2005 NTPEP Report Series

NTPEP Report 7003.1

AASHTO's National Transportation Product Evaluation Program

FIELD PERFORMANCE EVALUATION RESULTS OF FLASHING ARROW PANELS AND PORTABLE CHANGEABLE MESSAGE SIGNS

WINTER 2005 EVALUATION
FINAL REPORT

September 2005

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National Transportation Product Evaluation Program (NTPEP)

Report 7003.1

Report of

FIELD PERFORMANCE EVALUATION RESULTS OF FLASHING ARROW PANELS (ARROWBOARDS) & PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

(WINTER 2005 TESTING CYCLE)

Evaluation & Report Completed for NTPEP by:

North Carolina Department of Transportation
Traffic Engineering & Safety Systems Branch

September 2005

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AASHTO's National Transportation Product Evaluation Program

American Association of State and Highway Transportation Officials

National Transportation Product Evaluation Program

For

Flashing Arrow Panels and Portable Changeable Message Signs

Winter 2005 Evaluation Final Report

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AASHTO's National Transportation Product Evaluation Program

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Acknowledgements

No project of this scope can be completed without the assistance and efforts of many individuals and groups. This NTPEP evaluation was certainly no exception.

Randy Hoyle and Jerry Bagwell of the NCDOT Equipment Depot in Raleigh provided space, movement of signs, and generally anything needed to aid in the evaluation of the signs.

Kent Dozier, Donnie Sherrod, Jimmy Williamson and Traffic Services of the NCDOT Division 4 Equipment Unit in Wilson provided invaluable assistance with moving the signs from Raleigh to Wilson. They also provided trucks that were used to maneuver the signs during the evaluations.

Background and Introduction

The NTPEP Oversight Committee voted in 1997 to establish a Project Panel to develop two separate draft work plans for the evaluation of Portable Changeable Message Signs (PCMS) and Flashing Arrow Panels (FAP), respectively. Input for this draft work plan was gathered from state standard specifications and general product evaluation criteria submitted by AASHTO members. Industry was an active participant in these discussions and offered guidance through the American Traffic Safety Services Association (ATSSA) technical committees. Many of the remaining specifications were found through state surveys and literature search. A final work plan with revisions from the NTPEP Oversight Committee was adopted in November 1998. The first evaluations of PCMSs and FAPs took place in winter of 1999. Since then, the work plans have been revised twice after input from the NTPEP lead testing state, AASHTO members and industry. There are two separate work plans; one for the PCMSs and one for the FAPs.

Only three signs were submitted for testing this year- two PCMSs and one FAP. The 2005 NTPEP evaluators used the same work plan from the 2004 NTPEP evaluation, which can be found in Appendix B. Modifications to the work plan were necessary during the 2004 evaluation and were discussed in detail in that report. Since the same work plan was used for this evaluation, those same modifications were necessary and are again discussed in this report. It is our intent to meet with the NTPEP-TTCD Project Panel to review these modifications and revise the work plan before the next evaluation.

Testing began on March 1, 2005 with the Reliability (Section 3.2) and Durability (Section 3.3) Operational Performance Tests. These tests were performed at the North Carolina DOT (NCDOT) Equipment Depot in Raleigh, NC.

The Dimming (Section 3.4) Operational Performance Test, Visibility (Section 2.3), Legibility (Section 2.4) and Angularity (Section 2.5) Sight Tests were performed May 25 & 26, 2005 at the Wilson Industrial Air Center in Wilson, NC.

Every effort was made to provide an accurate report of data collected during the implementation of the work plans for the PCMSs and the FAP.

North Carolina DOT strongly supports the NTPEP program and hopes the information contained in this report will be useful in making decisions about what products or types of products best suit the purchaser's needs. While it is never recommended to buy any device prior to an inspection of the device, using the information contained in this report can eliminate costly and time-intensive evaluations by individual agencies. If you have any specific questions about the data in this report, please feel free to contact Meredith McDiarmid at (919) 250-4159.

Discussion of the Project Work Plan

Editor's Note: As you read the "Discussion of the Project Work Plan", you will find that the evaluation team made a number of adjustments and modifications to the official NTPEP Project Work Plan. The Lead State would like to express to the AASHTO member states that all changes were made in a genuine attempt to report the most accurate results possible.

Recommendations to member departments on utilization of resulting data can be found in the "Observations and Suggestions" Section (Page 8) of this report.

Section 2.0 Sight Tests

The Visibility (Section 2.3), Legibility (Section 2.4), and Angularity (Section 2.5) Sight Tests were performed during May 2005 at the Wilson Industrial Air Center in Wilson, NC (see Appendix A, page A1, for location diagram). The runway was surveyed and marked per the work plan (see Test Deck Layout in Appendix A, page A2). All three tests for the signs were performed with three evaluators using a 2002 Ford Taurus. Signs were tested one at a time with a unique three-line message for each PCMS sign and a randomly chosen "Right Arrow" or "Left Arrow " for the FAP sign. Evaluations were performed during daytime and nighttime, and a NCDOT onboard vehicle distance meter was used to determine the distances.

As with the 2004 NTPEP testing, adjustments to the Sight Test section of the work plan were needed. The adjustments the team made are as follows:

- To be consistent with the 2004 NTPEP testing, the three tests were performed in one run.
- Due to technical issues and a delay in registration, the team was not able to perform the Sight Tests until May. Average temperature during testing was approximately 79ºF instead of the 32ºF as specified in the work plan.
- The Visibility (Section 2.3) and Legibility (Section 2.4) Sight Tests were performed with three evaluators seated at the same time starting at the 4800-foot mark. The test sight area did not meet the one mile Legibility requirement for Type "C" FAPs per the Manual on Uniform Traffic Control Devices (MUTCD). All distances for Legibility were measured from the 4800-foot mark.
- The Angularity (Section 2.5) Sight Test was performed with each evaluator in the driver's seat. The distance meter was reset at the 200-foot mark for each evaluator's run to insure a consistent distance measurement.

Results for the Section 2.0 PCMS Sight Tests can be found on page 11 and results for Section 2.0 FAP Sight tests can be found on page 16. All results

shown are the "Averages" of the evaluators' data except for the Angularity Test results. Each evaluator's vision was sometimes obstructed by the rear-view mirror affecting the Angularity Test results. Instead of averaging the evaluator's results or omitting the affected data, the team decided to present the data for each evaluator and let each member state evaluate the resulting data for its merit. The affected data is shown "shaded" on the chart.

