



**AASHTO's
National Transportation
Product Evaluation
Program**

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

**WINTER 2006 EVALUATION
FINAL REPORT**



September 2006

American Association of State Highway and Transportation Officials (AASHTO)

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National Transportation Product Evaluation Program (NTPEP)

Report 7003.1

Report of

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

(WINTER 2005 TESTING CYCLE)

Evaluation & Report Completed for NTPEP by:

**North Carolina Department of Transportation
*Traffic Engineering & Safety Systems Branch***



September 2005

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**American Association of State and Highway
Transportation Officials**

National Transportation Product Evaluation Program

For

**Flashing Arrow Panels
and Portable Changeable Message Signs**

**Winter 2006 Evaluation
Final Report**

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Table of Contents

SUBJECT	PAGE
Acknowledgements	5
Background and Introduction	6
Discussion of the Project Work Plan	7
Observations and Suggestions	9
Test Results Summary	11
PCMS(2006)- 01 Silent Messenger MB-1548, Solar Technology, Inc.	13
PCMS(2006)- 02 Silent Messenger MB-4048, Solar Technology, Inc.	19
PCMS(2006)- 03 KKAB5025, K&K Systems.....	25
PCMS(2006)- 04 KKMB3L-240, K&K Systems.....	31
PCMS(2006)- 05 WTLMB-SLL(A)06, Wanco, Inc.	37
PCMS 3.0 Sight Test Results Summary.....	43
Test Deck Pictures	45
Appendix A	
Project Work Plan for PCMS	A1
Project Work Plan for FAP	A13
Test Deck Layout	A23
Open-Circuit Voltage Test Procedure	A24
.	
Appendix B	
Wilson Industrial Air Center	B1
Weather Data	B2

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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.

Five signs were submitted for the 2006 NTPEP evaluation: four PCMSs 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 10, 2006 with the Durability test and was followed with the Reliability test, which ended on March 29, 2006. The Sight Tests (Section 3.0) took place at the Wilson Industrial Air Center in Wilson, NC with all tests conducted on May 1, 2006

The evaluation team used a new work plan for 2006, which can be found in Appendix A. The work plan was rewritten 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

Editor's Note: One of the intents of the new 2006 work plan was to eliminate the adjustments and modifications of the 2004 work plan. Even though we believe we succeeded in resolving the major issues, a few minor adjustments with the 2006 work plan were still necessary during this year's testing. Those modifications are discussed in the following sections where applicable and also in the test results summary for each sign affected.

Even though another goal of the 2006 work plan was to establish "clearly" what data would be reported, the team has come to the realization that we will never achieve a "cut-and-dry" report. During testing each year, we learn something new about the operation of the signs and this year was no exception. In the "Observations and Suggestions" Section you will not only find recommendations on how to utilize the resulting data per the work plan but also additional information we learned during this year's testing.

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 May 1, 2006 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 a NCDOT onboard vehicle distance meter was used to determine the distances. The Legibility test was different this year with results given for two distances- a two-line "word" message and an "eye chart" message.

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 an "one-half" angle calculation. Since there were four PCMS signs tested, there is also a spreadsheet with each sign's results for a quick comparison of the data (see Figure 6 on page 43).

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 10 and ended on March 13, 2006.

The Reliability test began on March 14 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.

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.

Voltage levels reported for the PCMS signs were found on the onboard diagnostics of each sign. In addition, the voltage levels were measured with a Fluke 179 multi-meter. The FAP onboard diagnostics were limited to LED status indicators so all voltage levels reported were 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.

Note: Modification to the work plan was necessary for K&K Systems' FAP, PCMS(2006)- 03, during the Reliability test. The FAP was equipped with two batteries having a capacity total of 430 Ah. During the early voltage readings, it became apparent that the FAP was capable of operating more than 30 days. Concerned the test could be extended longer than 30 days, the team asked permission from K&K Systems to set the sign to full LED brightness and to disconnect one battery from the battery-bank to speed the shutdown of the sign. Since the main purpose of the Reliability test is to verify the sign's ability to cease operation at a preset "shutdown" voltage, the team felt this was suitable solution to the problem. Obviously, the Days of Operation data for the FAP as reported in the summary is not an accurate result of the sign's battery-bank capacity and should not be used judge the to sign's true performance. The team would like to thank K&K Systems for allowing that modification.

