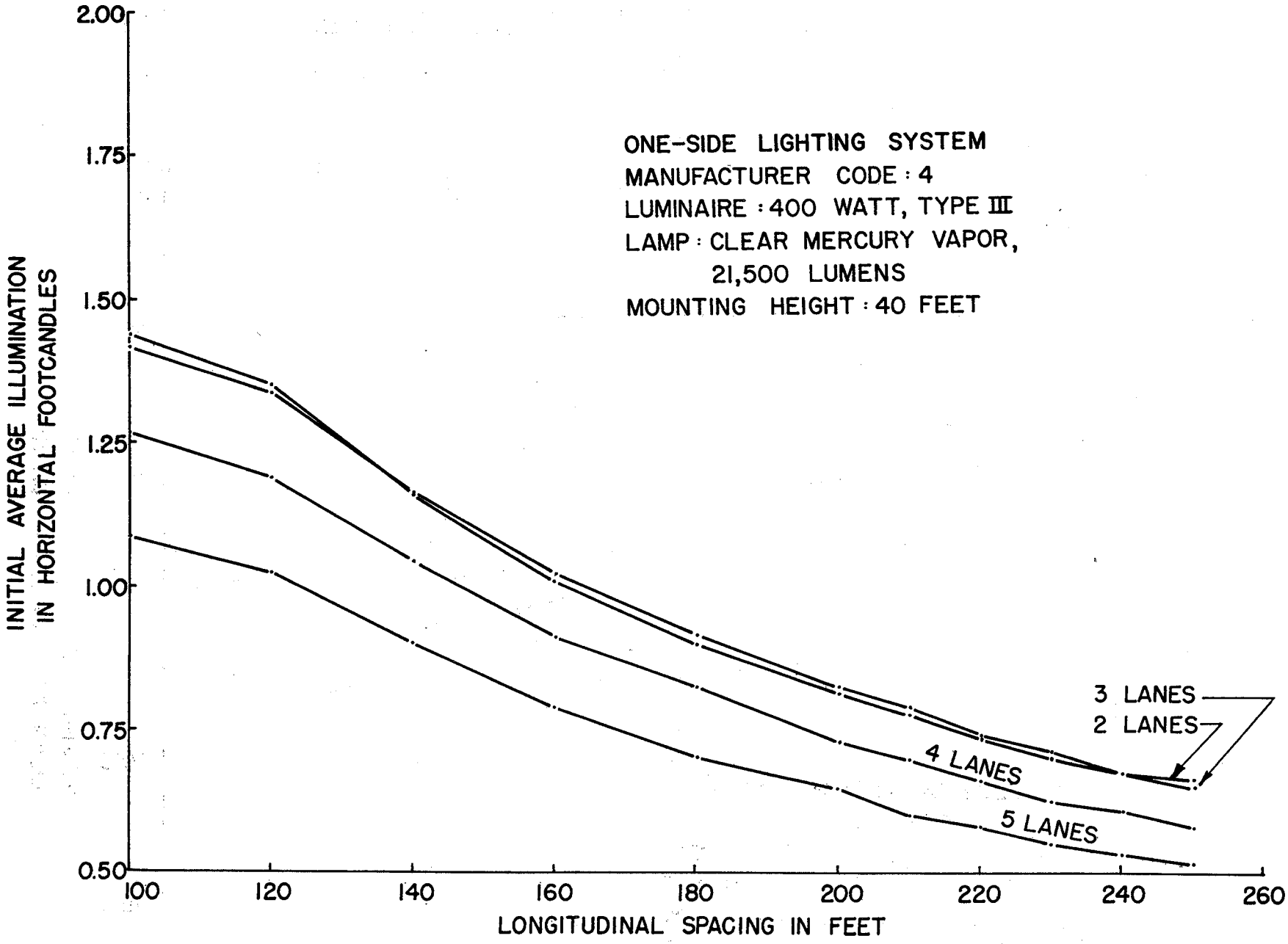


FIGURE 26-INITIAL AVERAGE ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

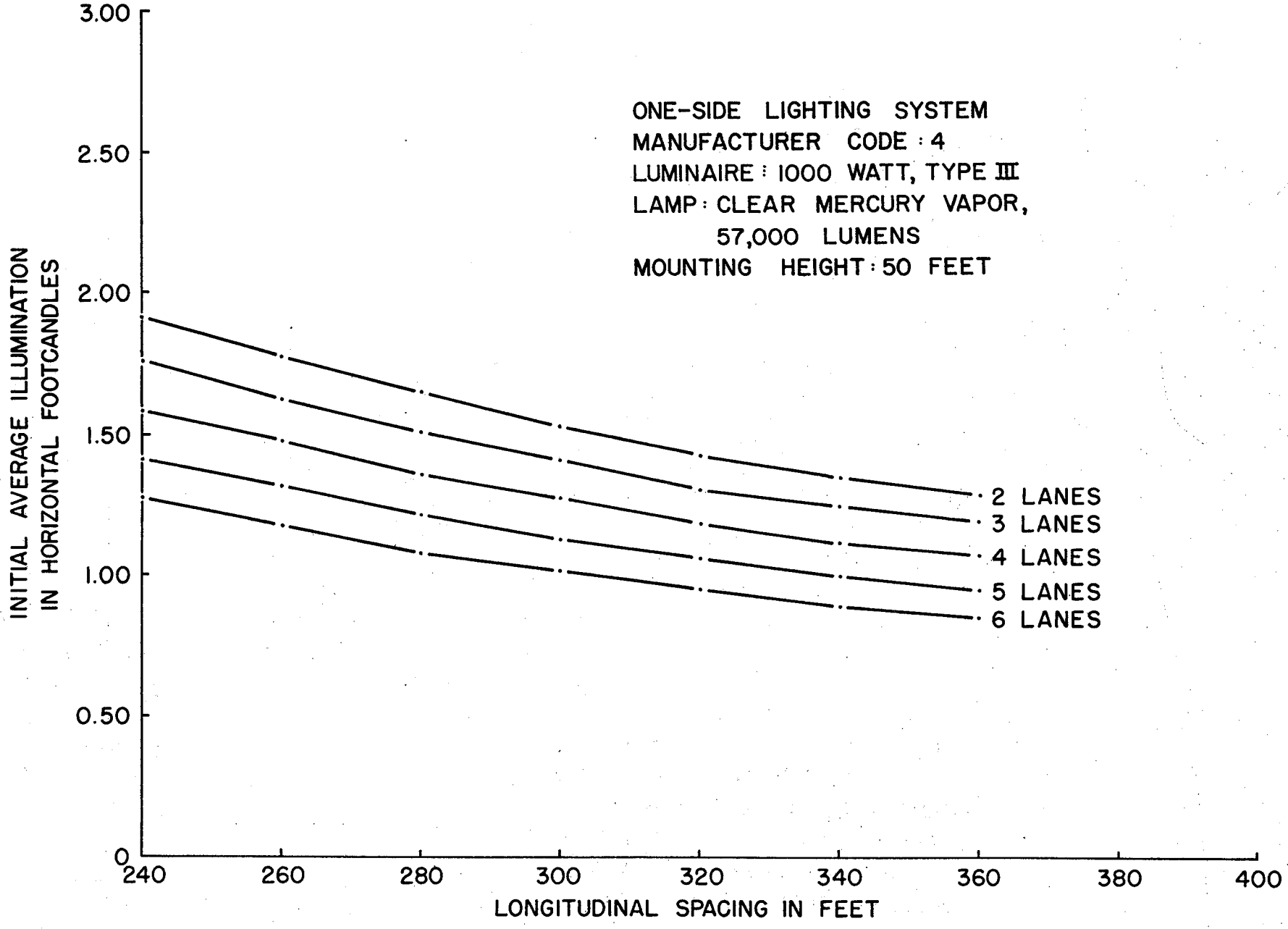


FIGURE 27 - INITIAL AVERAGE ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

