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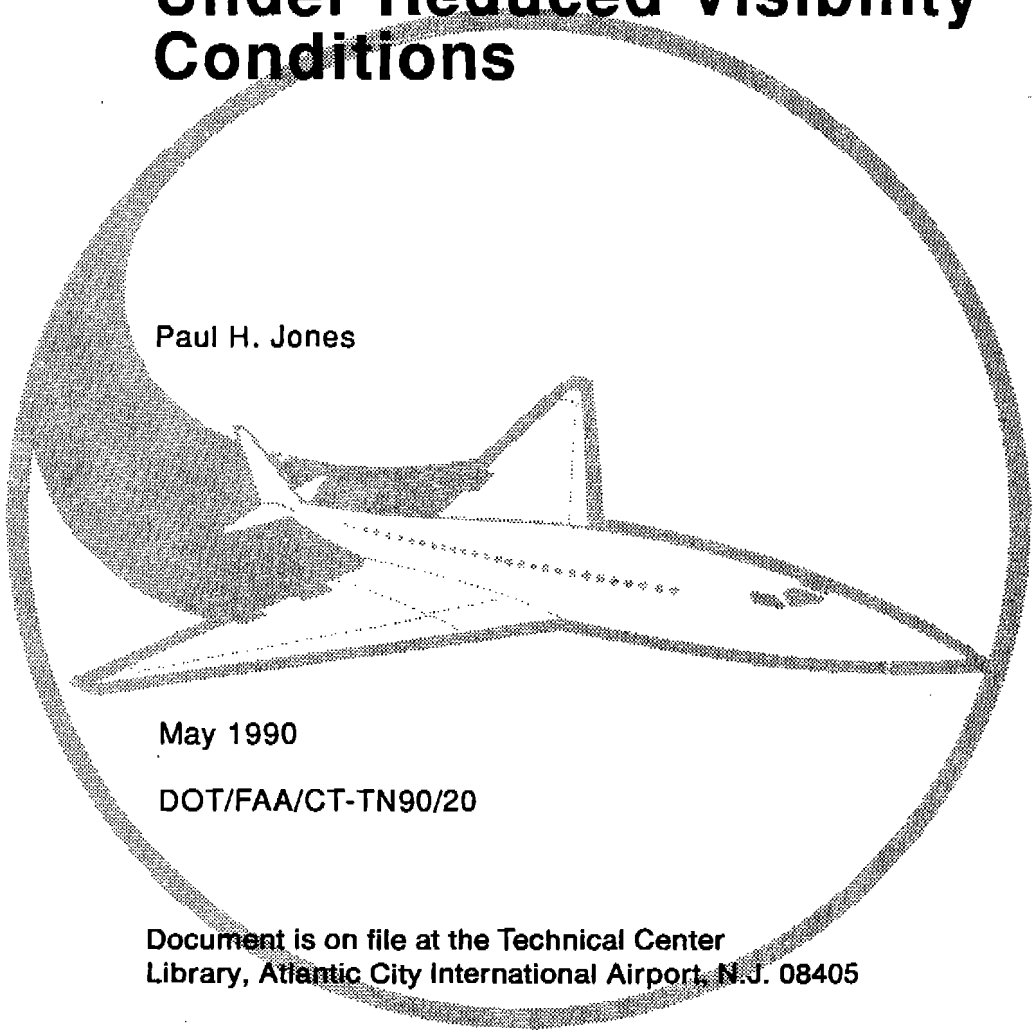
Taxiway Sign Effectiveness Under Reduced Visibility Conditions

Paul H. Jones



May 1990

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16. Abstract

An evaluation was conducted to determine whether any or all of the standard internally lighted taxiway guidance sign sizes, when located at the current recommended distance from the taxiway edge, provide adequate guidance in reduced visibility conditions. The L858R mandatory and L858Y informational types of taxiway guidance signs were used for the evaluation. The three standard sizes of each type of sign were set up at the maximum recommended distance from the taxiway edge. Tests were conducted at the intersection of taxiway "B" and runway "4-22" on the Atlantic City International Airport. Data were collected during periods of actual reduced visibility. Over 200 observations in visibilities between 400 to 1900 feet were collected. Typical "low-speed" taxi stopping distances were obtained through actual tests with a Boeing 727 aircraft. These stopping distance values were then compared to the actual recognition distances for the signs under low visibility conditions. From the data collected, all sizes of signs tested provided adequate guidance to allow a pilot to recognize the sign message and take appropriate actions when needed.

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EXECUTIVE SUMMARY

At the request of Airports Division, AAS-200, the Visual Guidance section of the Airport Technology Branch, ACD-110 conducted an evaluation to determine the effectiveness of standard internally lighted taxiway guidance signs used during reduced visibility conditions. Advisory Circulars 150/5340-18 and 150/5345-44 specify the locations and sizes of taxiway guidance signs acceptable for use on airports. The usage of these sizes and locations are based on aircraft wing tip and engine pod location clearances, and jet blast and snow removal operation requirements. Under reduced visibility conditions, there may be one sign size and location which is more effective than others. This evaluation was designed to determine whether any, or all, of the various sign sizes, when located at the current recommended distance from the taxiway edge, would provide the required guidance to a pilot in reduced visibility conditions. The mandatory and the informational types of taxiway guidance signs were used for the evaluation. The three standard sizes of each type of sign were set up at the maximum recommended distance from the taxiway edge. Tests were conducted on the Atlantic City International Airport. Over 200 observations in actual reduced visibility conditions of between 400 to 1900 feet observed visibility were accomplished. Minimum recognition distances ranged from 273 feet for the large size sign to 241 feet for the small size sign. Typical "low-speed" taxi stopping distances were obtained through actual tests with a Boeing 727 aircraft. These stopping distance values were then compared to the actual recognition distances for the signs under low visibility conditions. From the data collected, all sizes of signs tested provided adequate guidance to allow a pilot to recognize the sign message and take the appropriate actions when needed.

INTRODUCTION

PURPOSE.

At the request of Airports Division, AAS-200, the Visual Guidance section of the Airport Technology Branch, ACD-110, conducted an evaluation to determine the effectiveness of the standard internally lighted taxiway guidance signs for use during reduced visibility conditions. This work was submitted through the System Technology Division, ARD-200 and accomplished under the Technical Center project number T1903N, "Airport and Heliport Lighting and Marking." The technical project manager is Paul H. Jones, ACD-110.

BACKGROUND.

Advisory Circular 150/5345-44 specifies three standard sizes of taxiway guidance signs acceptable for use on airports. Sign locations can vary from 10 to 60 feet from the taxiway edge, depending on which size sign is used, as specified in Advisory Circular 150/5340-18 and shown in table 1.

TABLE 1. SIGN SIZE AND LOCATION INFORMATION FROM A/C 150/5340-18

SIGN SIZE	MAXIMUM SIGN HEIGHT (IN) LEGEND	FACE	INSTALLED	DISTANCE FROM PAVEMENT (FT)
1 (SMALL)	12	18	30	10-20
2 (MEDIUM)	15	24	36	20-35
3 (LARGE)	18	30	42	35-60

The usage of these sizes and locations is based on aircraft wing tip and engine pod location clearances, and jet blast and snow removal operation requirements. Under reduced visibility conditions, there may be a combination of size and location for the sign which is more effective than the other combinations. This evaluation was designed to determine whether any, or all, of the various sign sizes, when located at the current recommended distance from the taxiway edge, would provide adequate guidance in reduced visibility conditions.