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" from the 2006 NTPEP evaluation. The 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. We decided this year to present the two results for comparison so each distance can be evaluated for its merit.
- In reviewing the Angularity (Section 3.1.4.3) test data, please note that the car's rear-view mirror sometimes obscured the view of the evaluators. The evaluators are instructed to record the distance when the message is not legible, even if the rear-view mirror is the cause. Each sign's Angularity result that was affected by the rear-view mirror is indicated on its summary and on the PCMS comparison spreadsheet (see Figure 6 on page 43). For those member states that have an Angularity requirement in their specification, we ask that you give special consideration to those results with the knowledge that the sign's performance would have been better than what was reported in the absence of the rear-view mirror.

The rear-view mirror obstructing the evaluator's view has occurred in previous NTPEP testing and had been discussed with the NTPEP-TTCD Project Panel. The data will continue to be reported as measured until this problem can be addressed.

- In reviewing 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 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.
- In reviewing 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. Although not required in the Project Work Plan, the team decided to provide this additional information for the Member States review:

- As the signs were being monitored during the Reliability testing, the team found that the signs had various preset "shutdown" voltages. These voltages ranged from 10.7 to 11.4 volts. 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 11.5 volts and as high as 12.6 volts. All 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

(Blank)



PCMS(2006)- 01

Product Information
Product Name/Model: Silent Messenger MB-1548
Company: Solar Technology, Inc.
Address: 7620 Cetronia Road, Allentown, PA, 18106
Phone: (610) 391-8600, FAX (610) 391-8601
Web Site: www.solartechnology.com

3.0 Sight Tests Results – PCMS(2006)- 01	
Visibility Results –	
Daytime: 4800 feet	
Nighttime: 4800 feet	
Legibility Results –	
Daytime “Word”: 1398 feet	
Daytime “Eye Chart”: 992 feet	
Nighttime “Word”: 1202 feet	
Nighttime “Eye Chart”: 893 feet	
Angularity Results –	
Daytime: 116 feet / 12.2 degrees (half-angle calculation)	
Nighttime: 67 feet / 20.6 degrees (half-angle calculation) (Rear-view mirror affected result)	

4.0 Operation Performance Tests Results – PCMS(2006)- 01	
Power System Configuration as Tested –	
Solar Array output: 300 W	
Battery-bank: Four Crown CR-225 6 V Deep-cycle batteries, 450 Ah @ 12 Vdc (20 hr. rate)	
Durability Results –	
Testing period: 2/10/06 through 3/13/06	
Beginning Voltage: 12.8 V per sign’s diagnostics, 12.91 V per voltmeter	
Ending Voltage: 12.8 V per sign’s diagnostics, 12.88 V per voltmeter	
Testing Comments:	
<ul style="list-style-type: none"> – 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: 3/14/06	
Date found non-operational: 3/26/06	
Days of operation: 12 days (see Figure 1)	
Sign’s “shutdown” voltage setting: 10.7 V	
Voltage measured at shutdown: 11.2 V per sign’s diagnostics, 11.29 V per voltmeter	

4.0 Operation Performance Tests Results – PCMS(2006)- 01

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck on 3/26 to find the display message off. Even though the sign's voltage reading was 11.2 V (11.29 V per the voltmeter), it is the team's opinion that the sign did cease operation at the 10.7 V voltage setting. By reviewing the voltage drops shown in Figure 1, the sign was only 0.3 V from reaching 10.7 V on 3/25. The 11.2 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 programmed message was still in the controller memory and the sign functioned properly.

Failures or Significant Problems –

There were no failures or significant problems found during testing.

