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EVALUATION OF A PORTABLE PHOTOMETER TO MEASURE THE LIGHT OUTPUT OF INSTALLED IN-PAVEMENT LIGHTING FIXTURES

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16. Abstract

The purpose of this effort was to determine the suitability of a portable photometer to rapidly measure the light output of inset runway lights. The work involved: (1) Laboratory measurements to compare the experimental unit with a standard laboratory photometer; (2) Field measurements of inset lighting by a team of technicians; and (3) Analysis of the photometer construction. The result of the tests indicated that the portable photometer was adequate for the measurement of L-850A inset lights, but that some minor changes should be incorporated in the final design to make the unit more rugged and to permit measurement of more than one fixture type.

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INTRODUCTION

PURPOSE.

The purpose of this activity was to evaluate the suitability of a portable measuring device for rapid determination of light level by photometry of inset light fixtures installed in airport paved surfaces. In addition, if applicable, changes to improve the photometer by rectifying deficiencies were to be recommended.

BACKGROUND.

In-runway lighting systems at airports are designed to provide the necessary visual guidance for landing and takeoff in low-visibility conditions. Due to their location in operating areas, the inset fixtures making up these lighting systems are unusually susceptible to deterioration of light output. Dirt, rubber, and other contaminants are deposited on lenses, and light output is often further reduced by corrosion, moisture, and other factors. The determination of whether or not inset lighting systems provide adequate guidance in low visibility is a problem of considerable magnitude.

The use of current or voltage monitoring methods too often has little relation to the actual light emitted. Visual inspection at suitable intervals is an improvement, but human eyes are notoriously susceptible only to large errors.

When equipment is being used to measure the light level of inset lights, the runway or taxiway being measured must be placed out of service. It is vitally important that this "downtime" at a busy airport be kept to a minimum. Consequently, all aspects of design must be directed toward a goal of maximum speed of measurement, consistent with accuracy, for use under operating airport conditions.

DISCUSSION

EQUIPMENT DESCRIPTION.

A portable photometer was developed under FAA Work Order WI 73 1212. It was manufactured to satisfy the measurement requirements as described in Advisory Circular AC-150/5340-22, Change 1. Figure 1 shows the instrument with its stand in position to make measurements. The stand raises the meter photocell to a height at which peak output of the light should be read. The angle in this position for this unit is 5 degrees. The unit is approximately 5 feet long, made of light aluminum with a photocell, microampere meter, and switch in one end. Located in the other end is a light flexible aluminum assembly that would interface with the aperture of a centerline inset light fixture. This unit was designed to operate with an L-850A fixture only and would not fit

FIGURE 1. THE OPERATING PORTABLE PHOTOMETER READY FOR USE

any other fixture. The microampere meter was calibrated in candlepower with a low scale of zero to 3,000 candles and a high scale of zero to 10,000 candles. The unit is extremely lightweight and is practically the same as the prototype developed at the National Aviation Facilities Experimental Center (NAFEC) (see Figure 2), except that there was no provision for a carrying handle on the unit, however, a handle was supplied with the vinyl carrying case which is used to transport the equipment. Basically, the unit is of very simple design, having a photocell which converts the light signal into an electrical current. This current is then read on a microampere meter. To simplify interpretation, the meter is calibrated in candlepower. The aluminum unit serves to: (1) maintain the photocell at a calibrated distance from the light source; (2) shield the photocell so that only the light from the fixture will be measured, and (3) establish the proper vertical and horizontal angles in which to interface with the light aperture.

Figure 3 shows the instrument with the stand folded and ready to be placed in the carrying case.

TEST PROCEDURES.

The portable photometer was first tested by the Metrology Laboratory at NAFEC and compared to a photometer whose calibration was traced to the light standards of the National Bureau of Standards. It was then taken into the field to measure the centerline inset light fixtures (L-850A) of Runway 13 at NAFEC. The tests were conducted over a 6-week period so that any change of measuring characteristics could be noted. All measurements were performed during daylight hours so that any light leakage from the sun would readily be detected. Five-hundred measurements were made to establish a satisfactory statistical quantity. The measurements were taken on five different days with the light intensity set for maximum output. After a 6-week period the photometer was returned to the Metrology Laboratory to determine whether or not it had maintained its initial calibration. Data collected in the field were collated and measurement variations were determined.

TEST RESULTS.

The portable photometer maintained its calibration throughout the test period of 6 weeks. When the unit was accidentally dropped, breaking the meter case, calibrations were easily reestablished after repairs were made to the broken case.

In the laboratory, with the photometer attached to the inset light fixture (L-850A) so that its axis was parallel with the light beam, the deviation of the meter readings, from those obtained with a standard photometer, was a maximum of 8 percent (Table 1). This error can be expected to increase under airport operation conditions if care is not exercised in interfacing the photometer properly on line with the beam axis. Approximately 5 degrees of horizontal movement between the light fixture and the photometer was detected and in the test fixture this caused a measured error of 28 percent.

