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12

EVALUATION OF A 100-WATT ELEVATED HIGH-INTENSITY RUNWAY EDGE LIGHT

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FINAL REPORT

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Systems Research & Development Service
Washington, D.C. 20590

NOTICE

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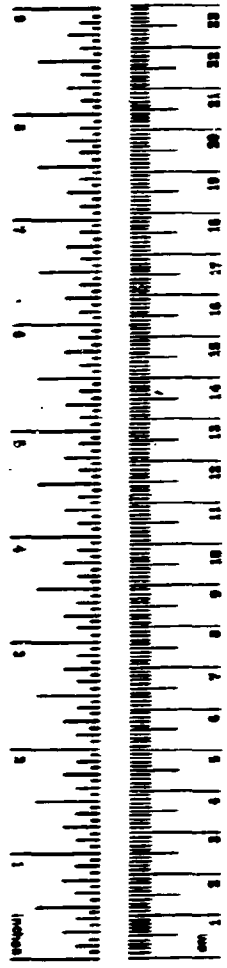
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

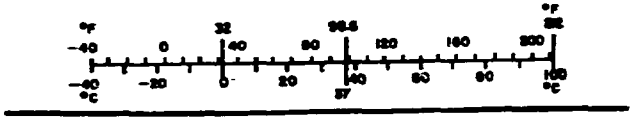
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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16. Abstract

The purpose of this project is to evaluate a newly designed, elevated, high-intensity runway edge light using a 100-watt lamp as its light source, rather than the standard 200-watt lamp, to determine if the lower wattage lamp and fixture combination would be satisfactory for category I and category II low-visibility operations, where a Federal Aviation Administration Specification type L-862 runway edge light fixture would be required. Pilot opinion during flight tests indicates that an installed group A version of the experimental runway edge light unit is visually adequate for category I weather operations and should be adequate for category II operations. Group A lights, however, did not meet the Office of Airport Programs Specification for L-862 runway edge lights (Advisory Circular 150/5345-48). An improved group B version will meet both requirements, since it satisfactorily passed the L-862 photometric specifications. This is the final report of a series that includes the following two interim reports: (1) FAA-RD-74-128, "Evaluation of an Experimental Elevated High-Intensity Runway Edge Light," and (2) FAA-RD-74-171, "Evaluation of an Experimental High-Intensity Inset Runway Edge Light Fixture."

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

PURPOSE.

The purpose of this project is to evaluate the effectiveness of a new type of elevated, runway edge light fixture employing a 100-watt lamp for operations during both category I and category II weather conditions. Also to be determined is whether or not the fixture will meet the photometric requirements of the Federal Aviation Administration (FAA) Specification L-862 runway edge light as described in the latest Advisory Circular issued by the FAA Office of Airport Programs.

BACKGROUND.

In this report, all Advisory Circulars quoted were issued by the Office of Airport Programs. The original (now superseded) FAA Specification L-819 elevated, high-intensity, runway edge light design has been in use since 1950. This fixture served satisfactorily until the use of large jet aircraft caused considerable damage to this runway edge light fixture. Modifications had been made by the manufacturers to improve the structural features of these fixtures to make them less susceptible to damage due to the increased stresses imposed by jet blast. These modifications did not completely remedy the problem caused by the jet blast. A new fixture was designed and developed under contract DOT-FA72WA-2726 issued in 1972 in accordance with the photometric standards of the Advisory Circular 150/5345-9C (reference 1). This fixture was intended to function in the environs of high-velocity jet blasts. It was designed to use a 200-watt, 6.6-ampere, prefocused, Halogen-cycle, Quartzline lamp for its source of light. The fixture was tested at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey, and was determined to be acceptable as a replacement for the then standard L-819 fixture. The tests are described in a report issued by the FAA in 1974 (reference 2) recommending further testing of this type of light with color filters when suitable filters were available. Glass absorption filters were later developed by the manufacturer and were determined to perform acceptably. Tests were also conducted on an experimental inset runway edge light fixture to determine if the main beam light distribution would meet the specifications for the L-819 fixture as described in Advisory Circular 150/5345-9C. Tests clearly showed that the fixture was suitable for use as an inset runway edge light where an elevated runway edge light could not be used (reference 3).