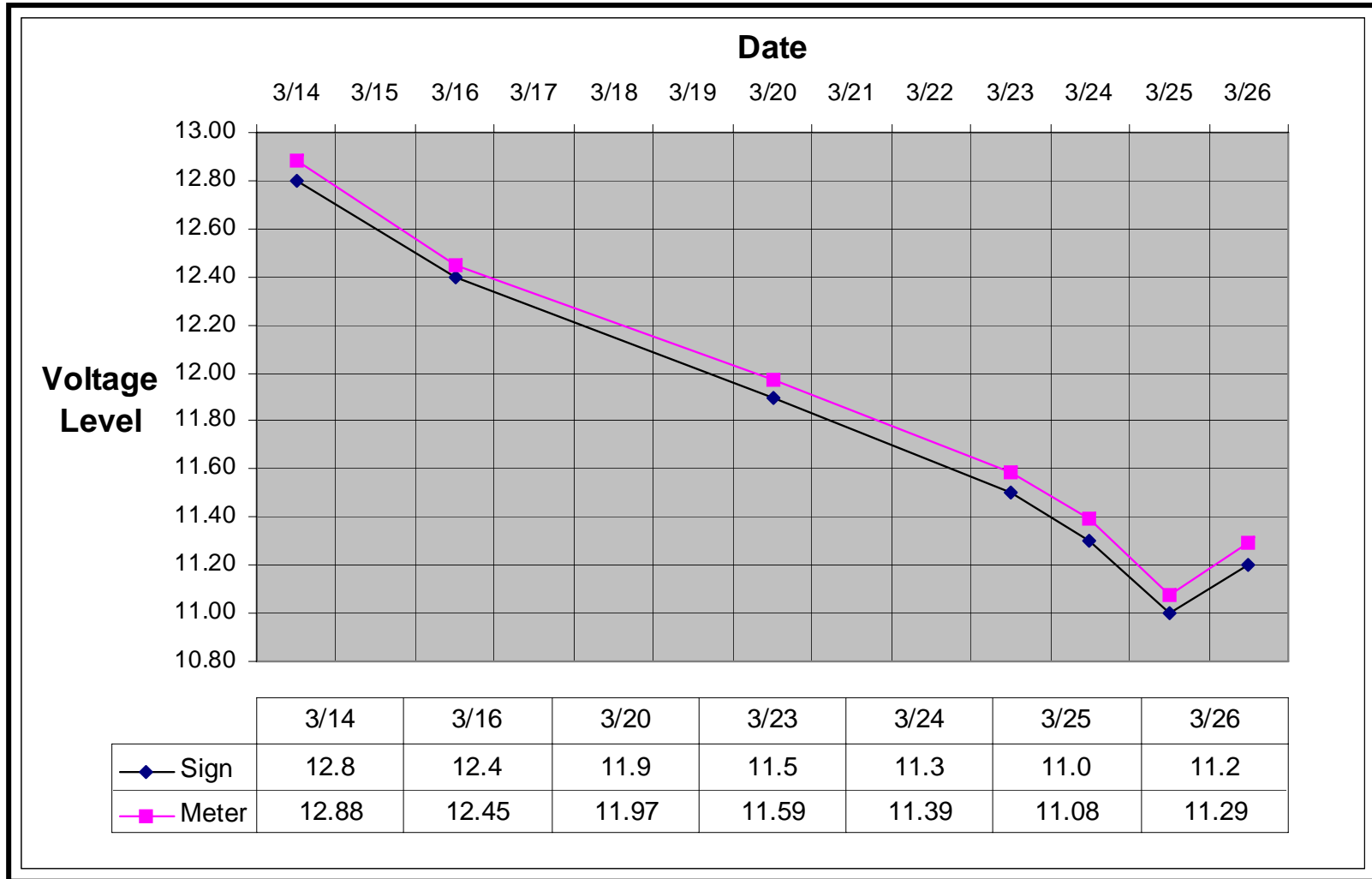


Figure 1 – PCMS(2006)- 01 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2006)- 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: 23 degree
- Alignment-sighting tube is located on sign panel
- Electro-hydraulic panel lift (optional manual back-up system)
- \pm 360 degree panel rotation