DISCUSSION

TEST PROCEDURE.

The two basic types of taxiway guidance signs were used for the evaluation. The L858R mandatory sign has a white legend on a red background. The L858Y informational sign has a black legend on a yellow background. The mandatory sign message read "4-22" and the informational sign message read "B". The three standard sizes of each type of sign were set up at the maximum recommended distance from the taxiway edge as per AC 150/5340-18 and shown in figure 1. Tests were conducted at the intersection of taxiway "B" and runway "4-22" on the Atlantic City International Airport.

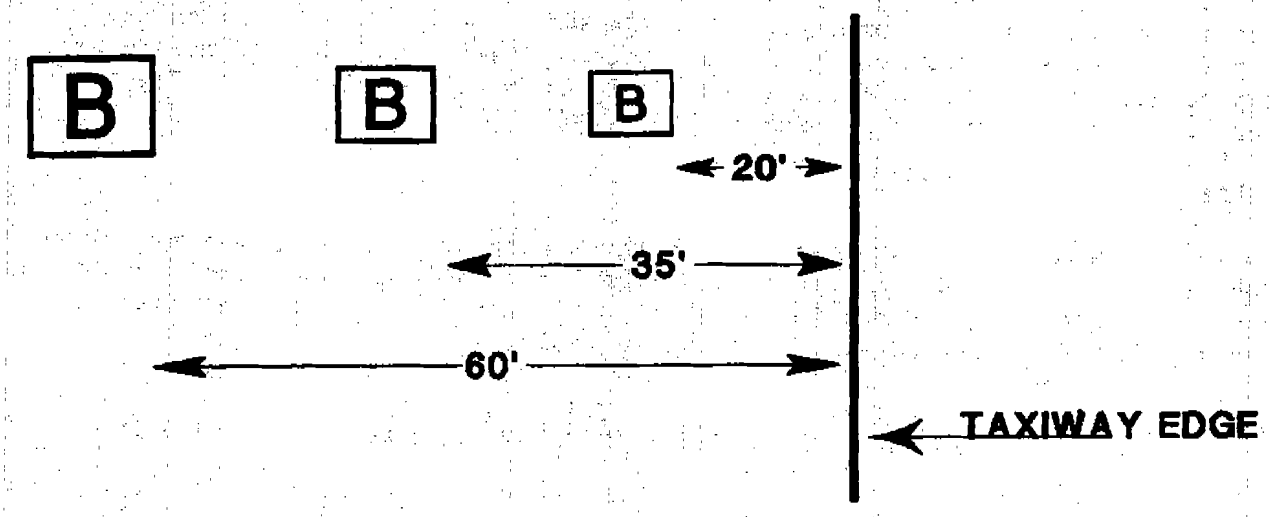

FIGURE 1. TAXIWAY SIGN TEST LOCATIONS

In order to collect data during periods of actual reduced visibility, the Visual Guidance Section was "on-call" 24 hours a day, 7 days a week. The data collection phase lasted from November 1985 until November 1989. Every time the reported tower visibility was less than 1/4-mile, the Visual Guidance Section was notified by Airport Operations. At that time, project personnel would proceed to the airfield to view the taxiway signs and record the appropriate data.

The data collected at the time of the observation included the date, time, tower visibility, runway visual range (RVR) for runway 13 (touchdown and rollout), observed visibility, sign type, acquisition distance, and recognition distance. (See sample data form in figure 2.) The observed visibility (which was taken near the test location) was determined by counting the number of high intensity runway edge lights that were visible on the highest intensity setting (step 5). The acquisition and recognition distances for each sign were obtained by approaching the signs in a truck at 5 to 10 miles per hour (mph) taxi speed, starting from a distance at which the signs were not visible. The acquisition distance was established as the range at which the sign was visible but not readable. The recognition distance was established as the range at which the sign was readable. A truck was used for observations because an aircraft and crew were not available to be "on-call" 24 hours a day, 7 days a week. Even if an aircraft was available, the time required to assemble a crew and start the aircraft taxiing would have made it highly likely that the fog would have already dissipated.

LOW VISIBILITY REPORT ON AIRPORT SIGNS

DATE: _____ OBSERVERS: _____ & _____

TIME: _____ TOWER VIS. _____ RVR T/D: _____ RVR R/O: _____

OBSERVED VISIBILITY: _____

SIGN LEGEND: _____

	LARGE	MEDIUM	SMALL
ACQUISITION DISTANCE:			
RECOGNITION DISTANCE:			

TIME: _____ TOWER VIS. _____ RVR T/D: _____ RVR R/O: _____

OBSERVED VISIBILITY: _____

SIGN LEGEND: _____

	LARGE	MEDIUM	SMALL
ACQUISITION DISTANCE:			
RECOGNITION DISTANCE:			

TIME: _____ TOWER VIS. _____ RVR T/D: _____ RVR R/O: _____

OBSERVED VISIBILITY: _____

SIGN LEGEND: _____

	LARGE	MEDIUM	SMALL
ACQUISITION DISTANCE:			
RECOGNITION DISTANCE:			

TIME: _____ TOWER VIS. _____ RVR T/D: _____ RVR R/O: _____

OBSERVED VISIBILITY: _____

SIGN LEGEND: _____

	LARGE	MEDIUM	SMALL
ACQUISITION DISTANCE:			
RECOGNITION DISTANCE:			

FIGURE 2. SAMPLE DATA COLLECTION FORM

Fog is not homogeneous and it varies with time, location, and weather conditions. It usually forms in the early morning when the temperature/dewpoint spread is close. Frequently fog can be patchy and move in and out of an area rapidly and unpredictably.

In order to determine effectiveness of the various sign size/location combinations, some measure of aircraft required stopping distances had to be obtained. Although data for required stopping distances from relatively high initial runway speeds (such as those typical for aborted takeoffs and full-length rollout) are readily available, very little information exists for distances needed for stopping from low (5 to 15 knots) taxiing speeds. Consequently, limited testing to determine these "low-speed" stopping distances was conducted at the Technical Center using the Center-based FAA Boeing 727 aircraft. To accomplish this testing, the aircraft was taxied, at three different constant speeds (5, 10, and 15 knots), over a measured section of taxiway. The pilot, upon being commanded to stop abeam a predesignated point, applied either light or moderate braking to bring the aircraft to a complete stop. The distance from the commanded stop point to the actual halt position was then measured precisely. The aircraft was instrumented to permit accurate determination of instantaneous taxi speed and deceleration "G" forces. The onboard accelerometer had a range of +1.0 to -1.0 G and samples were taken at a rate of 200/second. Comparison of these experimentally determined required stopping distances with the actual weather sign combination recognition distances or ranges would then provide some indication of sign performance and effectiveness under reduced visibility conditions.

TEST RESULTS.

Over 200 observations in conditions of between 400 to 1900 feet observed visibility were accomplished. See the appendix for actual data collected. Table 2 shows the number of observations collected under each visibility condition. During data collection, discrepancies between the different types of visibility measurements were noted. Over one-half of the data collected were obtained when the tower's reported visibility was zero-zero. During the same periods, the RVR values varied from 600 to 1800, while the observed visibility varied from 400 to 1700 feet. This discrepency was due to the distant location of the control tower. Due to these considerations, it was felt that the observed visibility was the most accurate standard against which to rate the sign effectiveness.