The FAA investigated the possibility of replacing the 200-watt lamp in the experimental elevated runway edge light with a lower wattage lamp while still maintaining satisfactory intensity and light distribution for guidance in category I and category II weather operations. The motivation for this study arose from results of photometric tests performed on a modified fixture using a 100-watt lamp. The tests indicated that because of improved optical control and increased light efficiency, the fixture and lamp could produce a light distribution similar to the L-819 specification. The value of such a fixture is readily evident in the large saving of electrical energy required to operate a runway lighting system.

Since these tests, Advisory Circular 150/5345-9C was canceled and superseded by Advisory Circular 150/5345-48 (reference 4), and the fixture was redesignated from L-819 to L-862. A basic photometric change was made in which the average axial light intensity of the main beam was reduced from 20,000 candela to 10,000 candela, and the beamspreads were increased. This change was in agreement with the standard established in Aerodromes Annex 14 (reference 5). However, it had yet to be determined whether or not the experimental fixture, as designed with the 100-watt light source, could meet all of the L-862 light distribution specifications and whether or not it could perform adequately under low-visibility weather conditions. To this end, the present study was undertaken.

DISCUSSION

EQUIPMENT DESCRIPTION.

Under an amendment to contract DOT-FA72WA-2726, the manufacturer modified the experimental light fixture, improving the optical control to make it adaptable for use with not only 200-watt lamps but also 100-watt lamps. This report concerns only the 100-watt lamp light source.

Figure 1 is a photograph comparing the salient features of the new fixture to those of the original L-819 fixture. It can be readily seen that the new fixture exposes considerably less surface area to jet blast than the L-819 fixture. The outer surface of the new glass dome was designed, as was the L-862, with a smooth surface, having the optical lens on the inside of the dome. This greatly reduces the resistance of the fixture to high winds and jet blasts and also affords ease in cleaning. On the other hand, the original L-819 fixture had optical lens surfaces on the outside of the dome, which exposed a large flat area to jet blasts. These surfaces are difficult to keep clean and reduce the light output by the accumulation of dirt in the grooves of the lenses on the dome.

Figure 2 is a photograph displaying the internal optical assembly of the new fixture as compared with the internal construction of the original L-819. It can be noted that the new fixture makes use of a small two-pin prefocused lamp, and the L-819 uses a medium prefocused lamp.

To produce colored light with the L-819 fixture, a colored glass filter was installed on the optical base of the fixture as shown in figure 3. The new fixture initially made use of a colored lens installed in front of the light source; however, this permitted white light spillover, causing difficulty in determining the color of the light. Instead of separate colored lens, the new fixture in the tests of the colored lights had a coating of silicone paint applied to a portion of the inside of the glass dome to produce the colored light desired (figure 4).

