2007 NTPEP Report Series

NTPEP Report 7005.1

AASHTO's National Transportation Product Evaluation Program

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

WINTER 2007 EVALUATION
FINAL REPORT

October 2007

American Association of State Highway and Transportation Officials (AASHTO)

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PROLOGUE

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National Transportation Product Evaluation Program (NTPEP)

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Report of

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

WINTER 2007 EVALUATION FINAL REPORT

NTPEP National Testing Facility Hosted by:

North Carolina Department of Transportation (NCDOT)

October 2007

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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 2007 Evaluation
Final Report

Prepared by

North Carolina Department of Transportation
Work Zone Traffic Control Unit

Tests conducted and report written by:

Meredith McDiarmid, PE
Dale Stokes

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AASHTO's National Transportation Product Evaluation Program

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Acknowledgements

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Jerry Bagwell, Ricky Ennis and the staff of the NCDOT Equipment Depot in Raleigh for assisting the vendors with the setup of their signs, providing test deck space, and generally any other support to make the evaluations successful.

Donnie Sherrod, Eric Boyette and the staff of the NCDOT Division 4 Equipment Unit in Wilson for moving the signs to and from the Wilson Industrial Air Center. They also provided trucks and other equipment needed to conduct the Sight Tests evaluations.

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

Gronna Jones and City of Wilson Transportation Department, NC for allowing us to the use the Wilson Industrial Air Center.

And finally, the following staff of the NCDOT Work Zone Traffic Control Unit who helped with the evaluations: Derrick Beard, Mark Manriquez, Scott Coats, David Abowd and Joseph Wright.

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). 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 from the NTPEP Oversight Committee was adopted in November 1998 with the first evaluations being completed in the winter of 1999.

Six signs were submitted for the 2007 NTPEP evaluation: four full size PCMSs, one medium size PCMS and one FAP. Testing began at the North Carolina DOT Equipment Depot in Raleigh, NC with the Operational Performance Tests (Section 4.0). The test began on February 15, 2007 with the Durability test and was followed with the Reliability test, which ended on May 3, 2007. The Sight Tests (Section 3.0) took place at the Wilson Industrial Air Center in Wilson, NC with all tests conducted on June 13, 2007.

The evaluation team used the same work plan introduced for the 2006 evaluation which can be found in Appendix A. The work plan was rewritten in 2006 to resolve issues with the past evaluations and to clarify the tests and testing procedures. The new work plan was a collective effort of the Project Panel and was accomplished by utilizing input from industry representatives and member states. Major changes included new Durability and Reliability tests, the removal of the Dimming test, and a procedure for repairing signs that become inoperable.

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

Section 3.0 Sight Tests

The Visibility (Section 3.1.4.1), Legibility (Section 3.1.4.2), and Angularity (Section 3.1.4.3) Sight Tests were performed on June 13, 2007 at the Wilson Industrial Air Center in Wilson, NC (see Appendix B, page B1, for location diagram). The runway was surveyed and marked per the work plan (see Test Deck Layout in Appendix A, page A23). 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 an onboard vehicle distance meter was used to determine the distances. Weather information for the day can be found in Appendix B, page B2.

Results and comments for the Section 3.0 Sight Tests can be found in the summary for each sign. All results shown are the "averages" of the evaluators' data and the angularity result is a "one-half" angle calculation. There is also a spreadsheet with each sign's results for a quick comparison of the data (see Figure 7 on page 49).

Section 4.0 Operational Performance Tests

The Durability (Section 4.1.4.1) and Reliability (Section 4.1.4.2) Operational Performance Tests were performed at the NCDOT Equipment Depot in Raleigh, NC. The Durability test began on February 15 and ended on March 17, 2007. The Reliability test began on March 18 and continued until each sign ceased operation as detailed in the work plan. Daily weather information with average temperatures for the period can be found in Appendix B, page B2 and B3.

The message "CAUTION ACCIDENT AHEAD" was programmed on each PCMS sign which met the requirement of the Message Content (Section 4.1.3.3) of the PCMS work plan. The FAP was programmed with the "Double Arrow" mode per the FAP work plan. The Flashing Rate (Section 4.2) of the FAP work plan was measured and recorded.

Except for the Daktronics VP-4000, voltage levels reported for the PCMS signs are from the signs onboard diagnostics and verified with a Fluke 179 multi-meter. The Daktronics VP-4000 submitted for testing did not have onboard voltage diagnostics so all voltage levels reported where measured with the multi-meter. The Protection Services Inc. FAP onboard diagnostics were limited to a LED status indicator so all voltage levels reported were also measured with the multi-meter.

Results and comments for Section 4.0 PCMS Operational Performance Tests can be found in the summary for each sign.

Section 5.0 Technical Desk Audit & Verification

Section 5.0 Technical Desk Audit & Verification of the work plan required the manufacturer to send this information to aid in describing their sign(s) in the final report. All results for Section 5.0 can be found in the summary for each sign.

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". This information is intended to assist AASHTO member departments in utilizing the results and to improve future testing:

- In reviewing the Legibility (Section 3.1.4.2) test data, two distances are reported for comparison: a two-line "word" message and a "eye chart" message. (In the 2004 and 2005 reports, the "eye chart" distance was the only distance reported since it was the lesser distance.) What the team found in the previous NTPEP testing is that the "eye chart" distance was always considerably less than the "word" message because the evaluator recognized the word sooner as compared to deciphering the individual letters of the "eye chart" message. As with the 2006 report, we are presenting both results for comparison so each distance can be evaluated for its merit.

- As part of the Durability and Reliability (Section 4.1.4) test data, the voltage level results shown are per the sign's diagnostics and the multi-meter. The multi-meter was used to confirm the accuracy of the sign's diagnostics and used when a sign did not have diagnostics that displayed a voltage reading.

- In reviewing the Durability test data, the team was looking for an ending voltage level of approximately 12.7 volts which is considered a full-charge on a 12-volt system.

- In the Reliability data reported, we indicate the number of days of operation the battery-bank was able to power the sign before shutdown. This information is not presented for comparison, but is only intended to inform the reader of what can be expected of the battery bank-up system submitted for testing. One has to remember that battery quantities, amp-hour capacities, ambient temperature and the sign's shutdown voltage will affect the sign's days of operation on battery back-up. If days of operation on battery back-up is a specification requirement, then it is suggested to consult with the manufacturer who can specify a battery back-up system capable of meeting your requirements.

- In addition to the Reliability data reported in the summary for each sign, we included a graph of the voltage measurements to illustrate the sign's power consumption.

- As part of the Technical Desk Audit & Verification (Section 5.0), the information provided by the manufacturer is not an attempt to replace the sign's technical manual but only to serve as a quick reference of how that sign was configured for testing. Also, most of the Sign Panel questions were specific to the basic requirements of the MUTCD. It is suggested users of this report contact the manufacturer to review all features and options available.

As the evaluation team tests each year, we learn something new about the operation of the signs. The information submitted below was presented in last year's report and is still relevant for this year. Although not required in the Project Work Plan, the team is providing this information again for the Member States review:

- As part of Reliability testing, the "shutdown" voltage for each sign is recorded and monitored to be sure each sign shuts down at their preset voltage. The team has found that the manufacturers do not use the same preset "shutdown" voltage. Voltages this year ranged from 10.6 to 11.5 volts. Last year, we questioned several technical advisers from the battery industry about what was a suitable "shutdown" voltage for a 12-volt system. Because of the different load currents and battery characteristics for each sign, the advisers could not give a definitive answer. One response was not to exceed 80 percent depth of discharge (DOD) which is approximately a 10.5-volt reading under load. Another response was not to exceed 50 percent DOD which is approximately a 11.5-volt reading under load.

  We are suggesting that before purchasing a sign, discuss the "shutdown" setting with the manufacturer to be sure the setting is appropriate with sign's power system. Even though the sign may rarely reach its "shutdown" voltage, it is important to note that discharging a battery more than 50 percent DOD on a regular basis can shorten battery life and a battery discharged to 75 percent DOD can freeze at 5 degrees F.

- Just as important as the "shutdown" voltage is the "startup" voltage. Again this varied on the signs tested which were set as low as 10.8 volts and as high as 12.5 volts. Some of the signs had the Auto-resume feature causing the message to resume after the signs reached their preset "startup" voltage. It is recommended to verify that the "startup" voltage setting is correct for sign's power system. Depending on the sign's solar array output, load current and battery-bank capacity, an incorrect "startup" voltage setting may not allow the battery-bank to be properly charged before the message is resumed.

Test Results Summary

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PCMS(2007)- 01

Product Information
Product Name/Model: Silent Messenger MB-4048
Company: Solar Technology, Inc.
Address: 7620 Cetronia Road, Allentown, PA, 18106
Phone: (610) 391-8600, FAX (410) 788-0714
Web Site: www.solartechnology.com

3.0 Sight Tests Results – PCMS(2007)- 01

Visibility Results –
Daytime: 4800 feet
Nighttime: 4800 feet
Legibility Results –
Daytime "Word": 1035 feet
Daytime "Eye Chart": 967 feet
Nighttime "Word": 904 feet
Nighttime "Eye Chart": 747 feet
Angularity Results –
Daytime: 56 feet / 24.2 degrees (half-angle calculation)
Nighttime: 16 feet / 57.4 degrees (half-angle calculation)

4.0 Operation Performance Tests Results – PCMS(2007)- 01

Power System Configuration as Tested –
Solar Array output: 450 W
Battery-bank: Eight Crown CR-225 6 V Deep-cycle batteries, 900 Ah @ 12 Vdc (20 hr. rate)
Durability Results –
Testing period: 2/15/07 through 3/17/07
Beginning Voltage: 13.0 V per sign's diagnostics, 13.02 V per voltmeter
Ending Voltage: 12.9 V per sign's diagnostics, 12.93 V per voltmeter
Testing Comments: – It is the opinion of the team that the sign's charging system kept the battery-bank properly charged during the test.
Reliability Results –
Solar array disconnect date: 3/18/07
Date found non-operational: 4/1/07 (see Testing Comments below)
Days of operation: 14 days (see Figure 1 and Testing Comments below)
Sign's "shutdown" voltage setting: 10.7 V
Voltage measured at shutdown: N/A (see Testing Comments below)

4.0 Operation Performance Tests Results – PCMS(2007)- 01

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck on 4/01 to find the display flashing "Caution". Since it appeared the MB-4048 was having the same problems as the MB2-3048 (see Failures or Significant Problems for the PCMS(2007)- 06) the team stopped the test to trouble shoot the sign. The team later learned that the flashing "Caution" was a default message to alert the operator that the battery-bank voltage was reaching a low voltage condition. Unfortunately, with the sign being stopped prematurely, the test could not be continued. With the positive results of the MB-4048 during the 2006 NTPEP evaluation, the team believes the sign was functioning properly.

- When reviewing the Days of Operation result, keep in mind that the number is not an accurate result of the sign's battery-bank performance. By reviewing the voltage chart below, it can be assumed that the sign would have operated several more days before reaching the sign's shutdown voltage of 10.7 volts.

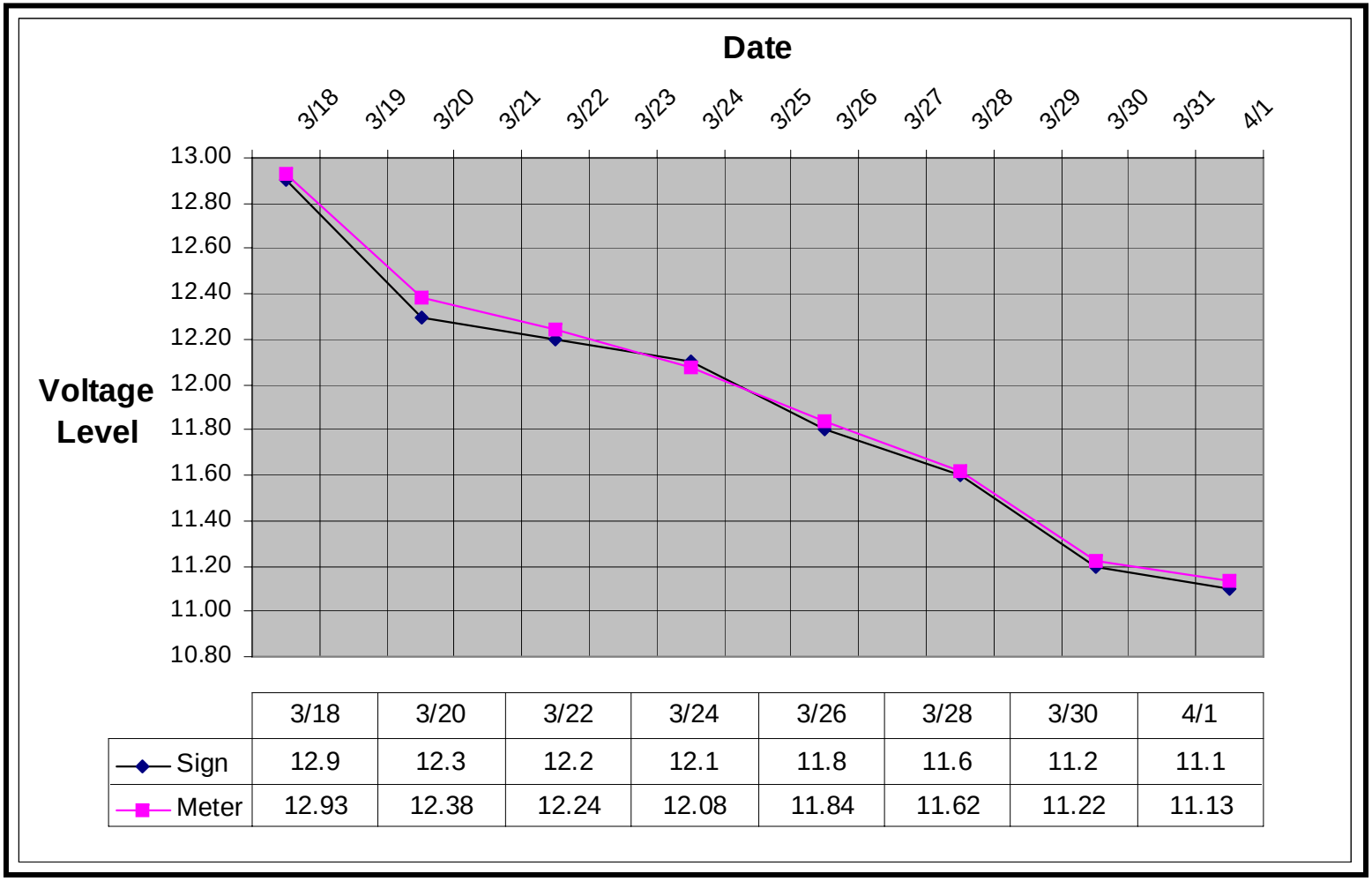
- The sign's solar array was reconnected and the battery-bank charged to operational voltage. The test's programmed message was in the controller memory and the sign functioned properly.