Graphs of recognition distance versus observed visibility in figures 3, 4, 5, and 6 show the trends of the data collected. Graphs show actual data points with a power regression curve to show the trend for each size of sign. Graphs are shown for both types of signs under day and night conditions. During the night condition, the taxiway signs were illuminated. The mandatory red/white signs were visible from slightly greater distances than the yellow/black informational signs. Minimum recognition distances ranged form 273 feet for the large size sign to 241 feet for the small size sign.

Results of the limited taxi speed stopping distance testing done at the Technical Center are shown in table 3 and repeated graphically in figure 7.

TABLE 2. NUMBER OF OBSERVATIONS AT SPECIFIC VISIBILITIES

"B" SIGN				"4-22" SIGN			
OBSERVED RVR	LARGE	MEDIUM	SMALL	OBSERVED RVR	LARGE	MEDIUM	SMALL
400	1	1	1	400	-	-	-
500	2	1	1	500	3	2	3
700	3	3	3	700	2	2	2
800	1	1	1	800	-	-	-
900	6	6	6	900	3	6	6
1000	1	1	1	1000	2	2	2
1100	10	10	10	1100	8	8	8
1300	4	4	4	1300	4	5	5
1500	2	2	2	1500	-	-	-
1700	5	5	3	1700	7	7	5
1900	2	2	2	1900	1	1	1

