Report 7002.1

AASHTO's National Transportation Product Evaluation Program

REPORT 7002.1:
FIELD PERFORMANCE EVALUATION RESULTS OF FLASHING ARROW PANELS (ARROWBOARDS) & PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

(WINTER 2004 TESTING CYCLE)

NTPEP Lead State:

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
Traffic Engineering & Safety Systems Branch

August 2004

American Association of State Highway and Transportation Officials (AASHTO)

Executive Office: 444 North Capitol Street, NW, Suite 249 • Washington, DC • 20001
(t) 202.624.5800 • (f) 202.624.5806 • www.aashto.org

PROLOGUE

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Meredith McDiarmid, PE **(NC)**
Chair, TTCD Project Panel

Danny Lane **(TN)**
Vice Chair, TTCD Project Panel

National Transportation Product Evaluation Program (NTPEP)

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Report of

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(WINTER 2004 TESTING CYCLE)

Evaluation & Report Completed for NTPEP by:

North Carolina Department of Transportation
Traffic Engineering & Safety Systems Branch

August 2004

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National Transportation Product Evaluation Program (NTPEP) Oversight Committee

Chair: Richard K. Smutzer, Indiana
Vice Chair: Thomas E. Baker, Washington
Liaison: Michael McGough, AASHTO

Member Department	Member/Delegate	Phone Number	Fax Number	E-mail Address
State Member				
Alabama				
	Lynn Wolfe P.E.	(334) 206-2335	(334) 834-5799	wolfel@dot.state.al.us
Alaska				
	Billy Connor	(907) 451-5479	(907) 451-5340	billy_connor@dot.state.ak.us
Arizona				
	Frank T. Darmiento P.E.	(602) 712-3134	(602) 712-3400	fdarmiento@dot.state.az.us
	A. Oscar Mousavi	(602) 255-8200	(602) 255-8415	omousavi@dot.state.az.us
Arkansas				
	Mark Bradley	(501) 569-2380	(501) 569-2070	mark.bradley@ahtd.state.ar.us
	Tony Sullivan	(501) 569-2661	(501) 569-2014	tony.sullivan@ahtd.state.ar.us
	Jerry Westerman	(501) 569-2185	(501) 569-2368	jerry.westerman@ahtd.state.ar.us
California				
	Donald E. Fogle	(916) 227-7185	(916) 227-7075	don_fogle@dot.ca.gov
	Wesley S.C. Lum	(916) 324-2713	(916) 324-2669	Wes_Lum@dot.ca.gov
Colorado				
	Tim Aschenbrener	(303) 757-9249	(303) 757-9242	tim.aschenbrener@dot.state.co.us
	David Kotzer	(303) 757-9421	(303) 757-9242	david.kotzer@dot.state.co.us
	Gabriela Vidal	(303) 757-9879	(303) 757-9219	gabriela.vidal@dot.state.co.us
Connecticut				
	Keith R. Lane	(860) 258-0371	(860) 258-0399	keith.lane@po.state.ct.us
	James M. Sime P.E.	(860) 258-0309	(860) 258-0399	james.sime@po.state.ct.us
Delaware				
	Teresa Lewandowski	(302) 760-2515	(302) 739-8282	TLewandowski@mail.dot.state.de.us
	James T. Pappas III, P.E.	(302) 760-2400	(302) 739-5270	jpappas@mail.dot.state.de.us
District of Columbia				
	Kwabena Ofori-Awuah	(202) 673-2155	(202) 671-0646	kwabena.ofori-awuah@dc.gov
Florida				
	David Bremer	(850) 414-4126	(850) 414-4199	david.bremer@dot.state.fl.us
	Karen Byram	(850) 414-4353	(850) 414-4199	karen.byram@dot.state.fl.us
	Phillip Lancaster	(352) 955-6654		phillip.lancaster@dot.state.fl.us

American Association of State Highway Transportation Officials (AASHTO)
NTPEP Oversight Committee

Georgia				
	Eric Pitts	(404) 363-7632		eric.pitts@dot.state.ga.us
	Don Wishon	(404) 362-2545	(404) 363-7684	donald.wishon@dot.state.ga.us
Hawaii				
	Gary C.P. Choy	(808) 832-3403	(808) 832-3407	gary.choy@hawaii.gov
Idaho				
	Stephen B. Loop	(208) 334-8267	(208) 334-4411	sloop@itd.state.id.us
Illinois				
	James DuBose	(217) 782-2921	(217) 782-2572	dubosejb@nt.dot.state.il.us
	Kenneth C. Wood	(217) 782-2076	(217) 782-7990	woodkc@nt.dot.state.il.us
Indiana				
	Mark A. Miller	(317) 610-7251	(317) 356-9351	mmiller@indot.state.in.us
Iowa				
	Joseph Putherickal	(515) 239-1259	(515) 239-1092	joseph.putherickal@dot.state.ia.us
	Kurtis Younkin	(515) 239-1184	(515) 239-1891	kurtis.younkin@dot.state.ia.us
Kansas				
	Rick Kreider	(785) 296-3899	(785) 296-6665	rickk@ksdot.org
	David Meggers P.E.	(785) 291-3845	(785) 296-2526	dmeggers@ksdot.org
Kentucky				
	Greta Smith	(502) 564-3160	(502) 564-7034	greta.smith@ky.gov
	Derrick Castle	(502) 564-3160	(502) 564-7034	derrick.castle@ky.gov
	John Mark Clements	(502) 564-4556		johnmark.clements@ky.gov
Louisiana				
	Jason Davis	(225) 248-4131	(225) 248-4187	jasondavis@dotd.louisiana.gov
	N. Douglas Hood Jr.	(225) 248-4101	(225) 248-4187	doughood@dotd.louisiana.gov
	Henry Lacinak	(225) 248-4103	(225) 248-4187	henrylacinak@dotd.louisiana.gov
Maine				
	Doug Gayne	(207) 624-3268	(207) 624-3301	doug.gayne@maine.gov
Maryland				
	Gil Rushton	(410) 321-3170	(410) 321-3099	grushton@sha.state.md.us
	Peter Stephanos P.E.	(410) 321-3100	(410) 321-3099	pstephanos@sha.state.md.us
	Russell A. Yurek	(410) 582-5505	(410) 582-9861	ryurek@sha.state.md.us
Massachusetts				
	David Phaneuf	(617) 973-7722	(617) 973-7554	david.r.phaneuf@state.ma.us
Michigan				
	Calvin Roberts	(517) 322-3333	(517) 322-2699	robertsc@michigan.gov
Minnesota				
	James McGraw	(651) 779-5548	(651) 779-5616	james.mcgraw@dot.state.mn.us
	David Iverson	(651) 779-5550	(651) 779-5616	david.iverson@dot.state.mn.us

American Association of State Highway Transportation Officials (AASHTO)
NTPEP Oversight Committee

Mississippi				
	John J. Smith	(601) 359-1454	(601) 359-5918	jjsmith@mdot.state.ms.us
	Celina Sumerall	(601) 359-7001	(601) 359-1716	csumerall@mdot.state.ms.us
	John D. Vance	(601) 359-7111	(601) 359-7126	jvance@mdot.state.ms.us
Missouri				
	Kenneth R. Lane	(573) 751-1046	(573) 526-4361	lanek@mail.modot.state.mo.us
Montana				
	Craig Abernathy	(406) 444-6269	(406) 444-6204	cabernathy@state.mt.us
Nebraska				
	Mostafa Jamshidi	(402) 479-4750	(402) 479-3975	mjamshid@dor.state.ne.us
Nevada				
	Masha B. Wilson Ph.D.	(775) 888-7894	(775) 888-7230	mwilson@dot.state.nv.us
New Hampshire				
	John W. Corcoran P.E.	(603) 271-2291	(603) 271-6083	jcorcoran@dot.state.nh.us
	Alan D. Rawson	(603) 271-3151	(603) 271-8700	arawson@dot.state.nh.us
	William L. Real	(603) 271-3151	(603) 271-8700	wreal@dot.state.nh.us
New Jersey				
	Brian Strizki	(609) 530-6363	(609) 530-3894	brian.strizki@dot.state.nj.us
New Mexico				
	Ernest D. Archuleta	(505) 827-5525	(505) 827-3202	ernest.archuleta@nmshtd.state.nm.us
New York				
	Gary A. Frederick	(518) 457-5826	(518) 457-7535	gfrederick@gw.dot.state.ny.us
	Orlando Picozzi P.E.	(518) 457-4285	(518) 457-8171	opicozzi@dot.state.ny.us
	L. David Suits	(518) 457-4704	(518) 457-8080	ldsuits@dot.state.ny.us
North Carolina				
	J. Stuart Bourne	(919) 250-4151	(919) 250-4195	sbourne@dot.state.nc.us
	Jack E. Cowsert	(919) 733-7088	(919) 733-8472	jcowsert@dot.state.nc.us
	Meridith McDiarmid P.E.	(919) 250-4159	(919) 250-4195	mmcdiarmid@dot.state.nc.us
North Dakota				
	Ron Horner	(701) 328-6904	(701) 328-6913	rhorner@state.nd.us
	Clayton Schumaker	(701) 328-6906	(701) 328-6913	cschumak@state.nd.us
Ohio				
	Brad Young	(614) 351-2882	(614) 644-7175	brad.young2@dot.state.oh.us
	Lloyd M. Welker Jr.	(614) 275-1351	(614) 275-1354	lloyd.welker@dot.state.oh.us
Oklahoma				
	Mark N. Andrews	(405) 522-4999	(405) 522-0552	mandrews3@odot.org
	Reynolds H. Toney	(405) 521-2677	(405) 522-0552	rtoney@odot.org
Oregon				
	Mike Dunning	(503) 986-3059	(503) 986-3096	mike.d.dunning@state.or.us