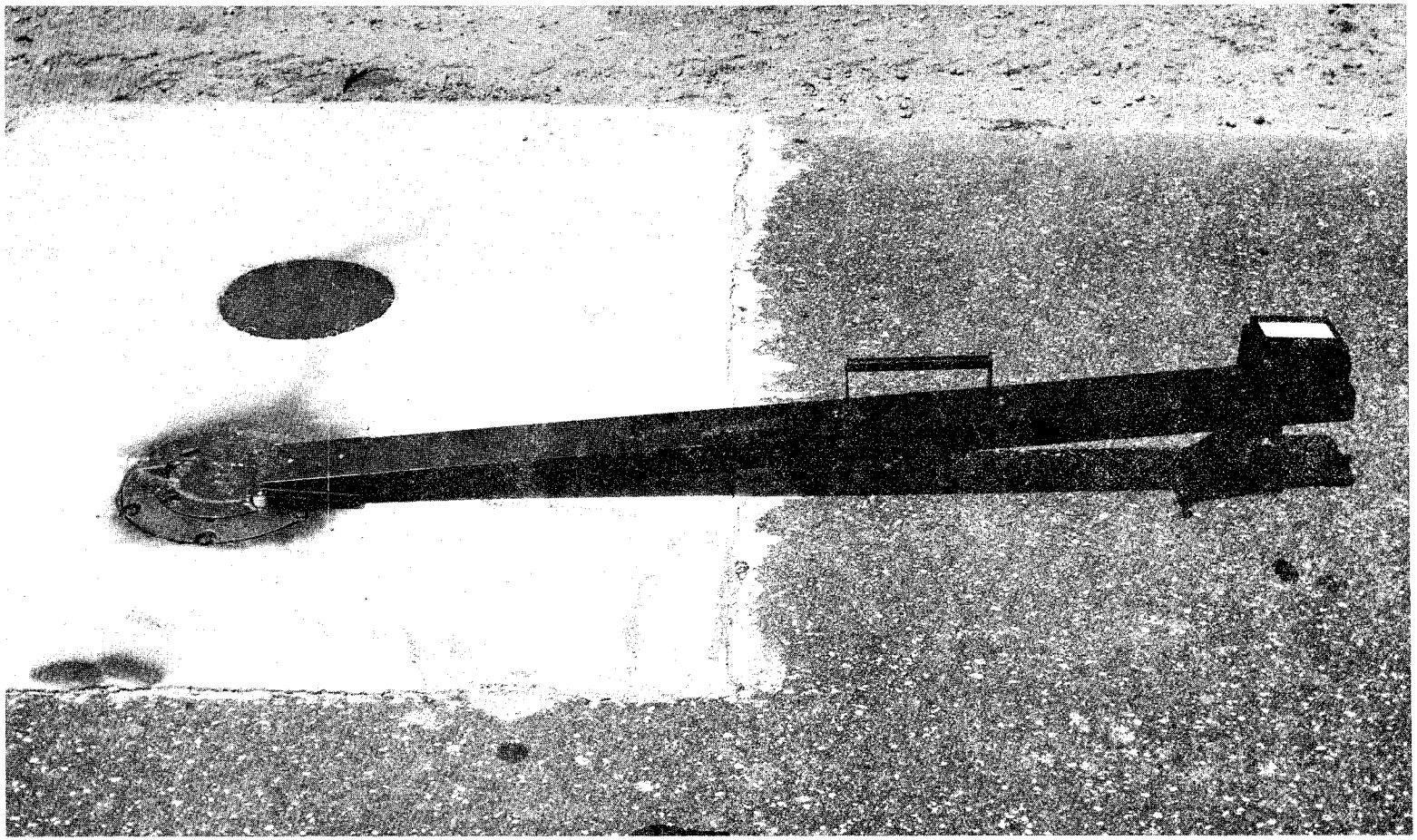

FIGURE 2. NAFEC PROTOTYPE PORTABLE PHOTOMETER, DEVELOPED IN 1970

FIGURE 3. PORTABLE PHOTOMETER READY FOR TRANSPORT

TABLE 1. DEVIATION OF READINGS OF PORTABLE PHOTOMETER COMPARED TO A STANDARD PHOTOMETER

Measured Candlepower Using a Standard Photometer	March 1973 Candela Deviation With Experimental Photometer	June 1973 Candela Deviation With Experimental Photometer
300	+25	+ 20
3200	+75	+100
5000	+14	- 50

A high degree of consistency was established by the personnel performing the 500 field measurement on the L-850A inset light fixture. The maximum inconsistency between members on the measurement team was 17 percent, with an average maximum single fixture disagreement inconsistency of 5.9 percent. When the light output was severely reduced (25 percent or less of optimum), inconsistencies increased substantially. This was disregarded, however, since all members agreed that the light output was insufficient. The majority of light output deficiencies were due to fixtures with broken lenses, water in the fixture, and/or defective light sources (lamps). A recurring deficiency of light output was noted and attributed to the fact that the runway was not level, and, therefore, the vertical measurements were made of other than the optimum 5 degrees. Also, at times, the light fixture was not perfectly installed in the runway, again attributing error to this variation of 5 degrees. The meter is not designed to compensate for this type error.

Measurement time per fixture was minimal. The normal measurement time averaged 45 seconds per fixture and many times the measurement was completed in less than 30 seconds. At this rate, a runway of 10,000 feet with 200 fixtures could easily be measured in 6 hours. This would include transportation time to and from the site and movement from fixture-to-fixture.

CONCLUSIONS

As a result of the testing accomplished and the data collected, it is concluded that the photometer is a satisfactory device for measuring degradation of L-850A fixture light output.

RECOMMENDATIONS

It is recommended that the basic design of the portable photometer used in this evaluation be adopted after modification to incorporate the following changes:

1. A carrying handle should be provided on the unit.

2. The photometer should be strengthened for use in the field and the meter more substantially protected.

3. The photometer should include a provision to accommodate variations in fixture height and runway profile.

4. Interchangeable heads should be provided to permit use with a variety of fixture types.