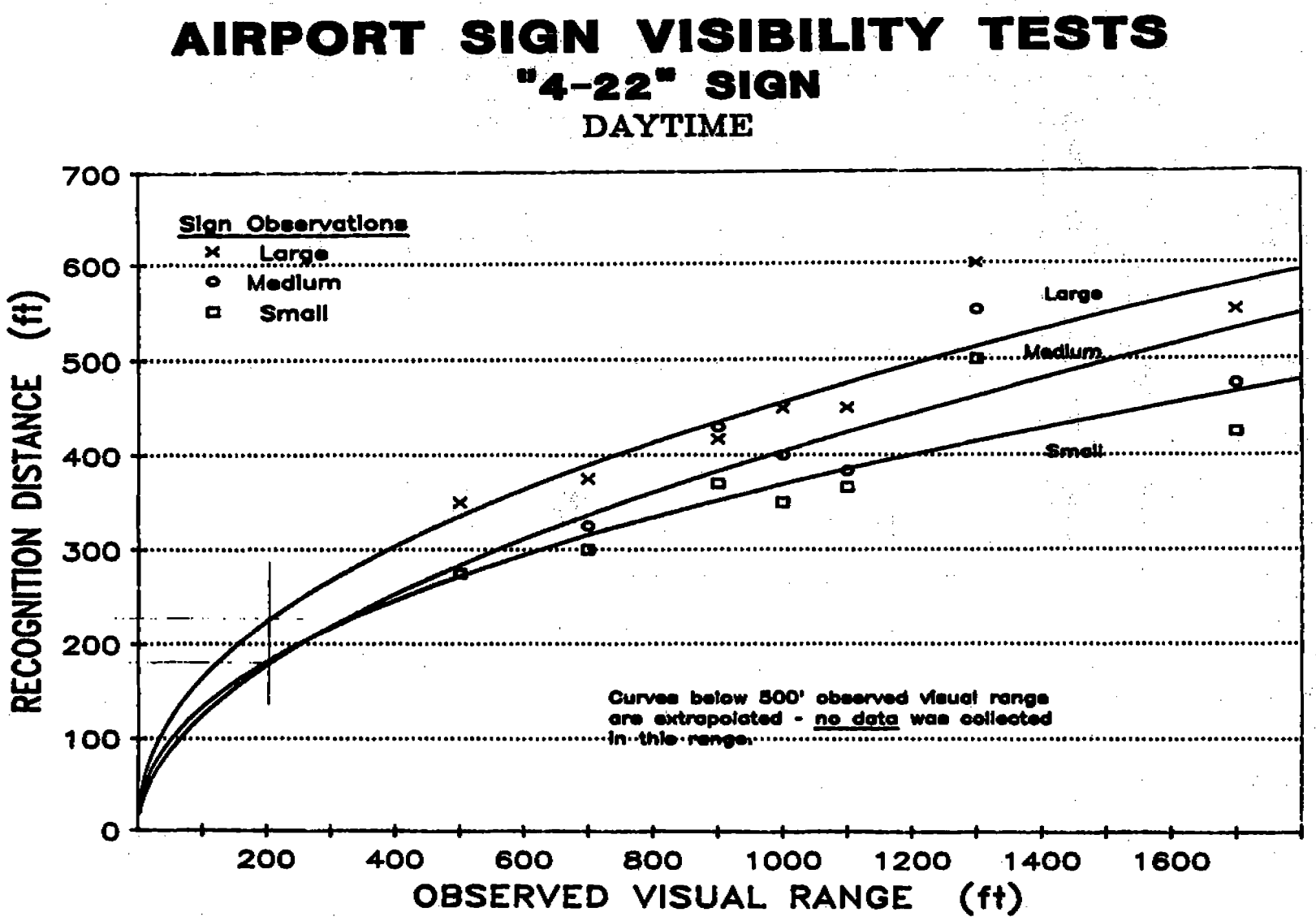

FIGURE 3. RECOGNITION DISTANCE CURVE FOR "4-22" SIGN, DAYTIME

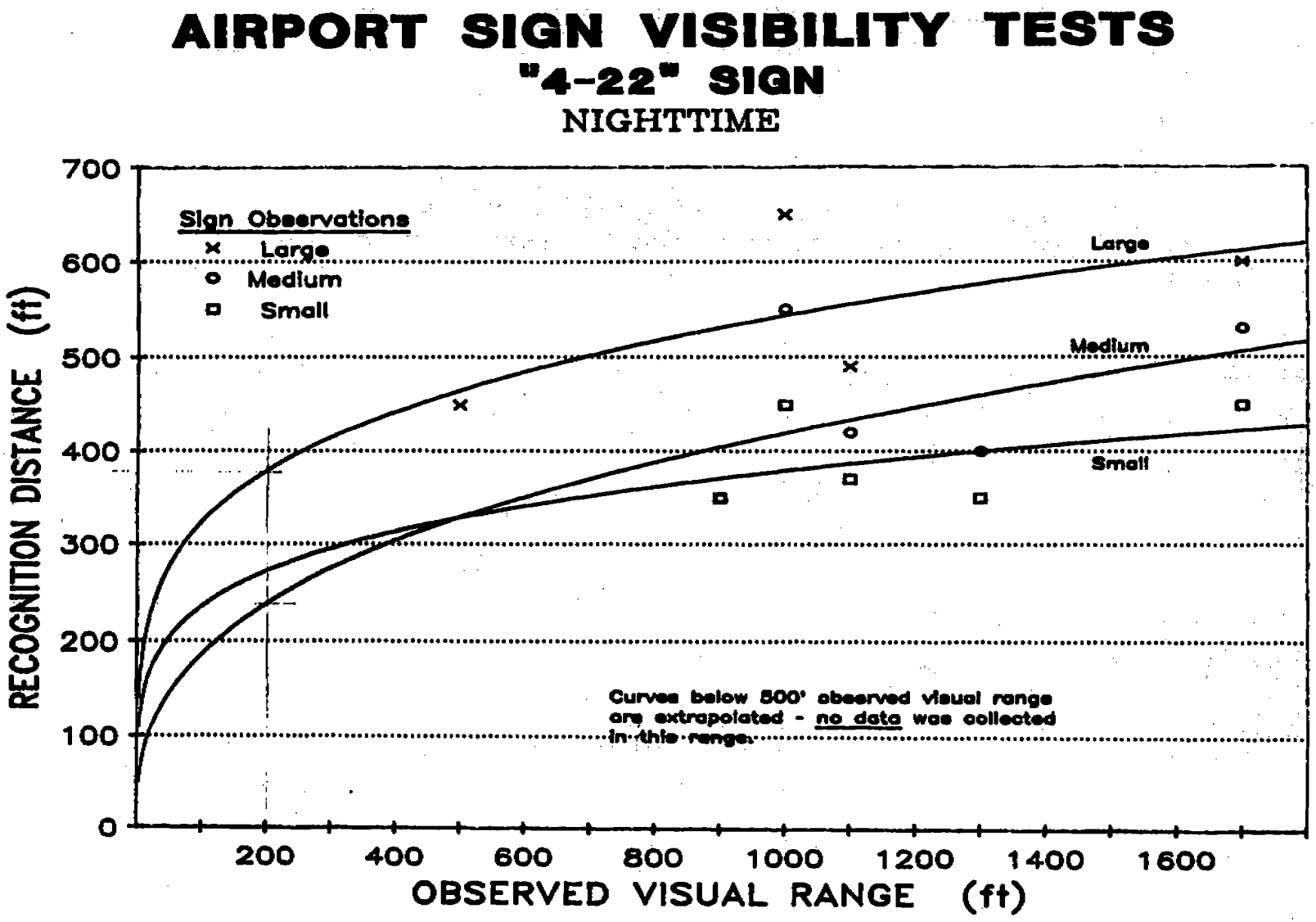

FIGURE 4. RECOGNITION DISTANCE CURVE FOR "4-22" SIGN, NIGHTTIME

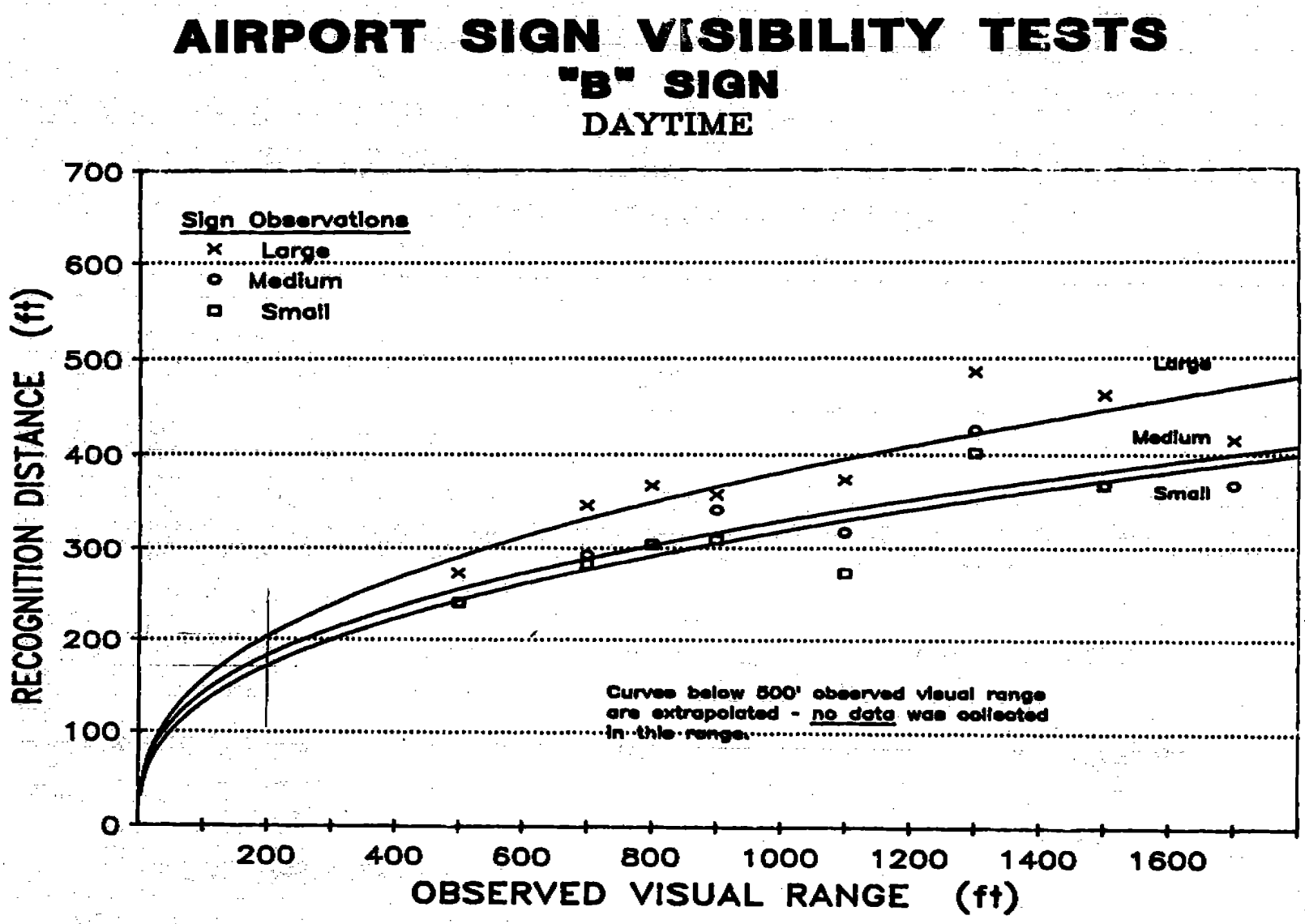

FIGURE 5. RECOGNITION DISTANCE CURVE FOR "B" SIGN, DAYTIME

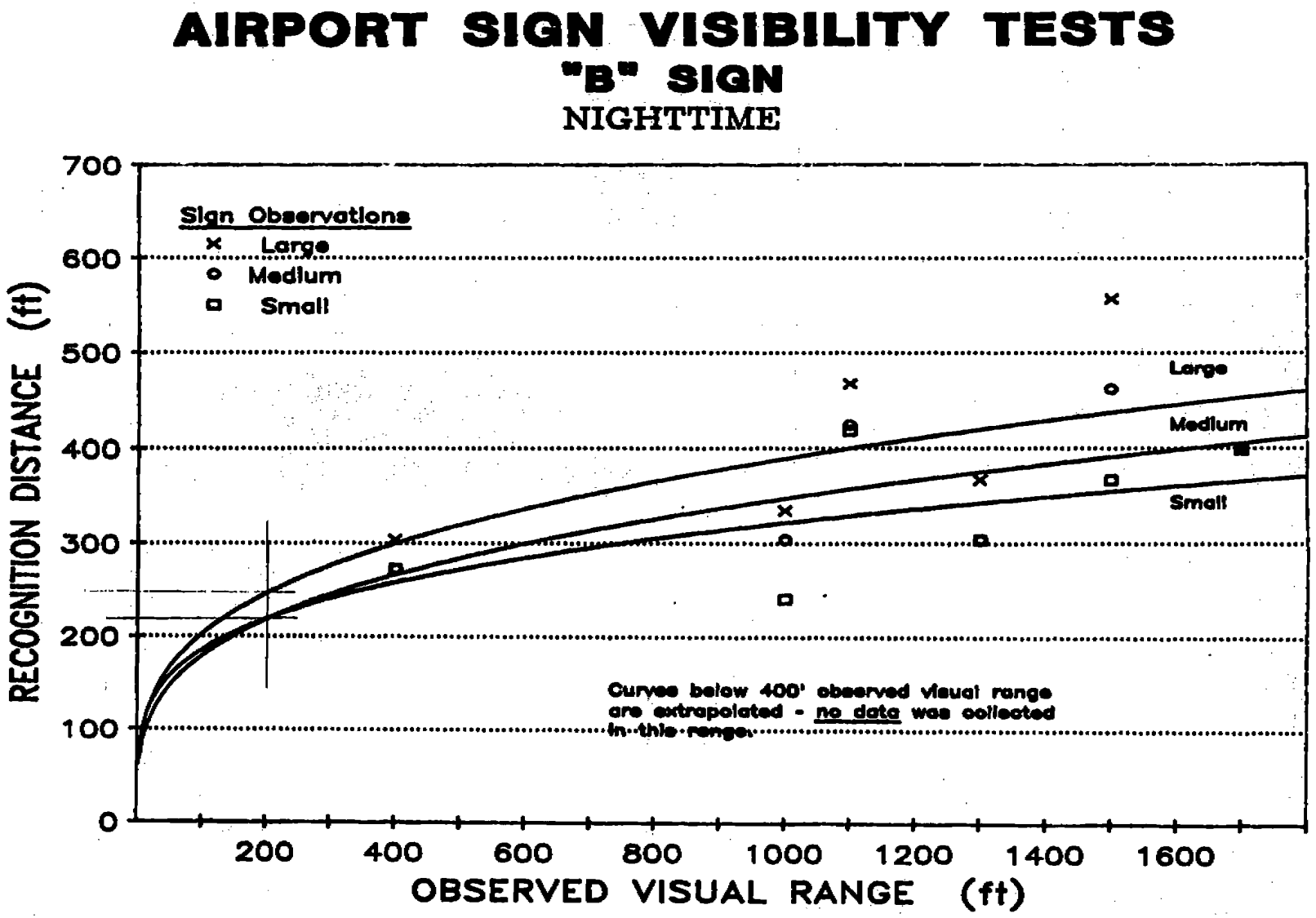

FIGURE 6. RECOGNITION DISTANCE CURVE FOR "B" SIGN, NIGHTTIME

TABLE 3. BOEING 727 AIRCRAFT STOPPING DISTANCES

RUN #	SPEED (Knots)	BRAKING	STOP DIST (Feet)	MAX G
1	5	LIGHT	27	-0.175
2	5	MODERATE	19	-0.199
3	10	LIGHT	48	-0.183
4	10	MODERATE	38	-0.194
5	15	LIGHT	89	-0.172
6	15	MODERATE	71	-0.186

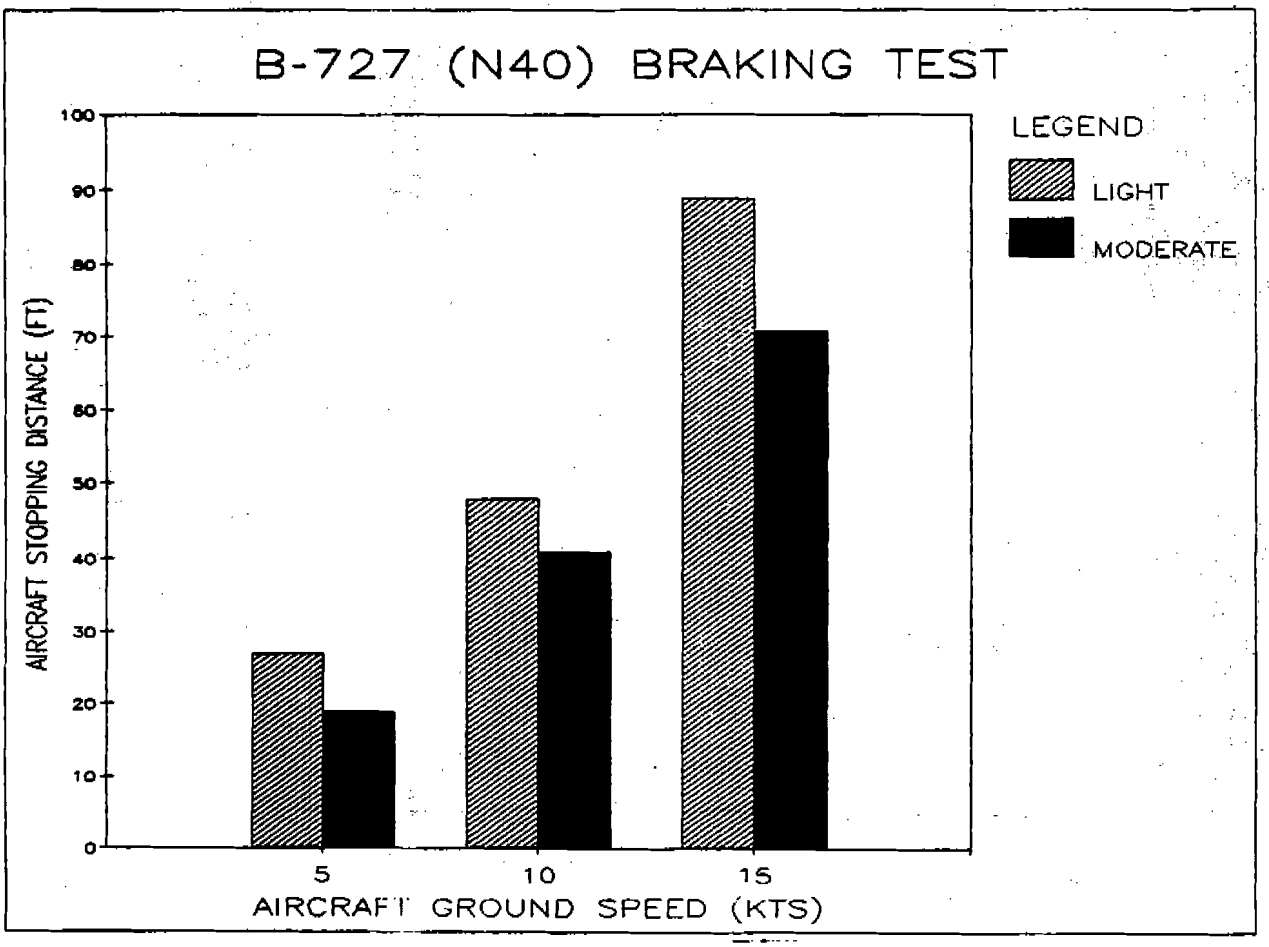

FIGURE 7. B727 AIRCRAFT STOPPING DISTANCES

Maximum stopping distance was encountered while using light braking pressure from a constant taxi speed of 15 knots. The deceleration G forces, shown in table 3, did not exceed the -0.200 level at any time during the brake application intervals. This deceleration level is within the acceptable passenger comfort range. While taxi speeds of 15 knots can be considered as representative of those normally used in good visibility, the slower 5-knot speed is more representative of speeds adopted by prudent pilots taxiing under very low (600-foot RVR and below) visibility conditions. Observations by personnel at the Center, made over a number of years while conducting low visibility taxi testing project efforts, support this presumption of markedly reduced taxi speeds in poor visibility situations.