Failures or Significant Problems –

- In preparing for the Sight Test at the Wilson Airport test deck on 6/08, the team found that both Solar Technology signs would not display a message. The CPU on each unit displayed the same "loss of data signal" warning message that the team experienced with MB2-3048 during Reliability testing. A technician arrived the next day and replaced a bad display module on each sign. At Solar Technology's suggestion, the technician returned on 6/11 and replaced all display modules on both signs.

The team gave Solar Technology an opportunity to explain the above problem. The following is their response:

- Solar Technology Inc. received faulty components (surface mount trimmers) from the manufacturer of the trimmer. This part is used to allow fine adjustment of the LED light output. Once we discovered the problem we took action to recall all units that contained the faulty components and replaced all of them at no cost to our customers per our standard warranty policy. The NTPEP test units fell within the recall.



	3/18	3/20	3/22	3/24	3/26	3/28	3/30	4/1
Sign	12.9	12.3	12.2	12.1	11.8	11.6	11.2	11.1
Meter	12.93	12.38	12.24	12.08	11.84	11.62	11.22	11.13

Figure 1 – PCMS(2007)- 01 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2007)- 01
Sign Panel
• Display Type: LED Full Matrix
• Panel Size: 126 in. wide x 76 in. high
• Maximum number of 5 x 7 characters per line: Eight
• 5 x 7 element character size: 18 in. high x 12 in. wide
• 5 x 7 element character spacing: 2.6 in.
• LEDs (pixels) per element: Three
• LED angularity specification tested: 60 degree
• Alignment sighting tube
• Electro-hydraulic panel lift (optional manual back-up system)
• ± 360 degree panel rotation
Power System
• Onboard diagnostics can check solar array and battery-bank status
• Available solar array wattage outputs: 225 W, 300 W, 375 W, 450 W (tested)
• Standard battery-bank: Eight 6 V Deep-cycle batteries, 900 Ah @ 12 Vdc (20 hr. rating)
• 45 amp battery charger is standard
• Recharge time of standard battery-bank: 24 hours
• AC power capability via battery charger
• Battery-bank is stored in a lockable weather-resistant enclosure
• Solar panels cannot be tilted during normal operation
Controller System
• Input device: Backlit QWERTY style custom keyboard
• Backlit Controller display
• Menu driven programming
• Multilevel password protection
• Automatic test function for pixels and modules
• Quick-program feature
• User controlled default message
• "Auto-resume" feature after power interruption
• 21 pre-programmed messages
• 200 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2007)- 01
Controller System (continued)
• Sixteen messages can be displayed sequentially
• Message display time: 0.1 to 99.0 seconds
• Message flash time: 0.1 to 99.0 seconds
• Manual dimming capability
• Controller software upgrades via laptop
• Controller is stored in lockable weather-resistant enclosure
General
• Operating temperature: – 40 to +185 ˚F
• Reverse surge trailer brakes
• Tongue wheel is optional
• Nominal operating height: 162 in.
• Maximum wind load: 80 mph
• Maximum towing speed: 75 mph
• Transport dimensions: 180 in. length x 92 in. width x 102 in. height
• Weight: 2675 lb., 2960 lb. with optional battery pack
• Tongue weight: 175 lb.

PCMS(2007)- 02

Product Information
Product Name/Model: Portable Vanguard Series VP-4000
Company: Daktronics
Address: 331 32nd Avenue, Brookings, SD, 57006
Phone: (605) 696-3061, FAX (605) 697-4700
Web Site: www.daktronics.com

3.0 Sight Tests Results – PCMS(2007)- 02
Visibility Results –
Daytime: 4800 feet
Nighttime: 4800 feet
Legibility Results –
Daytime "Word": 1028 feet
Daytime "Eye Chart": 946 feet
Nighttime "Word": 872 feet
Nighttime "Eye Chart": 820 feet
Angularity Results –
Daytime: 62 feet / 22.1 degrees (half-angle calculation)
Nighttime: 26 feet / 43.5 degrees (half-angle calculation)

4.0 Operation Performance Tests Results – PCMS(2007)- 02
Power System Configuration as Tested –
Solar Array output: 440 W
Battery-bank: Eight Rayonac 2GC-220 6V batteries, 880 Ah @ 12 Vdc (20 hr. rate)
Durability Results –
Testing period: 2/15/07 through 3/17/07
Beginning Voltage: 12.96 V per voltmeter
Ending Voltage: 13.02 V per voltmeter
Testing Comments: – It is the opinion of the team that the sign's charging system kept the battery-bank properly charged during the test.
Reliability Results –
Solar array disconnect date: 3/18/06
Date found non-operational: 3/28/06
Days of operation: 10 days (see Figure 2)
Sign's "shutdown" voltage setting: 11.5 V
Voltage measured at shutdown: 11.64 V per sign's diagnostics, 11.26 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2007)- 02

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck on 3/28 to find the display message off and the Low Voltage Disconnect LED illuminated. Even though the sign's voltage reading was 11.64 V per the voltmeter, it is the team's opinion that the sign did cease operation at the 11.5 V shutdown voltage setting. The 11.64 V reading is the result of battery recovery once the sign ceased operation.

- The sign's solar array was reconnected and the battery-bank charged to operational voltage. The test's programmed message was in the controller memory and the sign functioned properly.

Failures or Significant Problems –

- When the sign was delivered at the Raleigh test deck, the sign would only rotate in one direction. The Daktronics' technician who delivered the sign found the problem and repaired the motor mechanism that rotates the sign. There were no further problems during testing.

- On 3/24 during Reliability testing, the team found two LEDs out in an element on the letter "I" .

The team gave Daktronics an opportunity to explain the above problems. The following is their response:

- Motorized display rotation problem: It was found that there was a faulty adjustment of the worm gear connecting key plate that caused the key to loosen up and lose connection with the worm gear. This adjustment is now corrected and is an item on the quality control verification list.

- LED Pixel defect: One LED in the pixel was defective. Daktronics' pixel design consists of four LEDs. Each pixel has two strings of two LEDs each. The failure of an individual LED or solder joint can result in the failure of one string while the redundant string will continue to function. All LEDs were tested and functioning prior to the unit leaving manufacturing facility.

Figure 2 – PCMS(2007)-02 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2007)- 02
Sign Panel
• Display Type: LED Full Matrix
• Panel Size: 131 in. wide x 75 1/8 in. high
• Maximum number of 5 x 7 characters per line: Eight
• 5 x 7 element character size: 18 in. high x 13 in. wide
• 5 x 7 element character spacing: 4 1/8 in.
• LEDs (pixels) per element: Four
• LED angularity specification tested: 30 x 30 degree
• Alignment sighting tube
• Electro-hydraulic panel lift (optional manual back-up system)
• ± 360 degree panel rotation
Power System
• Onboard diagnostics to check solar array and battery-bank status was not available for sign tested
• Available solar array wattage outputs: 220 W, 440 W (tested)
• Standard battery-bank: Eight 6 V Deep-cycle batteries, 880 Ah @ 12 Vdc (20 hr. rating)
• 45 amp battery charger is optional
• Recharge time of standard battery-bank: 24 hours
• AC power capability via battery charger
• Battery-bank is stored in a lockable weather-resistant enclosure
• Solar panels can be tilted with optional tilt system
Controller System
• Input device: Keyboard and keypad with external lighting
• Backlit Controller display
• Menu driven programming
• Multilevel password protection
• Automatic test function
• Quick-program feature
• User controlled default message
• "Auto-resume" feature after power interruption
• 364 pre-programmed messages
• 500 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2007)- 02
Controller System (continued)
• Six messages can be displayed sequentially
• Message display time: 0.1 to 25.5
• Message flash time: 0.1 to 25.5
• Manual dimming capability
• Controller software upgrades via local Ethernet, Serial Port or Data Key
• Controller is stored in lockable weather-resistant enclosure
General
• Operating temperature: – 40 to +176 ˚F
• Trailer brakes: SAE Class III Hydraulic brake with breakaway cable activated emergency and manual reverse lockout lever
• Tongue wheel is optional
• Nominal operating height: 162 in.
• Maximum wind load: 80 mph using AASHTO standard
• Maximum towing speed: 65 mph
• Transport dimensions: 187 in. length x 79 in. width x 103 in. height
• Weight: 2950 lb. with standard battery pack and 2 solar panels, 3450 lb. with optional battery pack and solar panels
• Tongue weight: 10 to 15 percent of total weight

PCMS(2007)- 03

Product Information
Product Name/Model: Solar Message Center SMC-1000 HE
Company: Precision Solar Controls Inc.
Address: 2985 Market St., Garland, TX, 75041
Phone: (972) 278-0553, FAX (972) 271-9583
Web Site: www.precisionsolarcontrols.com

3.0 Sight Tests Results – PCMS(2007)- 03

Visibility Results –
Daytime: 4800 feet
Nighttime: 4800 feet
Legibility Results –
Daytime "Word": 1107 feet
Daytime "Eye Chart": 994 feet
Nighttime "Word": 920 feet
Nighttime "Eye Chart": 669 feet
Angularity Results –
Daytime: 126 feet / 11.3 degrees (half-angle calculation)
Nighttime: 29 feet / 40.8 degrees (half-angle calculation)

4.0 Operation Performance Tests Results – PCMS(2007)- 03

Power System Configuration as Tested –
Solar Array output: 110 W
Battery-bank: Three Continental 4DMT-DC Deep-cycle batteries, 600 Ah @12 Vdc (20 hr. rate)
Durability Results –
Testing period: 2/15/07 through 3/17/07
Beginning Voltage: 12.85 V per sign's diagnostics, 12.89 V per voltmeter
Ending Voltage: 12.85 V per sign's diagnostics, 12.93 V per voltmeter
Testing Comments: – It is the opinion of the team that the sign's charging system kept the battery-bank properly charged during the test.
Reliability Results –
Solar array disconnect date: 3/18/07
Date found non-operational: 4/18/07
Days of operation: 31 days (see Figure 3)
Sign's "shutdown" voltage setting: 10.6 V
Voltage measured at shutdown: 10.85 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2007)- 03

Reliability Results (continued)–

Testing Comments:

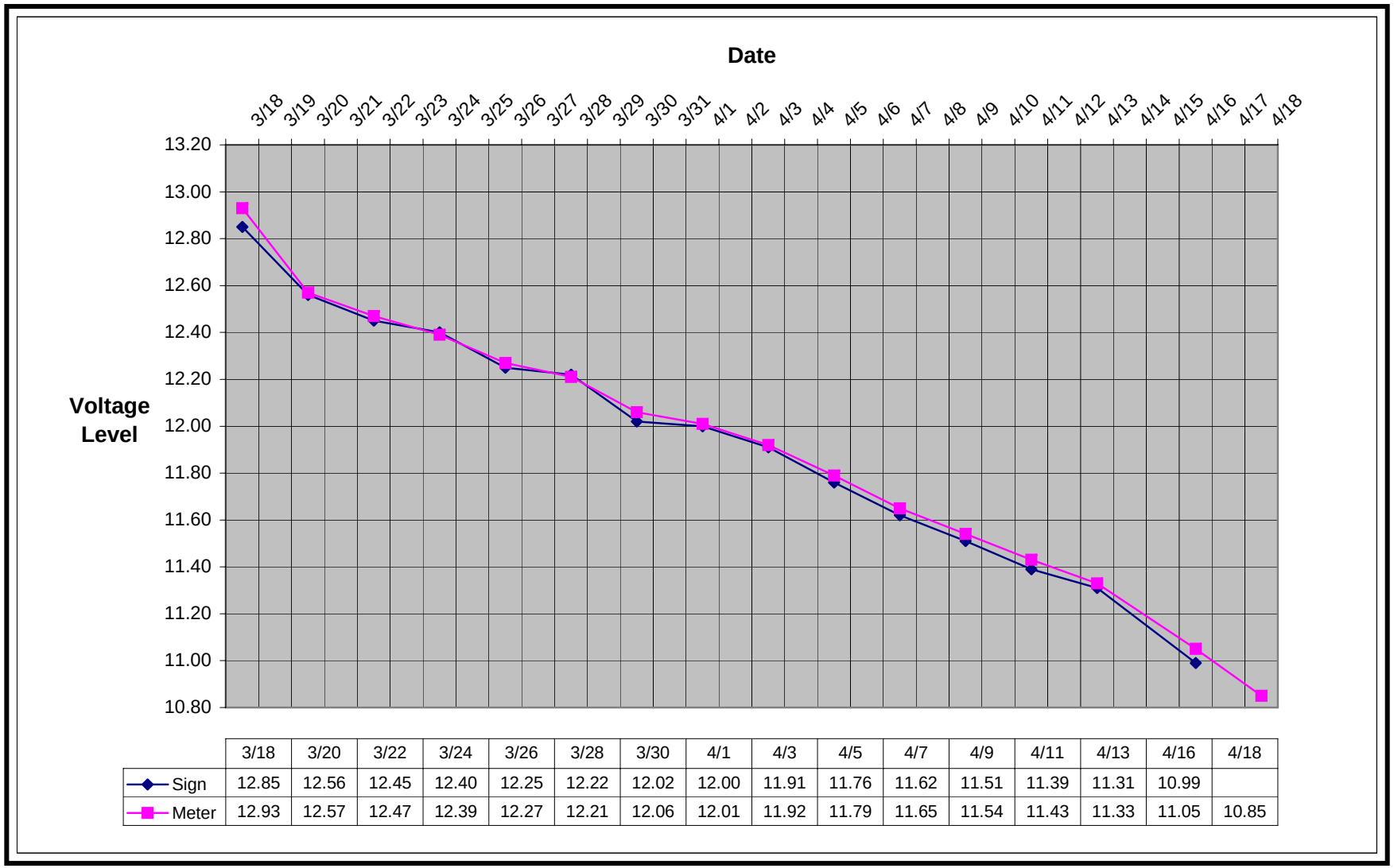
- The sign is programmed to change to a default message when the battery-bank voltage drops to a low voltage condition. The default message by the factory is a "Four Point Caution" and will default to the message when the voltage drops below 11.0 volts. Since the default message is programmable, the team decided to change the factory default message to a three-line message. The team arrived at the test deck on 4/16 to find the sign had defaulted to the programmed message, battery-bank voltage was 10.99 V per the sign's diagnostics.

- The team arrived at the test deck on 4/18 to find the display message off, the CPU off and the Battery Condition LED illuminated. Even though the sign's voltage reading was 10.85 V per the voltmeter, it is the team's opinion that the sign did cease operation at the 10.6 V shutdown voltage setting. The 10.85 V reading is the result of battery recovery once the sign ceased operation.

- The sign's solar array was reconnected and the battery-bank charged to operational voltage. The test's programmed message was in the controller memory and the sign functioned properly.

Failures or Significant Problems –

There were no failures or significant problems found during testing.



	3/18	3/20	3/22	3/24	3/26	3/28	3/30	4/1	4/3	4/5	4/7	4/9	4/11	4/13	4/16	4/18
Sign	12.85	12.56	12.45	12.40	12.25	12.22	12.02	12.00	11.91	11.76	11.62	11.51	11.39	11.31	10.99	
Meter	12.93	12.57	12.47	12.39	12.27	12.21	12.06	12.01	11.92	11.79	11.65	11.54	11.43	11.33	11.05	10.85

Figure 3 – PCMS(2007)- 03 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2007)- 03
Sign Panel
• Display type: LED Character Matrix
• Panel size: 127 in. wide x 74 1/2 in. high
• Maximum number of 5 x 7 characters per line: Eight
• 5 x 7 element character size: 18 in. high x 12 in. wide
• 5 x 7 element character spacing: 3 in.
• LEDs (pixels) per element: Four
• LED angularity specification tested: Minimum 21 degrees horizontal x 7 degrees vertical
• Alignment sighting tube
• Electro-hydraulic panel lift (optional manual back-up system)
• ± 360 degree panel rotation
Power System
• Onboard diagnostics can check solar array and battery-bank charging status
• Available solar array wattage outputs: 110 W (tested)
• Standard battery-bank: Three 12 V Deep-cycle batteries, 600 Ah @ 12 Vdc (20 hr. rating)
• 25 amp battery charger is standard
• Recharge time of standard battery-bank: 24 – 36 hours
• The sign does not have AC power capability
• Battery-bank is stored in a lockable weather-resistant enclosure
• Solar panels cannot be tilted for normal operation
Controller System
• Input device: Keyboard with external lighting
• External lighted Controller display
• Menu driven programming
• Single level password protection
• No automatic test functions
• Quick-program feature
• User controlled default message
• Does not have “Auto-resume” feature after power interruption
• 250 pre-programmed messages
• 100 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2007)- 03
Controller System (continued)
• Thirteen messages can be displayed sequentially
• Message display time intervals: 0.1 to 25.5 seconds
• Message flash time: Default is 0.7 on – 0.7 off, changeable by user
• Manual dimming capability
• Controller software can be updated via laptop or factory technician
• Controller is stored in lockable weather-resistant enclosure
General
• Operating temperature: – 40 to +165 ˚F
• Surge trailer brakes
• Tongue wheel is optional
• Nominal operating height: 158 in.
• Maximum wind load: 65 mph with gusts to 92 mph
• Maximum towing speed: 65 mph
• Transport dimensions: 194 1/2 in. length x 95 in. width x 105 1/2 in. height
• Weight: 2600 lb.
• Tongue weight: 385 lb.

PCMS(2007)- 04

Product Information
Product Name/Model: Solar Message Center SMC-2000 FM
Company: Precision Solar Controls Inc.
Address: 2985 Market St., Garland, TX, 75041
Phone: (972) 278-0553, FAX (972) 271-9583
Web Site: www.precisionsolarcontrols.com

3.0 Sight Tests Results – PCMS(2007)- 04

Visibility Results –
Daytime: 4028 feet
Nighttime: 4800 feet
Legibility Results –
Daytime "Word": 1055 feet
Daytime "Eye Chart": 913 feet
Nighttime "Word": 990 feet
Nighttime "Eye Chart": 899 feet
Angularity Results –
Daytime: 142 feet / 10 degrees (half-angle calculation)
Nighttime: 27 feet / 42.8 degrees (half-angle calculation)

4.0 Operation Performance Tests Results – PCMS(2007)- 04

Power System Configuration as Tested –
Solar Array output: 150 W
Battery-bank: Four Continental 4DMT-DC Deep-cycle batteries, 800 Ah @12 Vdc (20 hr. rate)
Durability Results –
Testing period: 2/15/07 through 3/17/07
Beginning Voltage: 12.91 V per sign's diagnostics, 12.94 V per voltmeter
Ending Voltage: 12.96 V per sign's diagnostics, 13.01 V per voltmeter
Testing Comments: – It is the opinion of the team that the sign's charging system kept the battery-bank properly charged during the test.
Reliability Results –
Solar array disconnect date: 3/18/07
Date found non-operational: 5/03/07
Days of operation: 46 days (see Figure 4 and Testing Comments)
Sign's "shutdown" voltage setting: 10.6 V
Voltage measured at shutdown: 10.83 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2007)- 04

Reliability Results (continued)–

Testing Comments:

- The main purpose of the Reliability test is to verify the sign's ability to cease operation at a preset "shutdown" voltage. After the sign had surpassed 30 days on battery back-up (the benchmark for most states requirements), the team wanted to end the test as soon as possible. On 4/22, the team decided to modify the sign by changing the dimming setting from automatic mode to manual mode. Under the manual mode setting, the display was set to Full Brightness (15) which the team felt was a suitable solution for increasing the drain on the battery-bank. When reviewing the Days of Operation result, keep in mind that the number is not an accurate result of the sign's battery-bank performance.

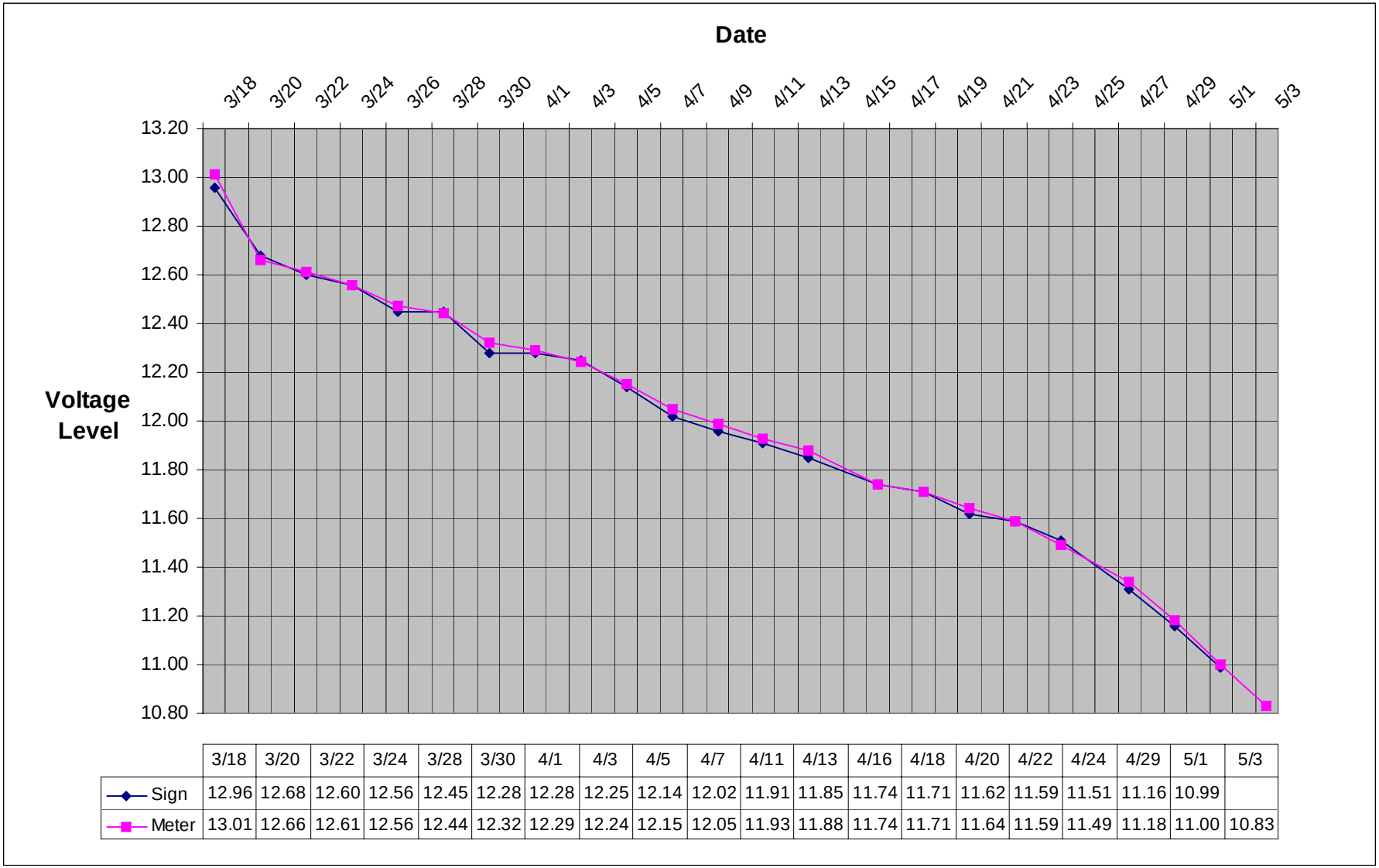
- The sign is programmed to change to a default message when the battery-bank voltage drops to a low voltage condition. The default message by the factory is a "Four Point Caution" and will default to the message when the voltage drops below 11.0 volts. Since the default message is programmable, the team decided to change the factory default message to a three-line message. The team arrived at the test deck on 5/01 to find the sign had defaulted to the programmed message, battery-bank voltage was 10.99 V per the sign's diagnostics.

- The team arrived at the test deck on 5/03 to find the display message off, the CPU off and the Battery Condition LED illuminated. Even though the sign's voltage reading was 10.83 V per the voltmeter, it is the team's opinion that the sign did cease operation at the 10.6 V shutdown voltage setting. The 10.83 V reading is the result of battery recovery once the sign ceased operation.

- The sign's solar array was reconnected and the battery-bank charged to operational voltage. The test's programmed message was in the controller memory and the sign functioned properly.

Failures or Significant Problems –

There were no failures or significant problems found during testing.