American Association of State Highway Transportation Officials (AASHTO)
NTPEP Oversight Committee

Pennsylvania				
	David H. Kuniega	(717) 787-7150	(717) 783-5955	dkuniega@state.pa.us
	William J. Miller	(717) 783-6602	(717) 783-5955	wijmiller@state.pa.us
Puerto Rico				
	Orlando Diaz-Quirindongo	(787) 729-1592	(787) 721-3245	oquirindongo@act.dtop.gov.pr
Rhode Island				
	Mark F. Felag P.E.	(401) 222-2524		mfelag@dot.state.ri.us
	Colin A. Franco P.E.	(401) 222-3030		cfranco@dot.state.ri.us
	Deborah Munroe	(401) 222-3030	(401) 222-4573	dmunroe@dot.state.ri.us
South Carolina				
	Patti Gambill	(803) 737-6702	(803) 737-6649	gambillps@dot.state.sc.us
	Terry Rawls	(803) 737-1498	(803) 737-0271	rawlstl@dot.state.sc.us
South Dakota				
	Joe J. Feller	(605) 773-3401	(605) 773-5867	joe.feller@state.sd.us
	John Forman	(605) 773-3704	(605) 773-6600	john.forman@state.sd.us
	David L. Huft	(605) 773-3292	(605) 773-4713	dave.huft@state.sd.us
Tennessee				
	Danny Lane	(615) 350-4175	(615) 350-4128	danny.lane@state.tn.us
	Steven M. Hall P.E.	(615) 350-4167	(615) 350-4128	steve.m.hall@state.tn.us
Texas				
	John Bassett	(512) 465-7922	(512) 302-2054	jbasset@dot.state.tx.us
	Scott Koczman	(512) 416-2073	(512) 416-2152	skoczman@dot.state.tx.us
Utah				
	Stan Burns P.E.	(801) 965-4196	(801) 965-4796	sburns@utah.gov
Vermont				
	Donald H. Lathrop P.E.	(802) 828-6911	(802) 828-2792	don.lathrop@state.vt.us
Virginia				
	William R. Bailey III	(804) 328-3106	(804) 328-3136	bill.bailey@virginiadot.org
	Stephen C. Brich	(804) 786-7941	(804) 225-4978	brichsc@vdot.state.va.us
	Wendy Ealding	(804) 328-3121	(804) 328-3136	Ealding_wd@vdot.state.va.us
West Virginia				
	Bruce E. Kenney III, P.E.	(304) 558-3044	(304) 558-1209	bkenney@dot.state.wv.us
	Dennis P. King	(304) 558-3004	(304) 558-6391	dking@dot.state.wv.us
Wisconsin				
	Peter J. Kemp	(608) 246-7953	(608) 246-4669	peter.kemp@dot.state.wi.us
Wyoming				
	Delbert McOmie P.E.	(307) 777-4484	(307) 777-4163	delbert.mcomie@dot.state.wy.us
U.S. DOT Member				
FHWA				
	Robert Kogler	(202) 493-3080	(202) 493-3086	bob.kogler@igate.fhwa.dot.gov
	Michael Rafalowski	(202) 366-1571	(202) 493-2070	michael.rafalowski@fhwa.dot.gov

(updates found at www.NTPEP.ORG)

American Association of State and Highway Transportation Officials

National Transportation Product Evaluation Program

For

Flashing Arrow Panels
and Portable Changeable Message Signs

Winter 2004 Evaluation
Final Report

Prepared by

North Carolina Department of Transportation
Traffic Control, Marking and Delineation Unit

Tests conducted and report written by:

Meredith McDiarmid, PE
Dale Stokes

With special assistance from:

Derrick Beard
Chris Howard
Spencer Franklin, PE
Jessica Kuse, PE
Chad Lanford
Mark Manriquez
Wayne Jacas

Bruce Thompson and staff of the Equipment Depot, Raleigh, NC
Kent Dozier and staff of Division 4 Equipment Unit, Wilson, NC
Keith Honeycutt and staff of Division 4 Location & Surveys Unit, Wilson, NC
Gronna Jones and City of Wilson Transportation Department, NC

AASHTO's National Transportation Product Evaluation Program

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Bruce Thompson, Charles Jones, Jerry Bagwell and Dan Cook of the NCDOT Equipment Depot in Raleigh provided space, movement of signs, and generally anything needed to aid in the evaluation of the signs.

Keith Honeycutt and his staff of Division 4 Location and Surveys Unit for marking the test deck at the Wilson Industrial Air Center. 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.

The 2004 NTPEP evaluation began in February 2004 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 during April 2004 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 FAPs.

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.

Section 2.0 Sight Tests

The Visibility (Section 2.3), Legibility (Section 2.4), and Angularity (Section 2.5) Sight Tests were performed during April 2004 at the Wilson Industrial Air Center in Wilson, NC (see Appendix A, page A-1, for location diagram). The runway was surveyed and marked per the work plan (see Test Deck Layout in Appendix A, page A-2). All three tests for the signs were performed with three evaluators using a 1997 Dodge Intrepid. 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 each FAP sign. Evaluations were performed during daytime and nighttime, and a NCDOT onboard vehicle distance meter was used to determine the distances.

While conducting the Sight Tests, it became evident that adjustments to the work plan were needed. The adjustments the team made are as follows:

- Because of time constraints, the three tests were performed in one run.
- Because the Section 3.0 Operational Performance Tests were performed first in February, the team was not able to perform the Sight Tests until April. Average temperature during testing was approximately 72ºF.
- 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 Visibility requirement for Type "C" FAPs per the Manual on Uniform Traffic Control Devices (MUTCD), but the evaluators judged that all FAPs tested would have exceeded the MUTCD Visibility requirement. 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 13 and results for Section 2.0 FAP Sight tests can be found on page 32. All results shown are the "Averages" of the evaluator's data.

Note: Crown Construction Equipment's AB15 FAP, had five (5) of it's fifteen (15) lamps non-operational when it arrived at the Wilson Industrial Air Center in Wilson, NC from the NCDOT Equipment Depot in Raleigh, NC. Even though not 100 percent operational, it was decided to test the FAP per the work plan and report the recorded data.

During Angularity Test of both PCMSs and FAPs, one of the evaluator's vision was sometimes obstructed by the vehicle's mirror or roofline. It was determined that the evaluator's measurements on those signs did not have a negative impact on that sign's final data results.

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. Testing began on February 12, 2004 and ended on March 13, 2004 at the NCDOT Equipment Depot in Raleigh, NC. The exception to this evaluation period was for the PCMS signs from Precision Solar Controls, Inc. Due to a delay in the ability to disconnect the solar panels, their tests were performed from February 16, 2004 and ended on March 17, 2004. From recorded weather data for each period, it was shown that the four-day delay was deemed neither favorable, nor unfavorable to the performance evaluation of the Precision Solar Control signs. Daily weather information with average temperatures for the period can be found in Appendix A, page A-3.

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 FAPs 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. With the various

battery bank configurations, there was no apparent method for accurately measuring the voltage change during dimming. The team decided not to record data for this requirement. *Editor's Note: Recommendations to member departments on utilization of resulting data can be found in the "Observations and Suggestions" Section (Page 9) of this report.*

The On/Off Time Periods (Section 3.5) of the PCMS work plan was programmed as close as possible to a two-second interval. The exception to this period was for Ver-Mac, Inc.'s Model PCMS-1210QS which could only be programmed to a one-second interval. (After consulting an industry advisor, it was determined there would be no advantage or disadvantage during testing.) Even though message content criteria was not specified, it was decided to use the following message- "CAUTION ACCIDENT AHEAD" 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 FAPs 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. 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. *Editor's Note: A detailed discussion of this decision can be found in the "Observations and Suggestions" Section (Page 9 & 10) of this report.*

Results for Section 3.0 PCMS Operational Performance Tests can be found on page 15 and results for Section 3.0 FAP Operational Performance Test can be found on page 34. All results are shown except for Dimming (Section 3.4) voltage data and Charging Time (Section 3.6) time data.

Note: The Reliability (Section 3.2) Operational Performance Test affected the Durability (Section 3.3) Operational Performance Test. During the 30-day period, batteries were drained to "low voltage" conditions shutting down the displays of five (5) of the sixteen (16) PCMS signs. Of these five, Crown Construction Equipment's CMS80FM sign became inoperable and could not be raised. To recharge this sign and complete Durability testing would have resulted in an additional extended test period for the sign. With two days remaining for the test, it was decided not to recharge the batteries.

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. NCDOT used the technical data provided by the manufacturers with the exception of Solar Technology, Inc. Their responses were condensed for reporting purposes. All results for the Section 40 PCMS

Technical Desk Audit & Verification can be found beginning on page 17 and results for Section 4.0 FAP Technical Desk Audit & Verification can be found beginning on page 36.

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" to assist AASHTO member departments in utilizing the 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. With this in mind, data shown on page 15 for PCMSs and page 34 for FAPs must be scrutinized for its merit. 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.