Power System

- Onboard diagnostics can check solar array and battery-bank status
- Available solar array wattage outputs: 150 (standard), 225, 300 (tested)
- Standard battery-bank: Four 6 V Deep-cycle batteries, 450 Ah @ 12 Vdc (20 hr. rating)
- 30 amp battery charger is standard
- Recharge time of standard battery-bank: 20 hours
- AC power capable 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 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
- 80 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2006)- 01

Controller System (continued)

- Sixteen messages can be displayed sequentially
- Message display time: 0.1 to 99.0 seconds per 0.1 second increments
- Message flash time: 0.1 to 99.0 seconds per 0.1 second increments
- Manual dimming capability
- Controller software upgrades via laptop
- Controller is stored in lockable weather-resistant enclosure

General

- Operating temperature: – 40 to +180 degrees F
- Trailer brakes are not required because of weight
- Tongue wheel is optional
- Nominal operating height: 162 in.
- Maximum wind load: 90 mph
- Maximum towing speed: 75 mph
- Transport dimensions: 180 in. length x 92 in. width x 102 in. height
- Weight: 2657 lb.
- Tongue weight: 175 lb.



PCMS(2006)- 02

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 (610) 391-8601
Web Site: www.solartechnology.com

3.0 Sight Tests Results – PCMS(2006)- 02	
Visibility Results –	
Daytime:	4800 feet
Nighttime:	4800 feet
Legibility Results –	
Daytime “Word”:	1113 feet
Daytime “Eye Chart”:	836 feet
Nighttime “Word”:	1115 feet
Nighttime “Eye Chart”:	909 feet
Angularity Results –	
Daytime:	79 feet / 17.7 degrees (half-angle calculation) (Rear-view mirror affected result)
Nighttime:	64 feet / 21.3 degrees (half-angle calculation) (Rear-view mirror affected result)

4.0 Operation Performance Tests Results – PCMS(2006)- 02	
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:	2/10/06 through 3/13/06
Beginning Voltage:	13.0 V per sign’s diagnostics, 13.04 V per voltmeter
Ending Voltage:	12.8 V per sign’s diagnostics, 12.77 V per voltmeter
Testing Comments:	<ul style="list-style-type: none"> – 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:	3/14/06
Date found non-operational:	3/24/06
Days of operation:	10 days (see Figure 2)
Sign’s “shutdown” voltage setting:	10.7 V
Voltage measured at shutdown:	11.3 V per sign’s diagnostics, 11.26 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2006)- 02

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck on 3/24 to find the display message off. Even though the sign's voltage reading was 11.3 V (11.26 V per the voltmeter), it is the team's opinion that the sign did cease operation at the 10.7 V voltage setting. By reviewing the voltage drops shown in Figure 2, the sign was only 0.5 V from reaching 10.7 V. on 3/23. The 11.3 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 programmed message was still in the controller memory and the sign functioned properly.

Failures or Significant Problems –

There were no failures or significant problems found during testing.