Section 3.0 Operational Performance Tests

The Reliability (Section 3.2) and Durability (Section 3.3) Operational Performance Tests were performed concurrently for a 30-day period at the NCDOT Equipment Depot in Raleigh, NC. Due to a late start in registration, the testing began in March instead of February as specified in the work plan. Daily weather information with average temperatures for the period can be found in Appendix A, page A3.

The Dimming (Section 3.4) Operational Performance Test was performed in conjunction with the Section 2.0 Sight Tests at the Wilson Industrial Air Center in Wilson, NC because of the distance requirements per the TTI: 4940 test procedure. Luminance readings were made using a Minolta LS-100 Luminance Light Meter. The work plan specified using Texas Transportation Institute's test procedure as outlined in their report TTI: 4940-1 for the FAP and report TTI: 4940-2 for the PCMSs. It was discovered that each report's purpose and testing procedure was devoted to establishing optimum luminance standards when purchasing signs and not for determining the dimming capabilities as outlined in the work plan. It was decided to modify the report's criteria to meet our objectives while still following the measuring methods as outlined in the report. The only change to the measuring method was in the report TTI: 4940-2 for the PCMSs. The procedure specified that all elements (35 in a 5-by-7 module) of one character be illuminated when measuring luminance, but it was determined this would be impractical because of special programming needed for each sign. It was decided to instead use the letter "H" because of the character's element count and common design. The luminance readings where recorded as candelas per meter squared (cd/m^2).

The Dimming (Section 3.4) Operational Performance Test also required the measurement of the voltage during the luminance readings. As with the 2004 NTPEP testing, there was no apparent method for accurately measuring the voltage change during dimming. The team decided not to record data for this requirement.

The On/Off Time Periods (Section 3.5) of the PCMS work plan was programmed and recorded. As with the 2004 NTPEP testing, the message "CAUTION ACCIDENT AHEAD" was used which met the 75 to 80 percent character availability requirement of the Message Content (Section 2.2). The Flashing

Rate (Section 3.5) of the FAP work plan was measured and recorded. The mode used on the FAP was the "Right Arrow".

The Charging Time (Section 3.6) Operational Performance Test of the Project Work Plan was evaluated by the team for it's value. As with the 2004 NTPEP testing, it was decided not to record data for re-charging the sign's battery banks because of the many variables that could affect charging times.

Results for Section 3.0 PCMS Operational Performance Tests can be found on page 12 and results for Section 3.0 FAP Operational Performance Test can be found on page 16. All results are shown except for Dimming (Section 3.4) voltage data and Charging Time (Section 3.6) time data.

Section 4.0 Technical Desk Audit & Verification

Section 4.0 Technical Desk Audit & Verification of the Project Work Plan required the manufacturer to send this information to aid in describing their product(s) in the evaluation report. All results for the Section 4.0 PCMS Technical Desk Audit & Verification can be found beginning on page 13 and results for Section 4.0 FAP Technical Desk Audit & Verification can be found on page 17.

Observations and Suggestions

The objective of the NTPEP Lead State was to conduct the best evaluation possible and provide sound data to AASHTO member departments as described in the Project Work Plan(s). To that end, the following points are the team's "Observations" and "Suggestions" from the 2004 NTPEP evaluation with additional points from the 2005 NTPEP evaluation. The information is intended to assist AASHTO member departments in utilizing the 2005 NTPEP results and to improve future testing:

- In reviewing the Reliability (Section 3.2.2) test data where amp-hour capacities were recorded, it became obvious to the evaluation team that some manufacturers had increased amp-hour capacity of their signs with additional batteries to meet this requirement. The thirty (30) day Reliability test is strongly influenced by the number of batteries and the amp-hour capacity of those batteries. The team is suggesting to the member states using the thirty (30) day Reliability requirement in their specifications to consult with the sign manufacturer to specify a battery bank with the number and amp-hour battery capacity to achieve their "running without solar power" needs. We are also suggesting the NTPEP-TTCD Project Panel review the Project Work Plan with input from participating manufacturers to determine what criteria needs to be specified in order for data to be comparable.

- In reviewing the Angularity (Section 2.5) test data, it was explained in the work plan discussion that the evaluators had problems with the rear-view mirror obstructing their view of the sign. It is suggested that the NTPEP-TTCD Project Panel discuss how to fairly report the data since this is likely to happen again in future testing.

- The Dimming (Section 3.4) test, noted above in the "Discussion of Work Plan", had numerous problematic issues as follows:
  - The TTI: 7-4940 report test procedures were not intended for measuring dimming capability of the signs;
  - Varying ambient light conditions (sunny to partly cloudy) made measuring difficult, which influenced luminance readings;
  - There was no procedure provided on how to accurately measure voltage change during dimming.

  Member departments should only use the data shown to confirm dimming. These values should not be used to calculate percentage of dimming. It is suggested that the NTPEP Temporary Traffic Control Device (TTCD) Project Panel review this test to define the proper procedures and expectations for future evaluations.

- The Charging Time (Section 3.6) of the Project Work Plan was evaluated for its value. It was decided not to record data for re-charging the signs for the following reasons:
  - Different battery manufacturers, battery quantities, and amp-hour capacities could affect each sign's results;
  - Not all manufacturers supply battery chargers with their signs;
  - Manufacturers can offer optional battery chargers with different amp outputs, which would affect charging times.

  The team recommends member departments review amp-hour capacity needs and consult with the sign manufacturer to identify a battery charger to meet their Charging Time requirement. It is suggested that the NTPEP-TTCD Project Panel review the Project Work Plan criteria and evaluate the merit of this test.

While the evaluation team tested the signs, various operational and "ease of use" features from particular signs were noted. Although not required in the Project Work Plan, it is suggested that member states review prospective signs for the benefit of the following features:

- Sight alignment tubes with setup instructions near the tube (or on the sign) to assist in the proper alignment;
- Sign's rotation-locking device to should be independent from the sign's raise/lower-locking device;
- A safety pin/bolt position on the sign mast for when the sign is fully raised;
- Quick programming instructions provided in the control box (e.g., label on the cover, laminated sheet);
- Reflective sheeting on the face of the trailer as seen by oncoming motorists (guidance from the MUTCD);
- Manual backup for the electrical hydraulic device used for raising the sign;
- Ability to program a "flash rate" of a single message instead of having to sequence a blank message.

Additional Comments

The PCMS(2005) - 01 changeable messages sign arrived at the Wilson, NC test site for the Sight Test with the first LED module located at the lower left of the bottom row not functioning. It was determined that the non-functioning module would not affect testing results so the Sight Test proceeded as planned.