	3/18	3/20	3/22	3/24	3/28	3/30	4/1	4/3	4/5	4/7	4/11	4/13	4/16	4/18	4/20	4/22	4/24	4/29	5/1	5/3
Sign	12.96	12.68	12.60	12.56	12.45	12.28	12.28	12.25	12.14	12.02	11.91	11.85	11.74	11.71	11.62	11.59	11.51	11.16	10.99	
Meter	13.01	12.66	12.61	12.56	12.44	12.32	12.29	12.24	12.15	12.05	11.93	11.88	11.74	11.71	11.64	11.59	11.49	11.18	11.00	10.83

Figure 4 – PCMS(2007)- 04 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2007)- 04
Sign Panel
• Display type: LED Full Matrix
• Panel size: 139 in. wide x 76 in. high
• Maximum number of 5 x 7 characters per line: Eight
• 5 x 7 element character size: 19.2 in. high x 13.6 in. wide
• 5 x 7 element character spacing: 3 in.
• LEDs (pixels) per element: Four
• LED angularity specification tested: Minimum 21 degrees horizontal x 7 degrees vertical
• Alignment sighting tube
• Electro-hydraulic panel lift (optional manual back-up system)
• ± 360 degree panel rotation
Power System
• Onboard diagnostics can check solar array and battery-bank charging status
• Available solar array wattage outputs: 150 W (tested)
• Standard battery-bank: Four 12 V Deep-cycle batteries, 800 Ah @ 12 Vdc (20 hr. rating)
• 25 amp battery charger is standard
• Recharge time of standard battery-bank: 24 – 36 hours
• No AC power capability
• Battery-bank is stored in a lockable weather-resistant enclosure
• Solar panels cannot be tilted for normal operation
Controller System
• Input device: Keyboard with external lighting
• External lighted Controller display
• Menu driven programming
• Single level password protection
• No automatic test functions
• Quick-program feature
• User controlled default message
• Does not have “Auto-resume” feature after power interruption
• 250 pre-programmed messages
• 100 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2007)- 04
Controller System (continued)
• Thirteen messages can be displayed sequentially
• Message display time intervals: 0.1 to 25.5 seconds
• Message flash time: Default is 0.7 on – 0.7 off, changeable by user
• Manual dimming capability
• Controller software can be updated via laptop or factory technician
• Controller is stored in lockable weather-resistant enclosure
General
• Operating temperature: – 40 to +165 ˚F
• Surge trailer brakes
• Tongue wheel is optional
• Nominal operating height: 160 in.
• Maximum wind load: 65 mph with gusts to 92 mph
• Maximum towing speed: 65 mph
• Transport dimensions: 194 1/2 in. length x 93 in. width x 107 in. height
• Weight: 2850 lb.
• Tongue weight: 445 lb.

PCMS(2007)- 05

Product Information
Product Name/Model: Advance Warner M-90
Company: Protection Services Inc.
Address: 635 Lucknow Road, Harriburg, PA 17110
Phone: (717) 257-4220, FAX (717) 236-1281
Web Site: www.protectionservices.com

3.0 Sight Tests Results – PCMS(2007)- 05
Visibility Results –
Daytime: 4800 feet
Nighttime: 4800 feet
Legibility Results –
Daytime: 4800 feet
Nighttime: 3525 feet
Angularity Results –
Daytime: 109 feet / 13 degrees (half-angle calculation)
Nighttime: 20 feet / 51 degrees (half-angle calculation)

4.0 Operation Performance Tests Results – PCMS(2007)- 05
Power System Configuration as Tested –
Solar Array output: 40 W
Battery-bank: Three NAPA 27DC #8270 Deep-cycle batteries, 315 Ah @ 12Vdc (20 hr. rate)
Durability Results –
Testing period: 2/15/07 through 3/17/07
Beginning Voltage: 12.72 V per voltmeter
Ending Voltage: 12.65 V per voltmeter
Testing Comments: – It is the opinion of the team that the sign's charging system kept the battery-bank properly charged during the test.
Reliability Results –
Solar array disconnect date: 3/18/07
Date found non-operational: 4/13/07
Days of operation: 26 days (see Figure 5)
Sign's "shutdown" voltage setting: 10.8 V
Voltage measured at shutdown: 9.30 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2007)- 05

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck on 4/11 to find the display in "Four Point Caution" mode. This is a default mode of the sign to indicate the battery-bank is in a low voltage condition and defaults when the voltage drops to 11.2 volts.

- The team arrived at the test deck on 4/13 and found the display off. The voltage found at shutdown was 9.30 volts which was much lower than the 10.8 volts per the shutdown voltage specification. The solar array was reconnected and the battery-bank charged to operational voltage. The sign functioned properly.

  The team questioned the final voltage reading and contacted a technical adviser with the battery industry for an explanation. He suggested that there may be a dead cell in one of the batteries and to verify with a hydrometer. On 4/18, each battery was checked for its voltage and all cells checked with a hydrometer. Each battery appeared good with no bad cells found.

  The team contacted the technical advisor again for an explanation, but the possible causes were again speculative with no apparent way to verify . Except for shutdown voltage deviation, it is the team's opinion that the sign functioned properly.

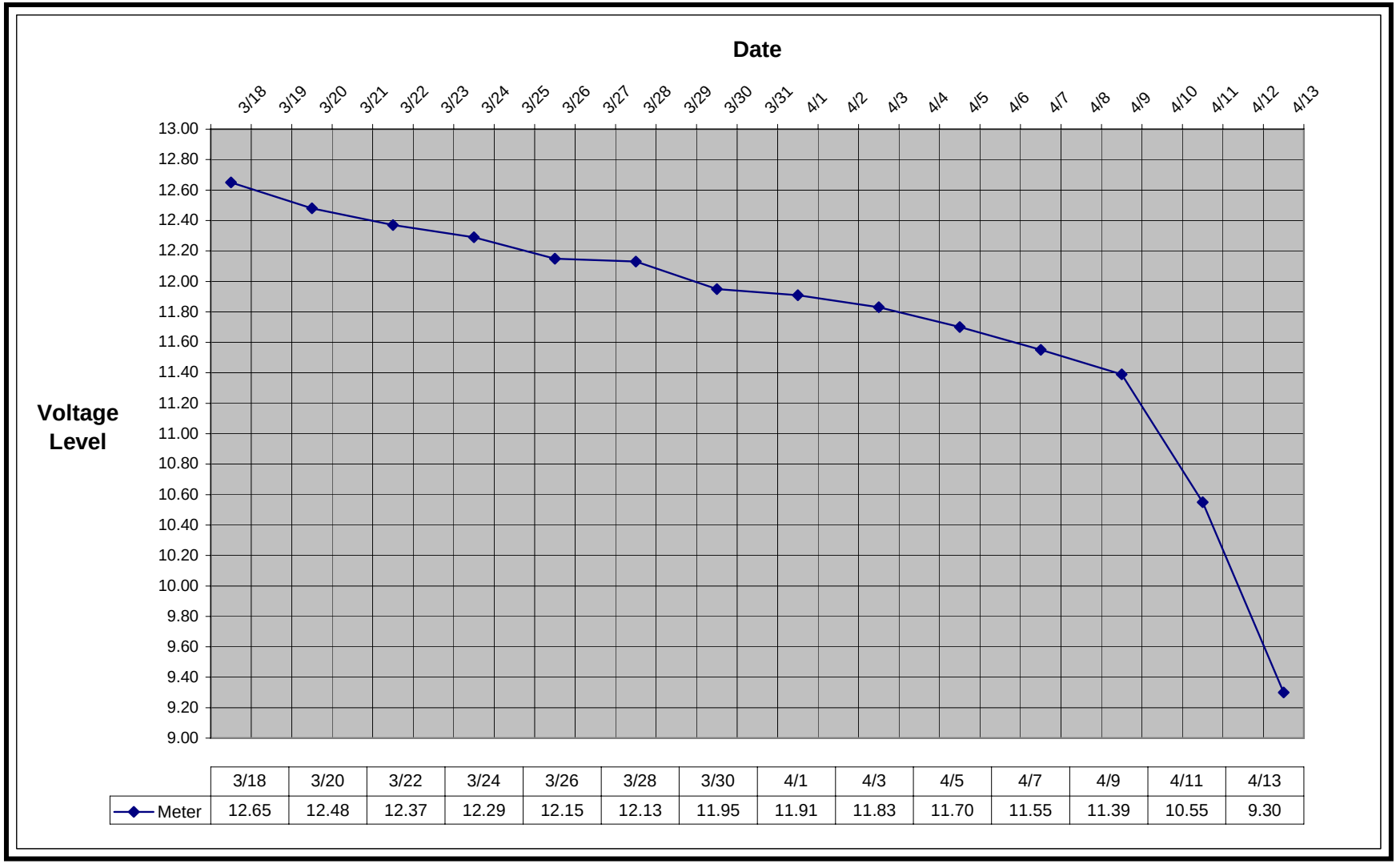
Flashing Rate Results –

Flashes per minute: 34

Dwell time ON: 0.80 seconds

Failures or Significant Problems –

- On 6/13 during Sight testing, the winch handle broke allowing the sign to be raised, but not lowered.



	3/18	3/20	3/22	3/24	3/26	3/28	3/30	4/1	4/3	4/5	4/7	4/9	4/11	4/13
Meter	12.65	12.48	12.37	12.29	12.15	12.13	11.95	11.91	11.83	11.70	11.55	11.39	10.55	9.30

Figure 5 – PCMS(2007)- 05 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2007)- 05
Sign Panel
• MUTCD panel type: Type C, 15 lamps
• Lamp type: LED Par 46
• Available display modes: Left and Right Single Flashing Arrow, Double Flashing Arrow, Left and Right Sequential Arrow, Center Bar Caution, Four-Corner Caution
• Alignment sighting device
Power System
• Available solar array wattage outputs: 40 W (tested)
• Standard battery-bank: Three 12 V Deep-cycle batteries, 315 Ah @ 12 Vdc (20 hr. rating)
• 10 amp battery charger is standard
• Recharge time of standard battery-bank: 30 hours @ 10 amps
• AC power capable via battery charger
• Battery-bank is stored in a lockable weather-resistant enclosure
• Solar panels cannot be tilted for normal operation
Controller System
• Controller display is backlit
• No manual dimming capability
• Battery-bank status indicator
• Controller is stored in lockable weather-resistant enclosure
General
• Operating temperature: –10 to +175 ˚F
• Nominal operating height: 142 in.
• Maximum wind load: N/A
• Maximum towing speed: 70 mph
• Transport dimensions: 110 in. length x 96 in. width x 88 in. height
• Weight: 940 lb.

(Blank)

PCMS(2007)- 06

Product Information
Product Name/Model: Silent Messenger II MB2-3048
Company: Solar Technology, Inc.
Address: 7620 Cetronia Road, Allentown, PA, 18106
Phone: (610) 391-8600, FAX (410) 788-0714
Web Site: www.solartechnology.com

3.0 Sight Tests Results – PCMS(2007)- 06
Visibility Results –
Daytime: 4800 feet
Nighttime: 4800 feet
Legibility Results –
Daytime "Word": 770 feet
Daytime "Eye Chart": 697 feet
Nighttime "Word": 640 feet
Nighttime "Eye Chart": 548 feet
Angularity Results –
Daytime: 63 feet / 21.5 degrees (half-angle calculation)
Nighttime: 20 feet / 51 degrees (half-angle calculation)

4.0 Operation Performance Tests Results – PCMS(2007)- 06
Power System Configuration as Tested –
Solar Array output: 300 W
Battery-bank: Eight Crown CR-225 6 V Deep-cycle batteries, 900 Ah @ 12 Vdc (20 hr. rate)
Durability Results –
Testing period: 2/15/07 through 3/17/07
Beginning Voltage: 12.7 V per sign's diagnostics, 12.90 V per voltmeter
Ending Voltage: 12.8 V per sign's diagnostics, 12.98 V per voltmeter
Testing Comments: – It is the opinion of the team that the sign's charging system kept the battery-bank properly charged during the test.
Reliability Results –
Solar array disconnect date: 3/18/07
Date found non-operational: 3/30/07 (see Failures or Significant Problems)
Days of operation: 12 days (see Figure 6 and Testing Comments)
Sign's "shutdown" voltage setting: 10.7 V
Voltage measured at shutdown: N/A (see Testing Comments)

4.0 Operation Performance Tests Results – PCMS(2007)- 06

Reliability Results (continued)–

Testing Comments:

- The Days of Operation result was based on the sign being found non-operational on 3/30. Even though the sign was not able to be shut down per the test plan, the voltage chart below can be used to estimate the days of operation.

Failures or Significant Problems –

- The team arrived at the test deck on 3/30 and found the intensity on some elements of "A" and "H" changing brightness. Except for those elements, the sign appeared to be functioning properly and voltage measurements were recorded. The team was preparing to leave the test deck and discovered the display was off. The CPU display was showing the following message: " >>Warning<<, loss of data signal from sign panel has occurred". The CPU was restarted and sign appeared to be functioning properly again.

  The team arrived at the test deck on 4/01 and found the display flashing "Caution". The CPU display was showing the following message: ">>Caution<<, temporary loss of data signal from sign panel has occurred". The CPU was restarted and sign again appeared to be functioning properly again.