It should also be noted that the aircraft used for the stopping distance tests, a Boeing 727-25C (-100 model), was configured with a gross weight of approximately 122,000 pounds. Since maximum gross weight for this type of aircraft can be as high as 160,000 pounds, it must be accepted that stopping distances for the fully loaded aircraft will probably be somewhat greater than those encountered in the tests. It is very likely, however, that at the slow taxi speeds (5 to 15 knots) used during low visibility, the increase in stopping distances for the more fully loaded aircraft will be not more than 10 percent greater than those obtained during testing. Therefore, we would expect that the maximum stopping distance will not exceed 100 feet, and that a range of 25 to 50 feet, even for a maximum weight aircraft, will be the norm.

It was also noted that, as the observed visibility decreased, the difference between the acquisition and recognition distance also decreased. This is shown in the graph in figure 8. This shows that, as the visibility decreases, the sign becomes readable almost as soon as it becomes visible.

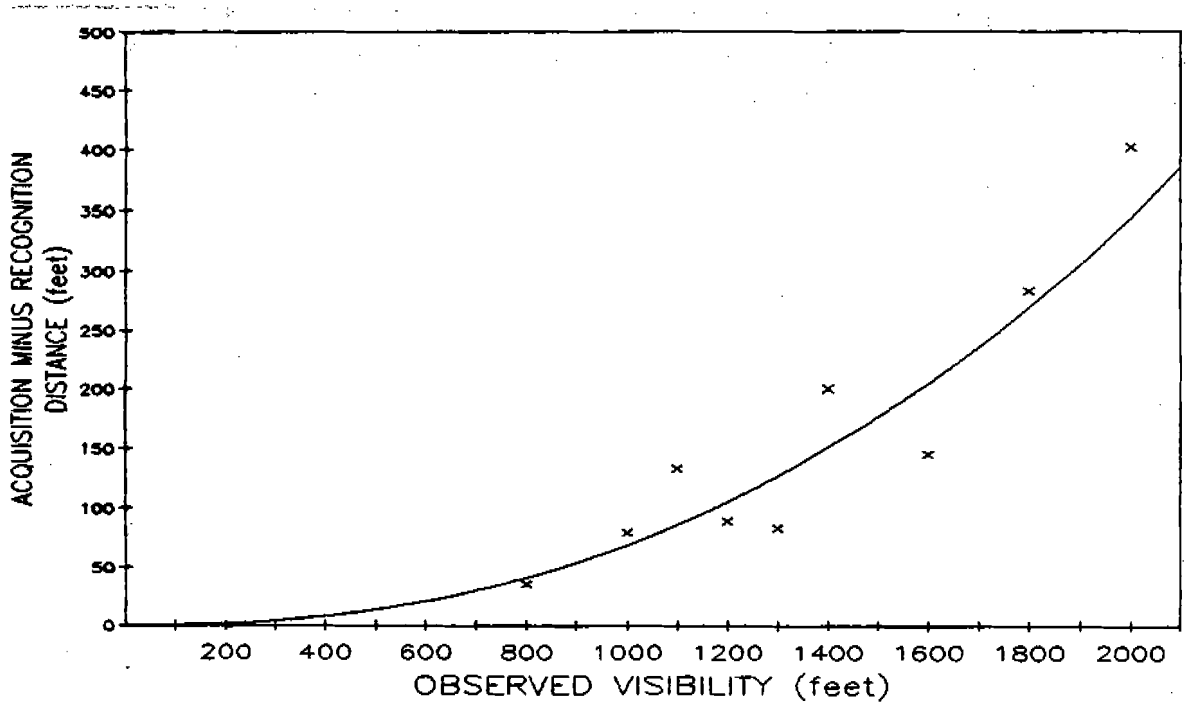

FIGURE 8. DIFFERENCE BETWEEN ACQUISITION AND RECOGNITION DISTANCES

ANALYSIS OF RESULTS.

Since very few data points, or observations, were obtained for visibility conditions below 600-foot RVR, a good deal of caution must be taken in extrapolating to obtain probable sign effectiveness for the lower visibility ranges. At best, assumptions as to likely recognition distances cannot be made for any visibility condition lower than 200-foot RVR. Taking this into account, we would interpret the results of the actual weather sign observation testing to indicate a strong probability that the smaller size signs will be effective, to a lower limit RVR of 200 feet, in providing pilots with location/guidance information at a minimum distance of approximately 175 feet. In like manner, it is very likely that the largest size signs will be effective (again, to the lower limit of 200-foot RVR) in providing pilots with location/guidance information at a minimum distance of approximately 200 feet. Accepting an effective range for all sizes of signs (with a minimum RVR condition of at least 200 feet) as being 175 feet, we can predict that the signs will provide the pilot with the necessary visual guidance information at a distance twice that required for stopping the aircraft from normal taxi speeds.

CONCLUSIONS

From analysis of data collected, we can conclude that:

1. All sizes of standard signs tested will provide adequate visual guidance information as to the location of critical maneuvering area intersections and destinations down to a minimum RVR of 200 feet.

2. Larger size signs will, in general, provide marginally better guidance in low visibility conditions and will allow installation at greater distances from the immediate taxiway/runway environment.

APPENDIX A

AIRPORT SIGN VISIBILITY TABLE

DATE	TIME	VISIBILITY MILES	T/D RVR	R/O RVR	OBS VIS	PLOT RVR	LEGEND	SIZE	ACQUISITION	RECOGNITION
11/27/85	0844		1600	2400	2200	2200	4-22	L	--	500
11/27/85	0844		1600	2400	2200	2200	4-22	M	--	400
11/27/85	0844		1600	2400	2200	2200	4-22	S	--	350
3/14/86	1050	1/8	1200	1200	800	800	B	L	550	450
3/14/86	1050	1/8	1200	1200	800	800	4-22	L	450	450
3/14/86	1050	1/8	1200	1200	800	800	4-22	S	--	400
4/28/86	0500		1200	1400	1300	1300	B	L	750	550
4/28/86	0500		1200	1400	1300	1300	B	M	650	500
4/28/86	0500		1200	1400	1300	1300	B	S	650	400
4/28/86	0500		1200	1400	1300	1300	4-22	L	650	650
4/28/86	0500		1200	1400	1300	1300	4-22	M	550	550
4/28/86	0500		1200	1400	1300	1300	4-22	S	450	450
10/13/86	0040	1/8	1200	1200	1400	1400	B	L	900	600
10/13/86	0040	1/8	1200	1200	1400	1400	B	M	800	600
10/13/86	0040	1/8	1200	1200	1400	1400	B	S	800	600
10/13/86	0056	1/8	1200	1200	1400	1400	4-22	L	600	500
10/13/86	0056	1/8	1200	1200	1400	1400	4-22	M	600	450
10/13/86	0056	1/8	1200	1200	1400	1400	4-22	S	600	400
10/26/86	2300	1/4	1200	1200	1600	1600	B	L	800	600
10/26/86	2300	1/4	1200	1200	1600	1600	B	M	800	500
10/26/86	2300	1/4	1200	1200	1600	1600	B	S	800	500
10/26/86	2300	1/4	1200	1200	1600	1600	4-22	M	550	400
10/26/86	2300	1/4	1200	1200	1600	1600	4-22	S	550	350
10/26/86	2300	1/4	1200	1400	1400	1800	B	L	900	800
10/26/86	2300	1/4	1200	1400	1400	1800	B	M	900	700
10/26/86	2300	1/4	1400	1400	1400	1800	B	S	900	600
4/22/87	0625		800	800	1400	1400	B	L	--	700
4/22/87	0625		800	800	1400	1400	B	M	--	500
4/22/87	0625		800	800	1400	1400	B	S	--	450
4/22/87	0645		800	800	1400	1400	B	L	--	600
4/22/87	0645		800	800	1400	1400	B	M	--	500
4/22/87	0645		800	800	1400	1400	B	S	--	450
8/5/87	0350	0/0	0	0	600	600	B	L	--	500
8/5/87	0325	0/0	0	0	600	600	B	M	--	450
8/5/87	0325	0/0	0	0	600	600	B	S	--	450
8/5/87	0445		2800	1000	1200	1200	4-22	M	--	350
8/5/87	0445		2800	1000	1200	1200	4-22	S	--	350
11/25/87	0640	1/4	1600	1600	1200	1200	4-22	M	--	550
11/25/87	0640	1/4	1600	1600	1200	1200	4-22	S	--	450
11/25/87	0640	1/4	1600	1600	1200	1200	4-22	M	--	400
11/25/87	0640	1/4	1600	1600	1200	1200	4-22	S	--	350
11/25/87	0650	1/4	4000	N/A	1200	1200	B	L	700	600
11/25/87	0650	1/4	4000	N/A	1200	1200	B	M	600	600
11/25/87	0650	1/4	4000	N/A	1200	1200	B	S	600	600
11/25/87	0650	1/4	4000	N/A	1200	1200	B	L	800	600
11/25/87	0650	1/4	4000	N/A	1200	1200	B	M	700	600