The PCMS(2005) - 01 changeable message sign also arrived with the LED module fourth-from-right on the second row not functioning. Per instructions from the manufacturer, the module was exchanged for another module from the display. The Reliability testing then proceeded as planned.

At the end of Reliability testing, the PCMS(2005) - 01 would not shut down with the "On/Off" toggle switch on the control panel. The display was turned off (blanked) and left in that state. The sign was checked a week later and found non-functional with the battery bank completely drained. The manufacturer was contacted and a member of their technical staff was sent to repair the sign. In order to get the sign functioning again, the technician replaced the Power Switching Board and exchanged eight of the non-functioning batteries with those from the PCMS(2005) - 02 changeable message sign.

Comments from the Manufacturer:
It was found that an out of specification shipment of screws was received. These screws hold the Power Supply Bar (PSB) on the bus bar and that was causing the PSB to have bad contact. This led to a situation where the PSB, after being "reset" unproperly so many times, finally just hangs. We have fixed that production issue.

PCMS Test Results

AASHTO's National Transportation Product Evaluation Program

NTPEP PCMS Product Listing

NTPEP ID#	Product Name	Company	Address	Phone	Contact	Web Site
PCMS(2005)-1	Portable Vanguard Series VP-1300-3-8-5x7-C-18-A	Daktronics Canada	1130 Levis Street #4 Lacheanie, QC J6W 5S6 Canada	(450) 492-1003 (450) 492-6066 Fax	Philippe Lefebvre	www.daktronicscanada.com
PCMS(2005)-2	Portable Vanguard Series VP-1400-27x48-F-18-A					

Section 2.0- PCMS Sight Test Results

Product Name	Company	Daytime				Nighttime			
		2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/θ)		2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/θ)	
Portable Vanguard Series VP-1300-3-8-5x7-C-18-A	Daktronics Canada	4800	963	43	30.2º	4800	660	24	46.2º
				54	**24.8º**			**54**	**24.8º**
				61	**22.3º**			**49**	**27º**
Portable Vanguard Series VP-1400-27x48-F-18-A		4800	910	35	35.5º	4800	779	38	33.3º
				59	**23º**			**49**	**27º**
				58	**23.3º**			**53**	**25.3º**

Note: Each evaluator's vision was sometimes obstructed by the rear-view mirror affecting the overall results on the Angularity Test. Instead of averaging the data or omitting the affected data, the team decided to present the data for each evaluator and let each member state evaluate the resulting data for its merit. The affected data is shown "shaded" on the chart.

AASHTO's National Transportation Product Evaluation Program

Section 3.0- PCMS Operational Performance Tests Results

NTPEP ID#	Product Name	Company	3.2 Reliability (Days)	3.2.2 Battery Bank Capacity (Ah@12Vdc, 20 hour Rating)	3.3 Durability (Days)	3.4 Dimming		
						Before (cd/m²)	During (cd/m²)	After (cd/m²)
PCMS(2005)-1	Portable Vanguard Series VP-1300-3-8-5x7-C-18-A	Daktronics Canada	30	16 Interstate Model #U2200 batteries in bank-1800AH total capacity	30	817	488	790
PCMS(2005)-2	Portable Vanguard Series VP-1400-27x48-F-18-A		30	16 Interstate Model #U2200 batteries in bank-1800AH total capacity	30	548	457	612

Note:

Section 4.0- PCMS Technical Desk Audit & Verification

NTPEP ID#	PCMS(2005)-1	PCMS(2005)-2
Product Name	Portable Vanguard Series VP-1300-3-8-5x7-C-18-A	Portable Vanguard Series VP-1400-27x48-F-18-A
Company	Daktronics Canada	Daktronics Canada
4.1.1 Display Type and Optical Characteristics of a Pixel's Output	LED Character matrix	LED Full matrix
4.1.2 Character Height	18"	18"
4.1.3 Maximum Lines	3	3
4.1.4 Max. Characters Per Line	8 characters	12 characters with proportional narrow font
4.1.5 Type of Matrix	Character matrix (also available in line and full matrix)	Full matrix (also available in line or character matrix)
4.1.6 Primary Power Charging Source	Solar and battery	Solar and battery
4.1.7 Can Solar Panels Be Tilted	Optional	Yes
4.1.8 Description of Dimming Capabilities Under Changing Light Conditions	256 levels of dimming and 256 levels of shade	256 levels of dimming and 256 levels of shade
4.1.9 AC Power Capable	Yes	Yes
4.1.10.1 Programmable Message Capability, Number of Storable Messages	200 pre-programmed, 100 programmable (same as the VP-1400 when PC-104 is added)	999 programmable, 200 pre-programmed (expandable upon request)
4.1.10.2 Capability and Procedure for Changing Messages	On display menu, select messages by number, message preview on LCD, and message activate. New messages can be created in the field.	On display menu, select messages by number and message activate. New messages can be created in the field.
4.1.10.3 Is Message System Menu-driven	Yes	Yes
4.1.10.4 Message Entry Device (removable Keyboard, other)	Keyboard with LCD display (with a laptop when PC-104 is added)	Keyboard with LCD display or with a laptop
4.1.10.5 Cellular Phone Capability and/or Radar Capability	Cellular and radar when PC-104 is added	Cellular and radar

Section 4.0 (continued)

NTPEP ID#	PCMS(2005)-1	PCMS(2005)-2
4.1.10.6 Control Console Security Description	Console is lockable and a password is needed. Four different user levels are available. Password can be programmed by the customer sign administrator.	Console is lockable and a password is needed. Four different user levels are available. Password can be programmed by the customer sign administrator.
4.1.10.7 Is Control Console Lighted (Keyboard and/or Console Display)	No, LCD display is backlighted.	No, LCD display is backlighted.
4.1.10.8 Is there a Default Message or a Pre-default Indicator	Yes, if PC-104 is added. The default message is selected by user.	Yes, the default message is selected by user.
4.1.11 Height of Panel Above the Road Surface	Fully raised, the top of the sign is 167.75", bottom of the sign is 89". Transport mode is 105".	Fully raised, the top of the sign is 167.75", bottom of the sign is 89". Transport mode is 105".
4.1.12 Range of Flashing Rates	Adjustable from 0.3 to 9 seconds	Adjustable through central software in 0.1 second increments from 0.3 to 9 seconds.
4.1.13 Maximum Wind Load	80 MPH when fully raised perpendicular from trailer, solar panel fully raised.	80 MPH when fully raised perpendicular from trailer, solar panel fully raised.
4.1.14 Rotation Capability	360º	360º
4.1.15 Alignment Device and Methodology for Pointing/Aiming	Not required because of the wide angle LEDs (30 and 70)	Not required because of the wide angle LEDs (30 and 70)
4.1.16 Type of Stabilizing Device(s)	Four jacks positioned at each corner	Four jacks positioned at each corner
4.1.17 Recharging Instructions	Adjustable as option. In the summer, position the solar panels parallel to the ground if the sun can directly hit the solar panels form 10 a.m. until 4 p.m. In the fall and spring, slant the solar panels perpendicular to the sun. In the winter, tilt the solar panels perpendicular to the sun, but insure that snow will slide off the panels (30 degrees is recommended).	In the summer, position the solar panels parallel to the ground if the sun can directly hit the solar panels form 10 a.m. until 4 p.m. In the fall and spring, slant the solar panels perpendicular to the sun. In the winter, tilt the solar panels perpendicular to the sun, but insure that snow will slide off the panels (30 degrees is recommended).
4.1.18 Theft/Vandalism Security Devices	Weather proof pad lock, optional lockable wheel bar.	Removable tongue, weather proof pad lock, optional lockable wheel bar.