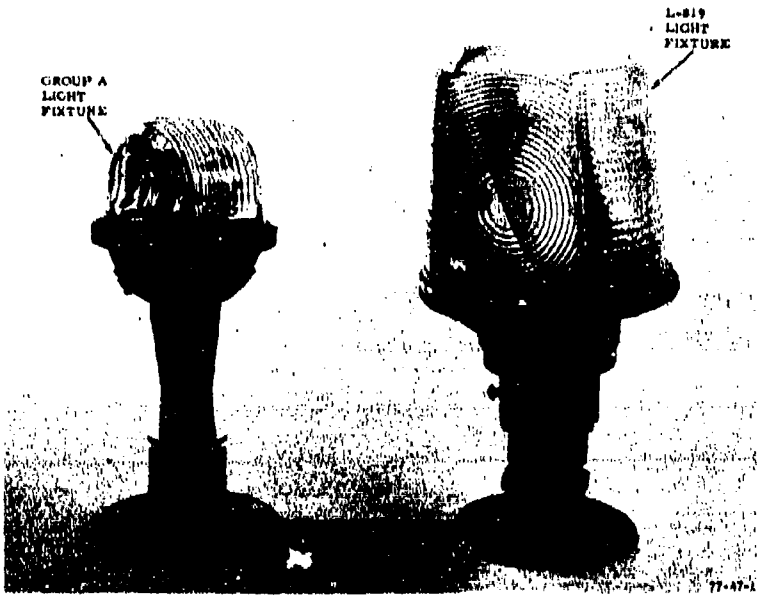

FIGURE 1. A 100-WATT EXPERIMENTAL AND A TYPICAL L-819 RUNWAY EDGE LIGHT FIXTURE

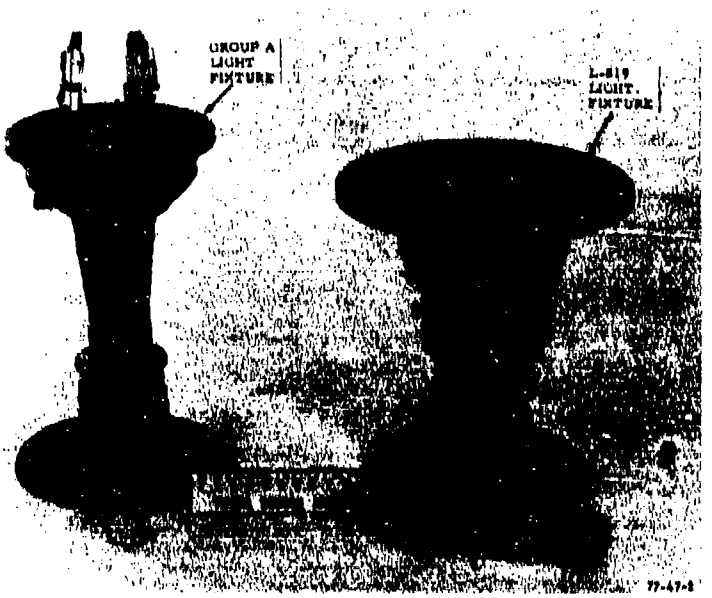

FIGURE 2. A 100-WATT EXPERIMENTAL AND A TYPICAL L-819 RUNWAY EDGE LIGHT FIXTURE DISASSEMBLED

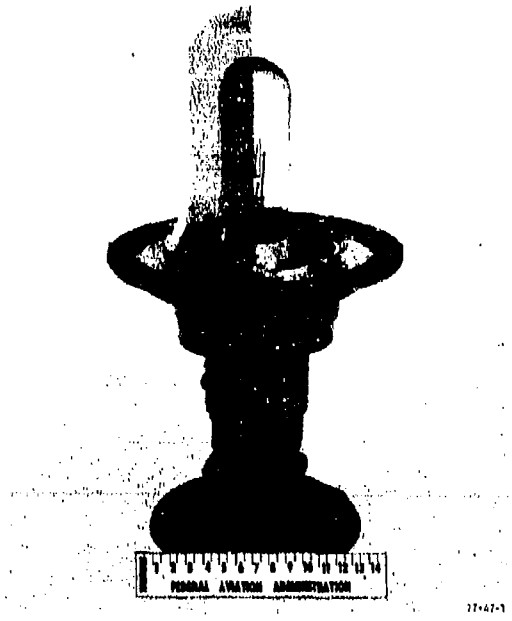

FIGURE 3. TYPICAL L-819 RUNWAY EDGE LIGHT WITH HALF-COLORED FILTER INSTALLED

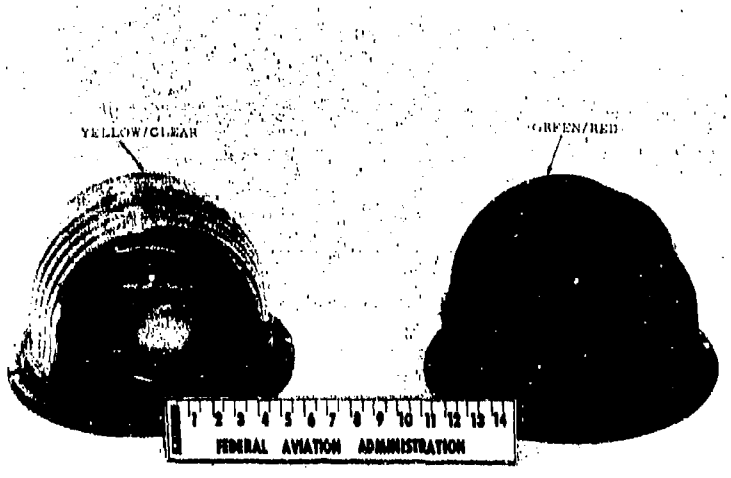

FIGURE 4. SILICONE-COATED DOMES FOR 100-WATT EXPERIMENTAL RUNWAY EDGE LIGHT FIXTURE

TEST PROCEDURES.

LABORATORY TESTS. Three types of laboratory tests were considered for the new fixture: (1) jet blast, (2) photometric, and (3) painted lens degradation. Controlled jet blasts had previously been conducted on the experimental and L-862 runway edge light fixtures (reference 2), and it was found that the structural design of these fixtures far exceeded the requirements as specified. It was decided that further wind tests were not required, since the structure of the fixtures used in this evaluation was essentially the same as those previously tested.

Photometric distribution tests were performed on several fixtures supplied under the development contract using group A 100-watt lamps. These fixtures are called group A in this report for the purpose of distinguishing them from a later version of the fixture called group B. Group B lights were supplied by the manufacturer using selected lamps that would work satisfactorily with the light fixture to meet the L-862 specification.

In addition to the photometric tests, chromaticity tests were made on several lights using silicone-coated domes to produce colored light. Green/red domes were to be used for threshold and runway end lights, and yellow/clear domes for rollout runway lights. Chromaticity was measured for several lights of each color with 200-watt lamps. Accelerated life tests were made for each color by operating the lights continually at rated intensity using 200-watt lamps. The chromaticity of these lights was measured at periodic intervals during and after this test. The chromaticity of some of these colored lights with 100-watt lamps was measured before and after 8 months of operation on runway 13/31 in the installation at NAFEC.