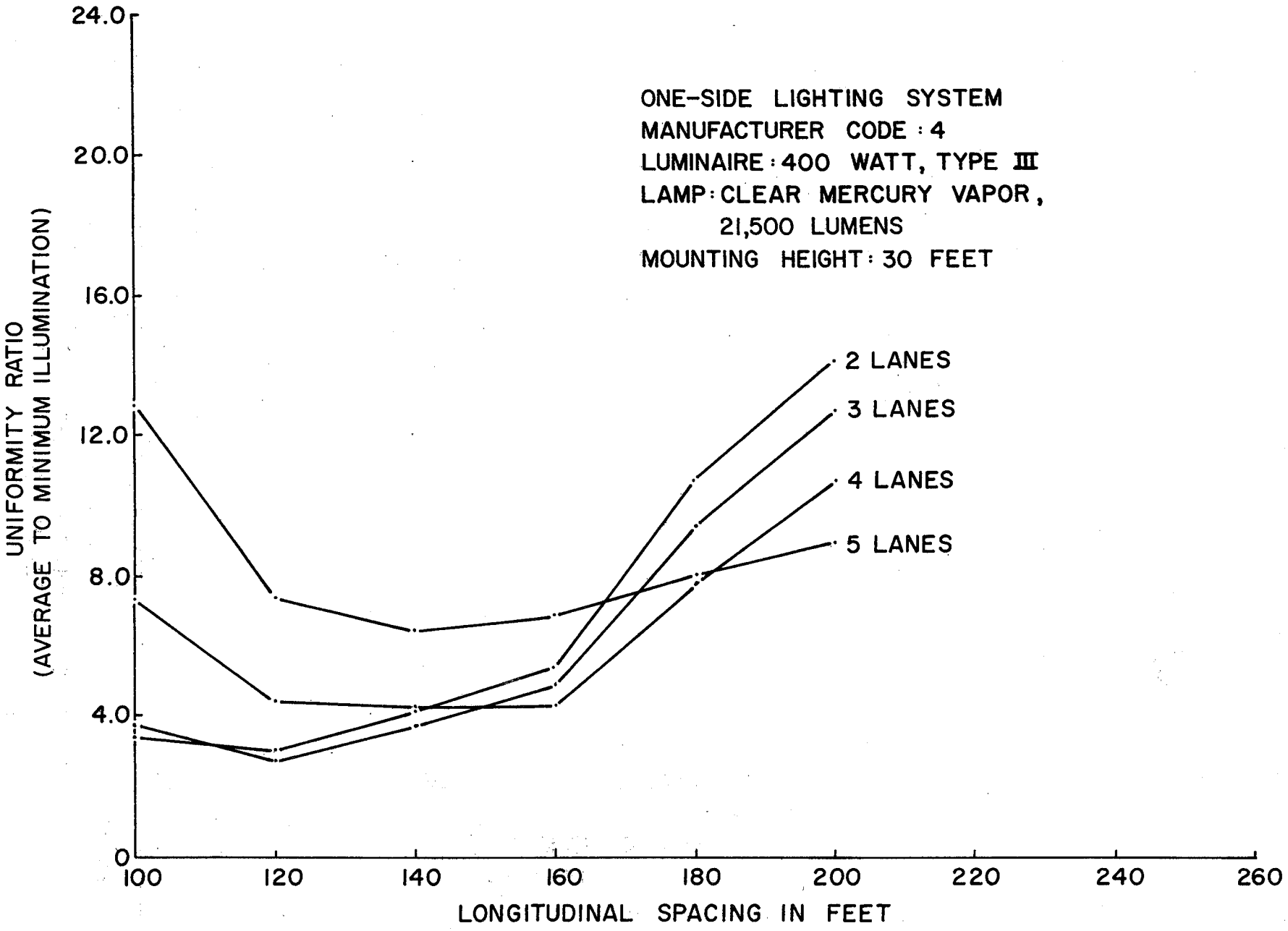


FIGURE 28 - UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

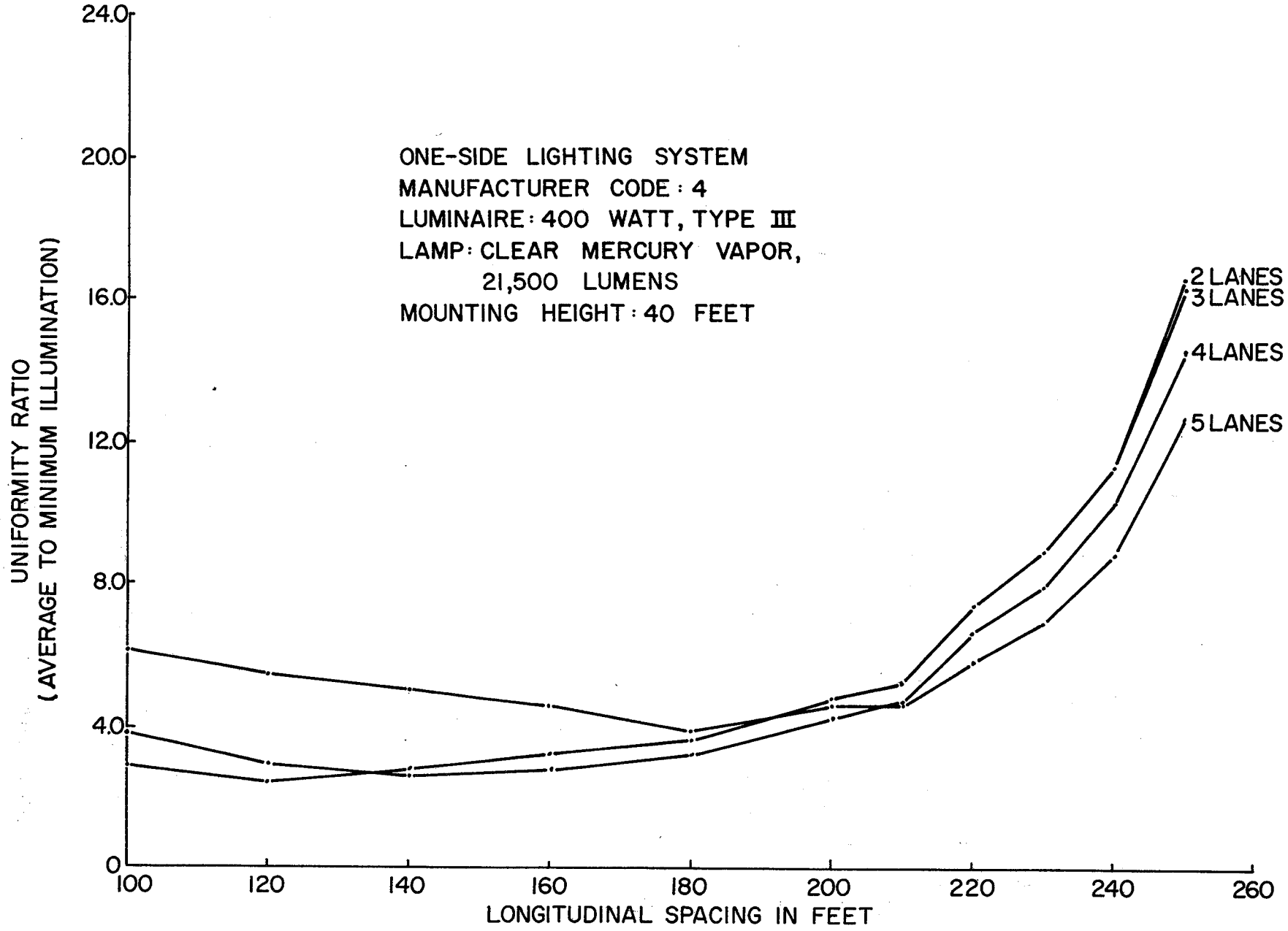


FIGURE 29- UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

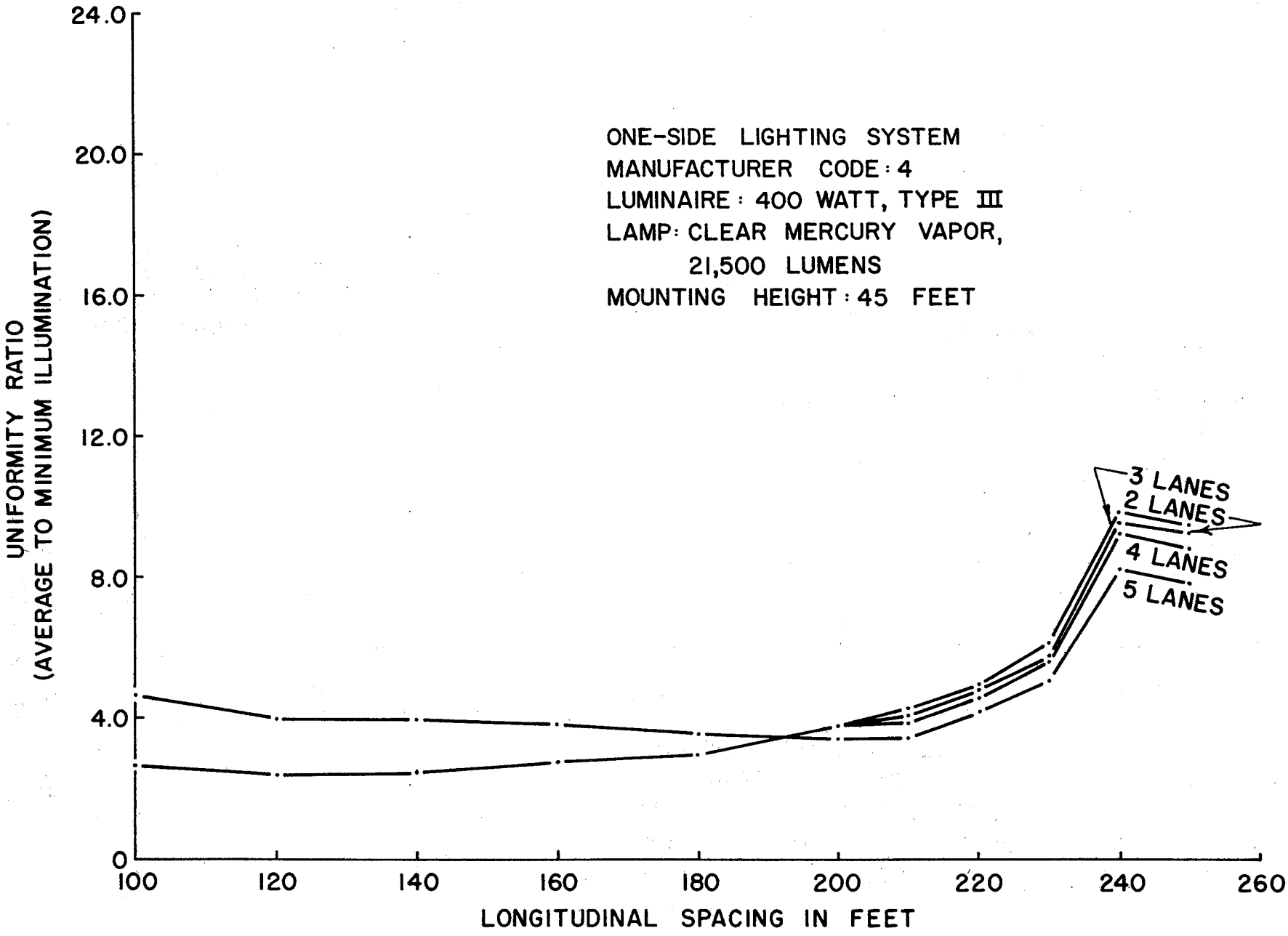


FIGURE 30- UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

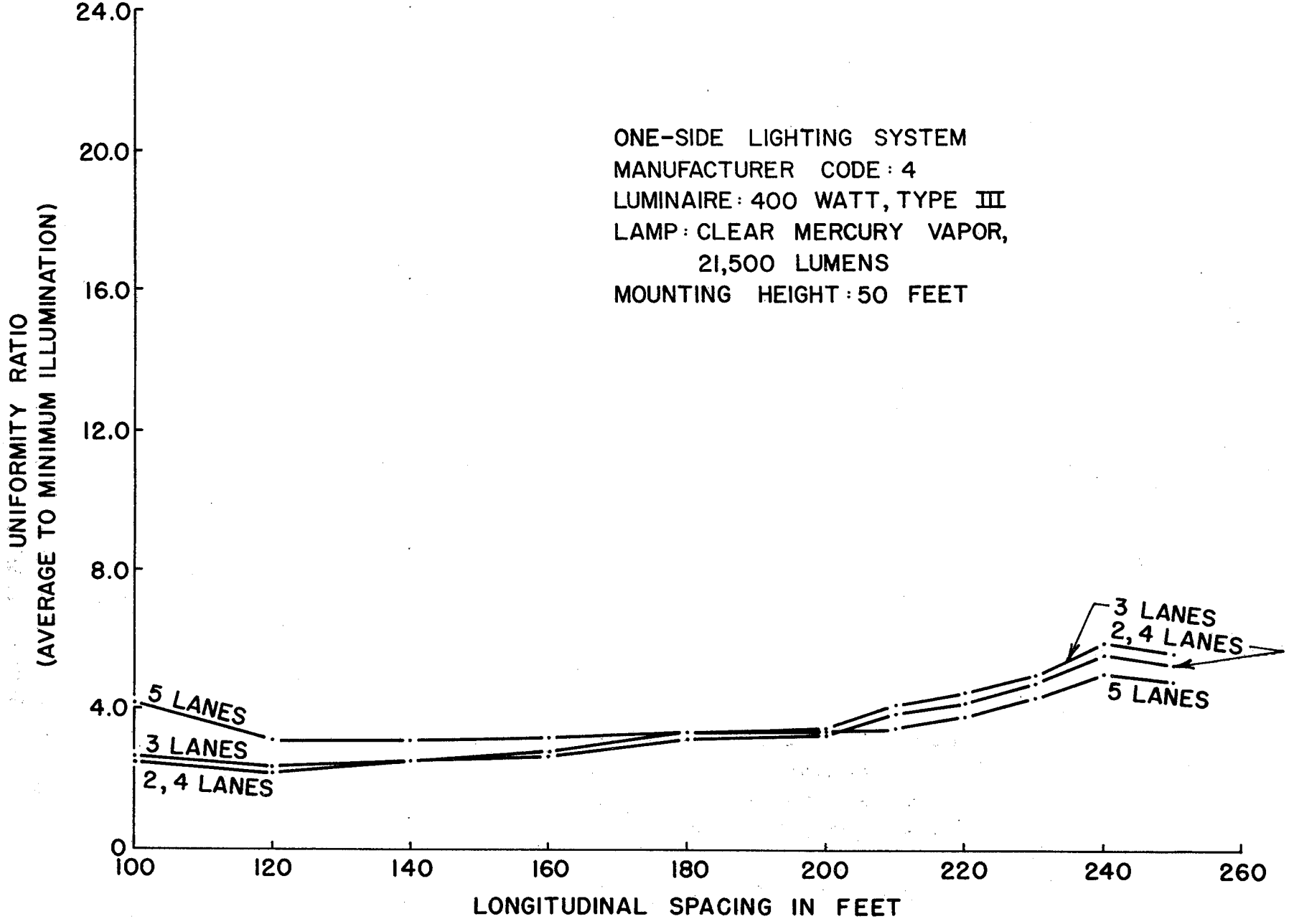


FIGURE 31 - UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

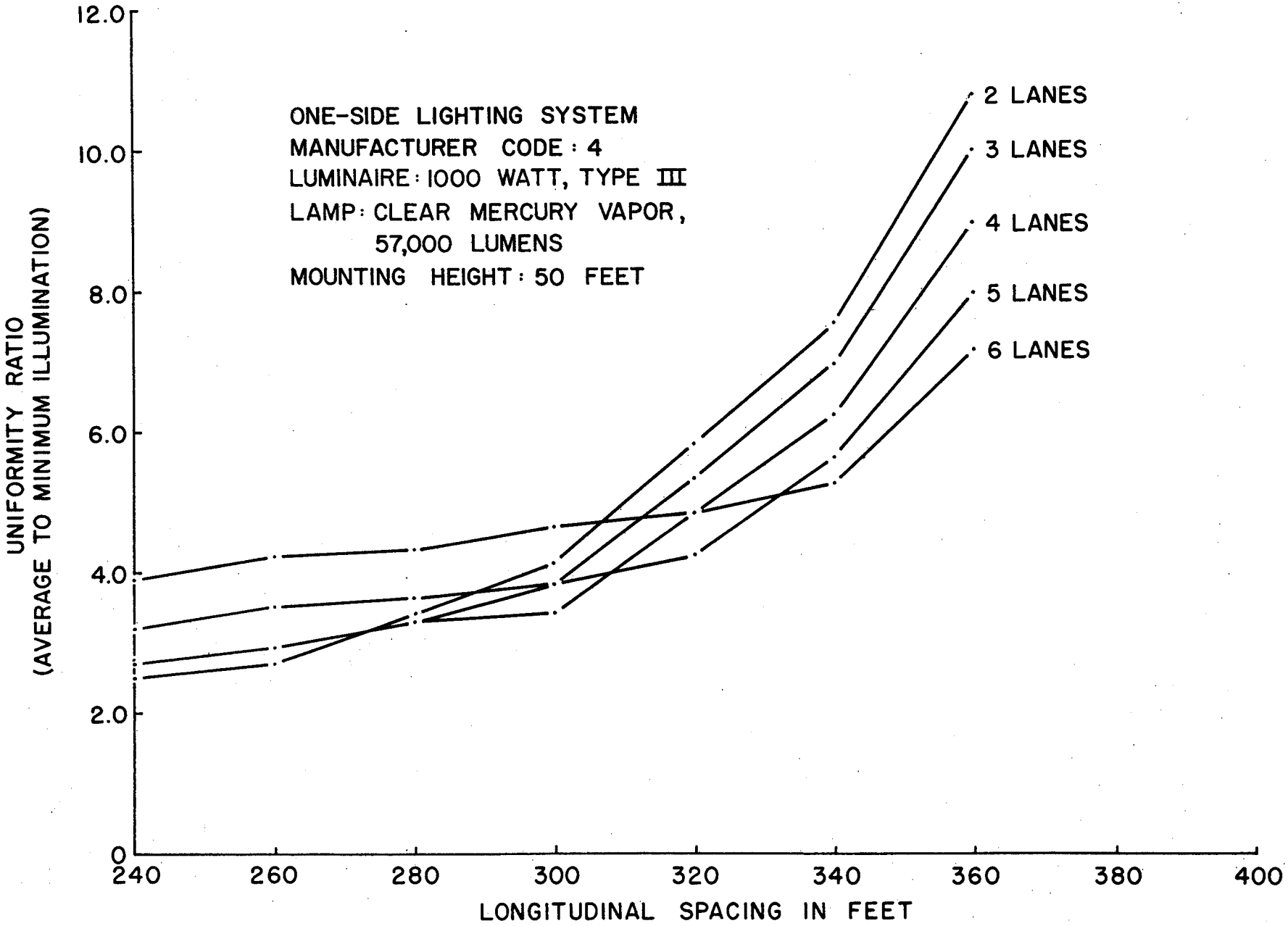


FIGURE 32- UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