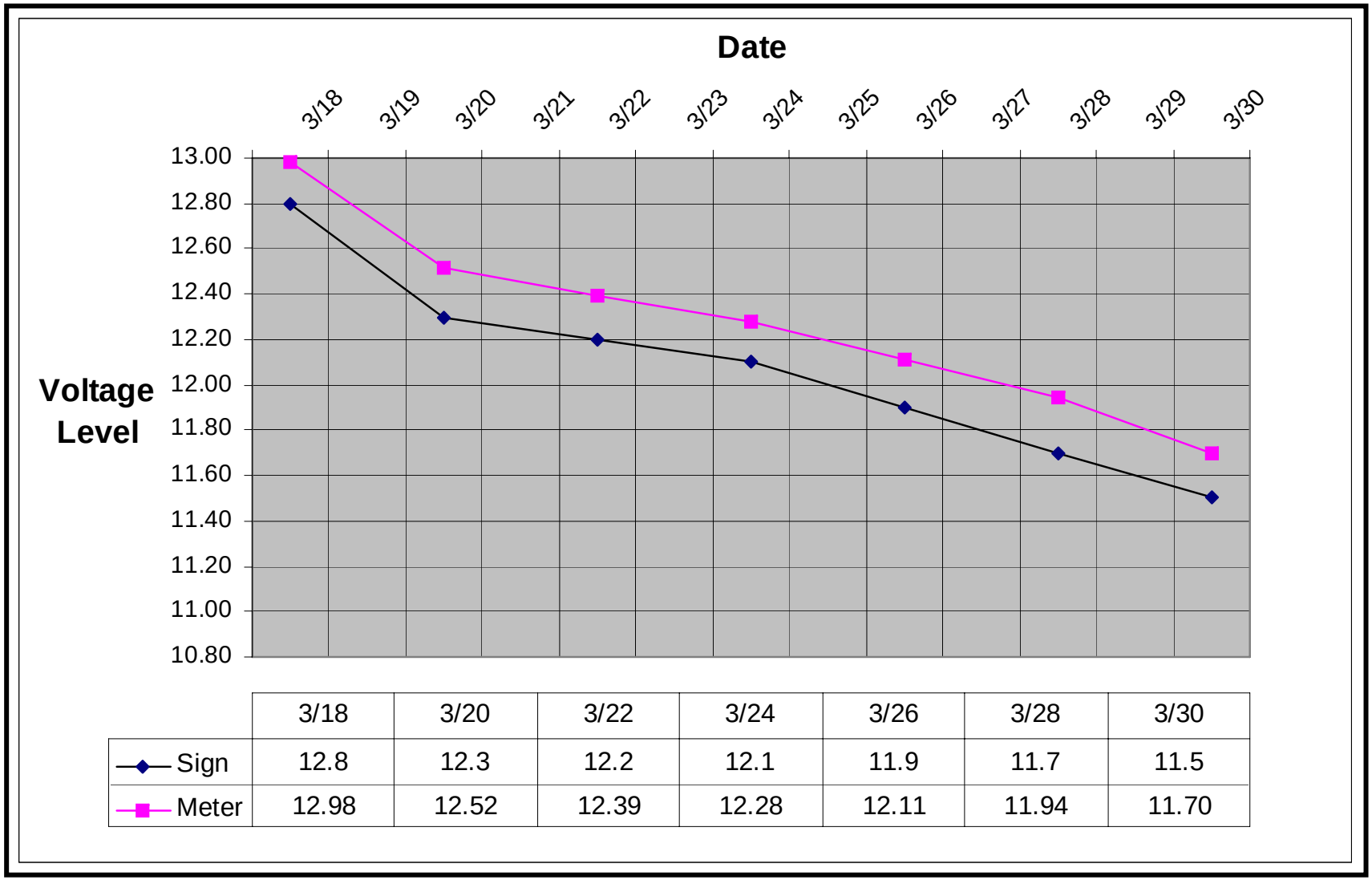
  On returning trips to the test deck the sign continued to either not display a message or display the "Caution" message with the "loss of data signal" warning message on the CPU. On 4/05, the solar array was reconnected and after charging, the sign appeared to be functioning properly. Message was turned off to allow the battery-bank to fully recharge.

- On 4/24, the sign was restarted but sign would not display a full message. The CPU was displaying the "loss of data signal" warning message. The team contacted Solar Technology who sent a technician to troubleshoot the problem. A bad display module was found and replaced.

- In preparing for the Sight Test at the Wilson Airport test deck on 6/08, the team found that both Solar Technology signs would not display a message. The CPU on each unit displayed the same "loss of data signal" warning message that the team experienced with MB2-3048 during Reliability testing. A technician arrived the next day and replaced a bad display module on each sign. At Solar Technology's suggestion, the technician returned on 6/11 and replaced all display modules on both signs.

The team gave Solar Technology an opportunity to explain the above problem. The following is their response:

- Solar Technology Inc. received faulty components (surface mount trimmers) from the manufacturer of the trimmer. This part is used to allow fine adjustment of the LED light output. Once we discovered the problem we took action to recall all units that contained the faulty components and replaced all of them at no cost to our customers per our standard warranty policy. The NTPEP test units fell within the recall.



	3/18	3/20	3/22	3/24	3/26	3/28	3/30
Sign	12.8	12.3	12.2	12.1	11.9	11.7	11.5
Meter	12.98	12.52	12.39	12.28	12.11	11.94	11.70

Figure 6 – PCMS(2007)- 06 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2007)- 06
Sign Panel
• Display Type: LED Full Matrix
• Panel Size: 92 in. wide x 54 in. high
• Maximum number of 5 x 7 characters per line: Eight
• 5 x 7 element character size: 12 in. high x 9 in. wide
• 5 x 7 element character spacing: 1.80 in.
• LEDs (pixels) per element: Three
• LED angularity specification tested: 60 degree
• Alignment sighting tubes
• Winch lift system for raising and lowering sign
Power System
• Onboard diagnostics can check solar array and battery-bank status
• Available solar array wattage outputs: 225 W, 300 W (tested)
• Standard battery-bank: Eight 6 V Deep-cycle batteries, 900 Ah @ 12 Vdc (20 hr. rating)
• 45 amp battery charger is standard
• Recharge time of standard battery-bank: 24 hours
• AC power capablility via battery charger
• Battery-bank is stored in a lockable weather-resistant enclosure
• Solar panels cannot be tilted during normal operation
Controller System
• Input device: Backlit QWERTY style custom keyboard
• Backlit Controller display
• Menu driven programming
• Multilevel password protection
• Automatic test function for pixels and modules
• Quick-program feature
• User controlled default message
• "Auto-resume" feature after power interruption
• 21 pre-programmed messages
• 200 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2007)- 06
Controller System (continued)
• Sixteen messages can be displayed sequentially
• Message display time: 0.1 to 99.0 seconds
• Message flash time: 0.1 to 99.0 seconds
• Manual dimming capability
• Controller software upgrades via laptop
• Controller is stored in lockable weather-resistant enclosure
General
• Operating temperature: – 40 to +185 ˚F
• Trailer brakes are not required because of weight
• Tongue wheel is optional
• Nominal operating height: 142 in.
• Maximum wind load: 80 mph
• Maximum towing speed: 75 mph
• Transport dimensions: 112 in. length x 92 in. width x 92 in. height
• Weight: 1560 lb., 1845 lb. with optional battery pack
• Tongue weight: 65 lb.

NTPEP ID# & Product	TYPE	Company	Daytime					Nighttime				
			Visibility (ft)	Legibility (ft)		Angularity (ft/Ø)		Visibility (ft)	Legibility (ft)		Angularity (ft/Ø)	
				Word	Eye Chart				Word	Eye Chart		
PCMS(2007)- 01 Silent Messenger MB-4048	PCMS	Solar Technology, Inc.	4800	1035	967	56	24.2˚	4800	904	747	16	57.4˚
PCMS(2007)- 02 Portable Vanguard VP-4000	PCMS	Daktronics	4800	1028	946	62	22.1˚	4800	872	820	26	43.5˚
PCMS(2007)- 03 Solar Message Center SMC-1000 HE	PCMS	Precision Solar Controls Inc.	4800	1107	994	126	11.3˚	4800	920	669	29	40.8˚
PCMS(2007)- 04 Solar Message Center SMC-2000 FM	PCMS	Precision Solar Controls Inc.	4028	1055	913	142	10˚	4800	990	899	27	42.8˚
PCMS(2007)- 05 Advance Warner M-90	FAP	Protection Services Inc.	4800	4800		109	13˚	4800	3525		20	51˚
PCMS(2007)- 06 Silent Messenger II MB2-3048	PCMS	Solar Technology, Inc.	4800	770	697	63	21.5˚	4800	640	548	20	51˚

Figure 7 – Sight Tests Results Comparison

Note: The Angularity data reported is a “one-half” angle calculation.

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Test Deck Pictures

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Section 3.0- Sight Tests Pictures

Evaluation vehicle approaching sign

Sight test message

Sight test setup

Sight test setup

Section 4.0- Operational Performance Tests Pictures

Test message

Test mode

Signs under test

Signs under test

AASHTO's National Transportation Product Evaluation Program

Appendix A

- Project Work Plan for PCMS
- Project Work Plan for FAP
- Test Deck Layout
- Open-Circuit Voltage Test Procedure

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AASHTO's National Transportation Product Evaluation Program

NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM (NTPEP)

PROJECT WORK PLAN FOR PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

2006

AASHTO's National Transportation Product Evaluation Program

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 is intended for the testing of solar powered signs only. The work plan includes sight tests, performance tests and a section describing the information provided by manufacturers to be included in the report after verification by the Lead 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 GENERAL GUIDELINES

2.1 Sign Configuration – Signs submitted shall be solar powered and in compliance to the Standards as stated in Section 6F.55 of the 2003 Manual on Uniform Traffic Control Devices (MUTCD). The manufacturer will configure their sign(s) with the standard number of batteries and amp-hour capacity as specified in the sign's technical documentation. (Optional battery-banks or higher amp-hour rated batteries will not be permitted.) The solar array output (Watts) of each sign shall be determined by the manufacturer and should be appropriate for the climate of the Lead State. The manufacturer will provide a switch or quick-disconnect connector to disable the solar array and instructions for the disconnection.

2.2 Sign Documentation – The manufacturer will supply to the Lead State a complete set of customer documentation (i.e., manual, specification, etc.) prior to testing. A configuration sheet of the submitted sign shall also be included. The configuration sheet should contain as a minimum the following items:

- Model name and/or model number.
- Login password.
- Instructions for disconnecting solar array.
- Solar panel wattage output.
- Battery manufacturer with battery model number and amp-hour rating (Ah@12Vdc, 20 hour rating).
- Any options.

2.3 Sign Verification – All signs will be checked for the requirements as specified in Section 2.1 Sign Configuration and Section 2.2 Sign Documentation. The following specific requirements will be verified before testing:

- The sign is able to display three lines with a minimum of eight characters per line. Each character must be comprised of a minimum of five wide and seven high elements.
- The sign is able to automatically dim.
- The sign's lifting mechanism is functioning properly.
- The power system is functioning properly (i.e., the solar array and battery-bank system).
- The battery back-up system is comprised with the standard number of batteries and amp-hour capacity as specified in the sign's technical specification.
- The manufacturer has provided a switch or quick-disconnect connector to disable the solar array.
- The manufacturer has provided a complete set of customer documentation which includes a configuration sheet of the sign submitted for testing.

If signs are found not functioning correctly or found not meeting the stated requirements, the manufacturer will be given the opportunity to repair their sign or satisfy the requirements before testing begins per the guidelines outlined in Section 2.4 – Inoperable Signs.

2.4 Inoperable Signs – To be fair-minded to the manufacturer and to submit the most complete report possible, signs that become inoperable before the Section 3.0 – Sight Tests or the Section 4.0 – Operational Performance Tests can be repaired. Signs can also be repaired between the Durability and Reliability Tests of the Section 4.0 – Operational Performance Tests.

The manufacturer will be given 48 hours from the time of notification to have their sign repaired. The manufacturer shall supply details of the repair to the Lead State. These details will be stated in the final report.

3.0 SIGHT TESTS

3.1 Visibility, Legibility and Angularity Tests – Visibility, Legibility and Angularity tests will be performed as described in the following sections. Test results and support information indicated in *Italics* must be reported in the final report.

3.1.1 Test Synopsis – A sign will be placed at the end of a long flat road surface displaying a three-line message that will be viewed by three evaluators. Driving a sedan toward the sign, each evaluator will check the sign for visibility, legibility and angularity. Using their best judgement, each evaluator will record a distance for each test. The evaluators will perform a daytime and nighttime evaluation for each sign.

3.1.2 Test Objective – The sight tests will demonstrate the performance of each sign for Visibility, Legibility and Angularity. The sight tests results are intended to assist the member states in their purchasing decisions.