FAP Test Results

AASHTO's National Transportation Product Evaluation Program

NTPEP FAP Product Listing

NTPEP ID#	Product Name	Company	Address	Phone	Contact	Web Site
PCMS(2004)-3	Advance Warner M90 15 Lamp	Protection Services Inc.	635 Ludlow Road Harrisburg, PA 17110 USA	(717) 257-4220 (717) 236-1281 Fax	Duane McHale	www.protectionservices.com

Section 2.0- FAP Sight Test Results

NTPEP ID#	Product Name	Company	Daytime				Nighttime			
			2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/θ)		2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/θ)	
PCMS(2004)-3	Advance Warner M90 15 Lamp	Protection Services Inc.	4800	4800	**54**	**24.8º**	4800	4023	32.0	38º
					62	**22º**			**53.0**	**25.3º**
					71	**19.4º**			**51.0**	**26.1º**

Note: Each evaluator's vision was sometimes obstructed by the rear-view mirror affecting the overall results on the Angularity Test. Instead of averaging the data or omitting the affected data, the team decided to present the data for each evaluator and let each member state evaluate the resulting data for its merit. The affected data is shown "shaded" on the chart.

Section 3.0- FAP Operational Performance Tests Results

NTPEP ID#	Product Name	Company	3.2 Reliability (Days)	3.2.2 Battery Bank Capacity (Ah@12Vdc, 20 Hour Rating)	3.3 Durability (Days)	3.4 Dimming			3.5 Flashing Rate	
						Before (cd/m²)	During (cd/m²)	After (cd/m²)	Flashes Per Minute	Dwell Time-On (s)
PCMS(2004)-3	Advance Warner M90 15 Lamp	Protection Services Inc.	30	2 Exide Model #NAPA-8274 batteries in bank- 320AH total capacity	30	1102	597	1159	34	0.8

Section 4.0- FAP Technical Desk Audit & Verification

NTPEP ID#	PCMS(2004)-3
Product Name	Advance Warner M90 15 Lamp
Company	Protection Services Inc.
4.1.1 **Display Type**	LED
4.1.2 **MUTCD Panel Type**	Type C
4.1.3 **Primary Power Charging Source**	Solar
4.1.4 **Can Solar Panels Be Tilted**	Panels can be tilted
4.1.5 **AC Power Capable**	Yes
4.1.6 **Mode Display Capabilities**	Flashing Arrow, Sequential Arrow, Flashing Caution, Straight Line and Four Corners
4.1.7 **Control Console Security Description**	Lockable cabinet
4.1.8 **Height to Bottom of FAP** **Above Road Surface**	7'- 9"
4.1.9 **Maximun Wind Load**	N/A
4.1.10 **Alignment Device and Methodology for Pointing/Aiming**	Target sight mounted on superstructure to aim Flashing Arrow Panel.
4.1.11 **Mode Switch for Maximum Dim, Maximum Bright and Automatic**	Automatic only
4.1.12 **Type of Stabilizing Device(s)**	Four outriggers and tongue jack (Top wind)
4.1.13 **Recharging Instructions**	48 hours
4.1.14 **Theft/Vandalism Security Devices**	Removable tongue, lockable battery and control cabinet