- 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 on page 15 for PCMSs and page 34 for FAPs 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 supplied battery chargers with their signs;
- Manufacturers offered, or could 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 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.

AASHTO's National Transportation Product Evaluation Program

PCMS
Test Results

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NTPEP PCMS Product Listing

NTPEP ID#	Product Name	Company	Address	Phone	Contact	Web Site
PCMS(2004)-1	Full Matrix Message Director WTMMB-S-LL(A)	Wanco, Inc	5870 Tennyson Street Arvada, CO 80003 USA	(303) 427-5700 (303) 427-5725 Fax	Scott Risby	www.wanco.com
PCMS(2004)-2	Three Line Message Director WTLMB-S-LL(A)					
PCMS(2004)-4	CMS-T331	American Signal Company, Inc	2755 Bankers Industrial Drive Atlanta, GA 30360 USA	(770) 448-6650 (770) 448-8970 Fax	Tim Paulino	www.amsig.com
PCMS(2004)-5	CMS-T332					
PCMS(2004)-6	CMS-T333					
PCMS(2004)-7	Silent Messenger	Solar Technology, Inc	7620 Cetronia Road Allentown, PA 18106 USA	(610) 391-8600 (610) 391-8601 Fax	Bill Wellman	www.solartechnology.com
PCMS(2004)-10	CMS80FM	Crown Construction Equipment	PO Box 234, Station "L" Winnipeg, MB R3J 3TR Canada	(204) 885-5800 (204) 885-7557 Fax	Jeff Hildebrand	www.crownequip.com
PCMS(2004)-13	DH1000 ALS	ADDCO, Inc	240 Arlington Av. East St. Paul, MN 55117 USA	(651) 488-8600 (651) 558-3600 Fax	Charlie Ginocchio	www.addco.com
PCMS(2004)-14	PCMS-1500	Ver-Mac, Inc	1781 Bresse Ste-Foy, QC G2G 2V2 Canada	(888) 488-7446 (418) 654-0517 Fax	Kim Jack	www.ver-mac.com
PCMS(2004)-15	PCMS-1210					
PCMS(2004)-16	PCMS-1210 QS					
PCMS(2004)-17	Vu-Pointe	National Signal, Inc	9603 John Street Santa Fe Springs, CA 90670 USA	(562) 923-9600 (562) 923-7555 Fax	Lupe Martinez	www.ustraffic.net
PCMS(2004)-18	Sunray 380	U.S. Traffic Corp				
PCMS(2004)-20	SMC 1000HE	Precision Solar Controls, Inc	2985 Market Street Garland, TX 75041 USA	(972) 278-0553 (972) 271-9583 Fax	Mike Merrill	www.precision solarcontrols.com
PCMS(2004)-21	SMC 2000FM					

Section 2.0- PCMS Sight Test Results

NTPEP ID#	Product Name	Company	Daytime				Nighttime			
			2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/q)		2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/q)	
PCMS(2004)-1	Full Matrix Message Director WTMMB-S-LL(A)	Wanco, Inc	4800	906	88	15.9º	4800	685	22	48.7º
PCMS(2004)-2	Three Line Message Director WTLMB-S-LL(A)		4800	834	139	10.2º	4800	714	80	17.4º
PCMS(2004)-4	CMS-T331	American Signal Company, Inc	4800	829	102	13.7º	4800	926	21	50.4º
PCMS(2004)-5	CMS-T332		4800	1041	126	11.2º	4800	915	29	40.8º
PCMS(2004)-6	CMS-T333		4800	851	60	22.7º	4800	916	21	49.5º
PCMS(2004)-7	Silent Messenger	Solar Technology, Inc	4800	817	120	11.8º	4800	820	20	50.9º
PCMS(2004)-10	CMS80FM	Crown Construction Equipment	4800	701	88	15.8º	4800	782	21	49.5º
PCMS(2004)-13	DH1000 ALS	ADDCO, Inc	4800	1023	152	9.3º	4800	769	100	14º
PCMS(2004)-14	PCMS-1500	Ver-Mac, Inc	4800	872	115	12.3º	4800	841	22	48.7º
PCMS(2004)-15	PCMS-1210		4800	849	122	11.6º	4800	692	20	50.9º
PCMS(2004)-16	PCMS-1210 QS		4800	761	144	9.8º	4800	785	61	22.4º
PCMS(2004)-17	Vu-Pointe	National Signal, Inc	4800	692	57	23.8º	4800	411	13	62.5º
PCMS(2004)-18	Sunray 380	U.S. Traffic Corp	4800	856	94	14.9º	4800	705	41	31.6º
PCMS(2004)-20	SMC 1000HE	Precision Solar Controls, Inc	4800	947	154	9.2º	4800	792	50	26.6º
PCMS(2004)-21	SMC 2000FM		4800	785	166	8.6º	4800	790	26	43.9º

Note:

1) One of the evaluator's vision was sometimes obstructed by the vehicle's mirror or roofline during the Angularity Tests. It was determined that the evaluator's measurements did not have a negative impact on that sign's final data results.

Section 2.0- PCMS Sight Tests Pictures

Evaluation vehicle approaching sign

Typical Sight Test message

Typical Sight Test message

Typical Sight Test message

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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(2004)-1	Full Matrix Message Director WTMMB-S-LL(A)	Wanco, Inc	30	Eight Interstate Battery Model #U2200 batteries in bank- 900 Ah total capacity	30	1569	1380	1826
PCMS(2004)-2	Three Line Message Director WTLMB-S-LL(A)		25	Eight Interstate Battery Model #U2200 batteries in bank- 900 Ah total capacity	30	1160	793	1028
PCMS(2004)-4	CMS-T331	American Signal Company, Inc	30	12 Deka Battery Model #GC15V batteries in bank- 1290 Ah total capacity	30	1150	647	1136
PCMS(2004)-5	CMS-T332		30	12 Deka Battery Model #GC15V batteries in bank- 1290 Ah total capacity	30	1580	802	1555
PCMS(2004)-6	CMS-T333		25	12 Deka Battery Model #GC15V batteries in bank- 1290 Ah total capacity	30	1518	766	1478
PCMS(2004)-7	Silent Messenger	Solar Technology, Inc	25	16 Crown Royal Battery Model #CR-225 batteries in bank- 1800 Ah total capacity	30	1483	1095	1485
PCMS(2004)-10	CMS80FM	Crown Construction Equipment	28	12 Trojan Battery Model #105 batteries in bank- 1350 Ah total capacity	28	1578	980	1606
PCMS(2004)-13	DH1000 ALS	ADDCO, Inc	30	12 Trojan Battery Model #105 batteries in bank- 1350 Ah total capacity	30	1972	927	1804
PCMS(2004)-14	PCMS-1500	Ver-Mac, Inc	30	16 Pow-R-Surge Battery Model #PS-200 batteries in bank- 1800 Ah total capacity	30	1780	1450	1780
PCMS(2004)-15	PCMS-1210		30	16 Pow-R-Surge Battery Model #PS-200 batteries in bank- 1800 Ah total capacity	30	1400	1210	1350
PCMS(2004)-16	PCMS-1210 QS		30	8 Pow-R-Surge Battery Model #PS-200 batteries in bank- 900 Ah total capacity	30	1336	1124	1379
PCMS(2004)-17	Vu-Pointe	National Signal, Inc	30	18 U.S. Battery Model #US2200 batteries in bank- 2025 Ah total capacity	30	1740	953	1757
PCMS(2004)-18	Sunray 380	U.S. Traffic Corp	30	8 Interstate Battery Model SRM-4D batteries in bank- 1872 Ah total capacity	30	1417	968	1426
PCMS(2004)-20	SMC 1000HE	Precision Solar Controls, Inc	21	3 Continental Battery Model 4D, #4DMT batteries in bank- 600 Ah total capacity	30	1549	1191	1443
PCMS(2004)-21	SMC 2000FM		30	6 Continental Battery Model 4D, #4DMT batteries in bank- 1200 Ah total capacity	30	1314	1130	1565

Note:

1) PCMS(2004)-10, Crown Construction Equipment's CMS80FM, became inoperable during the thirty (30) day Reliability testing and could not be raised. To recharge this sign and complete Durability testing would have resulted in an additional extended test period for the sign. With two days remaining in the test, it was decided not to recharge the batteries to complete testing on this sign.