FLIGHT TESTS. Runway 13/31 at NAFEC was the site for the flight tests. The complete runway edge lighting system was refurbished with the group A fixtures using 100-watt lamps in lieu of the 200-watt lamps. The tests were conducted under both day and night category I and category II weather conditions.

In addition to the local flights at NAFEC, a flight was made to the Newark International Airport, Newark, New Jersey. This airport has a dual runway system; one runway equipped with the original L-819, 200-watt edge lights, and the other runway with the new group A runway edge lights employing 100-watt and 200-watt lamps installed alternately along the length of the runway. This flight was conducted for visual inspection of both systems under visual flight rule (VFR) conditions.

RESULTS

LABORATORY TEST RESULTS.

PHOTOMETRIC TESTS. Intensity distribution measurements were made of several group A light fixtures using 100-watt lamps by the photometric laboratory at NAFEC. The intensity distribution approached the 10,000-candela average

axial requirements but lacked the beamspread at the lower elevation angles to meet the 5,000-candela minimum requirements of Advisory Circular 150/5345-48 for type L-862 lights. The results from a typical light are given in isocandela form in appendix A (figure A-1). Later measurements of the light, group B modified with improved intensity distribution, showed that this light met the L-862 requirements. The results from a typical light are given in isocandela form in appendix B (figure B-1).

CHROMATICITY TESTS. Results of the chromaticity tests conducted on the coated glass domes indicated that, under operating conditions over an extended period of time, the paint faded and cracked due to heat generated by the lamp. Figure 4 shows the results after a period of about 1 month of continual operation using a 200-watt light source at full rated output. It can be seen that the paint on the yellow/clear dome has burned off at the axis, changing the color of the light. For the green/red unit, the green side exhibits no deterioration at the beam axis; however, the top of the unit displays considerable cracking and peeling for both the green and the red coated portions. The red side of this unit exhibited some fading at the beam axis, but not as pronounced as the yellow.