Test Deck Pictures

Section 2.0- Sight Tests Pictures

Evaluation vehicle approaching sign

Typical Sight Test message

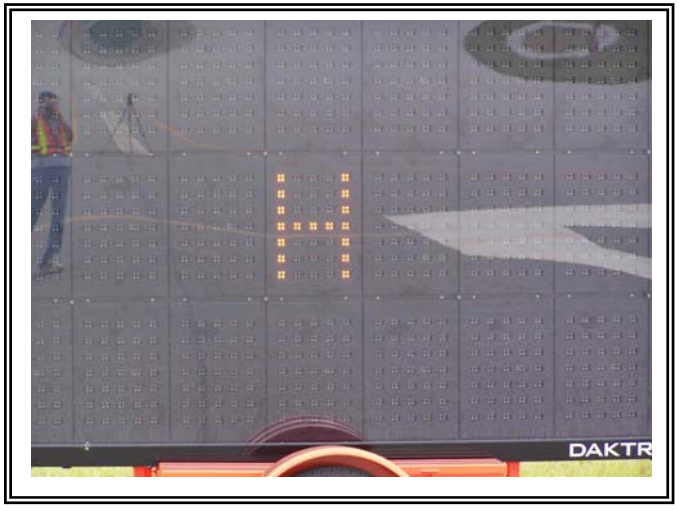
Typical Sight Test mode

Evaluator's view of sign during Angularity Test

Section 3.4- Dimming Pictures

Luminance meter setup

Sign setup for measurements



Character “H” used for measurements

Sign setup for measurements

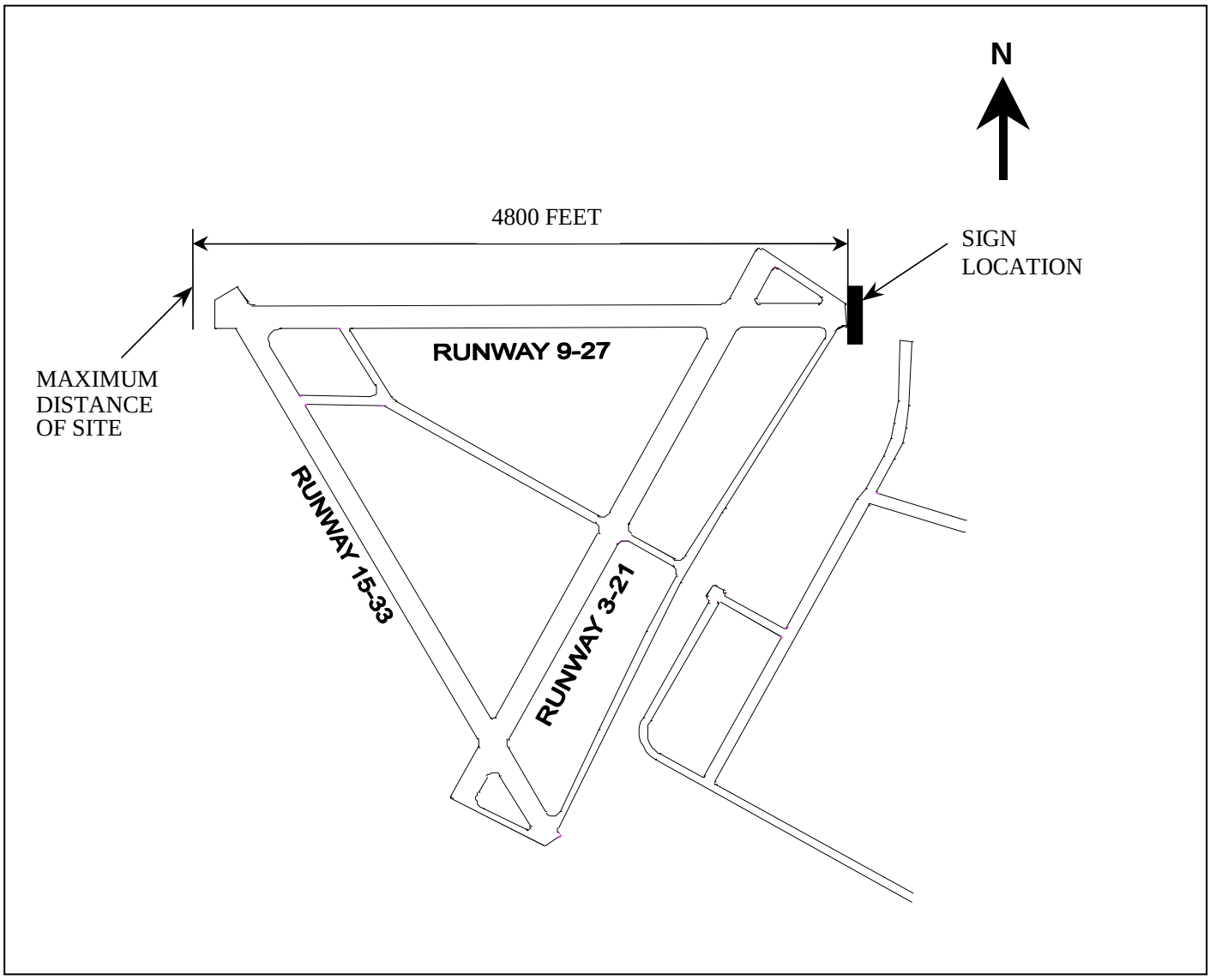
Appendix A

- Wilson Industrial Air Center
- Test Deck Layout
- Weather Data

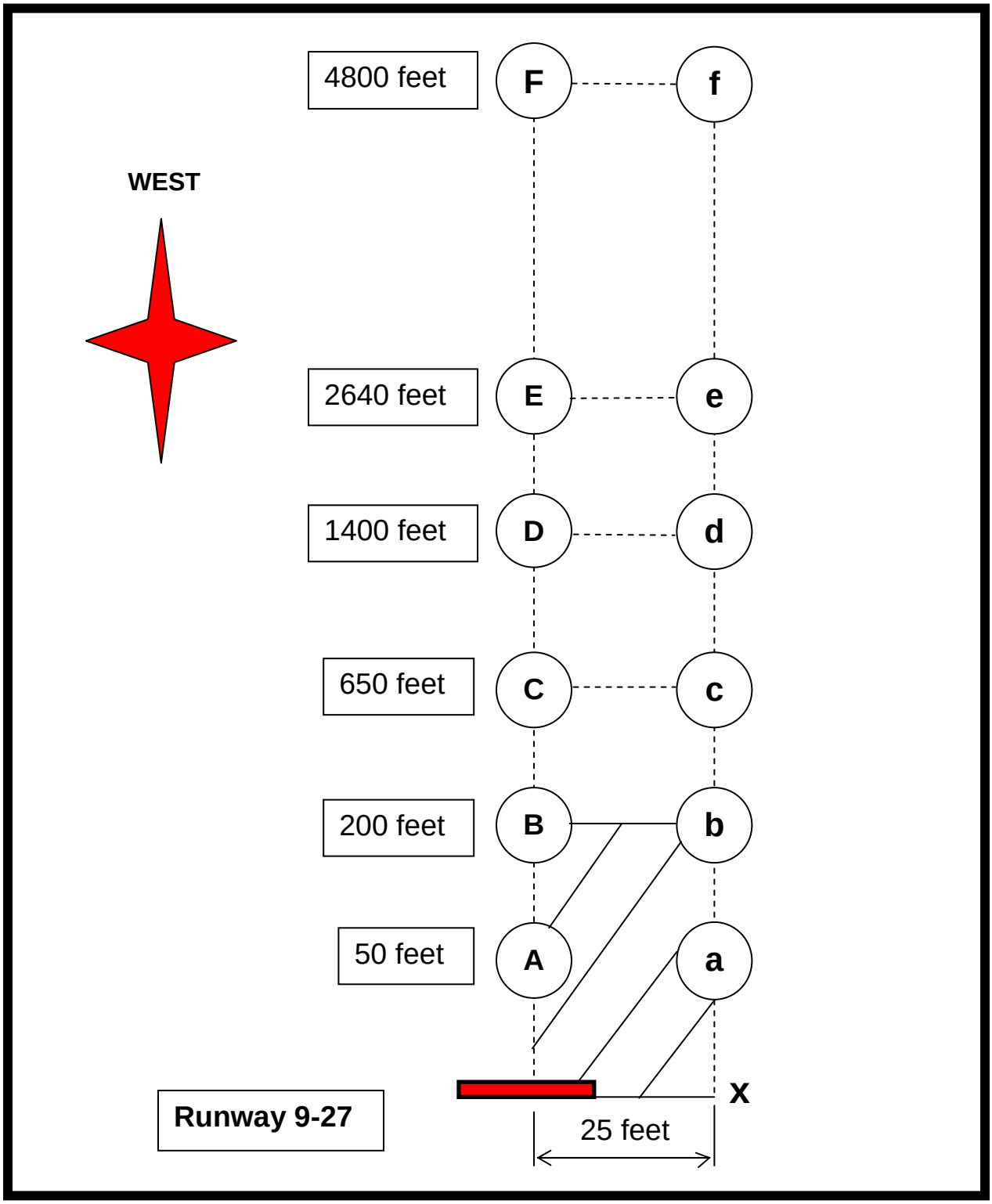
AASHTO's National Transportation Product Evaluation Program

