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Evaluation of Supplemental Lights for Caution Bars

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Final Report

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16. Abstract

Caution Bars (stop bars or hold bars) are used to identify taxiway hold lines and warn pilots of an approaching runway. Caution Bars are difficult to see when they are covered by snow or sand, or when a high-cockpit aircraft is at or close to the caution bars. Under these conditions, supplemental lights (taxi-holding position lights) could help. This project was to determine the desired characteristics of horizontal and vertical coverage, intensity, flash rate, and orientation of the supplemental lights. The results indicated that these characteristics were acceptable or desired:

Horizontal and vertical coverage: ±15 degrees (as shown by photometric data)
Intensity: 30-percent night; 100-percent day (1600 candela light)
Flash rate: 58 flashes/minute (off the shelf equipment)
Orientation: toe-in 20 degrees toward taxiway pitch-up 10 degrees above horizon

The results also indicated that the lights would enhance identification of the taxi-holding position.

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EXECUTIVE SUMMARY

This evaluation was performed in response to a request from the Office of Airport Standards. Caution bars are used to identify taxiway hold lines and warn pilots that they are nearing a runway. The caution bars are difficult to see when they are covered by snow or sand, or when a high-cockpit aircraft is at or close to the caution bar. Under these conditions, supplemental lights could help the pilot identify their location in relation to the hold line. This project was to determine the horizontal and vertical coverage, intensity, flash rate, and orientation of the supplemental light.

The literature uses various names and terms for the concept of supplemental lights. This report uses the name "taxi-holding position lights" as proposed by the Aerodromes, Air Routes and Ground Aids Division (AGA) of the international Civil Aviation Organization (ICAO) instead of the term "supplemental lights."

The evaluation compared two different fixtures by obtaining FAA test pilot responses. Six different variables were tested. They were intensity, flash rate, distance from taxiway edge, lens diameter, toe-in (towards taxiway), vertical angle (pitch-up). Also a general response to the overall usefullness was obtained. In addition, photometric data were obtained for the fixtures. The following characteristics were determined to be the most effective:

1. Intensity: 30-percent night, 100-percent day (1600 candela light)
2. Flash rate: 58 flashes/minute (off-the-shelf equipment)
3. Distance from taxiway edge: 20 feet from pavement edge and 36 inches above grade.
4. Lens diameter: 12 inches
5. Toe-in: 20 degrees toward taxiway
6. Vertical Angle: 10 degrees pitch-up
7. Horizontal and vertical coverage: ±15 degrees (as shown by photometric data)

The data also showed that the pilots felt that the taxi-holding position lights would provide enhanced identification of the taxi-holding position. However, they expressed the reservation that the lights should only be employed where operational experience showed that they are NEEDED.

INTRODUCTION

PURPOSE.

The purpose of this project was to determine the desired characteristics of supplemental lights for caution bars used at taxiway hold lines. The evaluation described in this report was performed in response to a request from the Office of Airports Standards (AAS-200). It was accomplished under Technical Program Document Number 08-493, Subprogram 081-502, Project 590 "Evaluation of Supplemental Lights for Caution Bars at Taxiway Hold Lines."

The request stated that "The present caution bar consist of a row of steady burning inpavement lights. These lights are difficult to see when the taxiway is covered with snow or when a high-cockpit aircraft is at or close to the lights. The addition of an elevated light on both sides of the taxiway and flashing in a wig-wag fashion could alleviate these deficiencies and would provide a bolder caution bar which could prove useful at locations having problems with inadvertent runway transgressions." The request also indicated that, as a result of the evaluation, recommendations should be provided for use in establishing the following equipment characteristics:

a. Horizontal and vertical coverage of the light beam.
b. Intensity of the light beam.
c. Flash rate of the lights.
d. Orientation of the main light beam.

The evaluation was also to consider whether the concept on use of such lights is an enhancement to the caution bars.

BACKGROUND.

CAUTION BARS. The Federal Aviation Administration (FAA) does not define "caution bars" in any Advisory Circular. The only related reference is to "hold bars" in AC 150/5340-19 "Taxiway Centerline Lighting System" which is defined as three bidirectional lights showing yellow in both directions, spaced at intervals of 1.5 M (5 ft) across the taxiway. Also these hold bars would only be used where the centerline lights are installed on straight centerlines and not with the curved centerline.