Section 3.4- PCMS Dimming Pictures

Luminance meter setup

Luminance measurement

Character “H” used for measurements

Photocell covering for dimming measurement

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Section 4.0- PCMS Technical Desk Audit & Verification

NTPEP ID#	Product Name	Company	4.1.1 Display Type and Optical Characteristics of a Pixel's Output	4.1.2 Character Height	4.1.3 Maximum Lines
PCMS(2004)-1	Full Matrix Message Director WTMMB-S-LL(A)	Wanco, Inc	LED	12 - 15 in.	4 Lines
PCMS(2004)-2	Three Line Message Director WTLMB-S-LL(A)		LED	18 in.	3 Lines
PCMS(2004)-4	CMS-T331	American Signal Company, Inc	LED- Approx. 590-592 nm Amber ITE LEDs, four LEDs each in Dynapoint lens configuration	18 in.	3 Lines
PCMS(2004)-5	CMS-T332		LED- Approx. 590-592 nm Amber ITE LEDs, four LEDs each in Dynapoint lens configuration	18 in.	3 Lines
PCMS(2004)-6	CMS-T333		LED- Approx. 590-592 nm Amber ITE LEDs, four LEDs each in Dynapoint lens configuration	18 - 53 in.	3 Lines
PCMS(2004)-7	Silent Messenger	Solar Technology, Inc	LED - 24 display modules with 54 elements per module, each element consist of 3 - 590 nm LEDs on 2.60 in. spacing	13, 18 , 28 or 52 in.	4 Lines
PCMS(2004)-10	CMS80FM	Crown Construction Equipment	LED- 2.6 in. x 2.6 in. pitch consisting of 3 LEDs per element	Three line font 18 in., two line font 29 in., one line font 52 in.	3 Lines
PCMS(2004)-13	DH1000 ALS	ADDCO, Inc	LED	18 in.	3 Lines
PCMS(2004)-14	PCMS-1500	Ver-Mac, Inc	LED	18 in.	3 Lines
PCMS(2004)-15	PCMS-1210		LED	18 in.	3 Lines
PCMS(2004)-16	PCMS-1210 QS		LED	18 in.	3 Lines
PCMS(2004)-17	Vu-Pointe	National Signal, Inc	LED- Amber, 23º, 590 nm	18 in.	3 Lines
PCMS(2004)-18	Sunray 380	U.S. Traffic Corp	LED- Amber, 20º, 590 nm	18 in.	3 Lines
PCMS(2004)-20	SMC 1000HE	Precision Solar Controls, Inc	LED Lamp Matrix	18 in.	3 Lines
PCMS(2004)-21	SMC 2000FM		LED Lamp Matrix	18 - 40 in.	3 Lines

Section 4.0 (continued)

NTPEP ID#	4.1.4 Max. Characters Per Line	4.1.5 Type of Matrix	4.1.6 Primary Power Charging Source	4.1.7 Can Solar Panels Be Tilted	4.1.8 Description of Dimming Capabilities Under Changing Light Conditions
PCMS(2004)-1	10 Characters	Full Matrix	Solar and AC Power	Yes, optional	Two photocells
PCMS(2004)-2	8 Characters	Line Matrix	Solar and AC Power	Yes, optional	Two photocells
PCMS(2004)-4	8 Characters	Character Matrix	Solar and Battery	Aimstar optional	Ten Levels, 1-9 adjustable in defined percentages, 0 = automatic based on ambient light level from photocell
PCMS(2004)-5	12 Characters	Line Matrix	Solar and Battery	Aimstar optional	Ten Levels, 1-9 adjustable in defined percentages, 0 = automatic based on ambient light level from photocell
PCMS(2004)-6	12 Characters	Full Matrix	Solar and Battery	Aimstar optional	Ten Levels, 1-9 adjustable in defined percentages, 0 = automatic based on ambient light level from photocell
PCMS(2004)-7	13 Characters	Full Matrix	Solar and AC Power	Does not require tilting for normal operaton	Automatic based on monitoring ambient light conditons via photocell input. Ten brightness levels with the minimum intensity 50% of the maximum intensity. The ambient light level set points can be manually adjusted to compensate for unusual shadowing conditions.
PCMS(2004)-10	8 Characters	Full Matrix	Solar	Solar panels can be tilted for cleaning. For operation, sign does not require tilting.	Sign will adjust sign brightness automatically depending on ambient light conditions, can set brightness manually
PCMS(2004)-13	8 characters	Line Matrix	Solar, 2 to 6 panels, 6 to 16 batteries	STAR (solar tilt and rotate) patented	Optical light sensing with adjustment for conditions
PCMS(2004)-14	8 characters	Full Matrix	Solar	Solar panels may tilt and rotate independently of the sign	Two independent photo cells read the ambient light and adjust the intensity
PCMS(2004)-15	8 to 12 characters	Character Matrix	Solar	Solar panels may tilt and rotate independently of the sign	Two independent photo cells read the ambient light and adjust the intensity
PCMS(2004)-16	8 characters	Character Matrix	Solar	Solar panels may tilt and rotate independently of the sign	Two independent photo cells read the ambient light and adjust the intensity
PCMS(2004)-17	8 characters	24 Discrete characters	Solar	Fixed panels	Will dim to 10% brightness at night
PCMS(2004)-18	8 characters	24 Discrete characters	Solar	Fixed panels	Will dim to 5% brightness at night
PCMS(2004)-20	8 characters	Character Matrix	Solar	No, it is not necessary	Auto dimming by photocell with manual override capabilities
PCMS(2004)-21	8 characters	Full Matrix	Solar	No, it is not necessary	Auto dimming by photocell with manual override capabilities

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Section 4.0 (continued)

NTPEP ID#	4.1.9 AC Power Capable	4.1.10.1 Programmable Message Capability, Number of Storable Messages	4.1.10.2 Capability and Procedure for Changing Messages
PCMS(2004)-1	Yes	300	Through keyboard
PCMS(2004)-2	Yes	500	Through keyboard
PCMS(2004)-4	Yes	Capable of running 6 messages in sequential order with varied timing & scheduling, 199 preprogrammed messages, 199 user defined messages, 250 user defined sequences	Instructional Quick Sheet for novice and expert users
PCMS(2004)-5	Yes	Capable of running 6 messages in sequential order with varied timing & scheduling, 199 preprogrammed messages, 199 user defined messages, 250 user defined sequences	Instructional Quick Sheet for novice and expert users
PCMS(2004)-6	Yes	Capable of running 6 messages in sequential order with varied timing & scheduling, 199 preprogrammed text messages, 99 preprogrammed graphics, 49 animations, 199 user defined text messages, 99 user defined graphics, 49 animations	Instructional Quick Sheet or novice and expert users
PCMS(2004)-7	Can be AC operated through battery charger	Capable of 7 standard fonts, 4 character heights (13, 18, 28 or 52 in.) and up to 4 message lines. Can also be programmed to display graphic images. Two programming modes: Standard and Quick. Quick mode allows a sequence with up to 8 messages. Standard mode will allow 200 pre-programmed messages and 200 pre-programmed sequences which can consist of up to 16 messages.	For standard programming-editing of messages, sequences and the sequence display queue is accomplished from the User Menu. For quick programming- re-enter new sequence at any time.
PCMS(2004)-10	Can be plugged into AC power	250	Messages can be changed in the field through a simple menu driven wizard that guides the user through the message change. User does not need to read the manual.
PCMS(2004)-13	Yes	200 user definable messages, standard library included	Two methods: hand-held terminal or via laptop PC (direct connect or modem)
PCMS(2004)-14	110 VAC option	300 pre-programmed text messages, 50 pictograms, 200 user programmable text messages , 50 user programmable pictograms	Four step quick start programming
PCMS(2004)-15	110 VAC option	300 pre-programmed messages, 200 programmable user messages	Four step quick start programming
PCMS(2004)-16	110 VAC option	No pre-programmed messages	Four step programming
PCMS(2004)-17	Can be AC operated through battery charger	13 Default, 10 User, 200 Cartridge	Hand-held operated
PCMS(2004)-18	Can be AC operated through battery charger	Over 300 pre-programmed and operator-created messages	Through keyboard
PCMS(2004)-20	Yes	250 pre-programmed and 250 user programmable for a total of 500 messages	Password protected menu driven message processing
PCMS(2004)-21	Yes	250 pre-programmed and 250 user programmable for a total of 500 messages	Password protected menu driven message processing

Section 4.0 (continued)

NTPEP ID#	4.1.10.3 Is Message System Menu-driven	4.1.10.4 Message Entry Device (removable Keyboard, other)	4.1.10.5 Celluar Phone Capability and/or Radar Capability
PCMS(2004)-1	Yes	Removable keyboard	Celluar Modem and Radar
PCMS(2004)-2	Yes	Removable keyboard	Celluar Modem and Radar
PCMS(2004)-4	Menu driven with confirmation questions	Alphanumeric backlit hand-held controller	Options: Cellular, Radar, Advisory Radio, Aimstar Adjustable Solar, High Autonomy, NTCIP, Wizard Alert Radio, Smart Work Zone, Side Fire Radar, Camera, RWIS
PCMS(2004)-5	Menu driven with confirmation questions	Alphanumeric backlit hand-held controller	Options: Cellular, Radar, Advisory Radio, Aimstar Adjustable Solar, High Autonomy, NTCIP, Wizard Alert Radio, Smart Work Zone, Side Fire Radar, Camera, RWIS
PCMS(2004)-6	Menu driven with confirmation questions	Alphanumeric backlit hand-held controller	Options: Cellular, Radar, Advisory Radio, Aimstar Adjustable Solar, High Autonomy, NTCIP, Wizard Alert Radio, Smart Work Zone, Side Fire Radar, Camera, RWIS
PCMS(2004)-7	System is menu driven	Waterproof QWERTY keyboard	Has both Cellular and Radar options, Radar option has up to 50 different activated sequences
PCMS(2004)-10	System is menu driven	Message entry is done on the local controller with a QWERTY keyboard	Cellular and Radar options
PCMS(2004)-13	HHT is menu-driven	HHT is an industrial level sealed hand-held board that includes a pig-tail cord reaching up to 15 ft	Cellular phone, GPRS, CMDA 1XRTT, Ethernet, land-line, multiple RF wireless, fiber optic communication and radar capable
PCMS(2004)-14	Yes	Removable keyboard	Cell and Radar capable
PCMS(2004)-15	Yes	Removable keyboard	Cell and Radar capable
PCMS(2004)-16	Yes	Hand-held controller	Cell and Radar capable
PCMS(2004)-17	Menu driven	Hand-held	Cellphone and Radar
PCMS(2004)-18	Menu driven	Removable keyboard	Cellphone and Radar
PCMS(2004)-20	Yes	Dedicated keyboard	Both Cellular and Radar capable
PCMS(2004)-21	Yes	Dedicated keyboard	Both Cellular and Radar capable