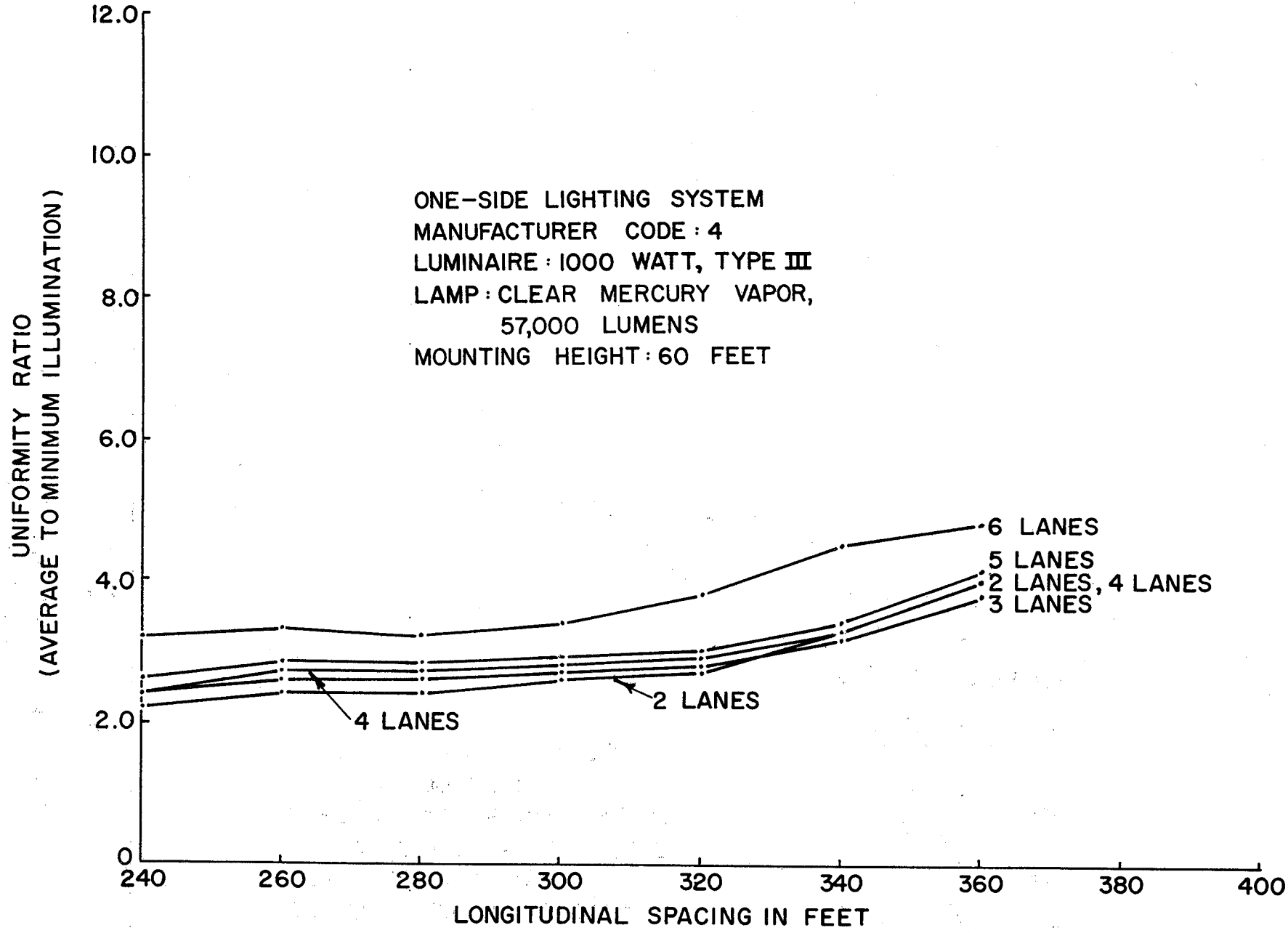


FIGURE 33-UNIFORMITY RATIO VS. LONGITUDINAL SPACING FOR DIFFERENT ROADWAY WIDTHS

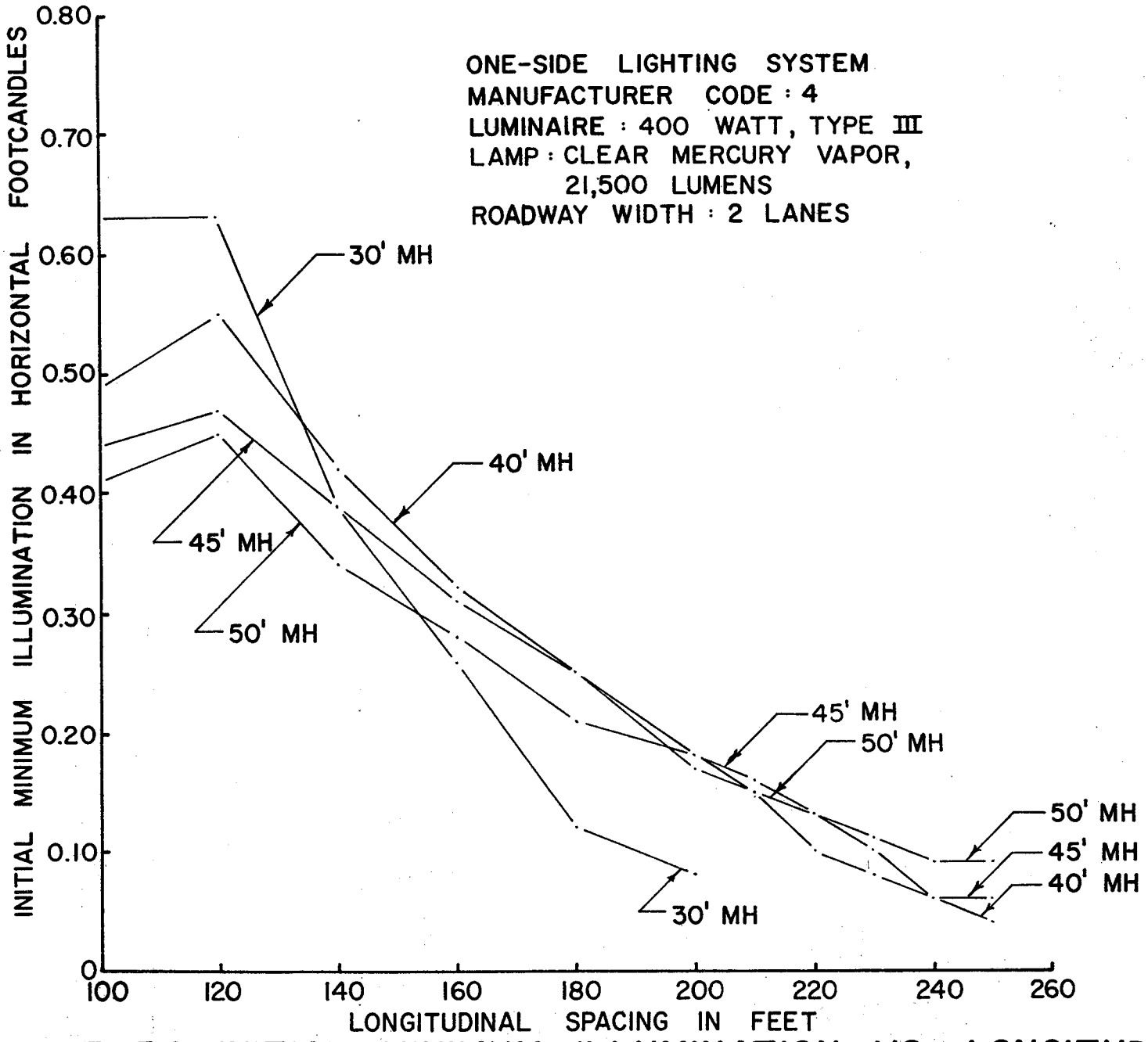


FIGURE 34-INITIAL MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTING HEIGHTS

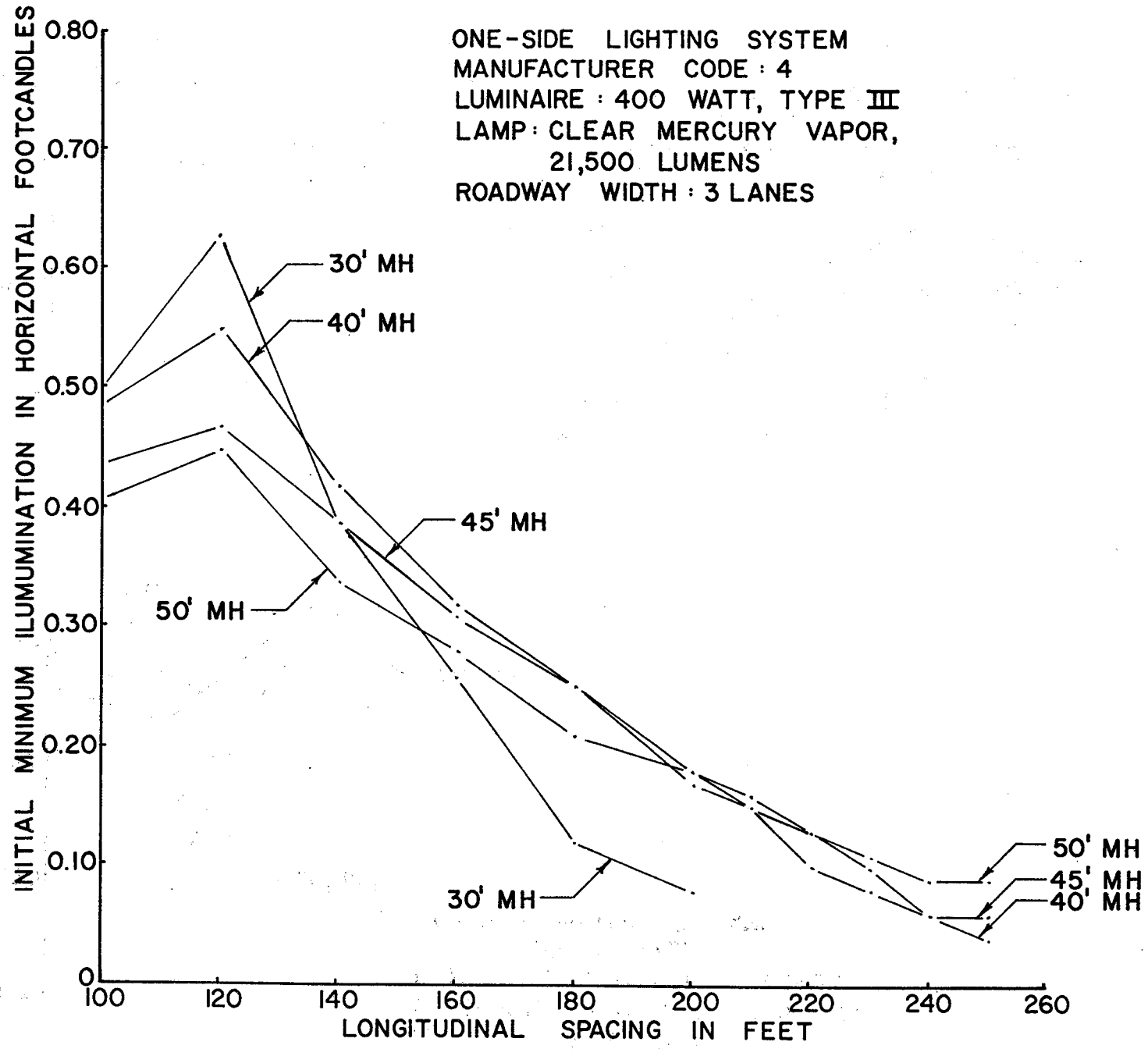


FIGURE 35–INITIAL MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTING HEIGHTS

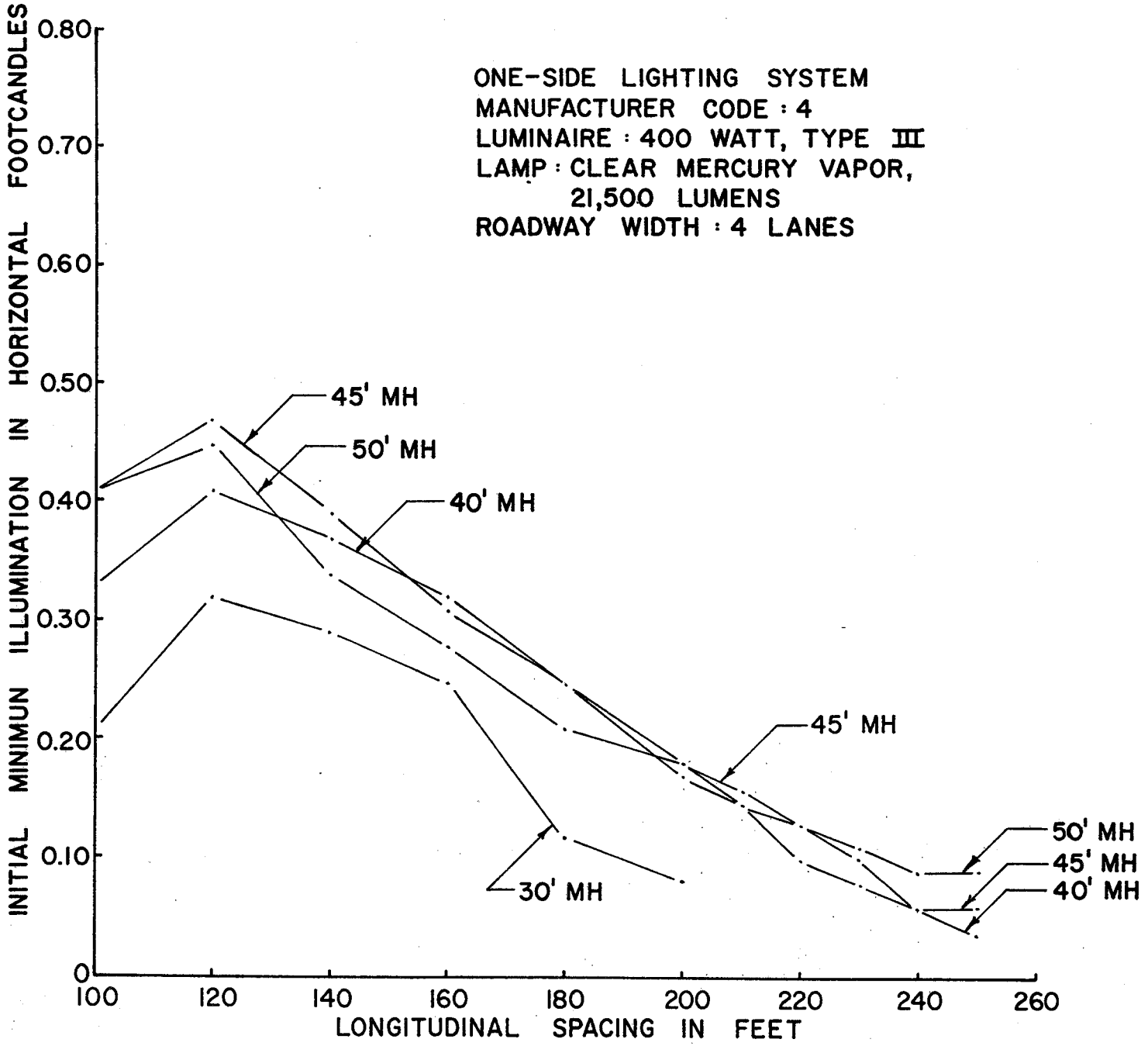


FIGURE 36-INITIAL MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTING HEIGHTS