The change of the x-y chromaticity coordinates for the silicone-coated glass domes initially tested with a 200-watt lamp (yellow/clear) and (red/green) is graphically illustrated in figures A-2, A-3, and A-4 of appendix A. Each measured point has been designated on the chart with the number of operating hours. The yellow-coated dome reached the limit for aviation yellow in approximately 575 hours. The red-coated dome reached the limit for aviation red in approximately 1,200 hours. The green-coated dome was well within the aviation green boundaries after 1,600 hours of operation.

Visual inspection of several of the yellow/clear fixtures installed in the runway edge light system of runway 13/31 using 100-watt lamps exhibited no apparent color deterioration after approximately 8 months of normal operation, but after 2 years had to be replaced, due to excessive fading of the pigment.

FLIGHT TEST RESULTS.

The actual flight tests were made between June and November of 1975, during periods of reported visibilities of 1/2 mile or greater and ceilings of 300 feet and above. A total of eight NAFEC test pilots participated, making several flights each. Pilots' comments indicated that for these types of restricted visibilities, the group A lights with 100-watt lamps provided adequate intensity and appeared compatible with the approach and runway centerline and touchdown zone lights. It had been stated by several pilots during the test flights that edge lights are a part of the integral approach light system for category I and category II operations and that a pilot makes use of the system as a whole, with a balance in lighting systems preferred over a dependency of one system over another. These lights were considered balanced with the complete lighting system.

A test flight incorporating several runs made at Newark International Airport was conducted under VFR conditions in which neither the pilot, copilot, nor observers could determine any subjective difference in light brightness or color between the runway with the 200-watt L-819 lights and the other runway with alternate 100-watt and 200-watt new-type runway edge lights.

During this evaluation, no test flights were conducted in category II or category III weather conditions; however, pilot comments on the appearance of these lights in category I conditions other than controlled test flights indicate that these lights using 100-watt lamps should provide adequate guidance for category II operations. For both category II and III operations, the touchdown zone and centerline lights, instead of runway edge lights, are the more important lighting systems. Since these new lights appeared to be adequately balanced with the approach and other runway lights, and especially since the modified lights, group B, meet the requirements for type L-862 lights, these modified lights with 100-watt lamps should be considered suitable as runway lights for category I, II, and III operations. The lights installed in 1975 are still (September 1977) being used and are considered by the NAFEC project pilots suitable for our operational requirements. NAFEC project pilots use this runway for category II weather landings and takeoffs.

SUMMARY OF RESULTS

The laboratory tests conducted on group A of these new-type runway edge lighting fixtures have shown that the photometric characteristics of this fixture using a 100-watt lamp nearly meet the L-862 specifications as described in Advisory Circular 150/5345-48. The 5,000 and 500 candela minimum requirements were not completely satisfied in the lower elevation angles. A slightly modified light, group B, of this type did meet the photometric requirements for the type L-862 runway edge lights.

The new modified light fixture can be used with both the 100-watt and the 200-watt lamp. This permits the use of the same type fixture with the 100-watt lamps along the runway edges and the 200-watt lamps for the threshold.

The chromaticity measurements for the silicone-coated glass domes indicate that more improvements are needed for these domes to be suitable for providing colored light. All units deteriorated when they were operated over an extended period of time. The yellow-colored dome experienced the greatest amount of change in the shortest period of time; whereas, the green dome exhibited the smallest amount of change in a longer time interval.

Results of the flight tests conducted indicated that, although category II conditions were not encountered under controlled flight, the 100-watt runway edge light fixtures were approximately as effective as the 200-watt L-819 fixtures which are acceptable for category II weather operations. With the edge lights operating at suitable intensity settings with the approach, touchdown, and centerline lights, pilot opinion indicated that there was a satisfactory balance of light output from all systems to provide the overall visual guidance needed on final approach, landing, and rollout.

These lights, group A, were installed in 1975 and are presently operational on runway 13/31, a 60-meter (m) (200-foot) wide runway at NAFEC, Atlantic City, for a period in excess of 2 years. Pilot opinion recently requested indicates that no operational problem exists.