Section 4.0 (continued)

NTPEP ID#	4.1.10.6 Control Console Security Description	4.1.10.7 Is Control Console Lighted (Keyboard and/or Console Display)	4.1.10.8 Is there a Default Message or has a Pre-default Indicator
PCMS(2004)-1	Three point lockable box and password entry	Panel light and backlit LCD	Adjustable default indicator
PCMS(2004)-2	Three point lockable box and password protection	Panel light and backlit LCD	Adjustable default indicator
PCMS(2004)-4	Two password levels for Master/User control, lockable control cabinet	Yes	Unit capable of a pre-default message
PCMS(2004)-5	Two password levels for Master/User control, lockable control cabinet	Yes	Unit capable of a pre-default message
PCMS(2004)-6	Two password levels for Master/User control, lockable control cabinet	Yes	Unit capable of a pre-default message
PCMS(2004)-7	Menu driven proprietary operating system with four levels of password security, control console is enclosed within a lockable enclosure	Automatic backlit QWERTY keyboard and LCD display	Has proprietary Sign Panel Error Detection and Correction System which monitors the status of the sign panel. Will blank sign if unable to correct fault and display message on control console on how to repair. Also, will flash the default message "CAUTION" if battery bank voltage drops below 11.0 VDC. Default message is user programmable.
PCMS(2004)-10	In a lockable box, password protected	Console LCD screen and keyboard are backlit	190 pre-programmed MUTCD phrases and a default message to show when battery levels are low
PCMS(2004)-13	Trailer hitch lock, console lock, user level password protected software terminal	Console includes retractable magnetic light, terminal controller not lighted.	User definable and factory default messages
PCMS(2004)-14	Lockable, password protected	Controller is lighted	Default message is optional
PCMS(2004)-15	Lockable, password protected	Control console is lighted	Default message is optional
PCMS(2004)-16	Lockable, password protected	Hand-held controller is lighted	Default message is optional
PCMS(2004)-17	Lockable enclosure	Backlighted Control and Hand-held	Displays default messages
PCMS(2004)-18	Lockable enclosure, password protected	Backlighted Control LCD Module	Displays default messages
PCMS(2004)-20	Lockable lid, 3 levels of password protection	Backlit LCD screen and automatic keyboard lighting	Both a default message and a pre-default indicator
PCMS(2004)-21	Lockable lid, 3 levels of password protection	Backlit LCD screen and automatic keyboard lighting	Both a default message and a pre-default indicator

Section 4.0 (continued)

NTPEP ID#	4.1.11 Height of Panel Above the Road Surface	4.1.12 Range of Flashing Rates	4.1.13 Maximun Wind Load	4.1.14 Rotation Capability	4.1.15 Alignment Device and Methodology for Pointing/Aiming
PCMS(2004)-1	7 ft	2.4 to 300 flashes per minute	98 MPH with outrigger option	360º plus	Sight tube on tower
PCMS(2004)-2	7 ft	6 to 240 flashes per minute	98 MPH with outrigger option	360º plus	Sight tube on tower
PCMS(2004)-4	Height to top of sign when raised w/ solar rack = 165.25 in., height to bottom of sign case from road surface when raised = 7 ft	0.2 - 9.0 seconds adjustable in 0.10 second intervals : 180 - 6 flashes per minute adjustable	100 MPH with 40% wind gusts	360º, dependent on sign cable	Sight tube on sign case to allow for user to aim at target and position sign display
PCMS(2004)-5	Height to top of sign when raised w/ solar rack = 165.25 in., height to bottom of sign case from road surface when raised = 7 ft	0.2 - 9.0 seconds adjustable in 0.10 second intervals : 180 - 6 flashes per minute adjustable	100 MPH with 40% wind gusts	360º, dependent on sign cable	Sight tube on sign case to allow for user to aim at target and position sign display
PCMS(2004)-6	Height to top of sign when raised w/ solar rack = 165.25 in., height to bottom of sign case from road surface when raised = 7 ft	0.2 - 9.0 seconds adjustable in 0.10 second intervals : 180 - 6 flashes per minute adjustable	100 MPH with 40% wind gusts	360º, dependent on sign cable	Sight tube on sign case to allow for user to aim at target and position sign display
PCMS(2004)-7	7 ft	Each message can be displayed 0.1 second to 99 seconds with increments of 0.1 second	80 MPH with outriggers	360º plus CW & CCW	Use sight tube on sign support assembly. Pivot sign panel until desired target is centered within the field of view of the sight tube.
PCMS(2004)-10	7 ft	From 300 flashes per minute to any number	80 MPH	360º plus	Aligns through a sight tube on sign cabinet, instructions are on a decal on sign cabinet
PCMS(2004)-13	7 ft-6 in. when fully extended	600 per minute, complete change of all three lines 100 milliseconds or less	80 MPH	360º	Includes sight tube for aiming, sign is turned manually and maintain in position by an adjustable friction clamp system
PCMS(2004)-14	7 ft	Flash rate is programmable	80 MPH	360º	Sighting mechanism is positioned on the bottom of the sign
PCMS(2004)-15	7 ft	Flash rate is programmable	80 MPH	360º	Sighting mechanism is positioned on the bottom of the sign
PCMS(2004)-16	7 ft	Flash rate is set at 26 flashes per minute	80 MPH	360º	Sighting mechanism is positioned on the bottom of the sign
PCMS(2004)-17	104 in.	Flash rate is 0.25 seconds to 7.75 seconds	85 MPH	360º	Sight alignment kit
PCMS(2004)-18	112 in.	Flash rate is 0.25 seconds to 7.75 seconds	85 MPH	360º	Sight alignment kit
PCMS(2004)-20	Total height 9 ft-7 in. travel, 7 ft above the roadway in display	60 flashes per minute	80 MPH straight / 105 MPH gusts	360º	Integrated sighting device to be aimed 500 ft to target
PCMS(2004)-21	Total height 9 ft-8 in. travel, 7 ft above the roadway in display	60 flashes per minute	80 MPH straight / 105 MPH gusts	360º	Integrated sighting device to be aimed 500 ft to target

Section 4.0 (continued)

NTPEP ID#	4.1.16 Type of Stabilizing Device(s)	4.1.17 Recharging Instructions	4.1.18 Theft/Vandalism Security Devices
PCMS(2004)-1	Four corner jacks standard, telescoping outrigger optional	Place in sun	Security screws for solar panels and hydraulic pump, locking computer box, locking battery box, locking rotating brake handle
PCMS(2004)-2	Four corner jacks standard, outriggers optional	Place in sun	Security screws for solar panels and hydraulic pump, keyed locking control box, pad locks for battery box, braking handle for sign rotation
PCMS(2004)-4	Optional adjustable outriggers, standard leveling screw jacks on each corner	Plug 120 VAC standard extension cord into outlet on side of control box for approximately 48-72 hours dependent on level of charge at time of recharge. Full slow charge takes 72 hours.	Lockable control cabinet and battery boxes, optional wheel locks, removable tongue hitch, optional locking lugnuts, optional security type bolts for solar assembly
PCMS(2004)-5	Optional adjustable outriggers, standard leveling screw jacks on each corner	Plug 120 VAC standard extension cord into outlet on side of control box for approximately 48-72 hours dependent on level of charge at time of recharge. Full slow charge takes 72 hours.	Lockable control cabinet and battery boxes, optional wheel locks, removable tongue hitch, optional locking lugnuts, optional security type bolts for solar assembly
PCMS(2004)-6	Optional adjustable outriggers, standard leveling screw jacks on each corner	Plug 120 VAC standard extension cord into outlet on side of control box for approximately 48-72 hours dependent on level of charge at time of recharge. Full slow charge takes 72 hours.	Lockable control cabinet and battery boxes, optional wheel locks, removable tongue hitch, optional locking lugnuts, optional security type bolts for solar assembly
PCMS(2004)-7	Four 3000 lb. capacity swivel jacks located on each corner of trailer	Locate extension cord in battery box containing recharger. Completely uncoil cord to prevent over heating. Charging should be complete in approximately 24 hours. Battery compartment containing charger should also be left opened during charging for proper cooling.	Battery boxes, control console box, and hydraulic power unit box are lockable. The sign rotation locking device and sign panel case is lockable. Trailer hitch may be locked or removed. Brake actuator can be removed. After properly set up, the tires and axle can be removed.
PCMS(2004)-10	Four jacks located on each corner of trailer	Plug provided AC charger into 120 VAC plug. Charger will regulate the rate of charge.	Lockable battery boxes prevent unauthorized tampering of controller and batteries. Lockable sign cabinet and brake to prevent tampering with the cabinet and rotation of the mast.
PCMS(2004)-13	Four 2000 lb top winding jacks	See owner's manual or contact ADDCO	Hitch lock, console lock, message board cover lock, operator software password protected
PCMS(2004)-14	Four 2000 lb jacks	55 Amp charger will recharge the battery pack in 24 hours	Locks
PCMS(2004)-15	Four 2000 lb jacks	55 Amp charger will recharge the battery pack in 24 hours	Locks
PCMS(2004)-16	Four 2000 lb jacks	30 Amp charger will recharge the battery pack in 24 hours	Locks
PCMS(2004)-17	Four screw jacks and one caster wheel jack	Recharge time is 36 hours with on-board charger	Lockable Controller box, optional wheel locks
PCMS(2004)-18	Four screw jacks and one caster wheel jack	Recharge time is 36 hours with on-board charger	Lockable Controller box, optional wheel locks
PCMS(2004)-20	Heavy duty 15 in. screw jacks	Plug-in on-board AC battery charger for 48 to 72 hours when necessary	Removable tongue, lockable battery compartment, display window, and control console
PCMS(2004)-21	Heavy duty 15 in. screw jacks	Plug-in on-board AC battery charger for 48 to 72 hours when necessary	Removable tongue, lockable battery compartment, display window, and control console

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). This document, and others published by NTPEP, may not be reproduced without written permission from 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.