11/25/87	0650	1/4	4000	N/A	1200	1200	B	S	600	500
1/18/88	1843	1/8	1800	1800	2000	2000	4-22	L	--	550
1/18/88	1843	1/8	1800	1800	2000	2000	4-22	M	--	450
1/18/88	1843	1/8	1800	1800	2000	2000	4-22	S	--	400
1/18/88	1843	1/8	1800	1800	2000	2000	B	L	--	700
1/18/88	1843	1/8	1800	1800	2000	2000	B	M	--	700
1/18/88	1843	1/8	1800	1800	2000	2000	B	S	--	700
3/4/88	0530	0/0	1000	1400	1400	1400	B	L	900	600
3/4/88	0530	0/0	1000	1400	1400	1400	B	M	800	500
3/4/88	0530	0/0	1000	1400	1400	1400	B	S	700	450
3/4/88	0544	0/0	1000	1400	1400	1400	4-22	L	800	500
3/4/88	0544	0/0	1000	1400	1400	1400	4-22	M	800	400
3/4/88	0544	0/0	1000	1400	1400	1400	4-22	S	800	300
3/4/88	0604	0/0	1200	1200	1800	1200	B	L	1000	500
3/4/88	0604	0/0	1200	1200	1800	1200	B	M	800	500
3/4/88	0604	0/0	1200	1200	1800	1200	B	S	800	400
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3/4/88	0610	0/0	1200	1400	1600	1400	4-22	M	650	400
3/4/88	0610	0/0	1200	1400	1600	1400	4-22	S	500	350
3/4/88	0635	0/0	600	600	1400	1400	B	L	650	500
3/4/88	0635	0/0	600	600	1400	1400	B	M	600	500
3/4/88	0635	0/0	600	600	1400	1400	B	S	550	400
3/4/88	0645	0/0	600	800	1200	1200	4-22	L	400	400
3/4/88	0645	0/0	600	800	1200	1200	4-22	M	400	350
3/4/88	0645	0/0	600	800	1200	1200	4-22	S	350	250
4/24/88	0357	1/8	1800	1800	2200	2200	B	L	1400	700
4/24/88	0357	1/8	1800	1800	2200	2200	B	M	1300	700
4/24/88	0357	1/8	1800	1800	2200	2200	B	S	1300	700
4/24/88	0400	1/8	1800	1800	2200	2200	B	L	1200	700
4/24/88	0400	1/8	1800	1800	2200	2200	B	M	900	700
4/24/88	0400	1/8	1800	1800	2200	2200	B	S	900	600
4/24/88	0405	1/8	1600	1600	2000	2000	4-22	L	1300	650
4/24/88	0405	1/8	1600	1600	2000	2000	4-22	M	1300	550
4/24/88	0405	1/8	1600	1600	2000	2000	4-22	S	1300	450
6/19/88	309	1/8	N/A	N/A	1400	1400	B	L	1000	600
6/19/88	309	1/8	N/A	N/A	1400	1400	B	M	800	550
6/19/88	309	1/8	N/A	N/A	1400	1400	B	S	800	550
6/19/88	314	1/8	N/A	N/A	1400	1400	4-22	L	550	450
6/19/88	314	1/8	N/A	N/A	1400	1400	4-22	M	550	350
6/19/88	314	1/8	N/A	N/A	1400	1400	4-22	S	550	350
8/3/88	0330	1/4	1800	2200	2000	2000	B	L	1200	600
8/3/88	0330	1/4	1800	2200	2000	2000	B	M	800	600
8/3/88	0330	1/4	1800	2200	2000	2000	B	S	800	600
8/3/88	0336	1/4	1800	2200	2000	2000	4-22	L	900	550
8/3/88	0336	1/4	1800	2200	2000	2000	4-22	M	900	500
8/3/88	0336	1/4	1800	2200	2000	2000	4-22	S	800	400
8/3/88	0404	1/4	1800	2200	2000	2000	B	L	1100	600
8/3/88	0404	1/4	1800	2200	2000	2000	B	M	800	600