CONCLUSIONS

Based on these laboratory and flight tests, it is concluded that:

1. The new-type fixtures, group A, developed for this project nearly meet the photometric requirements for the type L-862 lights with 100-watt lamps.

2. A modification of this type, group B, using 100-watt lamps meets the photometric requirements for the type L-862 lights.

3. These type fixtures using 100-watt lamps as runway edge lights when used with 200-watt threshold and appropriate approach, touchdown zone, and centerline lights can provide adequate guidance for approaches and landings in category I weather conditions and probably in category II conditions.

4. The silicone pigment coating of these domes to produce colored light was not satisfactory for operation with 200-watt or 100-watt lamps.

REFERENCES

1. DOT/FAA, Airports Service (Office of Airport Programs) Specification for L-819 Fixed Focus Bidirectional High-Intensity Runway Light, Washington, AC 150/5345-9C, December 1969.

2. Reamer, E. Leon, Evaluation of an Experimental Elevated High-Intensity Runway Edge Light, FAA/NAFEC, Atlantic City, New Jersey, Report No. FAA-RD-74-128, September 1974.

3. Reamer, E. Leon, Evaluation of an Experimental High-Intensity, Inset Runway Edge Light Fixture, FAA/NAFEC, Atlantic City, New Jersey, Report No. FAA-RD-74-171, November 1974.

4. DOT/FAA Office of Airport Programs, Specification for Runway and Taxiway Edge Lights, Washington, AC 150/5345-48, August 1975.

5. Aerodromes Annex 14, International Standards and Recommended Practices, International Civil Aviation Organization (ICAO).

APPENDIX A

PHOTOMETRIC AND CHROMATICITY MEASUREMENTS OF GROUP A LIGHT FIXTURE

LIST OF ILLUSTRATIONS (APPENDIX A)