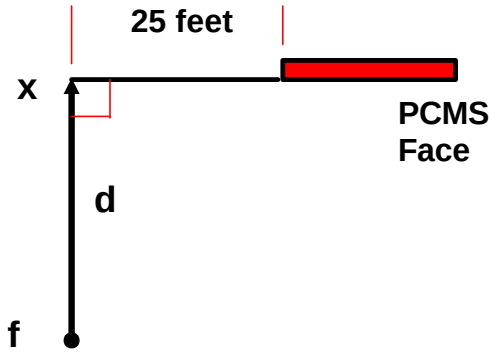


Figure 1
(Note: Pointing/Aiming of PCMS face will be adjusted for test

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 q shown. Record this angle as the Angularity.

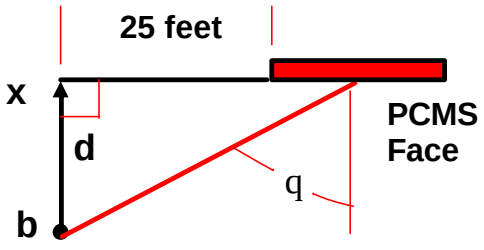


Figure 2
(Note: Pointing/Aiming of PCMS face will be adjusted for test)

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.

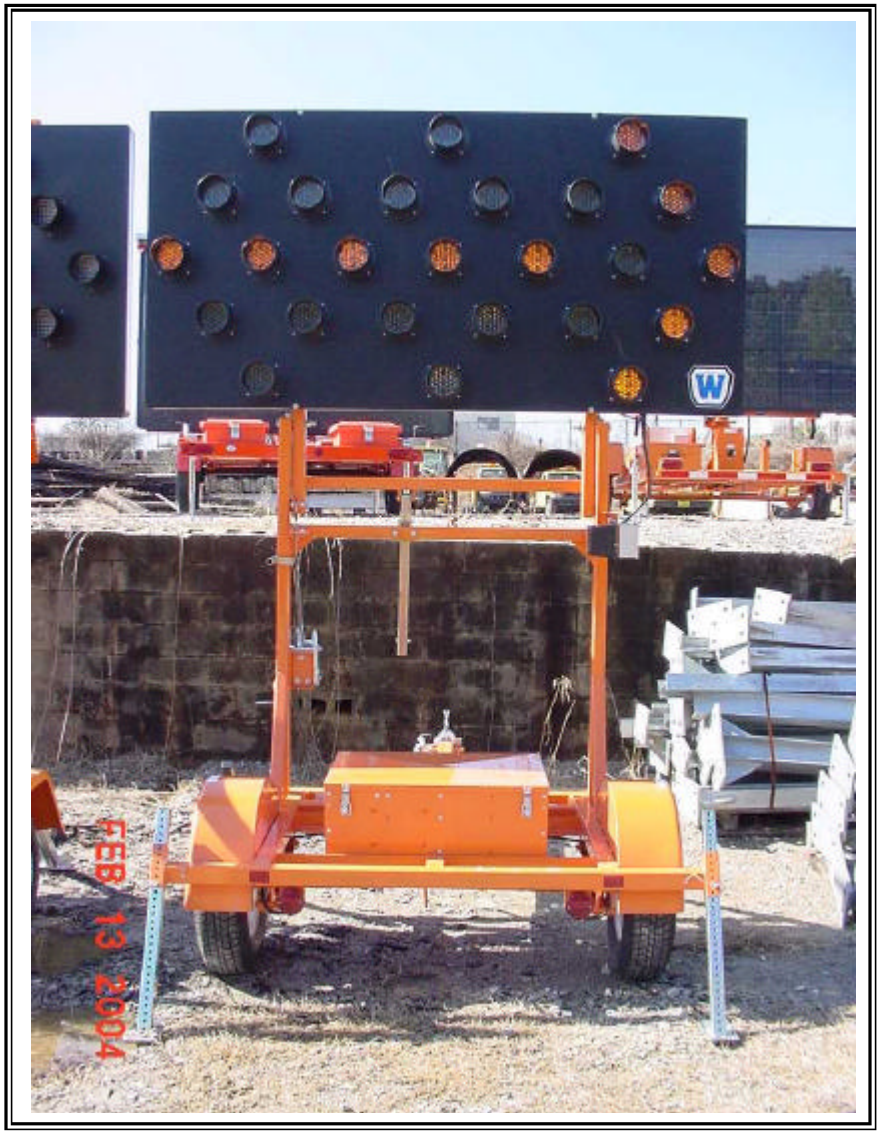
4.1.15 Type of PCMS alignment device and methodology to use in pointing/aiming. Include instructions necessary to achieve proper alignyment to the roadway. If instructions are not provided, the PCMS will be placed parallel to the datum line.

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.

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	Solar Traffic Director WTSP55-LSAC	Wanco, Inc	5870 Tennyson Street Arvada, CO 80003 USA	(303) 427-5700 (303) 427-5725 Fax	Scott Risby	www.wanco.com
PCMS(2004)-8	Silent Sentinel-15 Lamp	Solar Technology, Inc	7620 Cetronia Road Allentown, PA 18106 USA	(610) 391-8600 (610) 391-8601 Fax	Bill Wellman	www.solartechnology.com
PCMS(2004)-9	Silent Sentinel-25 Lamp					
PCMS(2004)-11	AB25	Crown Construction Equipment	PO Box 234, Station "L" Winnipeg, MB R3J 3TR Canada	(204) 885-5800 (204) 885-7557 Fax	Jeff Hildebrand	www.crownequip.com
PCMS(2004)-12	AB15					
PCMS(2004)-19	Sun-Up	National Signal, Inc	9603 John Street Santa Fe Springs, CA 90670 USA	(562) 923-9600 (562) 923-7555 Fax	Lupe Martinez	www.ustraffic.net

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/q)		2.3 Visibility (ft)	2.4 Legibility (ft)	2.5 Angularity (ft/q)	
PCMS(2004)-3	Solar Traffic Director WTSP55-LSAC	Wanco, Inc	4800	4800	56.0	24.1º	4800	4800	13.3	61.9º
PCMS(2004)-8	Silent Sentinel-15 Lamp	Solar Technology, Inc	4800	4800	57.3	23.6º	4800	4480	16.3	56.8º
PCMS(2004)-9	Silent Sentinel-25 Lamp		4800	4800	88.7	15.7º	4800	4800	15.7	57.9º
PCMS(2004)-11	AB25	Crown Construction Equipment	4800	4800	91.7	15.3º	4800	4800	12.3	63.7º
PCMS(2004)-12	AB15		4800	2282	34.0	36.3º	4800	1267	12.7	63.1º
PCMS(2004)-19	Sun-Up	National Signal, Inc	4800	4800	50.7	26.3º	4800	4800	14.0	60.8º

Note:

1) PCMS(2004)-12, Crown Construction Equipment's AB15, had five (5) out fifteen (15) lamps non-operational when it arrived at Wilson Industrial Air Center in Wilson, NC from the NCDOT Equipment Depot in Raleigh, NC. Even though not 100 percent operational, it was decided to test the FAP per the work plan and report the recorded data.
2) One of the evaluator's vision was sometimes obstructed by the vehicle's mirror or roofline during the Angularity Tests. It was determined that the evaluator's measurements did not have a negative impact on that sign's final data results.