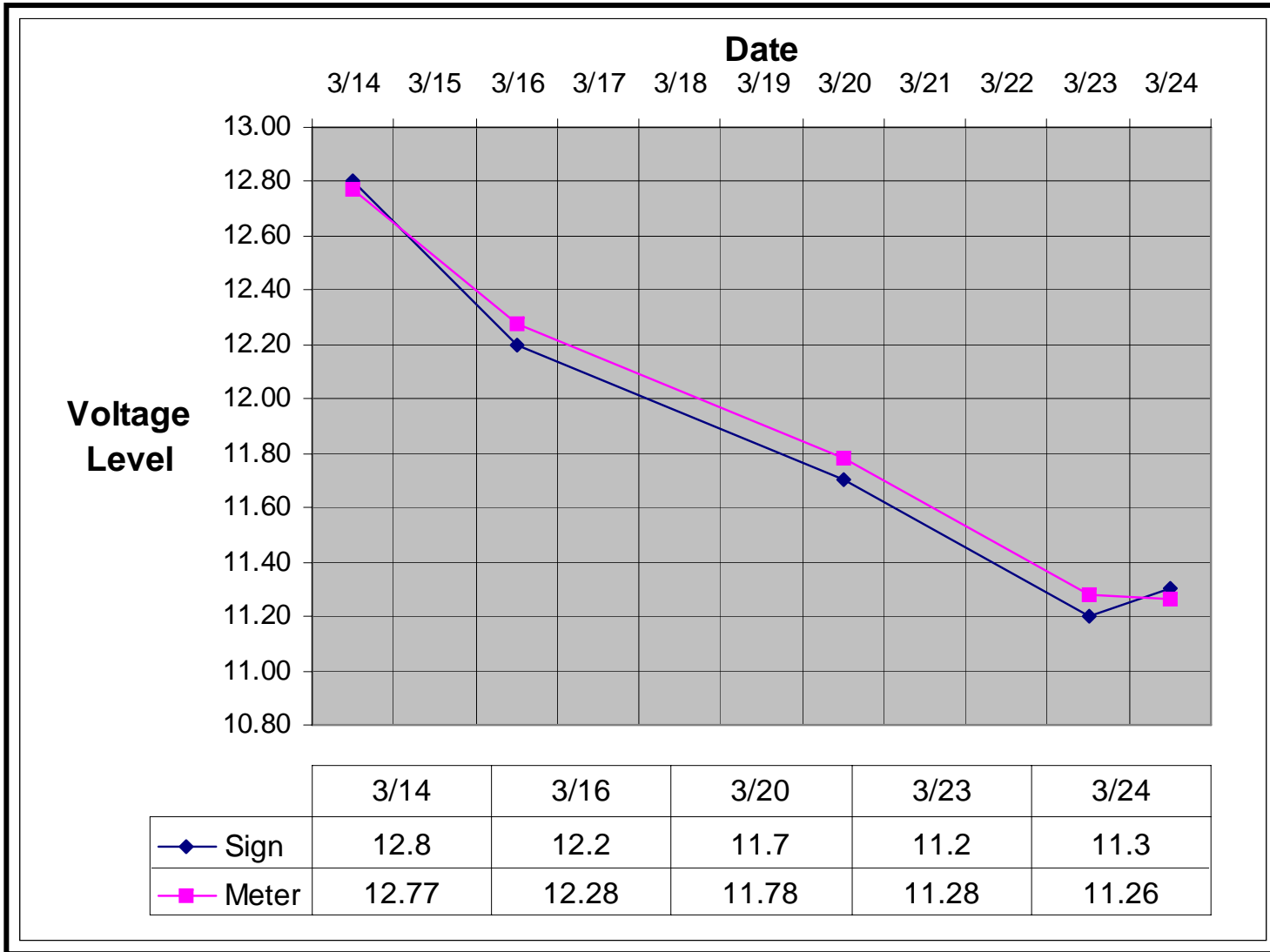


Figure 2 – PCMS(2006)-02 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2006)- 02

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: 23 degree LED with custom lens that increased effective angularity to 30 degrees
- Alignment-sighting tube is located on sign panel
- 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, 300, 375, 450 (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: 27 hours
- AC power capable 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 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
- 80 user programmed messages

5.0 Technical Desk Audit and Verification – PCMS(2006)- 02

Controller System (continued)

- Sixteen messages can be displayed sequentially
- Message display time: 0.1 to 99.0 seconds per 0.1 second increments
- Message flash time: 0.1 to 99.0 seconds per 0.1 second increments
- Manual dimming capability
- Controller software upgrades via laptop
- Controller is stored in lockable weather-resistant enclosure

General

- Operating temperature: – 40 to +180 degrees F
- Trailer brakes are reverse surge
- Tongue wheel is optional
- Nominal operating height: 162 in.
- Maximum wind load: 90 mph
- Maximum towing speed: 75 mph
- Transport dimensions: 180 in. length x 92 in. width x 102 in. height
- Weight: 2857 lb.
- Tongue weight: 175 lb.