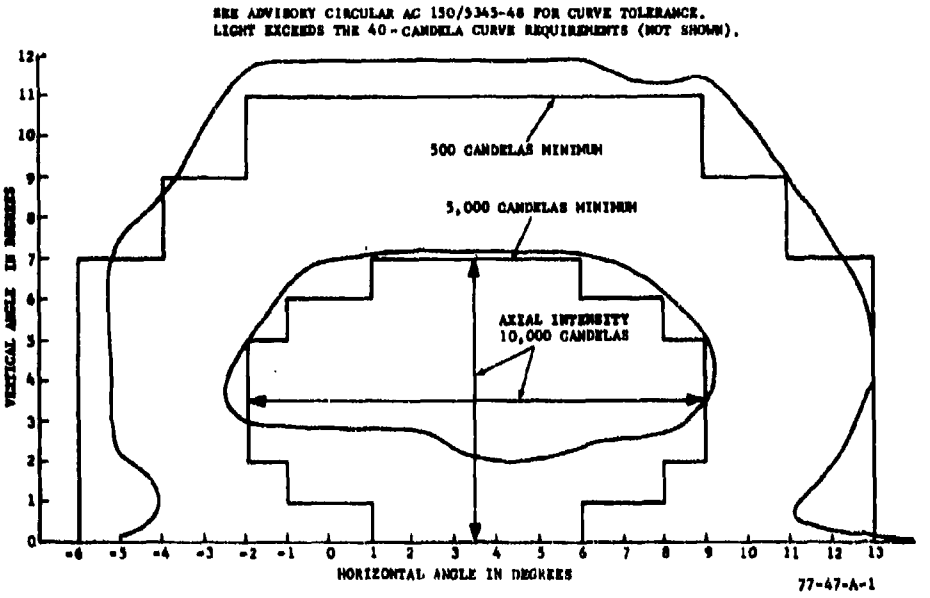

FIGURE A-1. PLOT OF 500 AND 5,000 ISOCANDELA CURVES OF A TYPICAL FIXTURE FROM GROUP A WITH L-862 SPECIFICATIONS SHOWN

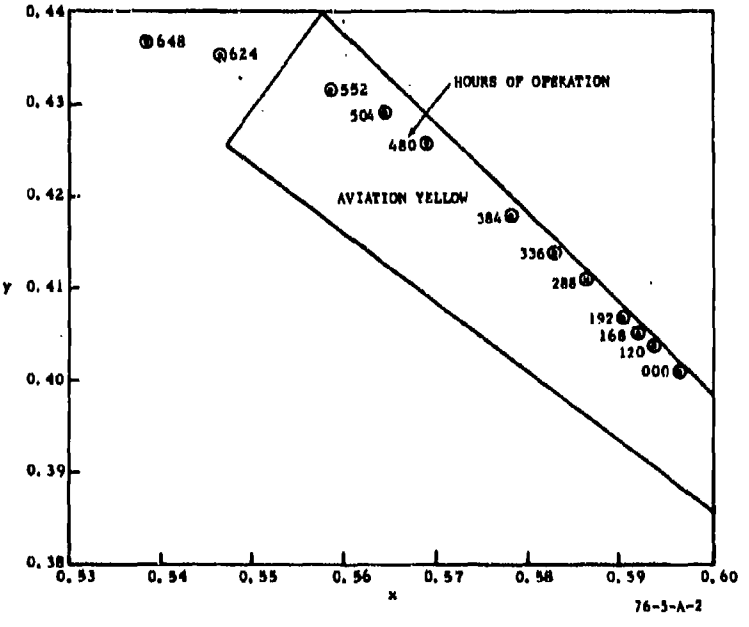

FIGURE A-2. CHROMATICITY SHIFT WITH NUMBER OF HOURS OF OPERATION FOR THE YELLOW-COATED LENS (DOME) USING A 200-WATT LAMP OPERATING AT MAXIMUM RATED INTENSITY

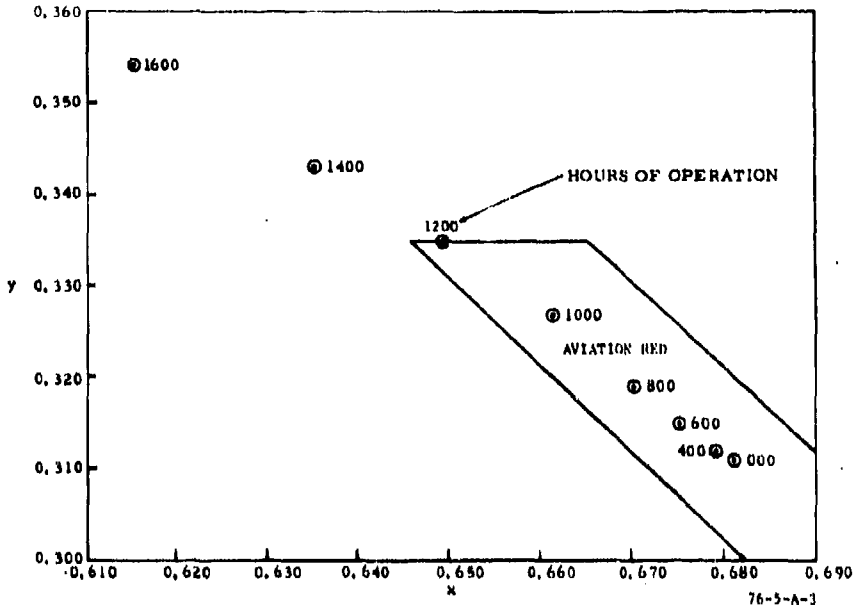

FIGURE A-3. CHROMATICITY SHIFT WITH NUMBER OF HOURS OF OPERATION FOR THE RED-COATED LENS (DOME) USING A 200-WATT LAMP OPERATING AT MAXIMUM RATED INTENSITY