Section 2.0- FAP Sight Tests Pictures

Angularity Test runs with evaluator

Typical Sight Test mode

Typical Sight Test mode

Typical Sight Test mode

AASHTO's National Transportation Product Evaluation Program

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	Solar Traffic Director WTSP55-LSAC	Wanco, Inc	30	4 Interstate Model #U2200 batteries in bank- 450 Ah total capacity	30	1673	1435	2404	36	0.8
PCMS(2004)-8	Silent Sentinel-15 Lamp	Solar Technology, Inc	30	4 Crown Royal Model #CR-225 batteries in bank- 450 Ah total capacity	30	1977	1417	2147	33	0.62
PCMS(2004)-9	Silent Sentinel-25 Lamp		30	4 Crown Royal Model #CR-225 batteries in bank- 450 Ah total capacity	30	2320	1784	2449	33	0.7
PCMS(2004)-11	AB25	Crown Construction Equipment	30	2 Trojan Battery Model #125 batteries in bank- 240 Ah total capacity	30	1809	806	1912	30	0.83
PCMS(2004)-12	AB15		30	2 Trojan Battery Model #125 batteries in bank- 240 Ah total capacity	30	2294	2255	2170	30	0.72
PCMS(2004)-19	Sun-Up	National Signal, Inc	30	6 U.S. Battery Model #US2200 batteries in bank- 675 Ah total capacity	30	1548	1306	1582	31	1.02

Section 3.4- FAP Dimming Pictures

Luminance meter setup

Luminance measurement

Luminance measurement

“Right Arrow” mode used for measurements

Section 4.0- FAP Technical Desk Audit & Verification

NTPEP ID#	Product Name	Company	4.1.1 Display Type	4.1.2 MUTCD Panel Type	4.1.3 Primary Power Charging Source	4.1.4 Can Solar Panels Be Tilted
PCMS(2004)-3	Solar Traffic Director WTSP55-LSAC	Wanco, Inc	LED lamps with optical lens	Type C	Solar assisted	Panels tilt (flat for operation and storage)
PCMS(2004)-8	Silent Sentinel-15 Lamp	Solar Technology, Inc	LED- lamp comprised of 36-590 nm LEDs	Type C	Solar, optional battery charger	Does not require tilting for normal operaton
PCMS(2004)-9	Silent Sentinel-25 Lamp		LED- lamp comprised of 36-590 nm LEDs	Type C	Solar, optional battery charger	Does not require tilting for normal operaton
PCMS(2004)-11	AB25	Crown Construction Equipment	LED	Type C	Solar	No
PCMS(2004)-12	AB15		LED	Type C	Solar	No
PCMS(2004)-19	Sun-Up	National Signal, Inc	PAR 46, LED lamp, 20 LEDs	Type C	Solar charging power	No

Section 4.0 (continued)

NTPEP ID#	4.1.5 AC Power Capable	4.1.6 Mode Display Capabilities	4.1.7 Control Console Security Description	4.1.8 Height to Bottom of FAP Above Road Surface
PCMS(2004)-3	AC thru optional charger	12 Functions	Lid has holes to accept pad lock	7 ft
PCMS(2004)-8	AC operated thru optional battery charger	Left Flashing Arrow, Left Sequential Arrow, Right Sequential Arrow, Right Flashing Arrow, Caution Bar, Four Corner Caution, Flashing Double Arrow	Lockable enclosure	7 ft
PCMS(2004)-9	AC operated thru optional battery charger	Left Flashing Arrow, Left Sequential Arrow, Right Sequential Arrow, Right Flashing Arrow, Sequential Double Arrow, Caution Bar, Right Sequential Chevron, Alternating Double Diamonds, Left Sequential Chevron, Four Corner Caution, Flashing Double Arrow	Lockable enclosure	7 ft
PCMS(2004)-11	Yes	Left Flashing Arrow, Left Sequential Arrow, Right Sequential Arrow, Right Flashing Arrow, Sequential Double Arrow, Caution Bar, Right Sequential Chevron, Alternating Diamonds, Left Sequential Chevron, Four Corner Caution, Flashing Double Arrow	Lockable enclosure	7 ft
PCMS(2004)-12	Yes	Left Flashing Arrow, Left Sequential Arrow, Right Sequential Arrow, Right Flashing Arrow, Sequential Double Arrow, Caution Bar, Four Corner Caution, Flashing Double Arrow	Lockable enclosure	7 ft
PCMS(2004)-19	AC powered thru battery charger	Flashing Arrows, Sequential Arrows, Sequential Chevron, Flashing Caution, Straight Line, Four Corners	Tactile switches, real time mode display	7 ft

Section 4.0 (continued)

NTPEP ID#	4.1.9 Maximun Wind Load	4.1.10 Alignment Device and Methodology for Pointing/Aiming	4.1.11 Mode Switch for Maximum Dim, Maximum Bright and Automatic
PCMS(2004)-3	Certified to 77 MPH gust (60 MPH sustained)	An eye sight tube mounted on upright post allows operator to rotate trailer to desired position	Yes
PCMS(2004)-8	80 MPH with outriggers in place	Aim the display panel at desired target using the sight tubes located on the frame uprights opposite the winch. Stand 2-4ft away from first sight tube and position oneself such that the second tube is centered in the center view of the first tube. Position trailer such that the desired target is centered within the field of view of both tubes.	Automatic based on monitoring ambient light conditons via photocell input. 16 brightness levels with the minimum intensity 50% of the maximum intensity. Automatic feature can be manually overridden by pushing the Lamp Intensity Selector Button.
PCMS(2004)-9	80 MPH with outriggers in place	Aim the display panel at desired target using the sight tubes located on the frame uprights opposite the winch. Stand 2-4ft away from first sight tube and position oneself such that the second tube is centered in the center view of the first tube. Position trailer such that the desired target is centered within the field of view of both tubes.	Automatic based on monitoring ambient light conditons via photocell input. 16 brightness levels with the minimum intensity 50% of the maximum intensity. Automatic feature can be manually overridden by pushing the Lamp Intensity Selector Button.
PCMS(2004)-11	80 MPH	Aligns through a sight tube on sign frame, instructions are on a decal on frame	Automatic mode, manual brightness of all 5 levels.
PCMS(2004)-12	80 MPH	Aligns through a sight tube on sign frame, instructions are on a decal on frame	Automatic mode, manual brightness of all 5 levels.
PCMS(2004)-19	85 MPH	Optional sight alignment kit	Automatic and manual dimming mode

Section 4.0 (continued)

NTPEP ID#	4.1.12 Type of Stabilizing Device(s)	4.1.13 Recharging Instructions	4.1.14 Theft/Vandalism Security Devices
PCMS(2004)-3	Four telescoping outriggers	Automatic, place in sun light	Solar panels have security screws, battery box and control box pad lockable, drawbar removable
PCMS(2004)-8	Four telescoping jackstands	Locate extension cord in battery box. Completely uncoil cord to prevent over heating. Charging should be complete in approximately 24 hours.	Battery box is lockable. Trailer hitch may be locked or removed. Handle can be removed from winch. After properly set up, the tires and axle can be removed.
PCMS(2004)-9	Four telescoping jackstands	Locate extension cord in battery box. Completely uncoil cord to prevent over heating. Charging should be complete in approximately 24 hours.	Battery box is lockable. Trailer hitch may be locked or removed. Handle can be removed from winch. After properly set up, the tires and axle can be removed.
PCMS(2004)-11	Four outrigger tubes and one jack on hitch	Plug provided AC charger into 120 VAC plug, charger will regulate the rate of charge	All enclosures are lockable
PCMS(2004)-12	Four outrigger tubes and one jack on hitch	Plug provided AC charger into 120 VAC plug, charger will regulate the rate of charge	All enclosures are lockable
PCMS(2004)-19	Four adjustable jack stands	36 hours recharge time through on-board optional battery recharger	Lockable control box, optional wheel locks

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). This document, and others published by NTPEP, may not be reproduced without written permission from 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.

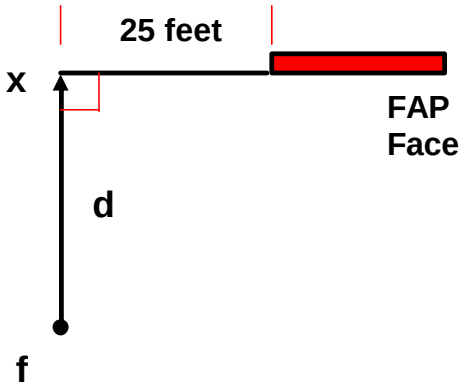


Figure 1

(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 q shown. Record this angle as the Angularity.

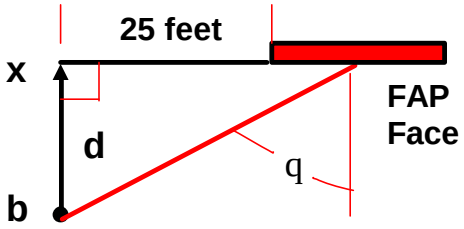


Figure 2

(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).