3.1.3 Test Setup –

3.1.3.1 Evaluators and Test Vehicle – Tests will be conducted using three evaluators with 20/20 corrected vision sitting in a sedan-style vehicle. The vehicle shall be equipped with an onboard distance meter for distance measuring. *Report type of vehicle used.*

3.1.3.2 Test Deck and Conditions – The test deck will be surveyed and marked as shown on page A23. The evaluation will be performed on a flat road surface in clear cloudless weather (or the best weather conditions possible) in a setting free from outside visual influences (i.e. city lights, billboards, etc.). *Report test dates, weather conditions and location of test deck.*

3.1.3.3 Sign Setup – The sign will be fully operational in accordance with the manufacturer's instructions. The sign will be positioned as shown on the test deck layout and leveled by adjusting the jack stands. The display panel will be raised to its highest position, set for automatic dimming mode, and aimed per manufacturer's instructions.

3.1.3.4 Message Content – The message will be three lines- two lines that use non-traffic related words and one line that uses letters that do not form a word (e.g., eye chart). In all cases and without using all characters in a single line, between 75 to 85 percent of the total available characters of the three lines should be illuminated. A different message will be created for each sign.

3.1.4 Test Procedure – The evaluators will be performing a daytime and nighttime evaluation for each sign as directed in the following subsections. A message programmed for that sign as described above will be the same in both evaluations. The evaluators will be seated in the sedan at the same time and, in one run, perform all tests for that sign. Per their judgement, each evaluator will record a distance for each test. (During the Legibility test, each evaluator will record the distance when both the two non-traffic words become legible and the distance when the "eye chart" word becomes legible.) The evaluators shall take turns driving during the Visibility and Legibility test but each must be in the driver's seat during the Angularity test. To insure accuracy during the Angularity test, each evaluator will reset the onboard distance meter at the 200-foot mark (see test deck layout on page A23). Each evaluator will record the time, weather condition, message and distance for each test.

3.1.4.1 Visibility – Starting at point **"f"** which is 25 feet from the center of the sign face and 4800 feet from point **"x"** (see page A23 and Figure 1) determine whether or not the sign message is visible. If not, move toward point **"x"** along a line perpendicular to the sign face until the message is visible. The sign message is considered visible whenever the message portion is apparent, though not necessarily legible. *Report the average of Visibility distances recorded.*

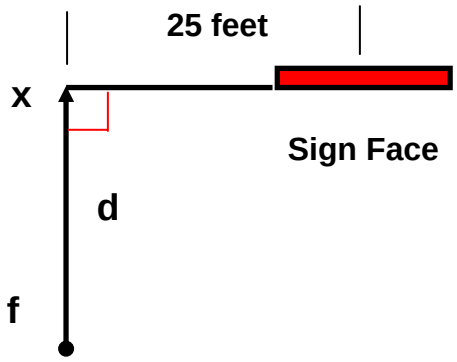

Figure 1

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

3.1.4.2 Legibility – Starting at point **"f"** which is 25 feet from the center of the sign face and 4800 feet from point **"x"** (see page A23 and Figure 1), attempt to read the sign message. If necessary, move toward point

"x" along a line perpendicular to the sign face until all lines of the message is legible. Measure the distance **"d"** from the first point of legibility to point **"x"**. *Report the average of Legibility distances recorded for the two non-traffic word message and the "eye chart" message.*

3.1.4.3 Angularity – Starting at point **"b"** which is 25 feet from the center of the sign face and 200 feet from **"x"** (see page A23 and Figure 2), move on a line perpendicular to the sign face until a character in the sign 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. *Report the average of the Angularity distances recorded and the calculated angle. The angle will be reported as a 1/2 angle measurement.*

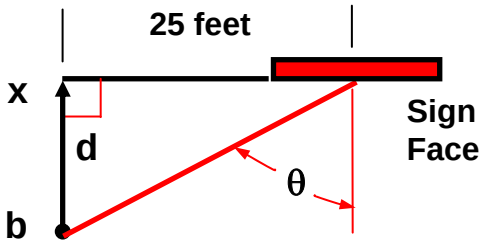

Figure 2

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

4.0 OPERATIONAL PERFORMANCE TESTS

4.1 Durability and Reliability Tests – Durability and Reliability tests will be performed as described in the following sections. Test results and support information indicated in *Italics* must be reported in the final report.

4.1.1 Test Synopsis – Signs will be tested concurrently on a flat test deck in cold weather conditions to best stress the equipment. The Durability test will be followed by the Reliability test. For Durability, the signs will be programmed to display a three-line message for a 30-day period with the display panel raised and lowered twice a week. The voltage level of the battery-bank will be checked at the beginning and end of the testing period.

For Reliability, the solar array for each sign will be disconnected. Each sign will continue operation utilizing battery back-up power until the sign ceases displaying its message. The battery-bank will be recharged via the sign's solar array and the sign checked for normal operation.

4.1.2 Test Objective – The intent of the Durability 30-day test period is to evaluate the performance of the solar array charging system and the operation of the controller system. The voltage level of the battery-bank will be checked to confirm that the solar array and the system controller are keeping the batteries properly charged. Raising and lowering the display panel will add additional stress to the charging system.

The intent of the Reliability test is to test the controller system and the battery back-up system when the primary power source fails. By disconnecting the solar array, the performance of the battery back-up system can be evaluated. The system controller will be evaluated for its ability to "shut down" the display panel before the battery-bank falls below predefined low-voltage levels. **It is not the intent to completely drain the battery-bank**. After recharging the battery-bank via the sign's solar array, the system controller and sign will be checked for normal operation.

Because it is a requirement that the sign cannot be configured with an enhanced battery back-up system, the resulting days of operation will be an approximate indication of the sign's battery back-up system capacity.

4.1.3 Test Configurations –

4.1.3.1 Test Deck and Conditions – The test shall be conducted in cold weather conditions to best stress the equipment. The test deck will be a flat surface with signs placed as not to affect each other's performance during testing. *Report test deck location and daily weather conditions during the testing period.*

4.1.3.2 Sign Setup – The sign will be fully operational in accordance with the manufacturer's instructions during Durability testing but will have the solar array disconnected during Reliability testing. The sign is to be leveled by adjusting the jack stands. The display panel should be raised to its highest position and set for automatic dimming mode. *Report sign's*

solar array output (Watts) and battery-bank configuration – number of batteries, manufacturer, model number and total amp-hour capacity (Ah@12Vdc, 20 hour Rating).

4.1.3.3 Message Content – Without using all the characters in a single line, program the sign with a three line message that uses between 75 to 85 percent of the total available characters of the three lines to be illuminated.

4.1.4 Test Procedure – All signs in this evaluation are to be tested concurrently to insure that all signs are subjected to the same weather conditions. The same message is to be programmed on each sign. Before the beginning of each test, it will be verified that all signs are operational and functioning properly with the programmed message. The testing will begin with Durability testing and followed with Reliability testing as directed in the following subsections.

4.1.4.1 Durability – First record the beginning voltage level of the battery-bank for each sign by using the Open-Circuit Voltage Test Procedure outlined on page A24. Record the starting date and operate the sign with the programmed message continuously for 30 days in accordance with the manufacturer's instructions. Raise and lower the display panel two times each week during the testing period. At the end of the 30 days, stop the test and use the Open-Circuit Voltage Test Procedure to record the ending battery-bank voltage level. *Report the testing period dates and the beginning and ending battery-bank voltage levels. Report any failures or significant problems with the associated date.*

4.1.4.2 Reliability – Following the Durability testing, disconnect the solar array either by a switch or quick-disconnect connector as instructed by the manufacturer. Record date the sign was disconnected from the solar array. Continue operating the sign with the programmed message until the sign shuts down and ceases to display message. Monitor the signs a minimum of every two days and record the date and voltage level when a sign is found non-operational.

Reconnect the solar array and charge to operational voltages. Once recharged, verify the programmed message still exists in the system controller, and the sign functions properly. *Report the number of days the sign operated on battery back-up, the "shutdown" voltage set by the manufacturer and the voltage level found at shutdown. Report any failures or significant problems with the sign and the associated date.*

5.0 TECHNICAL DESK AUDIT & VERIFICATION

5.1 Objective – The manufacturers will provide the following information to aid in describing their sign(s) that was evaluated per the work plan. This information is not an attempt to replace the manufacturer's technical manual but to only serve as a quick reference to the member states to compare features of the signs. Whenever practical, the Lead State will verify the accuracy of the following information.

5.2 Sign Panel

5.2.1 What is the element type? (e.g., LED, reflective disk, other.)

5.2.2 If LED, what is the angularity specification?

5.2.3 What is the display matrix type? (e.g., Full Matrix, Continuous Line Matrix, Character Matrix.)

5.2.4 How many LEDs (pixels) are there per element?

5.2.5 What is the maximum number of 5x7 element characters per line?

5.2.6 What is the height and width (inches) of the 5x7 element characters?

5.2.7 What is the spacing (inches) between characters?

5.2.8 What is the display panel size?

5.2.9 What is the sign panel rotation capability?

5.2.10 Does the sign panel have an alignment-sighting device?

5.2.11 Does the electro-hydraulic sign panel lift have a manual back-up system? If yes, standard or optional?

5.3 Power System

5.3.1 Are there onboard diagnostics to check the charging status of the solar array?

5.3.2 Are there onboard diagnostics to check the voltage output status of the battery-bank system?

5.3.3 Can the solar panels be tilted?

5.3.4 List the available solar panel wattage outputs.

5.3.5 List the standard number of batteries in the battery-bank.

5.3.6 List battery type. (Indicate 6 or 12 V.)

5.3.7 What is the standard battery-bank capacity? (Indicate the Ah@12Vdc, 20 hour rating.)

5.3.8 Does the sign have an outlet for AC power capability? (If yes, indicate standard, optional or only with battery charger.)

5.3.9 Is a battery charger standard or optional?

5.3.10 What is the typical recharging time for the standard battery-bank? (Indicate time with the associated amp output of charger.)

5.3.11 Is the battery-bank stored in a lockable vandal resistant enclosure?

5.3.12 Is battery-bank stored in a weatherproof or weather-resistant enclosure?

5.4 Controller System

5.4.1 What type is the controller input device? (e.g., keyboard, keypad, handheld, or other.)

5.4.2 Is the input device lighted? (If yes, backlit or external?)

5.4.3 Is the controller display lighted? (If yes, backlit or external?)

5.4.4 Does the controller use a menu driven program?

5.4.5 Does the controller have password protection?

5.4.6 Does the controller have multi-level password protection?

5.4.7 Does the controller software include an automatic test function?

5.4.8 Does the controller software include a quick-program feature?

5.4.9 Does the controller software include a programmable default message?

5.4.10 If the sign loses power, does the controller software have an auto-resume feature when the sign regains power?

5.4.11 List the number of pre-programmed messages.

5.4.12 List the number of user programmable messages.

5.4.13 What is the message display time intervals for message phasing? (Indicate min. to max. intervals with time increments.)

5.4.14 How many messages can be displayed sequentially?

5.4.15 Can the message be flashed? (If yes, indicate flash time intervals.)

5.4.16 Is there manual dimming capability?

5.4.17 What is the method for updating controller software? (e.g., via laptop, factory technician, etc.)

5.4.18 Is the controller stored in a lockable, vandal resistant enclosure?

5.4.19 Is the controller stored in a weatherproof or weather-resistant enclosure?

5.5 Trailer

5.5.1 What are the brake options? (e.g., surge, electric, or both.)

5.5.2 Is there a tongue wheel option?

5.6 General Specifications

5.6.1 What is the operating temperature?

5.6.2 What is the nominal operating height?

5.6.3 What is the maximum wind load of sign when extended?

5.6.4 What is the maximum towing speed in the transport position?

5.6.5 What are the overall dimensions (L x W x H inches) in the transport position?

5.6.6 What is the gross weight?

5.6.7 What is the tongue weight?

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AASHTO's National Transportation Product Evaluation Program

NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM (NTPEP)

PROJECT WORK PLAN FOR FLASHING ARROW PANELS (FAP)

2006

AASHTO's National Transportation Product Evaluation Program

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 is intended for the testing of solar powered signs only. The work plan includes sight tests, performance tests and a section describing the information provided by manufacturers to be included in the report after verification by the Lead 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 GENERAL GUIDELINES

2.1 Sign Configuration – Signs submitted shall be solar powered and in compliance to the Standards as stated in Section 6F.56 of the 2003 Manual on Uniform Traffic Control Devices (MUTCD). The manufacturer will configure their sign(s) with the standard number of batteries and amp-hour capacity as specified in the sign's technical documentation. (Optional battery-banks or higher amp-hour rated batteries will not be permitted.) The solar array output (Watts) of each sign shall be determined by the manufacturer and should be appropriate for the climate of the Lead State. The manufacturer will provide a switch or quick-disconnect connector to disable the solar array and instructions for the disconnection.

2.2 Sign Documentation – The manufacturer will supply to the Lead State a complete set of documentation (i.e., manual, specification, etc.) prior to testing. A configuration sheet of the submitted sign shall also be included. The configuration sheet should contain as a minimum the following items:

- Model name and/or model number.
- Instructions for disconnecting solar array.
- Solar panel wattage output.
- Battery manufacturer with battery model number and amp-hour rating (Ah@12Vdc, 20 hour rating).
- Any options.