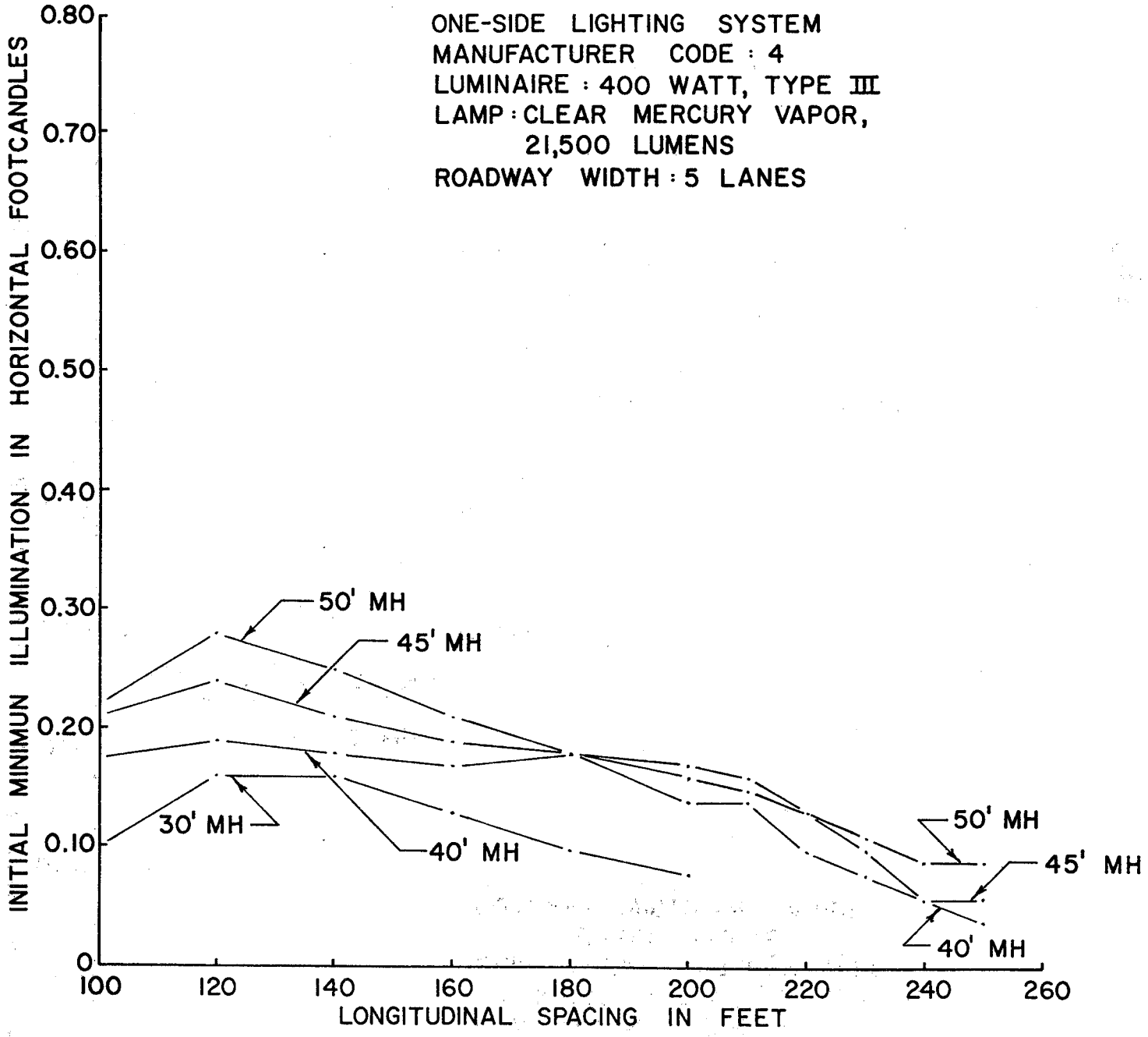


FIGURE 37-INITIAL MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTING HEIGHTS

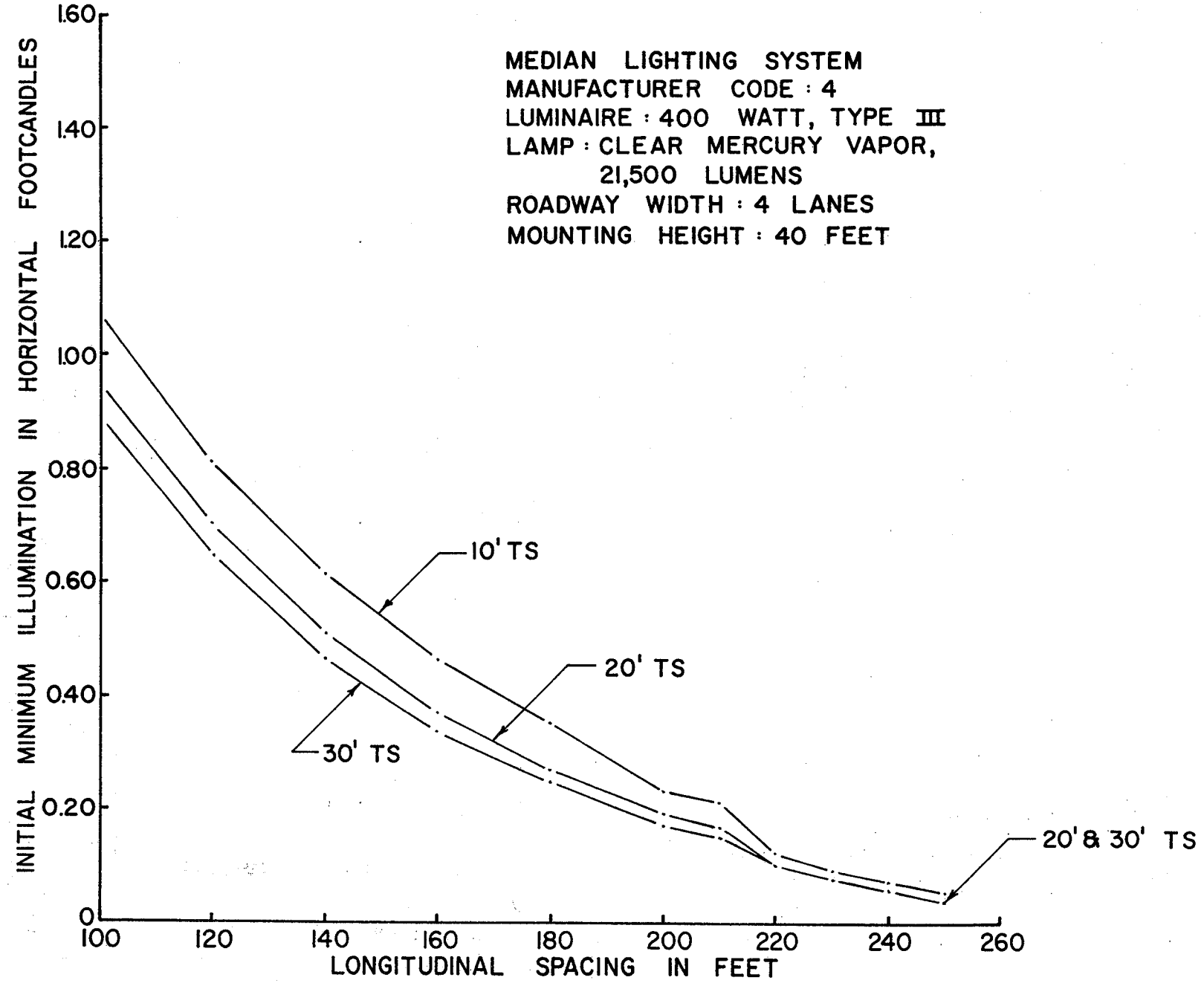


FIGURE 38 - INITIAL MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT TRANSVERSE SPACINGS