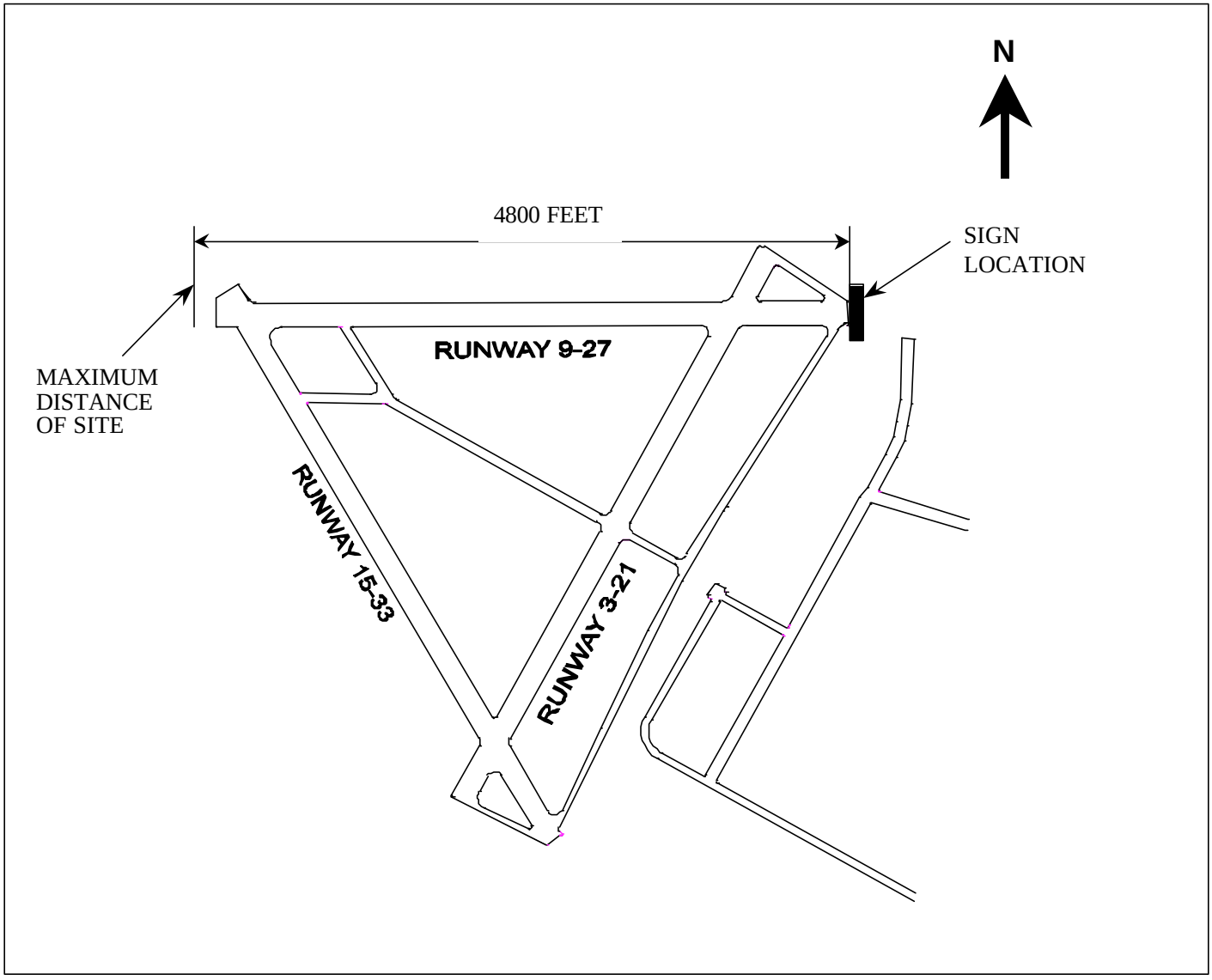
4.1.13 Recharging instructions for solar powered devices.

4.1.14 Available Security measures to prevent theft/vandalism of

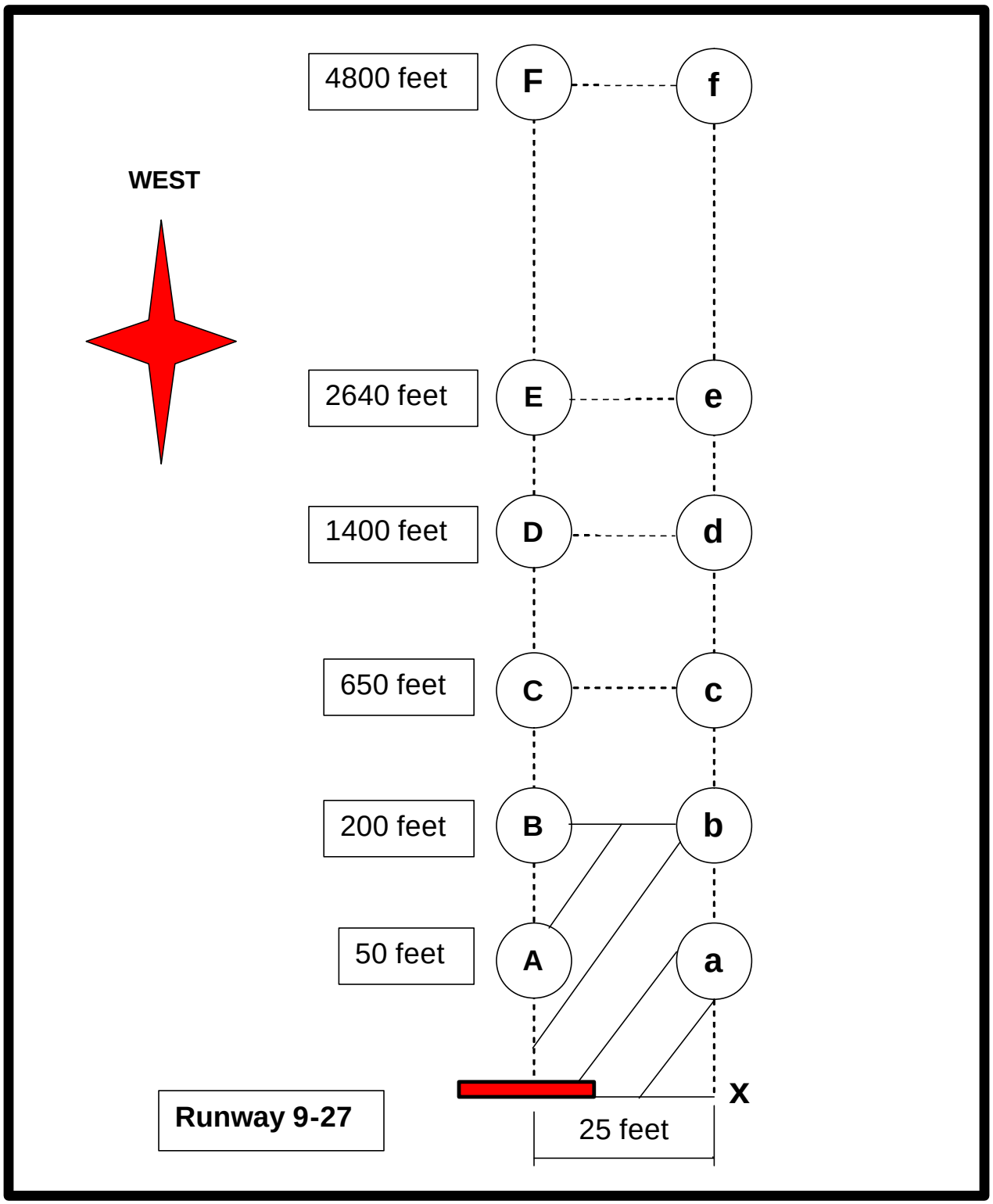
Appendix "A"

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			
04/22/04	82°	72°	62°	67	0.00	
04/23/04	87°	74°	61°	70	0.00	

3.0 Operational Performance Tests Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
02/12/04	44°	38°	32°	73	0.51	Fog, Rain
02/13/04	57°	44°	30°	68	0.00	Fog
02/14/04	53°	46°	38°	75	0.08	Rain
02/15/04	45°	39°	32°	73	0.38	Fog, Rain, Snow
02/16/04	35°	29°	23°	72	0.04	Snow
02/17/04	32°	29°	25°	80	0.06	Rain, Snow
02/18/04	50°	39°	27°	59	0.00	
02/19/04	65°	47°	28°	53	0.00	
02/20/04	68°	52°	36°	48	0.00	
02/21/04	64°	55°	45°	55	0.00	
02/22/04	57°	47°	36°	57	0.00	
02/23/04	53°	43°	32°	69	0.00	Rain
02/24/04	58°	51°	43°	64	0.00	
02/25/04	51°	43°	34°	55	0.00	
02/26/04	38°	35°	31°	70	0.12	Fog, Snow
02/27/04	46°	38°	30°	69	0.55	Rain, Snow
02/28/04	59°	43°	27°	58	0.00	
02/29/04	67°	47°	26°	64	0.00	
03/01/04	70°	52°	33°	75	0.00	
03/02/04	66°	62°	57°	89	0.10	Rain
03/03/04	75°	65°	54°	72	0.00	Fog
03/04/04	82°	69°	56°	71	0.00	
03/05/04	77°	69°	61°	80	0.00	
03/06/04	71°	65°	59°	72	0.17	Rain
03/07/04	70°	58°	46°	74	0.16	Rain, Thunderstorm
03/08/04	54°	46°	37°	50	0.00	
03/09/04	53°	42°	30°	70	0.07	Rain
03/10/04	51°	42°	32°	70	0.00	
03/11/04	62°	45°	27°	65	0.00	Fog
03/12/04	66°	50°	33°	58	0.00	
03/13/04	57°	47°	36°	51	0.00	
03/14/04	65°	51°	36°	62	0.00	
03/15/04	60°	57°	53°	90	0.88	Rain
03/16/04	67°	55°	43°	97	0.62	Fog, Rain
03/17/04	47°	42°	37°	91	0.01	Rain

3.0 Operational Performance Tests Temperature Summary			
Temperature	Maximum	Average	Minimum
High Temperature (°F)	82°	58°	32°
Mean Temperature (°F)	69°	48°	29°
Low Temperature (°F)	61°	38°	23°

Weather data was provided by the Federal Aviation Administration

"The National Transportation Product Evaluation Program (NTPEP) was established by the American Association of State Highway and Transportation Officials (AASHTO) in early 1994. The program pools the professional and physical resources of the AASHTO member departments in order to test materials, products and devices of common interest. The primary goals of the program are to provide cost-effective evaluations for the states by eliminating duplication of routine testing by the states; and to reduce duplication of effort by the manufacturers who produce and market commonly used proprietary, engineered products." **NTPEP**

-- Rick Smutzer (IN), NTPEP Chairman

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