2.3 Sign Verification – All signs will be checked for the requirements as specified in Section 2.1 Sign Configuration and Section 2.2 Sign Documentation. These specific requirements will be verified before testing:

- All arrow modes on the control panel display correctly.
- The sign is able to automatically dim.
- The sign's lifting mechanism is functioning properly.
- The power system is functioning properly (i.e., the solar array and battery-bank system).
- The battery back-up system is comprised with the standard number of batteries and amp-hour capacity as specified in the sign's technical specification.
- The manufacturer has provided a switch or quick-disconnect connector to disable the solar array.
- The manufacturer has provided a complete set of customer documentation which includes a configuration sheet of the sign submitted for testing.

If signs are found not functioning correctly or found not meeting the stated requirements, the manufacturer will be given the opportunity to repair their sign or satisfy the requirements before testing begins per the guidelines outlined in Section 2.4 – Inoperable Signs.

2.4 Inoperable Signs – To be fair-minded to the manufacturer and to submit the most complete report possible, signs that become inoperable before the Section 3.0 – Sight Tests or the Section 4.0 – Operational Performance Tests can be repaired. Signs can also be repaired between the Durability and Reliability Tests of the Section 4.0 – Operational Performance Tests.

The manufacturer will be given 48 hours from the time of notification to have their sign repaired. The manufacturer shall supply details of the repair to the Lead State. These details will be stated in the final report.

3.0 SIGHT TESTS

3.1 Visibility, Legibility and Angularity Tests – Visibility, Legibility and Angularity tests will be performed as described in the following sections. Test results and support information indicated in *Italics* must be reported in the NTPEP report.

3.1.1 Test Synopsis – A sign will be placed at the end of a long flat road surface displaying an "Arrow" mode that will be viewed by three evaluators. Driving a sedan toward the sign, the evaluators will check the sign for visibility, legibility and angularity. Per their judgement, each evaluator will record a distance for each test. The evaluators will perform a daytime and nighttime evaluation for each sign.

3.1.2 Test Objective – The sight tests will demonstrate the performance of each sign for Visibility, Legibility and Angularity. The sight tests results are intended to assist the member states in their purchasing decisions.

3.1.3 Test Setup –

3.1.3.1 Evaluators and Test Vehicle – Tests will be conducted using three evaluators with 20/20 corrected vision sitting in a sedan-style vehicle. The vehicle shall be equipped with an onboard distance meter for distance measuring. *Report type of vehicle used.*

3.1.3.2 Test Deck and Conditions – The test deck will be surveyed and marked as shown on page A23. The evaluation will be performed on a flat road surface in clear cloudless weather (or the best weather conditions possible) in a setting free from outside visual influences (i.e., city lights, billboards, etc.). *Report test dates*, *weather conditions and location of test deck.*

3.1.3.3 Sign Setup – The sign will be fully operational in accordance with the manufacturer's instructions. The sign will be positioned as shown on the test deck layout and leveled by adjusting the jack stands. The display will be set for automatic dimming mode and aimed per manufacturer's instructions.

3.1.3.4 Display Mode – The mode will be a "Right Arrow" or "Left Arrow" randomly chosen for each sign.

3.1.4 Test Procedure – The evaluators will be performing a daytime and nighttime evaluation for each sign as directed in the following subsections. An "Arrow" mode will be randomly chosen as described above. The evaluators will be seated in the sedan at the same time and, in one run, perform all tests for that sign. Per their judgement, each evaluator will record a distance for each test. The evaluators shall take turns driving during the Visibility and Legibility test but each must be in the driver's seat during the

Angularity test. To insure accuracy during the Angularity test, each evaluator will reset the onboard distance meter at the 200-foot mark (see test deck layout on page A23). Each evaluator will record the time, weather condition, "Arrow" mode and distance for each test.

3.1.4.1 Visibility – Starting at point **"f"** which is 25 feet from the center of the sign face and 4800 feet from point **"x"** (see page A23 and Figure 1) determine whether or not the display mode is visible. If not, move toward point **"x"** along a line perpendicular to the sign face until the display is visible. The display is considered visible whenever the "Arrow" mode is apparent, though not necessarily legible. *Report the average of Visibility distances recorded.*

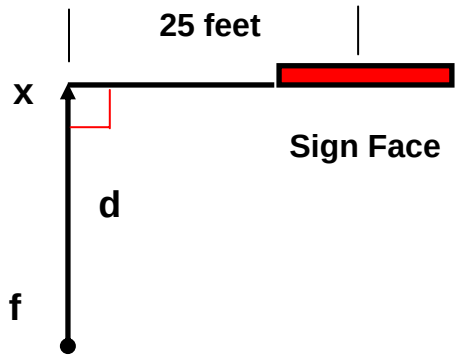


Figure 1

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

3.1.4.2 Legibility – Starting at point **"f"** which is 25 feet from the center of the sign face and 4800 feet from point **"x"** (see page A23 and Figure 1), attempt to read the display mode. If necessary, move toward point **"x"** along a line perpendicular to the sign face until the display mode is legible. Measure the distance **"d"** from the first point of legibility to point **"x"**. *Report the average of Legibility distances recorded.*

3.1.4.3 Angularity– Starting at point **"b"** which is 25 feet from the center of the sign face and 200 feet from **"x"** (see page A23 and Figure

2), move on a line perpendicular to the sign face until a lamp in the "Arrow" mode displayed is no longer visible. Measure the distance **"d"** from point **"x"** to the point of legibility. Record this number and calculate the angularity of the angle θ shown. *Report the average of the Angularity distances recorded and the calculated angle. The angle will be reported as a 1/2 angle measurement.*

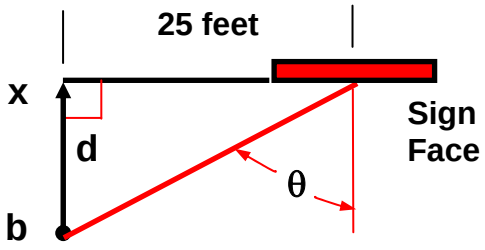


Figure 2

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

4.0 OPERATIONAL PERFORMANCE TESTS

4.1 Durability and Reliability Tests – Durability and Reliability tests will be performed as described in the following sections. Test results and support information indicated in Italics must be reported in the final report.

4.1.1 Test Synopsis – Signs will be tested concurrently on a flat test deck in cold weather conditions to best stress the equipment. The Durability test will be followed by the Reliability test. For Durability, the signs will be set to the "Double Arrow" mode for a 30-day period. The voltage level of the battery-bank will be checked at the beginning and end of the testing period.

For Reliability, the solar array for each sign will be disconnected. Each sign will continue operation utilizing battery back-up power until the sign ceases displaying the flashing arrow. The battery-bank will be recharged via the sign's solar array and the sign checked for normal operation.

4.1.2 Test Objective – The intent of the Durability 30-day test period is to evaluate the performance of the solar array charging system and the operation of the system controller. The voltage level of the battery-bank will

be checked to confirm that the solar array and system controller are keeping the batteries properly charged.

The intent of the Reliability test is to test the controller system and the battery back-up system when the primary power source fails. By disconnecting the solar array, the performance of the battery back-up system can be evaluated. The system controller will be evaluated for its ability to "shut down" the display panel before the battery-bank falls below predefined low-voltage levels. **It is not the intent to completely drain the battery-bank**. After recharging the battery-bank via the sign's solar array, the system controller and sign will be checked for normal operation.

Because it is a requirement that the sign cannot be configured with an enhanced battery back-up system, the resulting days of operation will be an approximate indication of the sign's battery back-up system capacity.

4.1.3 Test Configurations –

4.1.3.1 Test Deck and Conditions – The test shall be conducted in cold weather conditions to best stress the equipment. The test deck will be a flat surface with signs placed as not to affect each other's performance during testing. *Report test deck location and daily weather conditions during the testing period.*

4.1.3.2 Sign Setup – The sign will be fully operational in accordance with the manufacturer's instructions during Durability testing but will have the solar array disconnected during Reliability testing. The sign is to be leveled by adjusting the jack stands. The display panel shall be set for automatic dimming mode. *Report sign's solar array output (Watts) and battery-bank configuration- number of batteries, manufacturer, model number and total amp-hour capacity (Ah@12Vdc, 20 hour Rating).*

4.1.3.3 Display Mode – The display shall be set to the "Double Arrow" mode.

4.1.4 Test Procedure – All signs in this evaluation are to be tested concurrently to insure that all signs are subjected to the same weather conditions. The display shall be set to the "Double Arrow" mode. Before the beginning of each test, it will be verified that all signs are operational and functioning properly. The testing will begin with Durability testing and followed with Reliability testing as directed in the following subsections.

4.1.4.1 Durability – First record the beginning voltage level of the battery-bank for each sign by using the Open-Circuit Voltage Test Procedure outlined on page A24. Record the starting date and operate the sign with the flashing arrow continuously for 30 days in accordance

with the manufacturer's instructions. At the end of the 30 days, stop the test and use the Open-Circuit Voltage Test Procedure to record the ending battery-bank voltage level. *Report the testing period dates and the beginning and ending battery-bank voltage levels. Report any failures or significant problems with the associated date.*

4.1.4.2 Reliability – Following the Durability testing, disconnect the solar array either by a switch or quick-disconnect connector as instructed by the manufacturer. Record date the sign was disconnected from the solar array. Continue operating the sign until the sign shuts down and ceases to display the flashing arrow. Monitor the signs a minimum of every two days and record the date and voltage level when a sign is found non-operational.

Reconnect the solar array and charge to operational voltages. Once recharged, verify the sign functions properly. *Report the number of days the sign operated on battery back-up, the "shut down" voltage set by the manufacturer and the voltage level found at shut down. Report any failures or significant problems with the sign and the associated date.*

4.2 Flashing Rate Test – A Flashing Rate test will be performed as described in the following sections. Test results and support information indicated in Italics must be reported in the NTPEP report

4.2.1 Test Synopsis – The signs flash rate will be counted for flashes per minute with the dwell time (lamp "on time") measured.

4.2.2 Test Objective – A Standard from the 2003 MUTCD requires that the lamps shall flash at a rate not less than 25 or more than 40 flashes per minute with a minimum lamp "on time" of 50 percent of the cycle. The test will verify the flash rate and dwell time.

4.2.3 Test Configurations –

4.2.3.1 Test Deck and Conditions – The test will be performed on a flat surface in conditions best suited for performing the test.

4.2.3.2 Sign Setup – The sign will be fully operational in accordance with the manufacturer's instructions.

4.2.3.3 Display Mode – The display shall be set to the "Right Arrow" mode.

4.2.4 Test Procedure – The display shall be set to the "Right Arrow" mode. Count and record the number of flashes per minute under normal

operating conditions. Measure the dwell time (lamp "on time") and record the period to the closest 1/10th of a second. *Report the flashes per minute and the dwell time.*

5.0 TECHNICAL DESK AUDIT & VERIFICATION

5.1 Objective – The manufacturers will provide the following information to aid in describing their sign(s) that was evaluated per the work plan. This information is not an attempt to replace the manufacturer's technical manual but to only serve as a quick reference to the member states to compare features of the signs. Whenever practical, the Lead State will verify the accuracy of the following information.

5.2 Sign Panel

5.2.1 What is the MUTCD panel type? (Indicate A, B or C.)

5.2.2 What is the number of lamps?

5.2.3 What is the lamp type and size? (e.g., LED Par 46, LED Par 36, or other.)

5.2.4 List the available of arrow modes.

5.2.5 Does the sign panel have an alignment-sighting device?

5.3 Power System

5.3.1 Can solar panels be tilted?

5.3.2 List the available solar panel wattage outputs.

5.3.3 List the standard number of batteries in the battery-bank.

5.3.4 List battery type. (Indicate 6 or 12 V.)

5.3.5 What is the standard battery-bank capacity? (Indicate the Ah@12Vdc, 20 hour rating.)

5.3.6 Does the sign have an outlet for AC power capability? (If yes, indicate standard, optional or only with battery charger.)

5.3.7 Is a battery charger standard or optional?

5.3.8 What is the typical recharging time for the standard battery-bank? (Indicate time with the associated amp output of charger.)