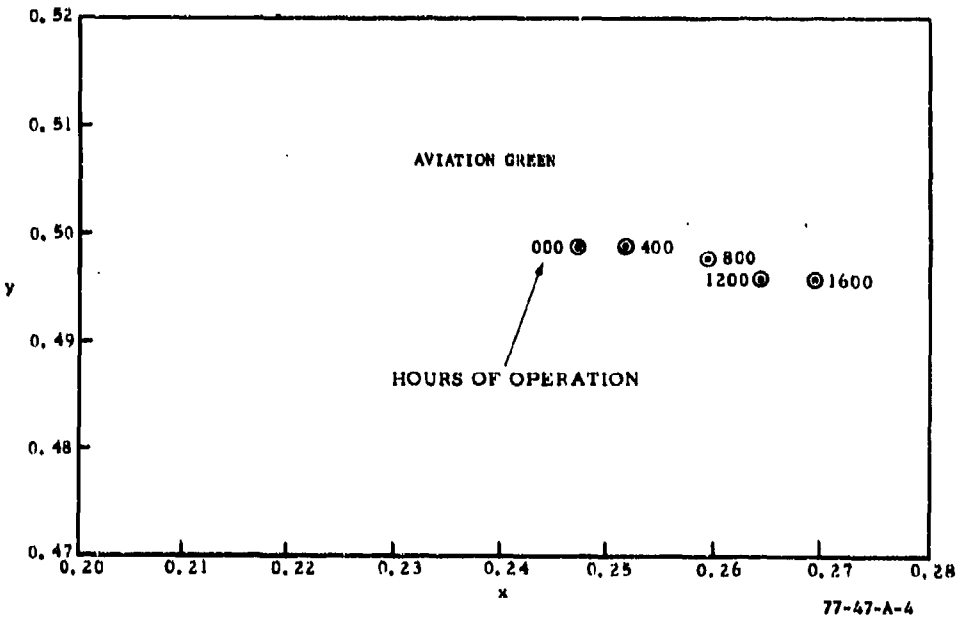

FIGURE A-4. CHROMATICITY SHIFT WITH NUMBER OF HOURS OF OPERATION FOR THE GREEN-COATED LENS (DOME) USING A 200-WATT LAMP OPERATING AT MAXIMUM RATED INTENSITY

APPENDIX B

PHOTOMETRIC MEASUREMENTS OF MODIFIED GROUP B LIGHT FIXTURE

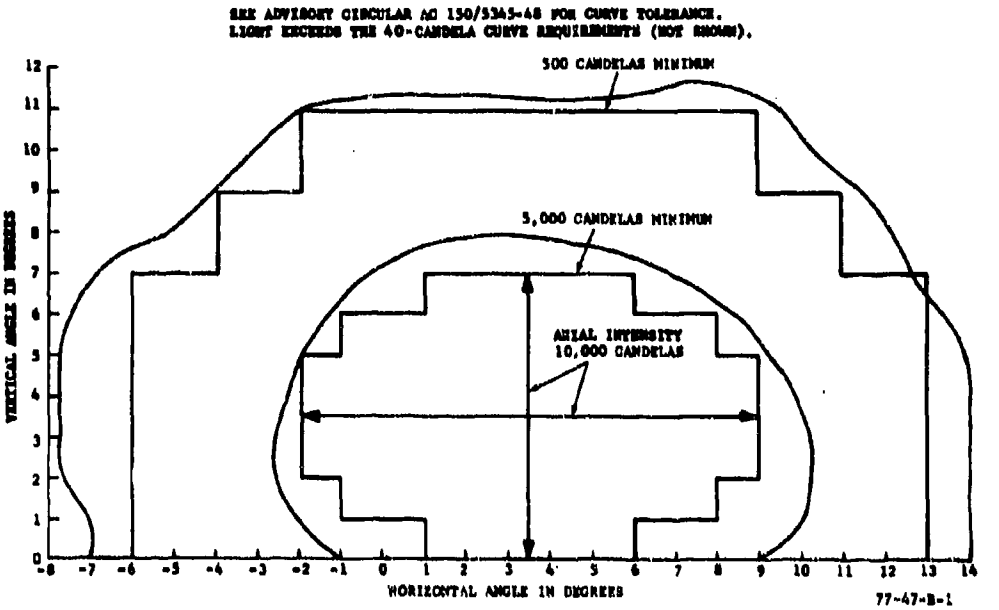

FIGURE B-1. PLOT OF 500 AND 5,000 ISOCANDELA CURVES OF A TYPICAL FIXTURE FROM GROUP B WITH L-862 SPECIFICATIONS SHOWN