The International Civil Aviation Organization (ICAO) Annex 14 "Aerodromes," Chapter 5 "Visual Aids for Navigation," does not define "caution bars" but does define "stop bars" as "unidirectional lights showing red in the direction of approach to the intersection or taxi-holding position, spaced at intervals of 3 M (10 ft) across the taxiway." The definition we used for this project is identical to the ICAO definition of stop bars except, we have used the color yellow instead of red as follows:

> Caution bars are unidirectional lights showing yellow in the direction of approach to the taxi-holding position, spaced at intervals of 3 M (10 ft) across the taxiway.

SUPPLEMENTAL LIGHTS. ICAO Annex 14, Chapter 5.3.20.2, recommends the use of a pair of elevated lights at each end of the stop bar where the stop bar may be obscured.

The taxi-holding position light may well serve the purpose of identifying the holding position when the caution-bar lights or painted markings are obscured by sand or snow. Reference 5 states that flashing lights adjacent to the edge of the taxiway at the taxi-holding location will provide an additional indication of the stopping point.

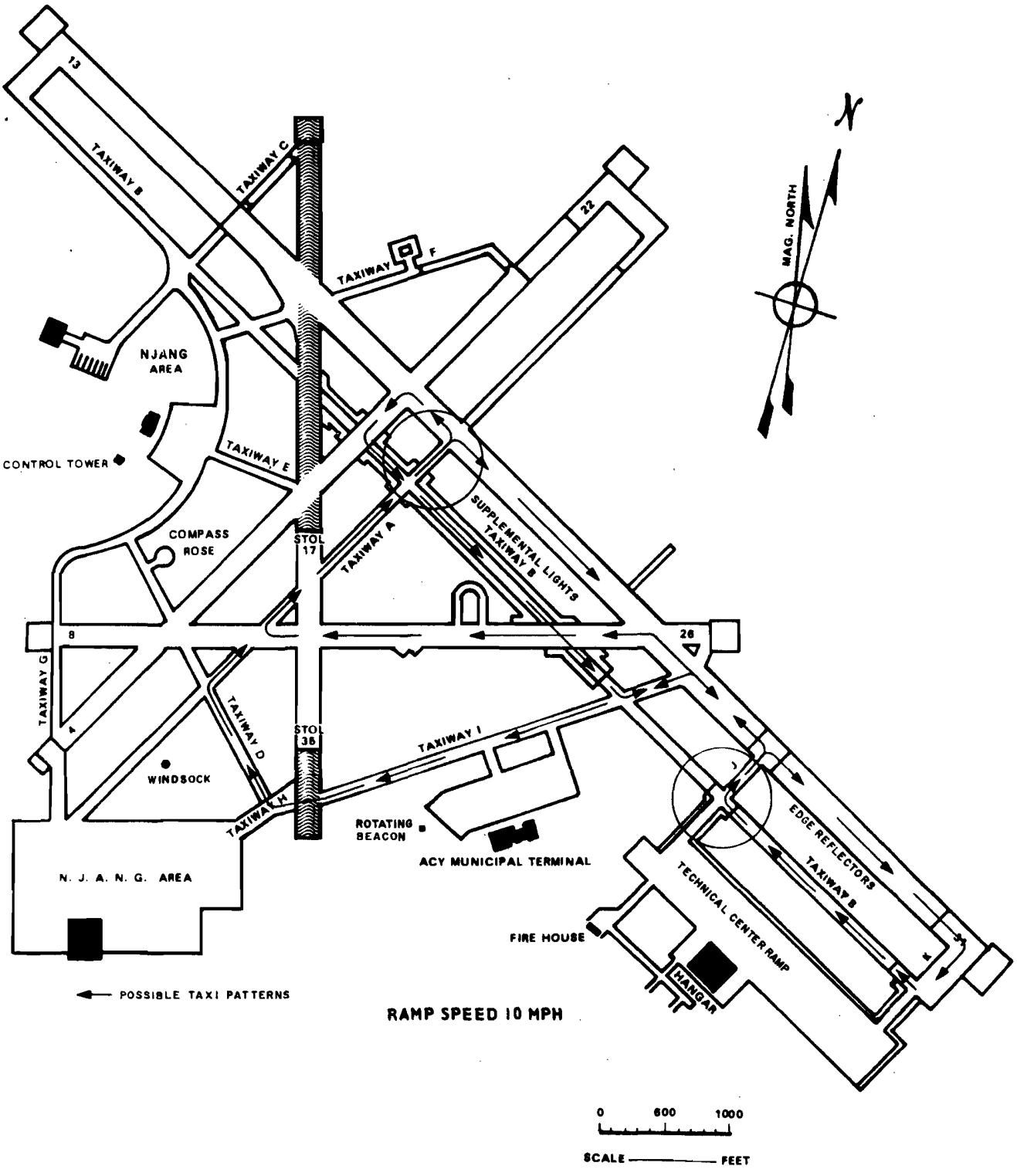
EVALUATION PROCEDURE

The evaluation compared effectiveness of two different light fixtures provided by AAS-200, a smaller fixture had two 8-inch diameter lenses and used two 69-watt 120-volt traffic signal lamps and a larger fixture had two 12-inch diameter lenses and used two 116-watt 120-volt traffic signal lamps (figure 1). Modifications to the standard fixtures were made to permit variations in intensity, flash rate, and orientation of the units.

The Taxi-Holding Position Lights were temporarily installed on taxiway A at the taxi-holding position line on the southwest side of runway 13-31 at the Federal Aviation Administration (FAA) Technical Center, Atlantic City Airport, New Jersey (figure 2). Taxiway A has green taxiway centerline lights and no caution-bar lights at the hold line. A temporary lighted caution-bar was set up using L-852W taxiway centerline lights. The FAA test pilots, using a Convair 540 and Aerocommander 680E aircraft, performed the necessary taxi testing of the system. Preliminary evaluation was accomplished at night, since the dark condition was assumed to be the most critical situation for potential inadvertent runway intrusions. During this major portion of the evaluation effort, all of the critical characteristics were determined. Additional limited daytime testing was also conducted, using a system having the characteristics that had been determined as most effective at night, to validate the previously obtained data and to establish the required daytime intensity levels.