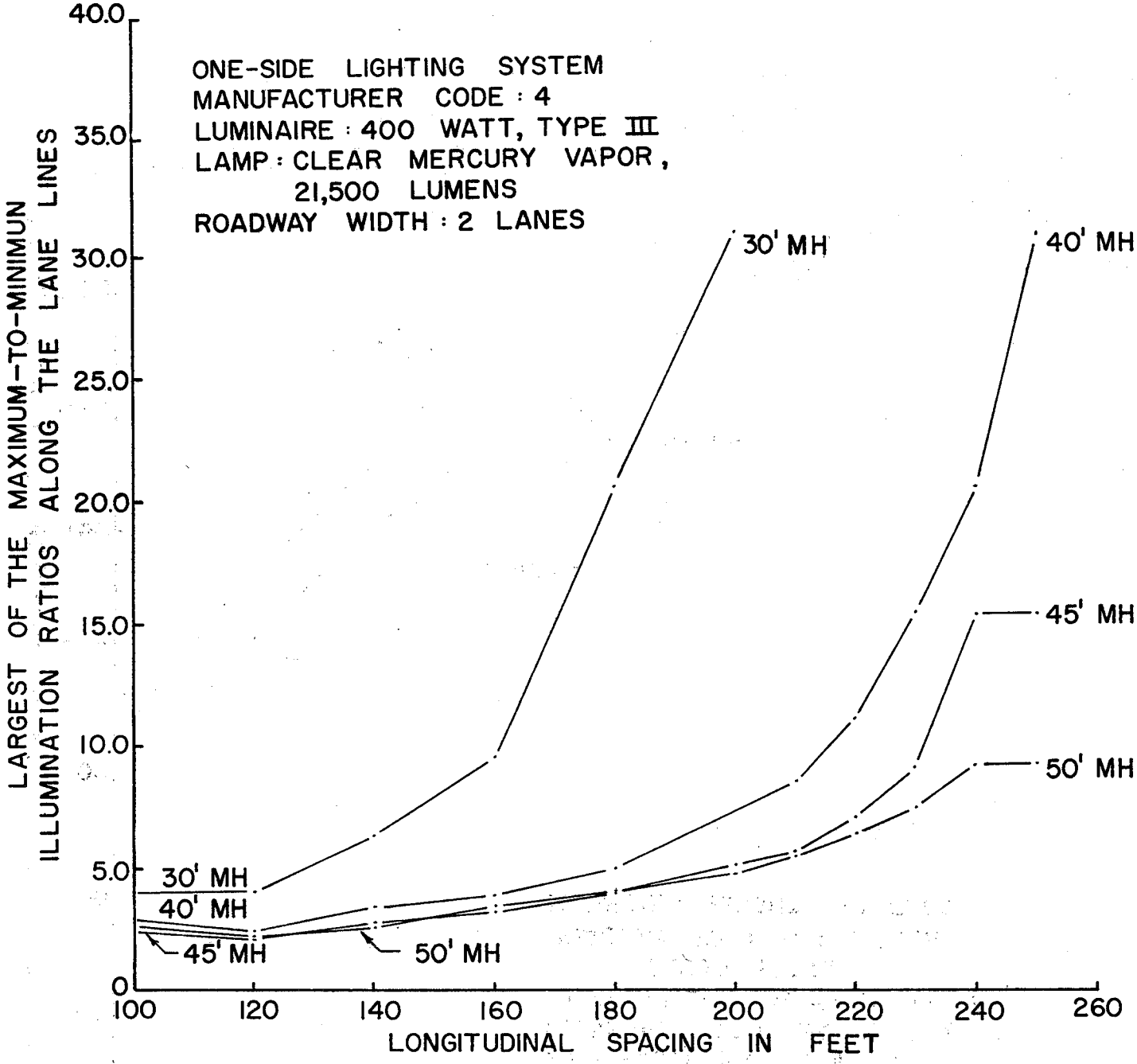


FIGURE 39-RATIO OF MAXIMUM TO MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT MOUNTNG HEIGHTS

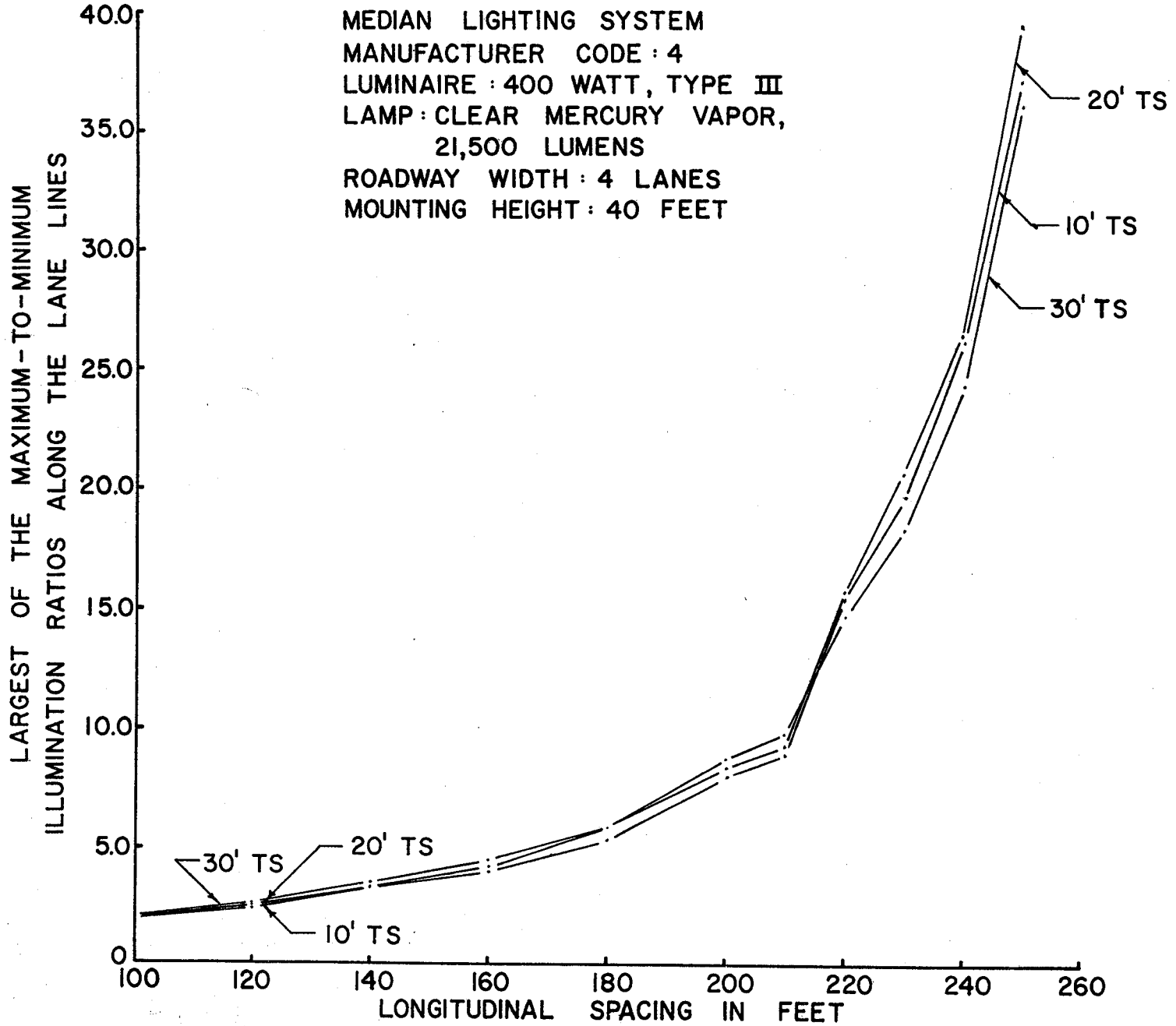


FIGURE 40-RATIO OF MAXIMUM TO MINIMUM ILLUMINATION VS. LONGITUDINAL SPACING FOR DIFFERENT TRANSVERSE SPACINGS

SUMMARY OF RESULTS

The results of this study of the effect of luminaire placement on the resultant light distribution of a roadway lighting system can be summarized as follows:

1. The initial average illumination on the roadway was inversely proportional to the mounting height, longitudinal spacing, and transverse spacing of the luminaires as well as the roadway width.

2. The uniformity of illumination on the roadway was directly proportional to the mounting height of the luminaires.

3. The 1000-watt luminaires provided a higher amount and more uniformity of illumination than the 400-watt luminaires, even at greater longitudinal spacings.

4. Differences in the amount and uniformity of illumination from luminaires of different manufacturers indicated that the optimum system configuration was dependent upon the luminaire used.

5. The higher the mounting height of the luminaires, the less is the effect of roadway width on uniformity of illumination.

6. Even though initial average illumination was inversely proportional to the mounting height of the luminaires, the initial minimum illumination was directly proportional to the mounting height at the longer spacings and on the wider roadways.

These results suggest that in order to design the most efficient lighting system which will satisfy the given specification, consideration must be given to the relationship between the geometrics of roadway lighting systems and the photometric characteristics being used as criteria. Also, in this study the luminaires were always located over the edge of the roadway. However, the transverse position of the luminaires with respect to the edge of the roadway does effect the resultant light distribution on the roadway. Thus, for a particular design situation a different transverse position is frequently better, and should be considered.

Field experience with the systems studied in this research had indicated uniformity of illumination to be a very important factor in roadway lighting design. Visual evaluations of these systems have indicated that a reduction in visibility due to a lower average illumination can usually be more than compensated for by an increase in visibility due to improved uniformity of illumination, as in the case of systems with luminaires at higher mounting heights. This experience also suggests that adequate visibility can be obtained at lower average intensities than are currently specified in design criteria, and that more emphasis should be placed on the minimum amount provided and the uniformity of illumination of the roadway such as by specifying maximum to minimum illumination.

RESEARCH IN PROGRESS

Research is continuing in the area of mounting height and spacing of light sources and other areas relating to the illumination of freeways. Immediate attention is being given to a comparison of glare and other factors affecting visibility and visual comfort for the systems presented herein. Also, consideration will be given to the determination of the design criteria which more closely reflect the relative visibility and visual comfort to be achieved.

High-Level Lighting for Interchanges

In another phase of the research, exploratory field studies were conducted to investigate the possibility of illuminating interchange areas with flood lights mounted at heights up to 100'. To facilitate these studies a 122-foot telescoping antenna tower was obtained and adapted to accommodate flood light units. During operations, one of the hoisting cables parted and the tower fell, telescoping down from approximately 85 feet. Considerable time was spent in re-designing and repairing the tower to put it back into operation.

Most of the work during the 1965-66 fiscal year in the area of high-level lighting consisted of collecting photometric data for 28 flood-light units obtained from various manufacturers. Each unit was tested individually at a mounting height of 100 feet. The units were aimed at a point 100 feet from the base of the pole, constituting a vertical angle of 45°. Light intensity measurements were made in horizontal footcandles to determine the light distribution characteristics of each of the flood-light units. Very limited studies were conducted to develop techniques of measuring light intensity in terms of vertical footcandles.

The objectives in obtaining the photometric data were (1) to provide an analytical basis for comparing the flood-lighting units and (2) to provide basic data to be used in analytical techniques for aiming flood-light units. Based on the photometric data and on a subjective evaluation of each of the units, the units were tentatively rated on the basis of the area that could be lighted with the unit. Additional units were obtained of those showing greatest promise and a complete system arrangement for one pole was assembled for further study. This system, composed of 1000-watt flood lights with clear mercury vapor lamps was studied at the test facilities and plans were made for a field study using this system at an interchange in the Fort Worth area. After considerable experimentation, the final arrangement consisted of ten of the 1000-watt units positioned symetrically 36° apart in the horizontal plane. Each of the units was set at a vertical angle of 65°. The photometric data, both horizontal and vertical footcandles, for this system are illustrated in Figures 40A and 40B. Based on a subjective evaluation of this system, vertical footcandles are more indicative of the visibility afforded by this system than the horizontal footcandle measurements. Based on these preliminary observations it is anticipated that pole spacings in an interchange area can be in excess of 1000 feet.

A technique was developed to predetermine the angles for systems of floodlights required to provide desired lighting patterns. This aiming technique was based upon the location of the center of the main beam and additional photometric studies made to determine the reliability of this method indicated a need for refinement. An attempt is being made to develop new aiming techniques which will utilize a computer to calculate the aiming angles based on given criteria. In order to provide a basis for evaluating these methods, limited field studies were conducted to determine the photometric characteristics of flood lighting units mounted at 100' heights and set at various angles.

A 100-foot fixed pole was installed at the Highway Illumination Test Facilities at the Texas A&M Research Annex to facilitate a field evaluation of its operational limitations and capabilities. Strain gages were installed at selected points along the pole in order that deflections could be measured. The fixed pole has been made operational, and it has been used in some of the field studies for high-level lighting.

In the high-level lighting phase of the research a study was conducted at the location of a 150-foot high "moonlight" tower in Austin. This tower was equipped with six vertical burning mercury vapor lamps mounted in radial reflectors at uniform angular spacings of 60^{o}. Photometric data were collected for clear and color-corrected mercury vapor lamps of both 400-and 1000-watt type to determine the applicability of this simplified system to interchange lighting.

Effects of Luminaires on Visibility of Signs

Sign visibility studies were conducted to determine the optimum sign locations within lighting systems and the effects of mounting height on sign visibility. Both a 30-foot and a 40-foot mounting height, one side lighting system of 400-watt Type III luminaires spaced 200 feet apart were used in the field studies. Results obtained from this research were correlated with the findings of earlier research by the Texas Transportation Institute. Brightness and glare measurements were made in conjunction with sign visibility to investigate the effects of relative brightness and glare on sign visibility. An interim report, Research Report 75-3, on sign visibility has been prepared for submission.

Data collected in the sign visibility study were analyzed in an attempt to further develop an analytical relationship between visibility and the various highway lighting systems' parameters. Successful development of these relationships will enable the lighting systems to be evaluated on the basis of visibility. Consideration is also being given to other techniques of rating lighting systems on the basis of relative visibility.

Impact Behavior of Lighting Poles

Seven full-scale crash tests have been conducted to determine the impact behavior of steel, aluminum and fiberglass lighting poles, some mounted on cast aluminum transformer bases and cast aluminum inserts. These tests were conducted using

standard and compact automobiles at impact speeds of 15 to 55 mph. Both photo and electronic instrumentation techniques were used to obtain data on the impact. Details of the seven tests already completed and four tests anticipated during the next fiscal year are listed in Table A-1.

An interim report, Research Report 75-2, "Impact Behavior of Light Standards-I", was submitted to the sponsoring agency. The report presents the results of tests on a cast aluminum insert to be used as a shear linkage with steel transformer bases already in use.

The data obtained from the other five tests are being analyzed and the results will be reported after the test series is complete. It is anticipated that a motion picture film will be produced to present the results of this series of tests.

APPLICATION OF STUDY DATA

To enable others to apply the photometric data obtained in this study summary tabulations of the photometric characteristics for several different lighting systems have been prepared. From these tables the engineer can readily select the designs that satisfy the given criteria for a particular lighting project. A cost analysis can then be made from which the most economical of the acceptable systems can be determined.

For example, suppose that a 2-lane roadway is to be illuminated according to the following photometric standards:

1. Minimum initial average illumination — 0.8 horizontal footcandles.
2. Maximum uniformity ratio (average to minimum illumination) — 4.0.

The summary tables containing the photometric characteristics for the lighting systems on a 2-lane roadway were scanned, and the systems that satisfy the criteria are listed as shown in Table A. Since median lighting systems are obviously impractical for a 2-lane roadway, only one-side lighting systems are considered. A cost analysis could now be made comparing the total costs of the various acceptable systems. If all other costs are the same, the system with the longest longitudinal spacing would be the most economical.

Summary tabulations are included in the Appendix for the following systems for one manufacturer:

A. One-side lighting (2-, 3-, 4-, and 5-lane roadway widths)
   1. 400-watt units
      a. Mounting heights - 40, 45, and 50 feet
      b. Longitudinal spacings - 200, 210, 220, 230, 240, and 250 feet.
   2. 1000-watt units
      a. Mounting heights - 50 and 60 feet
      b. Longitudinal spacings - 240, 260, 280, 300, 320, and 340 feet
B. Median Lighting (4-, 6-, 8- and 10-lane roadway widths)
   1. 400-watt units
      a. Mounting heights - same as for one-side lighting
      b. Longitudinal spacings - same as for one-side lighting
      c. Transverse spacings - 10, 20 and 30 feet
   2. 1000-watt units
      a. Mounting heights - same as for one-side lighting
      b. Longitudinal spacings - same as for one-side lighting
      c. Transverse spacings - 10, 20 and 30 feet

When using these tables it should be remembered that the luminaire is set at its maximum vertical adjustment and located over the edge of the roadway.

TABLE A

LIGHTING SYSTEMS WHICH SATISFY THE

CRITERIA USED IN THE EXAMPLE APPLICATION OF THE STUDY DATA

Manufacturer	Wattage	Mounting Height, ft.	Longitudinal Spacing, ft.	Transverse Spacing, ft.	Initial Average Illumination hor.fc	Uniformity Ratio
1	400	40	160	--	1.2	3.3
1	400	45	200	--	0.8	4.0
1	400	50	180	--	0.8	3.0
4	400	40	180	--	0.9	3.6
4	400	45	180	--	0.8	3.0
4	400	50	160	--	0.8	2.7
5	400	40	160	--	0.9	4.1
5	400	45	160	--	0.8	3.2
5	400	50	140	--	0.9	2.1
6	400	40	210	--	0.8	4.0
6	400	45	200	--	0.8	3.5
6	400	50	180	--	0.8	2.7
1	1000	50	340+	--	1.2	3.4
1	1000	60	340+	--	1.0	2.4
4	1000	50	300	--	1.5	4.1
4	1000	60	340+	--	1.2	3.3
5	1000	50	260	--	1.4	3.8
5	1000	60	240	--	1.2	3.9

APPENDIX

APPENDIX

Summary of Photometric Data for

Roadway Lighting Systems

The following should be noted when using the summary tabulations:

1. The 400-watt and 1000-watt units had clear mercury-vapor lamps with outputs of 21,500 and 57,000 lumens, respectively.

