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Evaluation for the Development of Taxiway Lighting Intensity Standards

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16. Abstract

The purpose of this evaluation was to gather data to produce taxiway lighting intensity standards to be incorporated into DOT/FAA Order 7110.65H, Air Traffic Control. Currently, there are no tables of standard intensity settings for taxiway lighting systems. Air traffic controllers are only instructed to operate the taxiway lights between sunset and sunrise and at other times they consider it necessary.

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EXECUTIVE SUMMARY

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Through research of five major United States airports, data were collected on the intensity ranges the airports operate their taxiway lighting systems in various visibilities. This data was then validated at the Federal Aviation Administration Technical Center by conducting actual taxiway tests with a Boeing 727 and a Convair 580. Tests were conducted in various visibility conditions by having FAA Technical Center flight-test pilots evaluate both the blue taxiway edge lights and the green centerline lights at different intensity settings (steps).

INTRODUCTION

BACKGROUND.

DOT/FAA Order 7110.65H, Air Traffic Control, prescribes air traffic control procedures and phraseology for use by personnel providing air traffic control services. The order covers procedures such as visual separation, radar approaches, IFR procedures, airport lighting and many others.

Chapter 3, Section 4, Airport Lighting, contains tables of standard airport lighting intensity settings for runway use during all visibility conditions. It also lists situations when deviations from the tables are permissible. To date, there are no tables of standard intensity settings for taxiway lighting systems. The controllers are only instructed to operate the taxiway lights between sunset and sunrise and at other times considered necessary by the controller.

With the new Surface Movement Guidance and Control System (SMGCS) Advisory Circular 120-57 for low visibility taxiway operations, standard intensities are needed to ensure an adequate level of guidance to the pilot. Before this table could be developed, data had to be collected to determine the exact intensity step setting (ampere reading) to be used for each visibility condition.

Establishing such a standard must take into account the fact that there are several variables involved, such as different types of regulators and taxiway lighting systems. Airports operate three- and five-step regulators and both blue edge and green centerline lights for guidance on the taxiways. Currently, green centerline taxiway lighting systems are required in visibilities under 600-foot runway visual range (RVR). Because of these factors, more than one operating standard was produced.

PURPOSE.

The purpose of this effort was to develop tables of standard taxiway lighting intensity settings for use during all visibility conditions and list situations when deviations from the tables are permissible.

OBJECTIVE.

This effort was directed specifically toward:

1. Developing tables of standard taxiway lighting intensity settings for use during all visibility conditions.

2. Obtaining test pilot evaluational opinion as to the optimum as well as minimum intensity usable in each visibility.

3. Investigating various situations when deviations from the tables are permissible.

TEST PROCEDURES.

Through research of five major U.S. airports, data were collected on the intensity ranges the airports operate their taxiway lighting systems in various visibilities. Those airports questioned were Dallas-Fort Worth International, John F. Kennedy International, Boston Logan International, Seattle-Tacoma International and Atlantic City International Airports.

This data was then validated at the FAA Technical Center by conducting actual taxiway tests with a Boeing 727 and a Convair 580. Tests were conducted on taxiway Bravo (B) between taxiways Kilo and Alpha (K and A), a distance of approximately 6000 feet, in various visibility conditions. FAA Technical Center flight-test pilots evaluated both the blue taxiway edge lights and the green centerline lights at different intensity settings (steps). The pilots were asked to determine the optimum intensity as well as the minimum intensity that was usable in each visibility.

During each taxiway test, each pilot evaluated the taxiway lighting systems at the four intensities listed in table 1 for that particular visibility condition. The range of intensities selected for evaluation were derived from data collected from the airports based on their current operational settings. Both green centerline and blue edge light fixtures were evaluated during each test.