Wilson Industrial Air Center

Wilson, NC



Test Deck Layout



Weather Data

2.0 Sight Tests Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
05/25/05	66°	58°	53°	82	0.00	
05/26/05	79°	66°	51°	63	0.00	

3.0 Operational Performance Tests Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
03/01/05	44°	38°	31°	67	0.00	Fog
03/02/05	46°	37°	27°	44	0.00	
03/03/05	48°	35°	22°	49	0.00	
03/04/05	59°	41°	22°	56	0.00	
03/05/05	62°	47°	31°	67	0.00	
03/06/05	63°	46°	28°	64	0.00	
03/07/05	73°	56°	39°	44	0.00	
03/08/05	57°	45°	32°	63	0.90	Rain, Thunderstorm
03/09/05	49°	37°	25°	52	0.00	
03/10/05	53°	40°	27°	41	0.00	
03/11/05	62°	48°	34°	63	0.17	Rain
03/12/05	66°	47°	28°	48	0.00	
03/13/05	73°	55°	36°	58	0.03	Rain, Thunderstorm
03/14/05	45°	38°	31°	81	0.00	
03/15/05	56°	42°	27°	62	0.00	Fog
03/16/05	45°	40°	35°	75	0.76	Rain
03/17/05	37°	35°	33°	96	0.38	Rain, Snow
03/18/05	58°	45°	31°	68	0.00	
03/19/05	62°	46°	29°	66	0.00	
03/20/05	70°	53°	36°	62	0.00	
03/21/05	65°	50°	35°	55	0.00	
03/22/05	63°	51°	38°	68	0.14	Rain
03/23/05	73°	62°	51°	68	0.47	Rain, Thunderstorm
03/24/05	67°	56°	45°	71	0.00	Fog
03/25/05	60°	52°	44°	77	0.00	
03/26/05	55°	49°	43°	85	0.01	Rain
03/27/05	57°	53°	49°	89	0.01	Rain
03/28/05	70°	60°	49°	74	0.59	Rain, Thunderstorm
03/29/05	76°	62°	48°	58	0.00	
03/30/05	76°	61°	45°	67	0.00	
03/31/05	66°	61°	56°	82	0.07	Rain

3.0 Operational Performance Tests Temperature Summary			
Temperature	Maximum	Average	Minimum
High Temperature (°F)	76°	60°	37°
Mean Temperature (°F)	62°	48°	35°
Low Temperature (°F)	56°	36°	22°

Weather data was provided by the Federal Aviation Administration

AASHTO's National Transportation Product Evaluation Program

Appendix B

- Project Work Plan for PCMS
- Project Work Plan for FAP

AASHTO's National Transportation Product Evaluation Program

NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM (NTPEP)

PROJECT WORK PLAN FOR PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

2004

PORTABLE CHANGEABLE MESSAGE SIGNS PROJECT WORK PLAN
National Transportation Product Evaluation Program

1.0 SCOPE

1.1 This project work plan covers the procedures used by the National Transportation Product Evaluation Program (NTPEP) to evaluate Portable Changeable Message Signs (PCMS). The work plan includes sight tests, durability and reliability tests and a section describing the information provided by manufacturers to be included in the report after verification by the lead test state.

1.2 The NTPEP is a voluntary program whereby manufacturers may choose to have their products evaluated for a fee that is used primarily to cover the costs of the evaluation and producing its associated reports. The NTPEP reports the results of these evaluations, but does not accept, reject, or develop specifications for products. However, transportation officials may choose to use the results of the evaluations in the development and maintenance of an approved products list.

1.3 The NTPEP is an engineering technical service program of the American Association of State Highway and Transportation Officials (AASHTO).

2.0 SIGHT TESTS

2.1 ***Test Conditions*** - All PCMS submitted for testing shall meet the minimum requirements set forth in the Manual on Uniform Traffic Control Devices (MUTCD) and shall be positioned for all sight tests as described in Part VI of the MUTCD. Conduct visibility, legibility and angularity tests using an evaluator with 20/20 corrected vision sitting in the driver's seat in a sedan-style vehicle. Perform all evaluations on a flat road surface, in clear, cloudless weather in a setting free from outside visual influences (i.e. city lights, billboards, etc.). Three different persons will perform the evaluations by performing daytime and nighttime evaluations at ambient temperature of 32 ± 5°F. Conduct all daytime evaluations with the PCMS facing east or west, record time of day and direction the message display panel is facing. The PCMS shall be in automatic dimming mode.

2.2 ***Message Content*** - Use a non-traffic related message that uses the maximum number of lines available and between 75 to 80 percent of the available characters be illuminated. The message shall have three lines of characters. One line of the message shall be a line of characters that do not form a word, e.g., eye chart. In all cases, ensure that single characters do not cover more than a single line. Record the message used and the character

height. Change the content of the message for each test in the evaluation. Test each standard character font available for a PCMS user selection from the PCMS control console (message must have three lines of characters).

2.3 ***Visibility*** - Starting at point **"f"** which is 25 feet from the front edge of the PCMS face and 4800 feet from point **"x"** (see Appendix A-2 and Figure 1), determine whether or not the PCMS message is visible. If not, move toward point **"x"** along a line perpendicular to the PCMS face until the message is visible. The PCMS message is considered visible whenever the message portion is apparent, though not necessarily legible. Record this distance as the visibility.

2.4 ***Legibility*** - Starting at point **"f"** which is 25 feet from the front edge of the PCMS face and 4800 feet from point **"x"** (see Appendix A-2 and Figure 1), attempt to read the PCMS message. If necessary, move toward point **"x"** along a line perpendicular to the PCMS face until the message is legible. Measure the distance **"d"** from the first point of legibility to point **"x"**. Record this distance as the legibility.