2. The light sources were set at their maximum vertical adjustment. Maximum vertical adjustment means that the luminaire was tilted upward on the street side as far as the luminaire's mounting assembly would permit when mounted on a horizontal mast arm.

3. The luminaires were mounted over the edge of the roadway.

4. The lanes were 12.5 feet wide.

5. Tabular values represent luminaires from only one manufacturer. Information on other luminaires may be obtained by contacting the authors.

CONTENTS OF APPENDIX

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	2 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.82	0.78	0.74	0.71	0.68	0.66
	Maximum Illumination (Horizontal Footcandles)	2.41	2.41	2.41	2.41	2.41	2.41
	Minimum Illumination (Horizontal Footcandles)	0.17	0.15	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	7.3	8.3	12.4	15.5	20.7	31.0
	Ratio: Average to Minimum Illumination	4.8	5.2	7.4	8.9	11.3	16.5
45	Average Illumination (Horizontal Footcandles)	0.69	0.65	0.62	0.59	0.57	0.55
	Maximum Illumination (Horizontal Footcandles)	1.77	1.77	1.77	1.77	1.77	1.77
	Minimum Illumination (Horizontal Footcandles)	0.18	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.1	5.7	7.1	9.2	15.3	15.3
	Ratio: Average to Minimum Illumination	3.8	4.1	4.8	5.9	9.5	9.2
50	Average Illumination (Horizontal Footcandles)	0.60	0.57	0.55	0.52	0.50	0.48
	Maximum Illumination (Horizontal Footcandles)	1.53	1.53	1.53	1.53	1.53	1.53
	Minimum Illumination (Horizontal Footcandles)	0.18	0.15	0.13	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	4.8	5.5	6.4	7.5	9.2	9.2
	Ratio: Average to Minimum Illumination	3.3	3.8	4.2	4.7	5.6	5.3

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	3 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.81	0.77	0.74	0.70	0.68	0.65
	Maximum Illumination (Horizontal Footcandles)	2.41	2.41	2.41	2.41	2.41	2.41
	Minimum Illumination (Horizontal Footcandles)	0.17	0.15	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	7.3	8.3	12.4	15.5	20.7	31.0
	Ratio: Average to Minimum Illumination	4.8	5.1	7.4	8.8	11.3	16.2
45	Average Illumination (Horizontal Footcandles)	0.71	0.68	0.65	0.62	0.59	0.57
	Maximum Illumination (Horizontal Footcandles)	1.77	1.77	1.77	1.77	1.77	1.77
	Minimum Illumination (Horizontal Footcandles)	0.18	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.1	5.7	7.1	9.2	15.3	15.3
	Ratio: Average to Minimum Illumination	3.9	4.3	5.0	6.2	9.8	9.5
50	Average Illumination (Horizontal Footcandles)	0.63	0.61	0.58	0.55	0.53	0.51
	Maximum Illumination (Horizontal Footcandles)	1.53	1.53	1.53	1.53	1.53	1.53
	Minimum Illumination (Horizontal Footcandles)	0.18	0.15	0.13	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	4.8	5.5	6.4	7.5	9.2	9.2
	Ratio: Average to Minimum Illumination	3.5	4.1	4.5	5.0	5.9	5.7

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	4 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, FEET					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.73	0.70	0.66	0.63	0.61	0.58
	Maximum Illumination (Horizontal Footcandles)	2.41	2.41	2.41	2.41	2.41	2.41
	Minimum Illumination (Horizontal Footcandles)	0.17	0.15	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	7.3	8.3	12.4	15.5	20.7	31.0
	Ratio: Average to Minimum Illumination	4.3	4.7	6.6	7.9	10.2	14.5
45	Average Illumination (Horizontal Footcandles)	0.67	0.63	0.60	0.58	0.55	0.53
	Maximum Illumination (Horizontal Footcandles)	1.77	1.77	1.77	1.77	1.77	1.77
	Minimum Illumination (Horizontal Footcandles)	0.18	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.1	5.7	7.1	9.2	15.3	15.3
	Ratio: Average to Minimum Illumination	3.7	3.9	4.6	5.8	9.2	8.8
50	Average Illumination (Horizontal Footcandles)	0.60	0.58	0.55	0.53	0.50	0.48
	Maximum Illumination (Horizontal Footcandles)	1.53	1.53	1.53	1.53	1.53	1.53
	Minimum Illumination (Horizontal Footcandles)	0.18	0.15	0.13	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	4.8	5.5	6.4	7.5	9.2	9.2
	Ratio: Average to Minimum Illumination	3.3	3.9	4.2	4.8	5.6	5.3

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	5 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.63	0.60	0.58	0.55	0.53	0.51
	Maximum Illumination (Horizontal Footcandles)	2.41	2.41	2.41	2.41	2.41	2.41
	Minimum Illumination (Horizontal Footcandles)	0.14	0.13	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	7.3	8.3	12.4	15.5	20.7	31.0
	Ratio: Average to Minimum Illumination	4.5	4.6	5.8	6.9	8.8	12.7
45	Average Illumination (Horizontal Footcandles)	0.59	0.56	0.53	0.51	0.49	0.47
	Maximum Illumination (Horizontal Footcandles)	1.77	1.77	1.77	1.77	1.77	1.77
	Minimum Illumination (Horizontal Footcandles)	0.17	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.1	5.7	7.1	9.2	15.3	15.3
	Ratio: Average to Minimum Illumination	3.5	3.5	4.1	5.1	8.2	7.8
50	Average Illumination (Horizontal Footcandles)	0.54	0.52	0.49	0.47	0.45	0.43
	Maximum Illumination (Horizontal Footcandles)	1.53	1.53	1.53	1.53	1.53	1.53
	Minimum Illumination (Horizontal Footcandles)	0.16	0.15	0.13	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	4.8	5.5	6.4	7.5	9.2	9.2
	Ratio: Average to Minimum Illumination	3.4	3.5	3.8	4.3	5.0	4.8

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	2 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.91	1.77	1.64	1.53	1.43	1.35
	Maximum Illumination (Horizontal Footcandles)	4.97	4.97	4.97	4.97	4.97	4.97
	Minimum Illumination (Horizontal Footcandles)	0.76	0.65	0.49	0.37	0.25	0.18
	*Ratio: Maximum to Minimum Illumination	6.0	7.2	9.5	12.6	18.7	25.9
	Ratio: Average to Minimum Illumination	2.5	2.7	3.4	4.1	5.7	7.5
60	Average Illumination (Horizontal Footcandles)	1.68	1.55	1.44	1.34	1.26	1.18
	Maximum Illumination (Horizontal Footcandles)	3.62	3.62	3.62	3.62	3.62	3.62
	Minimum Illumination (Horizontal Footcandles)	0.75	0.66	0.60	0.52	0.46	0.36
	*Ratio: Maximum to Minimum Illumination	4.3	4.8	5.7	6.4	7.7	9.7
	Ratio: Average to Minimum Illumination	2.2	2.4	2.4	2.6	2.7	3.3

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	3 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.76	1.63	1.51	1.41	1.32	1.25
	Maximum Illumination (Horizontal Footcandles)	4.97	4.97	4.97	4.97	4.97	4.97
	Minimum Illumination (Horizontal Footcandles)	0.66	0.57	0.46	0.37	0.25	0.18
	*Ratio: Maximum to Minimum Illumination	6.0	7.2	9.5	12.6	18.7	25.9
	Ratio: Average to Minimum Illumination	2.7	2.9	3.3	3.8	5.3	6.9
60	Average Illumination (Horizontal Footcandles)	1.58	1.46	1.36	1.27	1.19	1.12
	Maximum Illumination (Horizontal Footcandles)	3.62	3.62	3.62	3.62	3.62	3.62
	Minimum Illumination (Horizontal Footcandles)	0.67	0.57	0.53	0.47	0.42	0.35
	*Ratio: Maximum to Minimum Illumination	4.3	4.8	5.7	6.4	7.7	9.7
	Ratio: Average to Minimum Illumination	2.4	2.6	2.6	2.7	2.8	3.2

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	4 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.59	1.47	1.36	1.27	1.19	1.12
	Maximum Illumination (Horizontal Footcandles)	4.97	4.97	4.97	4.97	4.97	4.97
	Minimum Illumination (Horizontal Footcandles)	0.57	0.50	0.41	0.37	0.25	0.18
	*Ratio: Maximum to Minimum Illumination	6.0	7.2	9.5	12.6	18.7	25.9
	Ratio: Average to Minimum Illumination	2.8	2.9	3.3	3.4	4.8	6.2
60	Average Illumination (Horizontal Footcandles)	1.46	1.35	1.25	1.17	1.10	1.03
	Maximum Illumination (Horizontal Footcandles)	3.62	3.62	3.62	3.62	3.62	3.62
	Minimum Illumination (Horizontal Footcandles)	0.60	0.50	0.46	0.42	0.38	0.31
	*Ratio: Maximum to Minimum Illumination	4.3	4.8	5.7	6.4	7.7	9.7
	Ratio: Average to Minimum Illumination	2.4	2.7	2.7	2.8	2.9	3.3

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	5 - LANE ROADWAY, ONE-SIDE LIGHTING SYSTEM						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.41	1.31	1.21	1.13	1.06	1.00
	Maximum Illumination (Horizontal Footcandles)	4.97	4.97	4.97	4.97	4.97	4.97
	Minimum Illumination (Horizontal Footcandles)	0.44	0.38	0.34	0.30	0.25	0.18
	*Ratio: Maximum to Minimum Illumination	6.0	7.2	9.5	12.6	18.7	25.9
	Ratio: Average to Minimum Illumination	3.2	3.5	3.6	3.8	4.2	5.6
60	Average Illumination (Horizontal Footcandles)	1.32	1.22	1.14	1.06	1.00	0.94
	Maximum Illumination (Horizontal Footcandles)	3.62	3.62	3.62	3.62	3.62	3.62
	Minimum Illumination (Horizontal Footcandles)	0.50	0.44	0.41	0.37	0.33	0.28
	*Ratio: Maximum to Minimum Illumination	4.3	4.8	5.7	6.4	7.7	9.7
	Ratio: Average to Minimum Illumination	2.6	2.8	2.8	2.9	3.0	3.4

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 4 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.96	0.91	0.87	0.83	0.80	0.77
	Maximum Illumination (Horizontal Footcandles)	2.70	2.70	2.70	2.70	2.70	2.70
	Minimum Illumination (Horizontal Footcandles)	0.23	0.21	0.12	0.09	0.07	0.05
	*Ratio: Maximum to Minimum Illumination	8.0	8.8	15.4	20.6	26.4	37.0
	Ratio: Average to Minimum Illumination	4.2	4.3	7.3	9.3	11.5	15.4
45	Average Illumination (Horizontal Footcandles)	0.82	0.78	0.75	0.72	0.69	0.66
	Maximum Illumination (Horizontal Footcandles)	2.03	2.03	2.03	2.03	2.03	2.03
	Minimum Illumination (Horizontal Footcandles)	0.27	0.23	0.17	0.13	0.08	0.08
	*Ratio: Maximum to Minimum Illumination	5.5	6.1	8.2	10.8	17.5	17.5
	Ratio: Average to Minimum Illumination	3.1	3.4	4.4	5.5	8.6	8.3
50	Average Illumination (Horizontal Footcandles)	0.72	0.69	0.66	0.63	0.60	0.58
	Maximum Illumination (Horizontal Footcandles)	1.75	1.75	1.75	1.75	1.75	1.75
	Minimum Illumination (Horizontal Footcandles)	0.27	0.23	0.20	0.17	0.12	0.13
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.5	7.4	10.4	9.7
	Ratio: Average to Minimum Illumination	2.7	3.0	3.3	3.7	5.0	4.5

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 6 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.93	0.88	0.85	0.81	0.78	0.75
	Maximum Illumination (Horizontal Footcandles)	2.70	2.70	2.70	2.70	2.70	2.70
	Minimum Illumination (Horizontal Footcandles)	0.23	0.21	0.12	0.09	0.07	0.05
	*Ratio: Maximum to Minimum Illumination	8.0	8.8	15.4	20.6	26.4	37.0
	Ratio: Average to Minimum Illumination	4.0	4.2	7.1	9.0	11.1	14.9
45	Average Illumination (Horizontal Footcandles)	0.83	0.79	0.75	0.72	0.69	0.66
	Maximum Illumination (Horizontal Footcandles)	2.03	2.03	2.03	2.03	2.03	2.03
	Minimum Illumination (Horizontal Footcandles)	0.27	0.23	0.17	0.13	0.08	0.08
	*Ratio: Maximum to Minimum Illumination	5.5	6.1	8.2	10.8	17.5	17.5
	Ratio: Average to Minimum Illumination	3.1	3.4	4.4	5.6	8.7	8.3
50	Average Illumination (Horizontal Footcandles)	0.74	0.71	0.67	0.64	0.62	0.59
	Maximum Illumination (Horizontal Footcandles)	1.75	1.75	1.75	1.75	1.75	1.75
	Minimum Illumination (Horizontal Footcandles)	0.27	0.23	0.20	0.17	0.12	0.13
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.5	7.4	10.4	9.7
	Ratio: Average to Minimum Illumination	2.8	3.1	3.4	3.8	5.1	4.6