The tests compared flash rates of 30, 40, 50, 60, and 120 flashes per minute. Intensities were compared by varying the voltages applied to the traffic signal lamps. The three voltges used were 120, 85, and 60 volts with corresponding levels of 100, 30, and 10 percent of rated intensity. The fixtures were tested at four different distances from the edge of the taxiway and heights above grade. These were 10, 20, 35, and 38 feet from the pavement edge and 30, 36, 42 and 48 inches above grade, respectively. It is noted that heights above grade were selected based on the maximum allowable as outlined in AC 150/5340-18A "Taxiway Guidance Sign System." The angles at which the fixtures were toed-in toward the taxiway were 0, 10, 20, and 30 degrees. Vertical aiming angles, above the horizontal, were 0, 10, 20, and 30 degrees.

Pilots were given the briefing sheet (figure 3) prior to the evaluation test and allowed to ask questions. Aircraft were then taxied from near the intersection of runway 8-26 and taxiway A north to the intersection of runway 13-31. Once the pilot had been afforded the opportunity to observe the light configuration, the aircraft was stopped and the pilots completed a questionnaire (figure 4).



NAFEC/ATLANTIC CITY AIRPORT, ATLANTIC CITY, NEW JERSEY

FIGURE 2. TAXI-PATTERN FOR TEST

EVALUATION SUPPLEMENTAL LIGHTS FOR CAUTION BARS

Project 081-502-590

TYPE AND MODEL AIRCRAFT_____ DATE_____

VISIBILITY_____ TEST CONFIGURATION (SUPPLIED BY TEST PERSONNEL)_____

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM

2. HOW WOULD YOU EVALUATE THE FLASH RATE OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO FAST	TOO FAST	ABOUT RIGHT	TOO SLOW	MUCH TOO SLOW

3. HOW WOULD YOU EVALUATE THE DISTANCE OF THE SUPPLEMENTAL LIGHTS FROM THE EDGE OF THE TAXIWAY?

1	2	3	4	5
MUCH TOO CLOSE	TOO CLOSE	ABOUT RIGHT	TOO FAR AWAY	MUCH TOO FAR AWAY

4. WHICH SUPPLEMENTAL LIGHT DID YOU PREFER?

1	2	3
PREFER LEFT	NO PREFERENCE	PREFER RIGHT

5. HOW WOULD YOU EVALUATE THE USEFULNESS OF THE SUPPLEMENTAL LIGHTS IN LOCATING THE TAXIWAY/RUNWAY HOLD LINES OR CAUTION BARS?