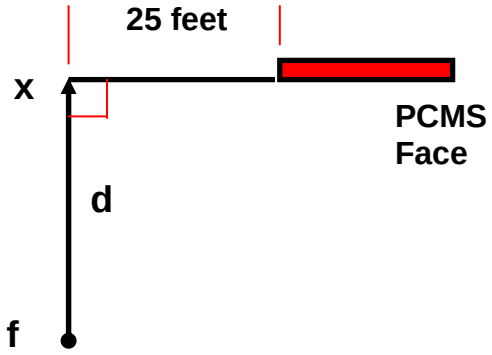


Figure 1
(Note: Pointing/Aiming of PCMS face will be adjusted for test

2.5 ***Angularity*** - Starting at point **"b"** which is 25 feet from the front edge of the PCMS and 200 feet from **"x"** (see Appendix A-2 and Figure 2), move on a line perpendicular to the PCMS face until the PCMS message is no longer legible. Measure the distance **"d"** from point **"x"** to the point of legibility. Record this number and calculate the angularity of the angle θ shown. Record this angle as the Angularity.

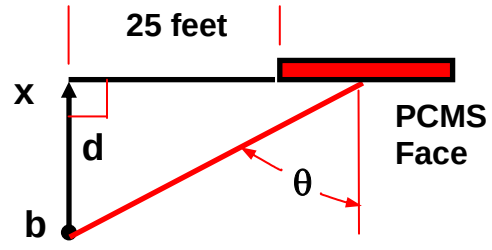


Figure 2
(Note: Pointing/Aiming of PCMS face will be adjusted for test)

3.0 OPERATIONAL PERFORMANCE TESTS

3.1 ***Test Conditions*** - The test shall be conducted in February.

3.2 ***Reliability*** - The reliability is the length of time that a PCMS will display its message without replenishment of its primary power source.

3.2.1 ***Diesel or Gas Powered Devices*** - Determine the reliability with the fuel tank full at the beginning of the test. Record the fuel tank's capacity.

3.2.2 ***Solar-Powered Devices*** - Determine the reliability with the battery fully charged by the manufacturer at the beginning of the test. The solar device shall be disconnected. If the solar device does not have a disconnect switch, the supplier and/or manufacturer shall provide and install the appropriate covering device to prevent the battery from recharging. (The device shall not permit any entrance of light). Record Amp-hour capacity of the unit's battery bank.

3.3 ***Durability*** - Operate the PCMS continuously for the month of February in accordance with the manufacturer's instructions. Raise and lower the PCMS two times each week. Measure the height from the ground to the bottom edge of the PCMS after each raising/lowering cycle. Note the general condition of the PCMS.

3.4 ***Dimming*** - Cover the light-sensing device and observe the dimming capability of the PCMS. The brightness and voltage shall be measured before, during and after dimming. Note whether the PCMS can be dimmed by manual and/or photocell controls. Repeat this test only if evaluator determines it is necessary to quantify decline of PCMS light output. Brightness readings to be measured by a luminance meter (using Test procedure in report TTI: 7-4940).

3.5 ***On/Off Time Periods*** - Record all "On/Off" time periods of the message to be used during this evaluation (if there is a "off" time period between a sequencing message repeat phase, then record it in the nearest $1/10^{th}$ of a second interval). Repeat this test only if evaluator determines it is necessary to quantify decline of PCMS light output.

3.6 **Charging Time** - Record the length of time required to re-charge the PCMS between the Durability and Sight Tests.

4.0 TECHNICAL DESK AUDIT & VERIFICATION

4.1 The manufacturers will provide information to aid in describing their product(s) in the evaluation report. Whenever practical, the lead state will verify the accuracy of the following information:

4.1.1 Display type (Lamp Matrix, Reflective Disk, LED, Fiber Optics, ReflectiveDisk-LED, Other) and optical characteristics of a pixel's output.

4.1.2 Character height in inches.

4.1.3 Maximum number of lines in the message.

4.1.4 Maximum number of characters per line.

4.1.5 Type of matrix (line matrix, full matrix, continuous matrix, other)

4.1.6 Primary power charging source (Solar, Diesel, Gas, AC Power).

4.1.7 If applicable, whether or not solar panels can be tilted.

4.1.8 Description of PCMS dimming capabilities under changing light conditions.

4.1.9 Whether or not the PCMS can be wired for AC power.

4.1.10 Message system description including the following items:

4.1.10.1 Programmable message capabilities including the number of pre-programmed messages that can be stored in the PCMS's computer system.

4.1.10.2 Capability and procedure for changing messages in the field.

4.1.10.3 Whether or not the message system is menu-driven.

4.1.10.4 Type of message entry (removable keyboard, other)

4.1.10.5 Cellular phone capability and/or Radar Capability.

4.1.10.6 Description of control console security (lockable, password protection, other).

4.1.10.7 Whether or not the control console (keyboard and/or console display) is lighted.

4.1.10.8 Whether or not the PCMS displays a default message or has a pre-default indicator.

4.1.11 The height of the panel in feet, above the road surface.

4.1.12 Range of message flashing rates, in flashes per minute

4.1.13 Maximum wind load of the sign.

4.1.14 PCMS rotation capability in degrees.

4.1.15 Type of PCMS alignment device and methodology to use in pointing/aiming. Include instructions necessary to achieve proper alignyment to the roadway. If instructions are not provided, the PCMS will be placed parallel to the datum line.

4.1.16 Type of stabilizing device(s), outriggers, other).

4.1.17 Recharging instructions for solar powered devices.

4.1.18 Available Security Measures to prevent theft/vandalism of sign.

AASHTO's National Transportation Product Evaluation Program

NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM (NTPEP)

PROJECT WORK PLAN FOR FLASHING ARROW PANELS (FAP)

2004

FLASHING ARROW PANELS PROJECT WORK PLAN
National Transportation Product Evaluation Program

1.0 SCOPE

1.1 This project work plan covers the procedures used by the National Transportation Product Evaluation Program (NTPEP) to evaluate Flashing Arrow Panels (FAP). The work plan includes sight, durability and reliability tests and a section describing the information provided by manufacturers to be included in the report after verification by the lead test state.

1.2 The NTPEP is a voluntary program whereby manufacturers may choose to have their products evaluated for a fee that is used primarily to cover the costs of the evaluation and producing its associated reports. The NTPEP reports the results of these evaluations, but does not accept, reject, or develop specifications for products. Transportation officials may choose to use the results of the evaluations in the development and maintenance of an approved product list.

1.3 The NTPEP is an engineering technical service program of the American Association of State Highway and Transportation Officials (AASHTO).