TABLE 1. VISIBILITY AND INTENSITY BREAKDOWNS

	VISIBILITY	INTENSITIES
DAYTIME	Less than 1 mile	5,4,3,2
	1 but not including 2 miles	5,4,3,2
	2 but not including 3 miles	4,3,2,1
NIGHTTIME	Less than 1 mile	5,4,3,2
	1 but not including 3 miles	4,3,2,1
	3 to 5 miles inclusive	4,3,2,1
	More than 5 miles	4,3,2,1

After each test session, the test pilots completed a brief questionnaire (figure 1). Atlantic City International Airport's taxiways are powered by five-step, 6.6 amp regulators. The pilots were asked for the minimum usable intensity for all visibilities as well as the optimum intensity. This data in conjunction with the data from the airports with three-step regulators were sufficient for compiling acceptable tables.

Both constant current regulators involved in the evaluation were inspected to ensure they were operating within the specifications outlined in AC 150/5345-10E for proper current output.

Taxiway Lighting Intensity Setting Standard Project
Pilot Briefing and Questionnaire

The Air Traffic Procedures Manual (7110.65F) contains various tables of runway lighting intensity setting standards for all visibility conditions. To date, there are no tables of standard intensity settings for taxiway lighting systems. With the new Surface Movement Guidance and Control (SMGC) standards for low visibility taxiway operations, standard intensities are needed to ensure an adequate level of guidance. The data compiled through this evaluation will be used to produce operating standards for taxiway operations.

Name _____ Date _____ Day ____ Night ____

Weather Conditions _____

Visibility _____ mile(s) Aircraft Type _____

1) What was the optimum intensity setting for the GREEN CENTERLINE fixtures at the visibility evaluated?

(circle one) 1 2 3 4 5

Comments

_____

_____

2) What was the minimum intensity setting for the GREEN CENTERLINE fixtures to be useful to a pilot at the visibility evaluated?

(circle one) 1 2 3 4 5

Comments

_____

_____

3) What was the optimum intensity setting for the BLUE EDGE LIGHT fixtures at the visibility evaluated?

(circle one) 1 2 3 4 5

Comments

_____

_____

4) What was the minimum intensity setting for the BLUE EDGE LIGHT fixtures to be useful to a pilot at the visibility evaluated?

(circle one) 1 2 3 4 5

Comments

_____

_____

FIGURE 1. SAMPLE PILOT BRIEFING AND QUESTIONNAIRE

RESULTS

After several taxiway tests the data were compiled to make the intensity setting recommendations the control tower personnel should use in various visibilities. These results are provided in tables 2 and 3. The consolidated data from each of the taxiway tests ran at the Technical Center that was used to create these tables can be found in appendices A and B.

TABLE 2. RECOMMENDED TAXIWAY LIGHTING INTENSITY SETTINGS (FIVE-STEP REGULATORS)

STEP	DAYTIME VISIBILITY	STEP	NIGHTTIME VISIBILITY
5	LESS THAN 1 MILE	5	WHEN REQUESTED
5	1 BUT NOT INCLUDING 2 MILES	4	LESS THAN 1 MILE
5	2 BUT NOT INCLUDING 3 MILES	3	1 BUT NOT INCLUDING 3 MILES
OFF	GREATER THAN 3 MILES / WHEN REQUESTED	3	3 TO 5 MILES
		3	MORE THAN 5 MILES

TABLE 3. RECOMMENDED TAXIWAY LIGHTING INTENSITY SETTINGS (THREE-STEP REGULATORS*)

STEP	DAYTIME VISIBILITY	STEP	NIGHTTIME VISIBILITY
3	LESS THAN 1 MILE	3	WHEN REQUESTED
3	1 BUT NOT INCLUDING 2 MILES	2	LESS THAN 1 MILE
3	2 BUT NOT INCLUDING 3 MILES	1	1 BUT NOT INCLUDING 3 MILES
OFF	GREATER THAN 3 MILES / WHEN REQUESTED	1	3 TO 5 MILES
		1	MORE THAN 5 MILES

*Based on percentages of light output coinciding with data obtained using a five-step regulator.

During the period of the evaluation the visibility condition of less than 1 mile at night did not arise. In order to complete this project without undue delay waiting for the appropriate weather conditions, the use of step 4 for this visibility was recommended. This was determined after a series of interviews of flight-test pilots as well as project personnel with vast experience in airport lighting. Using step 4 would also coincide with the intensity setting that is required for runway centerline lights in less than 1 mile at night as indicated in the Air Traffic Procedures Manual (7110.65F).