5.3.9 Is the battery-bank stored in a lockable vandal resistant enclosure?

5.3.10 Is the battery-bank stored in a weatherproof or weather-resistant enclosure?

5.4 Controller System

5.4.1 Is the Controller display lighted? (If yes, backlit or external?)

5.4.2 Is there manual dimming capability?

5.4.3 Is there a battery-bank status indicator?

5.4.4 Is Controller stored in a lockable, vandal resistant enclosure?

5.4.5 Is Controller stored in a weatherproof or weather-resistant enclosure?

5.5 General Specifications

5.5.1 What is the operating temperature?

5.5.2 What is the nominal operating height?

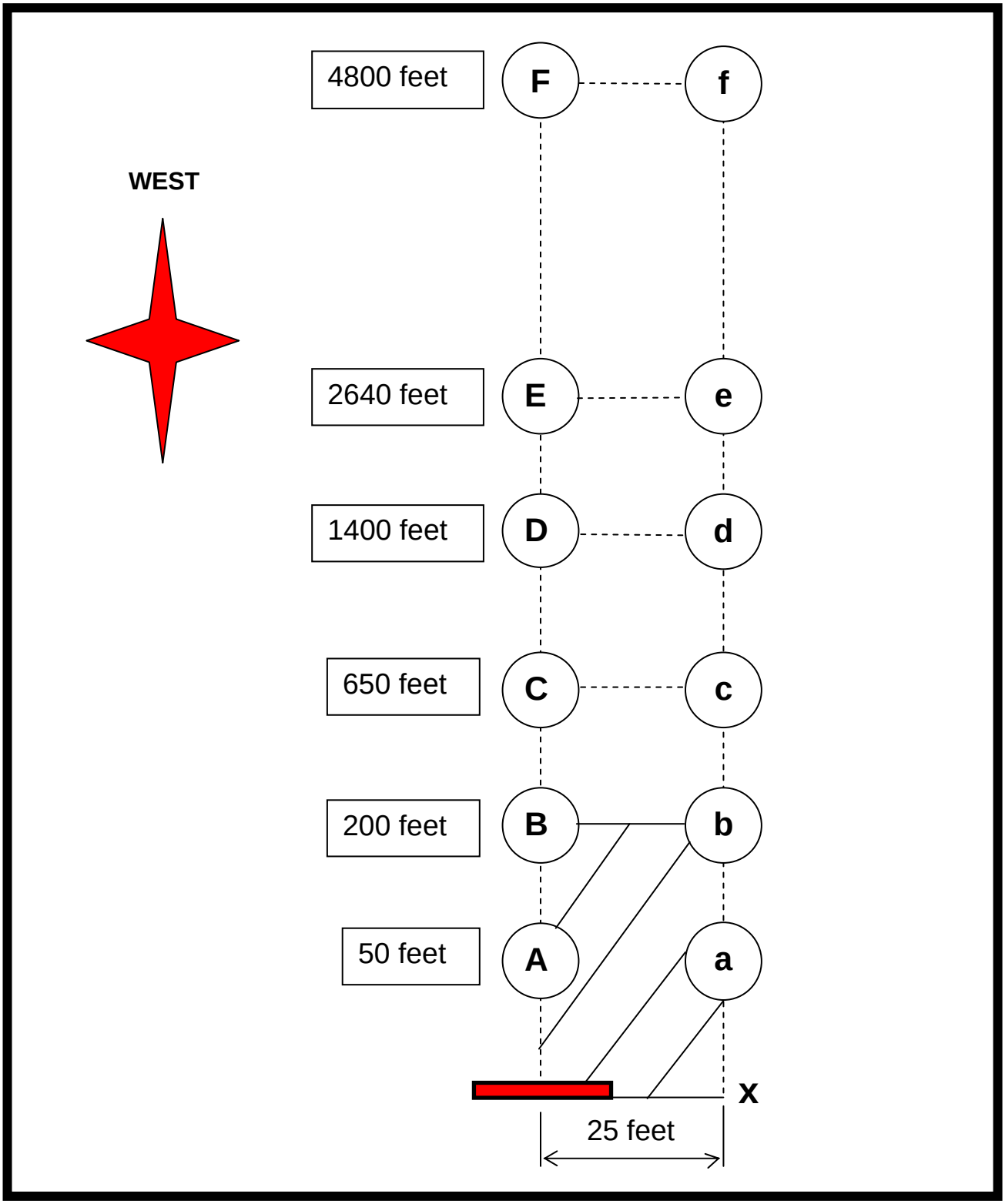
5.5.3 What is the maximum wind load of sign when extended?

5.5.4 What is the maximum towing speed in the transport position?

5.5.5 What are the overall dimensions (L x W x H inches) in the transport position?

5.5.6 What is the gross weight?

Test Deck Layout



Open-Circuit Voltage Test Procedure

Sign Setup –

- Sign should be off (i.e., display, controller, etc.).
- Disconnect the solar array either by a switch or quick-disconnect connector as instructed by the manufacturer.
- Leave the sign in the above state for a minimum of 6 hours, but do not exceed 24 hours before checking voltage level.

Checking Voltage Level –

- Check the sign's voltage level by running the onboard diagnostics and by measuring the battery-bank with a digital voltmeter. Voltage should be measured to the nearest hundredth of a volt. Use a digital voltmeter if onboard diagnostics are not provided. (Note: To protect one's safety and to prevent damage to sign, contact the manufacturer for instructions on how to correctly measure the voltage level with a voltmeter).

APPENDIX B

- Wilson Industrial Air Center
- Weather Data

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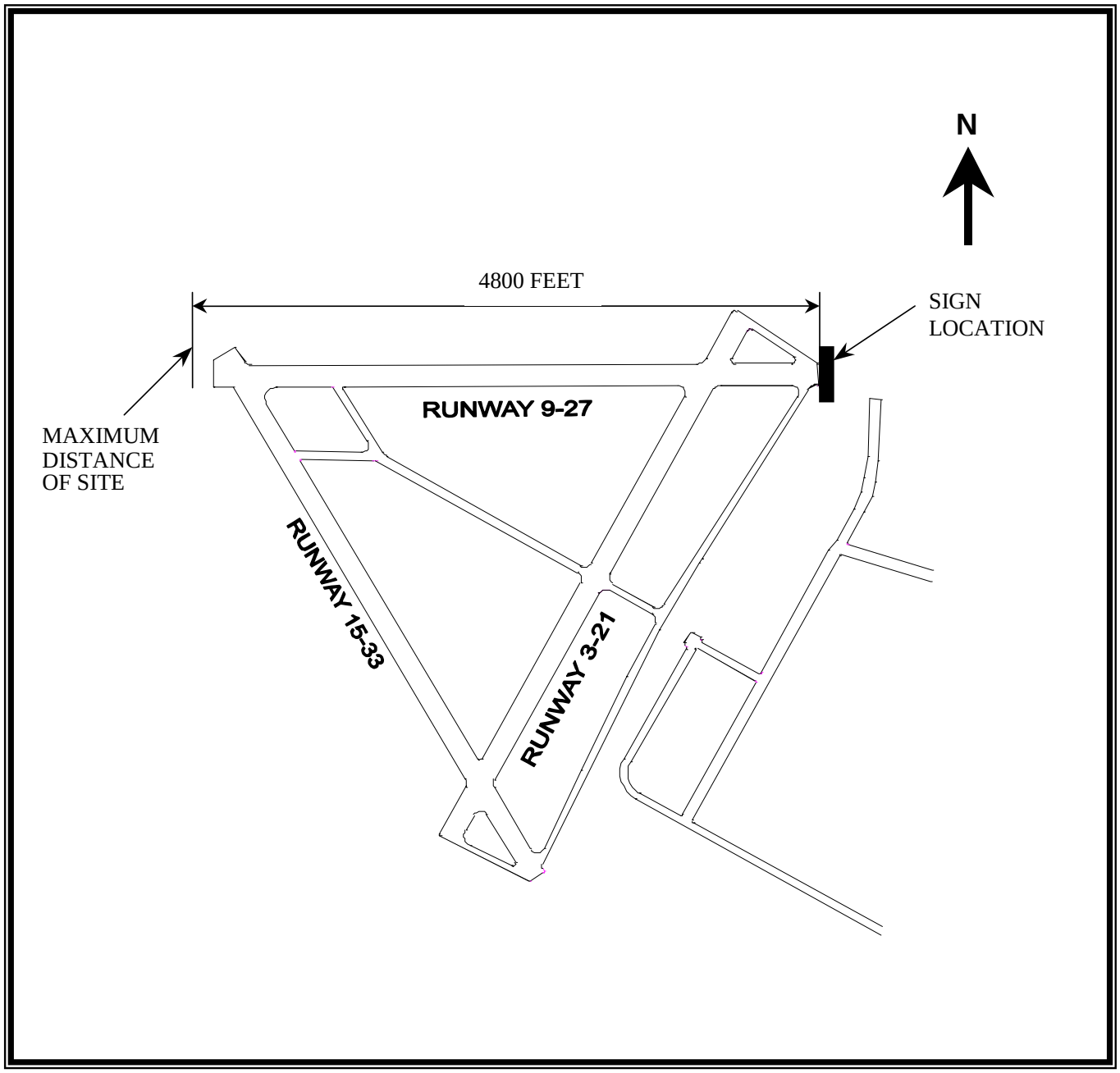
AASHTO's National Transportation Product Evaluation Program

Wilson Industrial Air Center

Wilson, NC



AASHTO's National Transportation Product Evaluation Program

Weather Data

Weather data was provided by the Federal Aviation Administration

3.0 Sight Tests Weather Data				
Date	Temperature (°F)			Weather Events
	High	Avg	Low	
06/13/07	82°	71°	62°	Clear, Partly Cloudy

4.0 Operational Performance Tests- Durability Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
02/15/07	40°	31°	22°	39	0.00	
02/16/07	39°	31°	23°	40	0.00	
02/17/07	48°	34°	19°	50	0.00	
02/18/07	45°	36°	26°	47	0.00	
02/19/07	50°	35°	19°	46	0.00	
02/20/07	66°	54°	41°	54	0.00	
02/21/07	73°	62°	50°	67	0.01	Rain
02/22/07	74°	62°	49°	56	0.00	Fog
02/23/07	55°	46°	37°	27	0.00	
02/24/07	57°	43°	28°	32	0.00	Snow
02/25/07	51°	47°	42°	63	0.56	Fog, Rain
02/26/07	61°	51°	41°	71	0.00	Fog
02/27/07	65°	50°	34°	59	0.00	Fog
02/28/07	61°	50°	38°	48	0.00	
03/01/07	67°	54°	41°	68	0.20	Rain
03/02/07	68°	58°	47°	52	0.96	Rain
03/03/07	69°	55°	41°	41	0.00	
03/04/07	50°	42°	34°	42	0.00	
03/05/07	64°	45°	26°	41	0.00	
03/06/07	55°	47°	38°	33	0.00	
03/07/07	70°	53°	35°	47	0.00	
03/08/07	55°	43°	30°	50	0.00	
03/09/07	59°	45°	31°	53	0.00	
03/10/07	71°	54°	37°	64	0.00	Fog
03/11/07	70°	55°	40°	53	Trace	
03/12/07	67°	53°	38°	54	0.00	
03/13/07	80°	62°	44°	58	0.00	Fog
03/14/07	81°	68°	54°	54	0.00	
03/15/07	81°	69°	57°	53	Trace	
03/16/07	66°	52°	38°	88	2.14	Rain
03/17/07	49°	41°	33°	62	0.00	

Durability Daily Weather Data Summary		
Temperature (°F)		
Maximum	Average	Minimum
81°	49°	19°

Weather Data

(continued)

4.0 Operational Performance Tests- Reliability Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
03/18/07	49°	39°	28°	46	0.00	
03/19/07	63°	45°	26°	50	0.00	
03/20/07	77°	63°	49°	51	0.00	
03/21/07	63°	57°	50°	54	0.00	
03/22/07	77°	60°	43°	66	0.00	
03/23/07	83°	68°	53°	62	0.00	
03/24/07	86°	72°	57°	55	0.00	
03/25/07	79°	65°	51°	61	0.00	
03/26/07	74°	59°	44°	67	0.00	
03/27/07	87°	73°	59°	64	0.04	Thunderstorm
03/28/07	86°	74°	61°	65	0.00	
03/29/07	61°	51°	41°	70	0.18	Rain
03/30/07	70°	52°	34°	60	0.00	Fog
03/31/07	79°	63°	47°	57	0.00	
04/01/07	77°	68°	59°	69	0.01	Rain
04/02/07	83°	72°	60°	62	0.02	Rain
04/03/07	86°	70°	53°	57	0.00	Fog, Thunderstorm
04/04/07	82°	69°	56°	58	Trace	Rain
04/05/07	58°	50°	41°	36	0.00	
04/06/07	57°	44°	30°	46	0.01	Rain
04/07/07	48°	40°	32°	55	0.12	Rain, Snow
04/08/07	56°	42°	27°	45	0.00	
04/09/07	56°	44°	32°	47	0.00	
04/10/07	64°	48°	32°	48	0.00	
04/11/07	59°	53°	46°	67	0.73	Rain
04/12/07	75°	66°	56°	58	0.93	Rain
04/13/07	67°	57°	46°	49	0.00	
04/14/07	70°	60°	49°	48	0.01	Rain
04/15/07	77°	60°	42°	86	1.76	Rain
04/16/07	60°	52°	43°	47	0.00	
04/17/07	72°	60°	47°	44	0.00	
04/18/07	67°	55°	42°	65	0.00	
04/19/07	58°	51°	44°	65	0.04	Rain
04/20/07	71°	58°	44°	61	0.00	
04/21/07	77°	59°	40°	56	0.00	
04/22/07	84°	67°	49°	46	0.00	
04/23/07	83°	68°	52°	49	0.00	
04/24/07	83°	71°	58°	56	0.00	
04/25/07	87°	74°	61°	58	0.00	
04/26/07	85°	75°	65°	58	0.00	
04/27/07	83°	73°	63°	65	0.25	Rain
04/28/07	76°	68°	59°	56	0.00	
04/29/07	80°	67°	53°	44	0.00	
04/30/07	87°	67°	47°	54	0.00	
05/01/07	92°	76°	59°	46	0.00	
05/02/07	90°	76°	63°	50	0.00	
05/03/07	71°	64°	57°	71	0.00	

Reliability Daily Weather Data Summary		
Temperature (°F)		
Maximum	Average	Minimum
92°	61°	26°

(Blank)

"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), former NTPEP Chairman

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