8/3/88	0404	1/4	1800	2200	2000	2000	B	S	800	600
8/3/88	0418	1/4	1200	2000	2000	2000	4-22	L	950	650
8/3/88	0418	1/4	1200	2000	2000	2000	4-22	M	950	600
8/3/88	0418	1/4	1200	2000	2000	2000	4-22	S	800	500
8/27/88	0822	0/0	800	600	1400	1400	4-22	L	550	400
8/27/88	0822	0/0	800	600	1400	1400	4-22	M	550	350
8/27/88	0822	0/0	800	600	1400	1400	4-22	S	550	350
8/27/88	0831	0/0	800	800	1100	1100	B	L	700	600
8/27/88	0831	0/0	800	800	1100	1100	B	M	650	500
8/27/88	0831	0/0	800	800	1100	1100	B	S	650	500
8/27/88	0854	0/0	800	800	1200	1200	4-22	L	550	450
8/27/88	0854	0/0	800	800	1200	1200	4-22	M	550	450
8/27/88	0854	0/0	800	800	1200	1200	4-22	S	550	400
8/27/88	0900	0/0	800	800	1200	1200	B	L	700	600
8/27/88	0900	0/0	800	800	1200	1200	B	M	600	500
8/27/88	0900	0/0	800	800	1200	1200	B	S	600	500
10/1/88	0730	0/0	1600	600	800	800	4-22	L	300	300
10/1/88	0730	0/0	1600	600	800	800	4-22	M	300	250
10/1/88	0730	0/0	1600	600	800	800	4-22	S	300	250
10/1/88	0734	0/0	1600	600	800	800	B	L	450	450
10/1/88	0734	0/0	1600	600	800	800	B	M	450	400
10/1/88	0734	0/0	1600	600	800	800	B	S	450	400
10/1/88	0738	0/0	1800	800	1000	1000	4-22	L	350	350
10/1/88	0738	0/0	1800	800	1000	1000	4-22	M	300	300
10/1/88	0738	0/0	1800	800	1000	1000	4-22	S	300	250
10/1/88	0741	0/0	1800	800	1000	1000	B	L	600	500
10/1/88	0741	0/0	1800	800	1000	1000	B	M	500	400
10/1/88	0741	0/0	1800	800	1000	1000	B	S	500	400
10/1/88	0746	0/0	1800	800	800	800	4-22	L	400	400
10/1/88	0746	0/0	1800	800	800	800	4-22	M	350	300
10/1/88	0746	0/0	1800	800	800	800	4-22	S	350	300
10/1/88	0750	0/0	1800	800	1000	1000	B	L	700	600
10/1/88	0750	0/0	1800	800	1000	1000	B	M	600	500
10/1/88	0750	0/0	1800	800	1000	1000	B	S	600	500
2/15/89	0936	0/0	800	1000	1000	1000	B	L	700	600
2/15/89	0936	0/0	800	1000	1000	1000	B	M	600	550
2/15/89	0936	0/0	800	1000	1000	1000	B	S	600	500
2/15/89	0945	0/0	800	1000	1000	1000	4-22	L	500	400
2/15/89	0945	0/0	800	1000	1000	1000	4-22	M	450	350
2/15/89	0945	0/0	800	1000	1000	1000	4-22	S	450	350
2/15/89	0950	0/0	1000	1000	1400	1400	B	L	800	600
2/15/89	0950	0/0	1000	1000	1400	1400	B	M	700	500
2/15/89	0950	0/0	1000	1000	1400	1400	B	S	700	400
2/15/89	0957	0/0	1000	1000	1300	1300	4-22	L	500	450
2/15/89	0957	0/0	1000	1000	1300	1300	4-22	M	450	400
2/15/89	0957	0/0	1000	1000	1300	1300	4-22	S	400	350
3/1/89	0100	0/0	1000	1000	1400	1400	4-22	L	600	400
3/1/89	0100	0/0	1000	1000	1400	1400	4-22	M	500	350

3/1/89	0100	0/0	1000	1000	1400	1400	4-22	S	500	350
3/1/89	0114	0/0	1000	1000	1400	1400	B	L	1100	900
3/1/89	0114	0/0	1000	1000	1400	1400	B	M	900	800
3/1/89	0114	0/0	1000	1000	1400	1400	B	S	900	800
3/1/89	0137	0/0	1000	1000	1400	1400	B	L	1200	900
3/1/89	0137	0/0	1000	1000	1400	1400	B	M	1000	800
3/1/89	0137	0/0	1000	1000	1400	1400	B	S	1000	800
3/1/89	0143	0/0	1000	1000	1400	1400	4-22	L	800	600
3/1/89	0143	0/0	1000	1000	1400	1400	4-22	M	800	550
3/1/89	0143	0/0	1000	1000	1400	1400	4-22	S	800	450
5/1/89	0615	0/0	800	800	1800	1800	B	L	1000	700
5/1/89	0615	0/0	800	800	1800	1800	B	M	700	600
5/1/89	0615	0/0	800	800	1800	1800	B	S	700	600
5/1/89	0630	0/0	1200	800	1600	1600	4-22	L	550	500
5/1/89	0630	0/0	1200	800	1600	1600	4-22	M	500	450
5/1/89	0630	0/0	1200	800	1600	1600	4-22	S	500	400
5/1/89	0640	0/0	1200	800	1600	1600	4-22	L	700	600
5/1/89	0640	0/0	1200	800	1600	1600	4-22	M	650	550
5/1/89	0640	0/0	1200	800	1600	1600	4-22	S	600	500
5/1/89	0650	0/0	1000	800	1600	1600	B	L	1200	1000
5/1/89	0650	0/0	1000	800	1600	1600	B	M	1000	900
5/1/89	0650	0/0	1000	800	1600	1600	B	S	1000	850
5/1/89	0900	0/0	600	800	1200	1200	4-22	L	450	400
5/1/89	0900	0/0	600	800	1200	1200	4-22	M	450	400
5/1/89	0900	0/0	600	800	1200	1200	4-22	S	450	400
5/1/89	0910	0/0	600	800	1200	1200	B	L	700	600
5/1/89	0910	0/0	600	800	1200	1200	B	M	600	550
5/1/89	0910	0/0	600	800	1200	1200	B	S	600	550
5/1/89	0915	0/0	600	800	1600	1600	B	L	700	600
5/1/89	0915	0/0	600	800	1600	1600	B	M	650	500
5/1/89	0915	0/0	600	800	1600	1600	B	S	650	500
5/1/89	0920	0/0	600	1000	1600	1600	4-22	L	700	650
5/1/89	0920	0/0	600	1000	1600	1600	4-22	M	700	600
5/1/89	0920	0/0	600	1000	1600	1600	4-22	S	700	550
10/15/89	1030	0/0	1200	1200	2000	2000	B	L	1200	700
10/15/89	1030	0/0	1200	1200	2000	2000	B	M	1000	600
10/15/89	1040	0/0	1200	1000	2000	2000	4-22	L	1300	600
10/15/89	1040	0/0	1200	1000	2000	2000	4-22	M	1300	550
10/15/89	1040	0/0	1200	1000	2000	2000	4-22	S	1300	500
10/16/89	0920	0/0	600	1000	2000	2000	B	L	1000	600
10/16/89	0920	0/0	600	1000	2000	2000	B	M	800	600
10/16/89	0920	0/0	600	1000	2000	2000	4-22	L	800	500
10/16/89	0920	0/0	600	1000	2000	2000	4-22	M	800	450
10/16/89	0920	0/0	600	1000	2000	2000	4-22	S	800	400
10/16/89	0920	0/0	600	1000	1200	1200	B	L	900	600
10/16/89	0920	0/0	600	1000	1200	1200	B	M	700	600
10/16/89	0920	0/0	600	1000	1200	1200	B	S	---	500
10/16/89	0920	0/0	600	1000	2000	2000	4-22	L	750	600

10/16/89	0920	0/0	600	1000	2000	2000	4-22	M	700	500
10/16/89	0920	0/0	600	1000	2000	2000	4-22	S	650	450
10/30/89	0830	1/16	600	800	1400	1400	B	L	700	600
10/30/89	0830	1/16	600	800	1400	1400	B	M	600	600
10/30/89	0830	1/16	600	800	1400	1400	B	S	600	550
10/30/89	0835	1/16	600	800	1400	1400	4-22	L	500	450
10/30/89	0835	1/16	600	800	1400	1400	4-22	M	450	400
10/30/89	0835	1/16	600	800	1400	1400	4-22	S	450	400
10/30/89	0840	1/16	800	1200	1600	1600	B	L	700	600
10/30/89	0840	1/16	800	1200	1600	1600	B	M	600	550
10/30/89	0840	1/16	800	1200	1600	1600	B	S	600	500
10/30/89	0845	1/16	800	1200	1600	1600	4-22	L	700	650
10/30/89	0845	1/16	800	1200	1600	1600	4-22	M	650	600
10/30/89	0845	1/16	800	1200	1600	1600	4-22	S	650	550