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 8 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.83	0.78	0.75	0.72	0.69	0.66
	Maximum Illumination (Horizontal Footcandles)	2.70	2.70	2.70	2.70	2.70	2.70
	Minimum Illumination (Horizontal Footcandles)	0.23	0.21	0.12	0.09	0.07	0.05
	*Ratio: Maximum to Minimum Illumination	8.0	8.8	15.4	20.6	26.4	37.0
	Ratio: Average to Minimum Illumination	3.6	3.7	6.3	8.0	9.9	13.3
45	Average Illumination (Horizontal Footcandles)	0.76	0.73	0.69	0.66	0.64	0.61
	Maximum Illumination (Horizontal Footcandles)	2.03	2.03	2.03	2.03	2.03	2.03
	Minimum Illumination (Horizontal Footcandles)	0.26	0.23	0.17	0.13	0.08	0.08
	*Ratio: Maximum to Minimum Illumination	5.5	6.1	8.2	10.8	17.5	17.5
	Ratio: Average to Minimum Illumination	2.9	3.2	4.1	5.1	8.0	7.6
50	Average Illumination (Horizontal Footcandles)	0.69	0.66	0.63	0.60	0.58	0.55
	Maximum Illumination (Horizontal Footcandles)	1.75	1.75	1.75	1.75	1.75	1.75
	Minimum Illumination (Horizontal Footcandles)	0.26	0.23	0.20	0.17	0.12	0.13
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.5	7.4	10.4	9.7
	Ratio: Average to Minimum Illumination	2.8	2.9	3.2	3.6	4.8	4.3

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 10 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.71	0.68	0.65	0.62	0.59	0.57
	Maximum Illumination (Horizontal Footcandles)	2.70	2.70	2.70	2.70	2.70	2.70
	Minimum Illumination (Horizontal Footcandles)	0.14	0.13	0.12	0.09	0.07	0.05
	*Ratio: Maximum to Minimum Illumination	8.0	8.8	15.4	20.6	26.4	37.0
	Ratio: Average to Minimum Illumination	5.1	5.2	5.4	6.9	8.5	11.4
45	Average Illumination (Horizontal Footcandles)	0.67	0.64	0.61	0.58	0.56	0.54
	Maximum Illumination (Horizontal Footcandles)	2.03	2.03	2.03	2.03	2.03	2.03
	Minimum Illumination (Horizontal Footcandles)	0.17	0.16	0.14	0.13	0.08	0.08
	*Ratio: Maximum to Minimum Illumination	5.5	6.1	8.2	10.8	17.5	17.5
	Ratio: Average to Minimum Illumination	4.0	4.0	4.4	4.5	7.0	6.7
50	Average Illumination (Horizontal Footcandles)	0.62	0.59	0.56	0.54	0.51	0.49
	Maximum Illumination (Horizontal Footcandles)	1.75	1.75	1.75	1.75	1.75	1.75
	Minimum Illumination (Horizontal Footcandles)	0.16	0.15	0.14	0.12	0.12	0.10
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.5	7.4	10.4	9.7
	Ratio: Average to Minimum Illumination	3.9	3.9	4.0	4.5	4.3	4.9

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 4 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.91	0.86	0.82	0.79	0.76	0.72
	Maximum Illumination (Horizontal Footcandles)	2.61	2.61	2.61	2.61	2.61	2.61
	Minimum Illumination (Horizontal Footcandles)	0.19	0.17	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.3	9.2	15.7	19.6	26.2	39.3
	Ratio: Average to Minimum Illumination	4.8	5.1	8.3	9.9	12.6	18.1
45	Average Illumination (Horizontal Footcandles)	0.78	0.74	0.71	0.68	0.65	0.62
	Maximum Illumination (Horizontal Footcandles)	1.95	1.95	1.95	1.95	1.95	1.95
	Minimum Illumination (Horizontal Footcandles)	0.21	0.18	0.14	0.11	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.8	6.7	8.6	11.0	20.2	20.2
	Ratio: Average to Minimum Illumination	3.7	4.1	5.1	6.2	7.8	10.4
50	Average Illumination (Horizontal Footcandles)	0.69	0.65	0.62	0.59	0.57	0.55
	Maximum Illumination (Horizontal Footcandles)	1.68	1.68	1.68	1.68	1.68	1.68
	Minimum Illumination (Horizontal Footcandles)	0.22	0.19	0.16	0.13	0.10	0.11
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.8	8,3	10.8	9.9
	Ratio: Average to Minimum Illumination	3.1	3.4	3.9	4.6	5.7	5.0

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 6 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.89	0.85	0.81	0.77	0.74	0.71
	Maximum Illumination (Horizontal Footcandles)	2.61	2.61	2.61	2.61	2.61	2.61
	Minimum Illumination (Horizontal Footcandles)	0.19	0.17	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.3	9.2	15.7	19.6	26.2	39.3
	Ratio: Average to Minimum Illumination	4.7	5.0	8.1	9.7	12.3	17.8
45	Average Illumination (Horizontal Footcandles)	0.79	0.75	0.72	0.69	0.66	0.63
	Maximum Illumination (Horizontal Footcandles)	1.95	1.95	1.95	1.95	1.95	1.95
	Minimum Illumination (Horizontal Footcandles)	0.21	0.18	0.14	0.11	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.8	6.7	8.6	11.0	20.2	20.2
	Ratio: Average to Minimum Illumination	3.8	4.2	5.1	6.3	11.0	10.6
50	Average Illumination (Horizontal Footcandles)	0.71	0.67	0.64	0.61	0.59	0.57
	Maximum Illumination (Horizontal Footcandles)	1.68	1.68	1.68	1.68	1.68	1.68
	Minimum Illumination (Horizontal Footcandles)	0.22	0.19	0.16	0.13	0.10	0.11
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.8	8.3	10.8	9.9
	Ratio: Average to Minimum Illumination	3.2	3.5	4.0	4.7	5.9	5.2

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 8 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.79	0.75	0.72	0.69	0.66	0.63
	Maximum Illumination (Horizontal Footcandles)	2.61	2.61	2.61	2.61	2.61	2.61
	Minimum Illumination (Horizontal Footcandles)	0.19	0.17	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.3	9.2	15.7	19.6	26.2	39.3
	Ratio: Average to Minimum Illumination	4.2	4.4	7.2	8.6	11.0	15.8
45	Average Illumination (Horizontal Footcandles)	0.73	0.69	0.66	0.64	0.61	0.58
	Maximum Illumination (Horizontal Footcandles)	1.95	1.95	1.95	1.95	1.95	1.95
	Minimum Illumination (Horizontal Footcandles)	0.21	0.18	0.14	0.11	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.8	6.7	8.6	11.0	20.2	20.2
	Ratio: Average to Minimum Illumination	3.5	3.9	4.7	5.8	10.1	9.8
50	Average Illumination (Horizontal Footcandles)	0.66	0.63	0.60	0.58	0.55	0.53
	Maximum Illumination (Horizontal Footcandles)	1.68	1.68	1.68	1.68	1.68	1.68
	Minimum Illumination (Horizontal Footcandles)	0.22	0.19	0.16	0.13	0.10	0.11
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.8	8.3	10.8	9.9
	Ratio: Average to Minimum Illumination	3.0	3.3	3.8	4.4	5.5	4.8

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 10 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.68	0.65	0.62	0.59	0.57	0.55
	Maximum Illumination (Horizontal Footcandles)	2.61	2.61	2.61	2.61	2.61	2.61
	Minimum Illumination (Horizontal Footcandles)	0.14	0.13	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.3	9.2	15.7	19.6	26.2	39.3
	Ratio: Average to Minimum Illumination	4.9	5.0	6.2	7.4	9.5	13.7
45	Average Illumination (Horizontal Footcandles)	0.64	0.61	0.58	0.56	0.53	0.51
	Maximum Illumination (Horizontal Footcandles)	1.95	1.95	1.95	1.95	1.95	1.95
	Minimum Illumination (Horizontal Footcandles)	0.17	0.16	0.14	0.11	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.8	6.7	8.6	11.0	20.2	20.2
	Ratio: Average to Minimum Illumination	3.8	3.8	4.2	5.1	8.9	8.6
50	Average Illumination (Horizontal Footcandles)	0.59	0.56	0.54	0.51	0.49	0.47
	Maximum Illumination (Horizontal Footcandles)	1.68	1.68	1.68	1.68	1.68	1.68
	Minimum Illumination (Horizontal Footcandles)	0.16	0.15	0.14	0.12	0.10	0.10
	*Ratio: Maximum to Minimum Illumination	5.2	5.8	6.8	8.3	10.8	9.9
	Ratio: Average to Minimum Illumination	3.7	3.8	3.8	4.3	4.9	4.7

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 4 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.87	0.84	0.79	0.76	0.73	0.70
	Maximum Illumination (Horizontal Footcandles)	2.57	2.57	2.57	2.57	2.57	2.57
	Minimum Illumination (Horizontal Footcandles)	0.17	0.15	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.6	9.7	14.6	18.3	24.3	36.5
	Ratio: Average to Minimum Illumination	5.2	5.6	8.0	9.6	12.2	17.6
45	Average Illumination (Horizontal Footcandles)	0.75	0.71	0.68	0.65	0.62	0.60
	Maximum Illumination (Horizontal Footcandles)	1.91	1.91	1.91	1.91	1.91	1.91
	Minimum Illumination (Horizontal Footcandles)	0.19	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.9	7.0	8.6	11.2	18.7	18.7
	Ratio: Average to Minimum Illumination	4.0	4.5	5.2	6.5	10.4	10.0
50	Average Illumination (Horizontal Footcandles)	0.66	0.63	0.60	0.57	0.55	0.52
	Maximum Illumination (Horizontal Footcandles)	1.64	1.64	1.64	1.64	1.64	1.64
	Minimum Illumination (Horizontal Footcandles)	0.19	0.16	0.14	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	5.3	6.3	7.1	9.1	11.1	11.1
	Ratio: Average to Minimum Illumination	3.5	3.9	4.3	5.2	6.1	5.8

* Largest of the maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 6 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.86	0.82	0.78	0.75	0.72	0.69
	Maximum Illumination (Horizontal Footcandles)	2.57	2.57	2.57	2.57	2.57	2.57
	Minimum Illumination (Horizontal Footcandles)	0.17	0.15	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.6	9.7	14.6	18.3	24.3	36.5
	Ratio: Average to Minimum Illumination	5.1	5.5	7.8	9.4	11.9	17.3
45	Average Illumination (Horizontal Footcandles)	0.77	0.73	0.69	0.67	0.64	0.61
	Maximum Illumination (Horizontal Footcandles)	1.91	1.91	1.91	1.91	1.91	1.91
	Minimum Illumination (Horizontal Footcandles)	0.19	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.9	7.0	8.6	11.2	18.7	18.7
	Ratio: Average to Minimum Illumination	4.0	4.6	5.3	6.7	10.6	10.2
50	Average Illumination (Horizontal Footcandles)	0.68	0.65	0.62	0.59	0.57	0.54
	Maximum Illumination (Horizontal Footcandles)	1.64	1.64	1.64	1.64	1.64	1.64
	Minimum Illumination (Horizontal Footcandles)	0.19	0.16	0.14	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	5.3	6.3	7.1	9.1	11.1	11.1
	Ratio: Average to Minimum Illumination	3.6	4.1	4.5	5.4	6.3	6.1

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 8 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.76	0.73	0.70	0.67	0.64	0.61
	Maximum Illumination (Horizontal Footcandles)	2.57	2.57	2.57	2.57	2.57	2.57
	Minimum Illumination (Horizontal Footcandles)	0.17	0.15	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.6	9.7	14.6	18.3	24.3	36.5
	Ratio: Average to Minimum Illumination	4.5	4.9	7.0	8.3	10.6	15.3
45	Average Illumination (Horizontal Footcandles)	0.71	0.67	0.64	0.61	0.59	0.56
	Maximum Illumination (Horizontal Footcandles)	1.91	1.91	1.91	1.91	1.91	1.91
	Minimum Illumination (Horizontal Footcandles)	0.19	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.9	7.0	8.6	11.2	18.7	18.7
	Ratio: Average to Minimum Illumination	3.7	4.2	4.9	6.2	9.8	9.4
50	Average Illumination (Horizontal Footcandles)	0.64	0.61	0.59	0.56	0.54	0.51
	Maximum Illumination (Horizontal Footcandles)	1.64	1.64	1.64	1.64	1.64	1.64
	Minimum Illumination (Horizontal Footcandles)	0.19	0.16	0.14	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	5.3	6.3	7.1	9.1	11.1	11.1
	Ratio: Average to Minimum Illumination	3.4	3.8	4.2	5.1	6.0	5.7

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 400w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 10 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		200	210	220	230	240	250
40	Average Illumination (Horizontal Footcandles)	0.66	0.63	0.60	0.58	0.55	0.53
	Maximum Illumination (Horizontal Footcandles)	2.57	2.57	2.57	2.57	2.57	2.57
	Minimum Illumination (Horizontal Footcandles)	0.14	0.13	0.10	0.08	0.06	0.04
	*Ratio: Maximum to Minimum Illumination	8.6	9.7	14.6	18.3	24.3	36.5
	Ratio: Average to Minimum Illumination	4.7	4.9	6.0	7.2	9.2	13.3
45	Average Illumination (Horizontal Footcandles)	0.62	0.59	0.56	0.54	0.52	0.50
	Maximum Illumination (Horizontal Footcandles)	1.91	1.91	1.91	1.91	1.91	1.91
	Minimum Illumination (Horizontal Footcandles)	0.17	0.16	0.13	0.10	0.06	0.06
	*Ratio: Maximum to Minimum Illumination	5.9	7.0	8.6	11.2	18.7	18.7
	Ratio: Average to Minimum Illumination	3.7	3.7	4.3	5.4	8.7	8.3
50	Average Illumination (Horizontal Footcandles)	0.57	0.55	0.52	0.50	0.48	0.46
	Maximum Illumination (Horizontal Footcandles)	1.64	1.64	1.64	1.64	1.64	1.64
	Minimum Illumination (Horizontal Footcandles)	0.16	0.15	0.14	0.11	0.09	0.09
	*Ratio: Maximum to Minimum Illumination	5.3	6.3	7.1	9.1	11.1	11.1
	Ratio: Average to Minimum Illumination	3.6	3.7	3.7	4.5	5.3	5.1

*Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 4 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.75	2.54	2.35	2.20	2.06	1.94
	Maximum Illumination (Horizontal Footcandles)	7.47	7.47	7.47	7.47	7.47	7.47
	Minimum Illumination (Horizontal Footcandles)	1.14	0.94	0.73	0.56	0.42	0.28
	*Ratio: Maximum to Minimum Illumination	4.9	6.1	8.1	11.3	16.2	24.1
	Ratio: Average to Minimum Illumination	2.4	2.7	3.2	3.9	4.9	6.9
60	Average Illumination (Horizontal Footcandles)	2.51	2.32	2.15	2.01	1.88	1.78
	Maximum Illumination (Horizontal Footcandles)	5.68	5.68	5.68	5.68	5.68	5.68
	Minimum Illumination (Horizontal Footcandles)	1.23	1.07	0.96	0.80	0.67	0.52
	*Ratio: Maximum to Minimum Illumination	3.1	3.6	4.2	5.2	6.4	8.2
	Ratio: Average to Minimum Illumination	2.0	2.2	2.2	2.5	2.8	3.4

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTUER CODE: 4 LUMINAIRE: 1000w, TYPEYIII

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 6 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.43	2.24	2.08	1.95	1.83	1.72
	Maximum Illumination (Horizontal Footcandles)	7.47	7.47	7.47	7.47	7.47	7.47
	Minimum Illumination (Horizontal Footcandles)	0.89	0.73	0.57	0.47	0.37	0.28
	*Ratio: Maximum to Minimum Illumination	4.9	6.1	8.1	11.3	16.2	24.1
	Ratio: Average to Minimum Illumination	2.7	3.1	3.7	4.1	4.9	6.1
60	Average Illumination (Horizontal Footcandles)	2.27	2.10	1.94	1.82	1.70	1.60
	Maximum Illumination (Horizontal Footcandles)	5.68	5.68	5.68	5.68	5.68	5.68
	Minimum Illumination (Horizontal Footcandles)	0.99	0.85	0.77	0.64	0.56	0.43
	*Ratio: Maximum to Minimum Illumination	3.1	3.6	4.2	5.2	6.4	8.2
	Ratio: Average to Minimum Illumination	2.3	2.5	2.5	2.8	3.0	3.7

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 8 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.14	1.97	1.83	1.71	1.60	1.51
	Maximum Illumination (Horizontal Footcandles)	7.47	7.47	7.47	7.47	7.47	7.47
	Minimum Illumination (Horizontal Footcandles)	0.71	0.60	0.48	0.41	0.33	0.25
	*Ratio: Maximum to Minimum Illumination	4.9	6.1	8.1	11.3	16.2	24.1
	Ratio: Average to Minimum Illumination	3.0	3.3	3.8	4.2	4.9	6.0
60	Average Illumination (Horizontal Footcandles)	2.03	1.88	1.74	1.63	1.52	1.44
	Maximum Illumination (Horizontal Footcandles)	5.68	5.68	5.68	5.68	5.68	5.68
	Minimum Illumination (Horizontal Footcandles)	0.81	0.67	0.60	0.52	0.45	0.37
	*Ratio: Maximum to Minimum Illumination	3.1	3.6	4.2	5.2	6.4	8.2
	Ratio: Average to Minimum Illumination	2.5	2.8	2.9	3.1	3.4	3.9

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines..

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 10 - LANE ROADWAY, 10 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.88	1.73	1.60	1.50	1.41	1.32
	Maximum Illumination (Horizontal Footcandles)	7.47	7.47	7.47	7.47	7.47	7.47
	Minimum Illumination (Horizontal Footcandles)	0.50	0.43	0.37	0.32	0.27	0.21
	*Ratio: Maximum to Minimum Illumination	4.9	6.1	8.1	11.3	16.2	24.1
	Ratio: Average to Minimum Illumination	3.8	4.0	4.3	4.7	5.2	6.3
60	Average Illumination (Horizontal Footcandles)	1.81	1.67	1.55	1.45	1.36	1.28
	Maximum Illumination (Horizontal Footcandles)	5.68	5.68	5.68	5.68	5.68	5.68
	Minimum Illumination (Horizontal Footcandles)	0.60	0.49	0.45	0.41	0.37	0.30
	*Ratio: Maximum to Minimum Illumination	3.1	3.6	4.2	5.2	6.4	8.2
	Ratio: Average to Minimum Illumination	3.0	3.4	3.5	3.5	3.7	4.3

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 4 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.44	2.25	2.09	1.95	1.83	1.72
	Maximum Illumination (Horizontal Footcandles)	6.21	6.21	6.21	6.21	6.21	6.21
	Minimum Illumination (Horizontal Footcandles)	1.02	0.85	0.65	0.52	0.40	0.27
	*Ratio: Maximum to Minimum Illumination	4.5	5.6	7.6	10.7	15.2	23.0
	Ratio: Average to Minimum Illumination	2.4	2.7	3.2	3.8	4.6	6.4
60	Average Illumination (Horizontal Footcandles)	2.24	2.07	1.92	1.79	1.68	1.58
	Maximum Illumination (Horizontal Footcandles)	4.79	4.79	4.79	4.79	4.79	4.79
	Minimum Illumination (Horizontal Footcandles)	1.11	0.96	0.86	0.71	0.61	0.46
	*Ratio: Maximum to Minimum Illumination	3.2	3.6	4.2	4.9	6.0	8.1
	Ratio: Average to Minimum Illumination	2.0	2.2	2.2	2.5	2.8	3.5

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 6 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.19	2.02	1.87	1.75	1164	1.54
	Maximum Illumination (Horizontal Footcandles)	6.21	6.21	6.21	6.21	6.21	6.21
	Minimum Illumination (Horizontal Footcandles)	0.81	0.68	0.53	0.43	0.34	0.27
	*Ratio: Maximum to Minimum Illumination	4.5	5.6	7.6	10.7	15.2	23.0
	Ratio: Average to Minimum Illumination	2.7	3.0	3.5	4.1	4.8	5.7
60	Average Illumination (Horizontal Footcandles)	2.05	1.89	1.76	1.64	1.54	1.45
	Maximum Illumination (Horizontal Footcandles)	4.79	4.79	4.79	4.79	4.79	4.79
	Minimum Illumination (Horizontal Footcandles)	0.90	0.77	0.69	0.58	0.51	0.40
	*Ratio: Maximum to Minimum Illumination	3.2	3.6	4.2	4.9	6.0	8.1
	Ratio: Average to Minimum Illumination	2.3	2.5	2.6	2.8	3.0	3.6

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 8 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.93	1.78	1.65	1.55	1.45	1.36
	Maximum Illumination (Horizontal Footcandles)	6.21	6.21	6.21	6.21	6.21	6.21
	Minimum Illumination (Horizontal Footcandles)	0.65	0.56	0.45	0.38	0.31	0.24
	*Ratio: Maximum to Minimum Illumination	4.5	5.6	7.6	10.7	15.2	23.0
	Ratio: Average to Minimum Illumination	3.0	3.2	3.7	4.1	4.7	5.7
60	Average Illumination (Horizontal Footcandles)	1.85	1.70	1.58	1.48	1.38	1.31
	Maximum Illumination (Horizontal Footcandles)	4.79	4.79	4.79	4.79	4.79	4.79
	Minimum Illumination (Horizontal Footcandles)	0.72	0.58	0.52	0.47	0.42	0.35
	*Ratio: Maximum to Minimum Illumination	3.2	3.6	4.2	4.9	6.0	8.1
	Ratio: Average to Minimum Illumination	2.6	2.9	3.1	3.2	3.3	3.7

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 10 - LANE ROADWAY, 20 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.71	1.57	1.46	1.36	1.28	1.20
	Maximum Illumination (Horizontal Footcandles)	6.21	6.21	6.21	6.21	6.21	6.21
	Minimum Illumination (Horizontal Footcandles)	0.46	0.40	0.35	0.31	0.26	0.20
	*Ratio: Maximum to Minimum Illumination	4.5	5.6	7.6	10.7	15.2	23.0
	Ratio: Average to Minimum Illumination	3.7	3.9	4.2	4.4	4.9	6.0
60	Average Illumination (Horizontal Footcandles)	1.66	1.53	1.42	1.33	1.24	1.17
	Maximum Illumination (Horizontal Footcandles)	4.79	4.79	4.79	4.79	4.79	4.79
	Minimum Illumination (Horizontal Footcandles)	0.54	0.45	0.42	0.38	0.35	0.28
	*Ratio: Maximum to Minimum Illumination	3.2	3.6	4.2	4.9	6.0	8.1
	Ratio: Average to Minimum Illumination	3.1	3.4	3.4	3.5	3.6	4.2

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
RAODWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 4 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.23	2.07	1.92	1.79	1.68	1.58
	Maximum Illumination (Horizontal Footcandles)	5.47	5.47	5.47	5.47	5.47	5.47
	Minimum Illumination (Horizontal Footcandles)	0.93	0.78	0.60	0.48	0.36	0.24
	*Ratio: Maximum to Minimum Illumination	4.8	5.9	7.8	10.5	14.8	22.8
	Ratio: Average to Minimum Illumination	2.4	2.7	3.2	3.7	4.7	6.6
60	Average Illumination (Horizontal Footcandles)	2.05	1.89	1.76	1.64	1.54	1.45
	Maximum Illumination (Horizontal Footcandles)	4.23	4.23	4.23	4.23	4.23	4.23
	Minimum Illumination (Horizontal Footcandles)	1.01	0.87	0.77	0.65	0.55	0.43
	*Ratio: Maximum to Minimum Illumination	3.3	3.9	4.4	5.2	6.3	8.7
	Ratio: Average to Minimum Illumination	2.0	2.2	2.3	2.5	2.8	3.4

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 6 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	2.02	1.87	1.74	1.62	1.52	1.43
	Maximum Illumination (Horizontal Footcandles)	5.47	5.47	5.47	5.47	5.47	5.47
	Minimum Illumination (Horizontal Footcandles)	0.75	0.64	0.50	0.41	0.32	0.24
	*Ratio: Maximum to Minimum Illumination	4.8	5.9	7.8	10.5	14.8	22.8
	Ratio: Average to Minimum Illumination	2.7	2.9	3.5	4.0	4.8	6.0
60	Average Illumination (Horizontal Footcandles)	1.89	1.75	1.62	1.5.	1.42	1.34
	Maximum Illumination (Horizontal Footcandles)	4.23	4.23	4.23	4.23	4.23	4.23
	Minimum Illumination (Horizontal Footcandles)	0.81	0.68	0.62	0.53	0.47	0.39
	*Ratio: Maximum to Minimum Illumination	3.3	3.9	4.4	5.2	6.3	8.7
	Ratio: Average to Minimum Illumination	2.3	2.6	2.6	2.9	3.0	3.4

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 8 - LANE ROADWAY, 30c- FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.80	1.66	1.54	1.44	1.35	1.27
	Maximum Illumination (Horizontal Footcandles)	5.47	5.47	5.47	5.47	5.47	5.47
	Minimum Illumination (Horizontal Footcandles)	0.60	0.52	0.42	0.37	0.30	0.24
	*Ratio: Maximum to Minimum Illumination	4.8	5.9	7.8	10.5	14.8	22.8
	Ratio: Average to Minimum Illumination	3.0	3.2	3.7	3.9	4.5	5.3
60	Average Illumination (Horizontal Footcandles)	1.72	1.59	1.47	1.37	1.29	1.21
	Maximum Illumination (Horizontal Footcandles)	4.23	4.23	4.23	4.23	4.23	4.23
	Minimum Illumination (Horizontal Footcandles)	0.65	0.52	0.48	0.43	0.39	0.32
	*Ratio: Maximum to Minimum Illumination	3.3	3.9	4.4	5.2	6.3	8.7
	Ratio: Average to Minimum Illumination	2.6	3.1	3.1	3.2	3.3	3.8

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.

SUMMARY OF PHOTOMETRIC DATA
FOR
ROADWAY LIGHTING SYSTEMS

MANUFACTURER CODE: 4 LUMINAIRE: 1000w, TYPE III

MOUNTING HEIGHT, (FEET)	MEDIAN LIGHTING SYSTEM 10 - LANE ROADWAY, 30 - FOOT TRANSVERSE SPACING						
	VARIABLE	LONGITUDINAL SPACING, (FEET)					
		240	260	280	300	320	340
50	Average Illumination (Horizontal Footcandles)	1.59	1.47	1.37	1.27	1.19	1.12
	Maximum Illumination (Horizontal Footcandles)	5.47	5.47	5.47	5.47	5.47	5.47
	Minimum Illumination (Horizontal Footcandles)	0.44	0.38	0.34	0.30	0.25	0.20
	*Ratio: Maximum to Minimum Illumination	4.8	5.9	7.8	10.5	14.8	22.8
	Ratio: Average to Minimum Illumination	3.6	3.9	4.0	4.3	4.8	5.6
60	Average Illumination (Horizontal Footcandles)	1.54	1.43	1.32	1.23	1.16	1.09
	Maximum Illumination (Horizontal Footcandles)	4.23	4.23	4.23	4.23	4.23	4.23
	Minimum Illumination (Horizontal Footcandles)	0.51	0.44	0.41	0.37	0.33	0.28
	*Ratio: Maximum to Minimum Illumination	3.3	3.9	4.4	5.2	6.3	8.7
	Ratio: Average to Minimum Illumination	3.0	3.2	3.2	3.3	3.5	3.9

* Largest of the Maximum-to-Minimum Ratios Along the Lane Lines.