1	2	3	4	5
VERY USEFUL	USEFUL	NO VALUE	DISTRACTING	VERY DISTRACTING

COMMENTS:

FIGURE 4. QUESTIONNAIRE USED TO COLLECT DATA

TABLE 1. INTENSITY TEST RESULTS

Intensity (Night) 10%

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		5	3	

Intensity (Night) 30%

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
	1	16	1	

Intensity (Night) 100%

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		4		

Intensity (Day) 30%

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
			6	

Intensity (Day) 100%

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		6		

TABLE 3. DISTANCE TESTS RESULTS

Distance 10ft

3. HOW WOULD YOU EVALUATE THE DISTANCE OF THE SUPPLEMENTAL LIGHTS FROM THE EDGE OF THE TAXIWAY?

1	2	3	4	5
		1	1	
MUCH TOO CLOSE	TOO CLOSE	ABOUT RIGHT	TOO FAR AWAY	MUCH TOO FAR AWAY

Distance 20ft

3. HOW WOULD YOU EVALUATE THE DISTANCE OF THE SUPPLEMENTAL LIGHTS FROM THE EDGE OF THE TAXIWAY?

1	2	3	4	5
		9	1	
MUCH TOO CLOSE	TOO CLOSE	ABOUT RIGHT	TOO FAR AWAY	MUCH TOO FAR AWAY

Distance 35ft

3. HOW WOULD YOU EVALUATE THE DISTANCE OF THE SUPPLEMENTAL LIGHTS FROM THE EDGE OF THE TAXIWAY?

1	2	3	4	5
		1		1
MUCH TOO CLOSE	TOO CLOSE	ABOUT RIGHT	TOO FAR AWAY	MUCH TOO FAR AWAY

Distance 38ft

3. HOW WOULD YOU EVALUATE THE DISTANCE OF THE SUPPLEMENTAL LIGHTS FROM THE EDGE OF THE TAXIWAY?

1	2	3	4	5
	1	14	2	
MUCH TOO CLOSE	TOO CLOSE	ABOUT RIGHT	TOO FAR AWAY	MUCH TOO FAR AWAY

TABLE 5. ORIENTATION RESULTS

Toe-In 10°

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		1	1	

Toe-In 20°

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		2	1	

Toe-In 30°

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		2		

Vertical 10°

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		1	1	

Vertical 20°

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		2		

Vertical 30°

1. HOW WOULD YOU EVALUATE THE INTENSITY OF THE SUPPLEMENTAL LIGHTS?

1	2	3	4	5
MUCH TOO BRIGHT	TOO BRIGHT	ABOUT RIGHT	TOO DIM	MUCH TOO DIM
		2	1	

1. Intensity

The intensity testing resulted in a pilot preference for the 100 percent level (table 1). If it were desired to have a variable intensity for night and day, then 30 percent intensity should be used for night and 100 percent for day.

2. Lens Diameter

Pilots indicated a preference for the 12-inch diameter lens (see table 4).

3. Overall Usefulness

The pilots rated the taxi-holding position lights as useful or very useful (see table 5.)

PHOTOMETRIC TESTS (HORIZONTAL AND VERTICAL COVERAGE).

The photometric data for the two taxi-holding position lights used are shown in figures 5, 6, 7, and 8. The horizonatal and vertical coverage provided by the test lights and shown by the photometric data would be adequate.

CONCLUSIONS AND RECOMMENDATIONS

The following equipment characteristics were determined to be the most effective:

1. Intensity: 30 percent for night and 100 percent for day
2. Flash Rate: 58 flashes/minute
3. Distance from T/W Edge: 20 feet from pavement edge and 36 inches above grade.
4. Lens Diameter: 12 inches
5. Toe-in angle: 20 degrees
6. Vertical Angle (pitchup): 10 degrees
7. Horizontal and vertical coverage of light beam: as shown by photometric data.

The use of supplemental lights with the above characteristics will provide enhanced identification of the taxi-holding position. To further validate the results of this limited evaluation, it is recommended that additional in-service testing of the system should be accomplished at an air-carrier airport.