Step 3 of the five-step regulator was the recommended intensity in all nighttime visibilities of 1 mile and greater. Increasing the intensity to step 4 would supply the necessary increase in guidance needed to offset a decrease in visibility down to less than a mile. In this situation a controller would still have the capability of increasing the intensity to step 5 if a pilot were to make a request for a brighter intensity.

In daylight conditions of shallow ground fog and clear skies with visibilities of less than two miles, the taxiway environment is bright enough that the paint markings provide adequate guidance, and taxiway lights do not add anything to the system. However, taxiway lights would be necessary in similar conditions with overcast skies.

In visibilities greater than two miles, the initial responses from those pilots informally asked were that the paint markings would be adequate enough to give the pilots sufficient guidance in either clear or overcast skies.

It is recommended to use the maximum intensity, step 5, (or step 3 on a 3-step regulator) for all daytime IFR conditions for taxiways with blue edge or green centerline lighting. As the visibility and sunlight increases so does the effectiveness of the paint markings. However, with increased visibility and sunlight the taxiway lighting becomes less conspicuous causing a need for a higher intensity setting.

It is also recommended to include exceptions to operating at step 4, much like those listed with the runway centerline intensity table. They are:

a. Where a facility directive specifies other settings to meet local conditions.

b. As requested by the pilot.

c. As deemed necessary, if not contrary to pilot request.

CONCLUSIONS

The tables of standard taxiway lighting intensity settings were successfully developed for use during all visibility conditions with both 3- and 5-step regulators.

All data obtained using test pilot evaluational opinion validate the numbers received from the major airports which indicated what intensity settings they use for their taxiway lighting under all visibility conditions. These data were used to complile the new tables.

It was deemed necessary to develop a list of situations when deviations from the tables are permissible. This list would allow the controller a degree of flexibility.

APPENDIX A - DAYTIME TESTING

The following summaries present the number of pilots that responded to the questionnaire specifying the optimum intensity setting as well as the minimum usable intensity. The data runs in daylight were in visibilities of 0, 1/2, 3/4 and 1 3/4 miles in fog. Of the pilots that responded to the questionnaire, the following tables indicate the number of pilots that chose the recommended step.

0 MILE IN FOG - SIX PILOTS EVALUATING

SYSTEM	OPTIMUM		MINIMUM	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	6	5	5	5
BLUE EDGE	4*	5	4	5

*While four pilots chose step 5 for the blue edge lights as optimum (the other two felt that even step 5 was not enough); all six stated that the blue edge lights really gave no guidance in these conditions.

1/2 MILE IN FOG - FOUR PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	4	5	3	4
BLUE EDGE	4	5	3	4

3/4 MILE IN FOG - TWO PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	step
GREEN CENTERLINE	2	5	2	4
BLUE EDGE	2	5	2	5

1 3/4 MILES IN FOG /LIGHT RAIN - FIVE PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	5	5	5	4
BLUE EDGE	2	5	2	5

APPENDIX B - NIGHTTIME TESTING

The following summaries present the number of pilots that responded to the questionnaire specifying the optimum intensity setting as well as the minimum usable intensity. The nighttime data runs were in visibilities of 1, 4, 6, 10 and 12 miles in fog/light rain with overcast skies. Of the pilots that responded to the questionnaire, the following tables indicate the number of pilots that chose the recommended step.

1 MILE IN FOG/LIGHT RAIN - SIX PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	5	3	4	2
BLUE EDGE	4	4	4	3

4 MILES IN FOG - FIVE PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	4	3	4	2
BLUE EDGE	4	4	5	3

6 MILES IN FOG/LIGHT RAIN - SIX PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	4	3	3	2
BLUE EDGE	4	4	5	3

10 MILES IN LIGHT RAIN - TEN PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	8	3	8	2
BLUE EDGE	7	3	7	2

12 MILES IN LIGHT RAIN - FOUR PILOTS EVALUATING

SYSTEM	OPTIMUM		AT VERY LEAST	
	Number of pilots	Step	Number of pilots	Step
GREEN CENTERLINE	3	3	3	2
BLUE EDGE	3	3	2	3