2.0 SIGHT TESTS

2.1 ***Test Conditions***- All FAPs submitted for testing shall meet the minimum requirements set forth in the latest edition and subsequent revisions of the Manual on Uniform Traffic Control Devices (MUTCD) and shall be positioned for all sight tests as described in Part VI of the MUTCD. Conduct visibility, legibility, and angularity test using an evaluator with 20/20 corrected vision sitting in the driver's seat in a sedan-style vehicle. Perform all evaluations on a flat road surface, in clear, cloudless weather and a setting free from outside visual influences (i.e. city lights, billboards, etc.). Three different persons will perform the evaluations by performing daytime and nighttime evaluations at an ambient temperature of 32 ± 5°F. Conduct all daytime evaluations with the FAP facing either east or west, record time of day and direction. FAP shall be in automatic dimming mode.

2.2 ***Mode Display*** - Record the mode used (left arrow, right arrow, etc.). Change the content of the mode display for each test in the evaluation.

2.3 ***Visibility*** - Starting at observation position **"f"** which is 25 feet from the front edge of the FAP face and 4800 feet from point **"x"** (see Appendix A-2 and Figure 1), move toward the FAP and determine whether or not the FAP mode display is visible. The FAP mode display is considered visible whenever

the mode is apparent, though not necessarily legible. Measure the distance from the first point of visibility to point **"x"**. Record this distance as the visibility.

2.4 ***Legibility*** - Starting at point **"f"** which is 25 feet from the front edge of the FAP face and 4800 feet from point **"x"** (see Appendix A-2 and Figure 1), attempt to read the FAP mode display. If necessary, move toward point **"x"** along a line perpendicular to the FAP face until the mode display is legible. Measure the distance **"d**" from the first point of legibility to point **"x"**. Record this distance as the legibility.

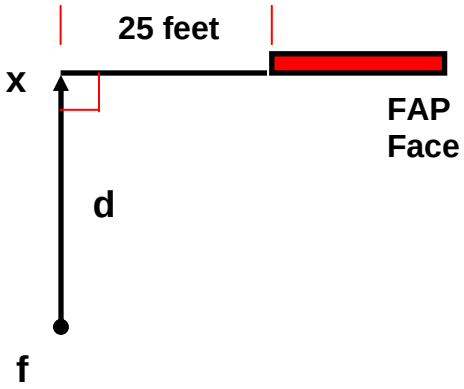


Figure 1
(Note: Pointing/Aiming of FAP face will be adjusted for test)

2.5 ***Angularity*** - Starting at point **"b"** which is 25 feet from the front edge of the FAP and 200 feet from **"x"** (see Appendix A-2 and Figure 2), move on a line perpendicular to the FAP until the FAP mode display is no longer legible. Measure the distance "**d"** from point **"x"** to the point of legibility. Record this number and calculate the angularity of the angle θ shown. Record this angle as the Angularity.

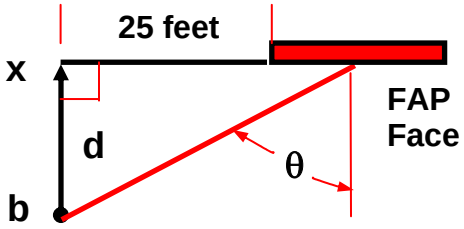


Figure 2
(Note: Pointing/Aiming of FAP face will be adjusted for test)

3.0 OPERATIONAL PERFORMANCE TESTS

3.1 ***Test Conditions*** - The test shall be conducted in February.

3.2 ***Reliability*** - The reliability is the length of time that an FAP will display its mode without replenishment of its primary power source.

3.2.1 ***Diesel or Gas Powered Devices*** - Determine the reliability with the fuel tank full at the beginning of the test. Record fuel tank capacity.

3.2.2 ***Solar-Powered Devices*** - Determine the reliability with the battery fully charged by the manufacturer at the beginning of the test. The solar device shall be disconnected. If the solar device does not have a disconnect switch, the supplier and/or manufacturer shall provide and install the appropriate covering device to prevent the battery from recharging. (The device shall not permit any entrance of light). Record Amp-hour capacity of the unit's battery bank.

3.3 ***Durability*** - Operate the FAP continuously for the month of February in accordance with the manufacturer's instructions. Raise and lower the FAP two times each week. Note the general condition of the FAP.

3.4 ***Dimming*** - Cover the light-sensing device and observe the dimming capability of the FAP. The brightness and voltage shall be measured before, during and after dimming. Note whether the FAP can be dimmed by manual and/or photocell controls. Repeat this test only if evaluator determines it is necessary to quantify decline of FAP light output. Brightness readings to be measured by a luminance meter (using Test procedure in report TTI: 7-4940).

3.5 ***Flashing Rate*** - Count and record the number of flashes per minute when the FAP operates under normal power. Measure the dwell time (duration of lamp "on time") and record this time period to the closest $1/10^{th}$ of a second. Repeat this test only if evaluator determines it is necessary to quantify decline of FAP light output.

3.6 **Charging Time** - Record the length of time required to re-charge the FAP between the Durability and Sight Tests.

4.0 TECHNICAL DESK AUDIT & VERIFICATION

4.1 The manufacturers will provide the following information to aid in describing their product(s) in the evaluation report. Whenever practical, the lead state will verify the accuracy of the following information:

4.1.1 Display type (Lamp Matrix, LED, halogen, Other) and optical characteristics of a typical lamps output.

4.1.2 MUTCD Panel Type (A/B/C).

4.1.3 Primary power charging (Solar, Diesel, Gas, AC Power).

4.1.4 If applicable, whether or not solar panels can be tilted.

4.1.5 Whether or not the FAP can be wired for AC power.

4.1.6 Mode display capabilities (flashing arrow, sequential arrow, sequential chevron, flashing caution, straight line, four corners).

4.1.7 Description of control console security (lockable, password protection, other).

4.1.8 The height of bottom of the FAP above the road surface, in feet.

4.1.9 Maximum wind load of the sign.

4.1.10 Type of FAP alignment device and methodology to use in pointing / aiming. Include instructions necessary to achieve proper alignment to the roadway. If instructions are not provided, the FAP will be placed parallel to datum line (See Appendix A).

4.1.11 Whether or not FAP has a mode switch for maximum dim, maximum bright and automatic.

4.1.12 Type of stabilizing device(s), (outriggers, other).

4.1.13 Recharging instructions for solar powered devices.

4.1.14 Available Security measures to prevent theft/vandalism of

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-- Rick Smutzer (IN), NTPEP Chairman

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