REFERENCES

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2. ICAO, Aerodromes Air Routes and Ground Aids Division Meeting, Doc. 9342, AGA/82, 22 April, 15 May 1981.

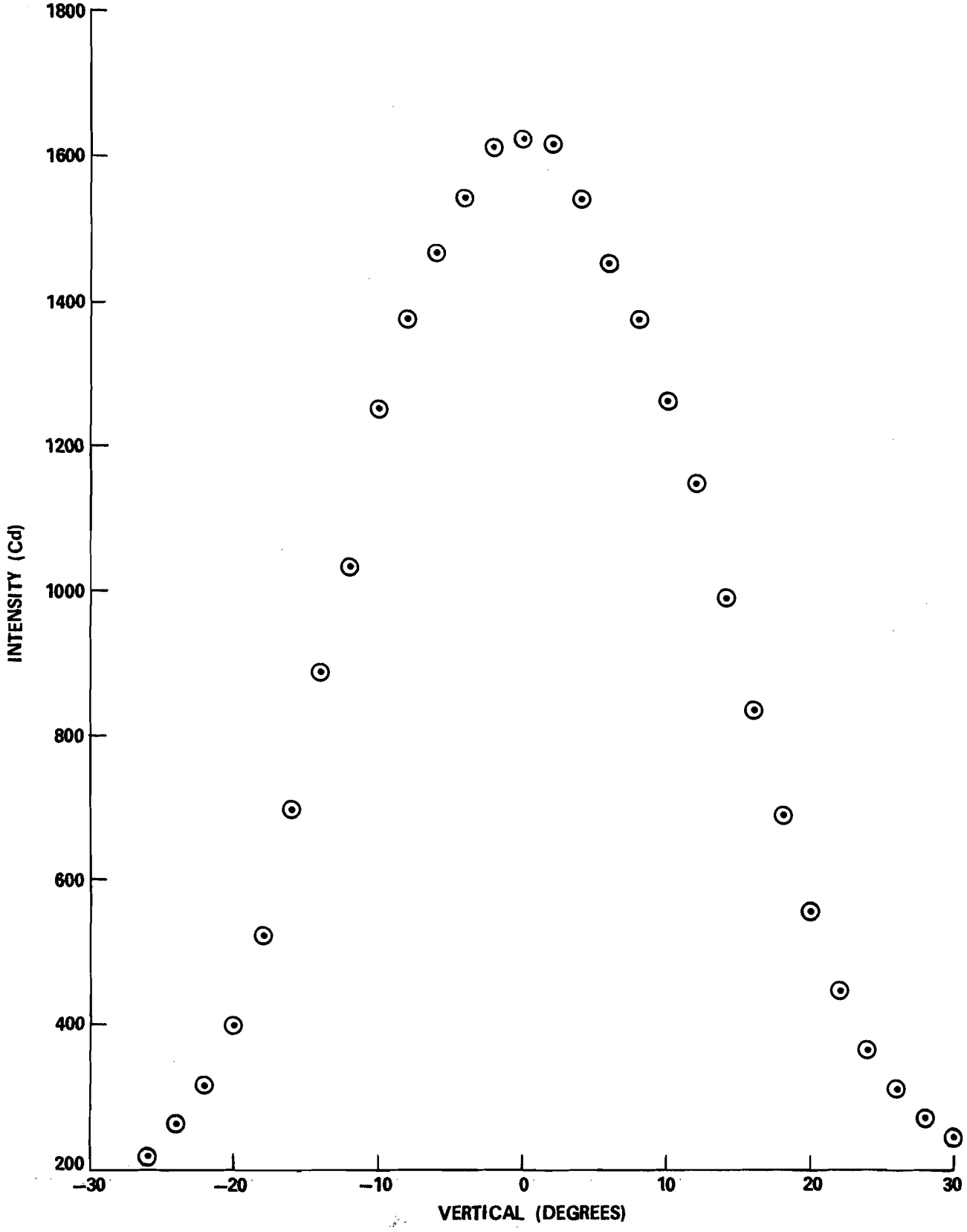

FIGURE 7. PHOTOMETRIC DATA (VERTICAL) FOR TAXI-HOLDING POSITION LIGHT WITH 12-INCH DIAMETER LENSE

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