PCMS(2006)- 03

Product Information
Product Name/Model: KKAB5025
Company: K&K Systems
Address: 687 Palmetto Road, Tupelo, MS 38801
Phone: (662) 566-2025, FAX (662) 566-7123
Web Site: www.k-ksystems.com

3.0 Sight Tests Results – PCMS(2006)- 03	
Visibility Results –	
Daytime: 4800 feet	
Nighttime: 4800 feet	
Legibility Results –	
Daytime: 4059 feet	
Nighttime: 3285 feet	
Angularity Results –	
Daytime: 248 feet / 5.8 degrees (half-angle calculation)	
Nighttime: 58 feet / 23.3 degrees (half-angle calculation) (Rear-view mirror affected result)	

4.0 Operation Performance Tests Results – PCMS(2006)- 03	
Power System Configuration as Tested –	
Solar Array output: 50 W	
Battery-bank: Two Crown 8D-1475 12 V Heavy-duty batteries, 430 Ah @ 12Vdc (20 hr. rate)	
(Note: During the Reliability test, one of the batteries was disconnected. See the Reliability test comments below for an explanation)	
Durability Results –	
Testing period: 2/10/06 through 3/13/06	
Beginning Voltage: 12.98 V per voltmeter	
Ending Voltage: 12.93 V per voltmeter	
Testing Comments:	
<ul style="list-style-type: none"> – 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: 3/14/06	
Date found non-operational: 3/28/06	
Days of operation: 14 days (see Figure 3)	
Sign's "shutdown" voltage setting: 10.7 V	
Voltage measured at shutdown: 10.87 V per voltmeter	

4.0 Operation Performance Tests Results – PCMS(2006)- 03

Reliability Results (continued)–

Testing Comments:

- Note: Modification to the work plan was necessary for the FAP during the test. The FAP was equipped with two batteries having a capacity total of 430 Ah. During the early voltage readings, it became apparent that the FAP was capable of operating more than 30 days. Concerned the test could be extended longer than 30 days, the team asked permission from K&K Systems to set the sign to full LED brightness and to disconnect one battery from the battery-bank to speed the shutdown of the sign. Since the main purpose of the Reliability test is to verify the sign's ability to cease operation at a preset "shutdown" voltage, the team felt this was suitable solution to the problem. Obviously, the Days of Operation data for the FAP as reported above is not an accurate result of the sign's battery-bank capacity and should not be used judge the to sign's true performance.
- The team arrived at the test deck on 3/28 to find the display off. Even though the sign's voltage reading was 10.87 V per the voltmeter, it is the team's opinion that the sign ceased operation at the 10.7 V voltage setting. The 10.87 V reading is the result of battery recovery once the sign ceased operation.
- The team questioned the 1.09 V voltage drop from 3/27 to 3/28 shown on Figure 3. The other signs had not exhibited a similar sudden drop in voltage so the team contacted a technical adviser with the battery industry for an explanation. The following is the statement we received:

"When a battery discharges you will notice a slow gradual voltage drop until a certain "point". At this "point" you will notice a sharper decline in voltage. In short, what is happening is the battery has used up the entire available sulfate in the electrolyte and the voltage will rapidly decrease."

What is shown on the graph is typical of batteries that become deeply discharged. The technical adviser suggested that the "shutdown" voltage of the FAP be raised to 11.5 V to eliminate the risk of this happening again.
- The sign's solar array was reconnected and the battery-bank charged to operational voltage. The sign functioned properly.

Flashing Rate Results –

Flashes per minute: 39

Dwell time ON: 0.69 seconds

Failures or Significant Problems –

There were no failures or significant problems found during testing.

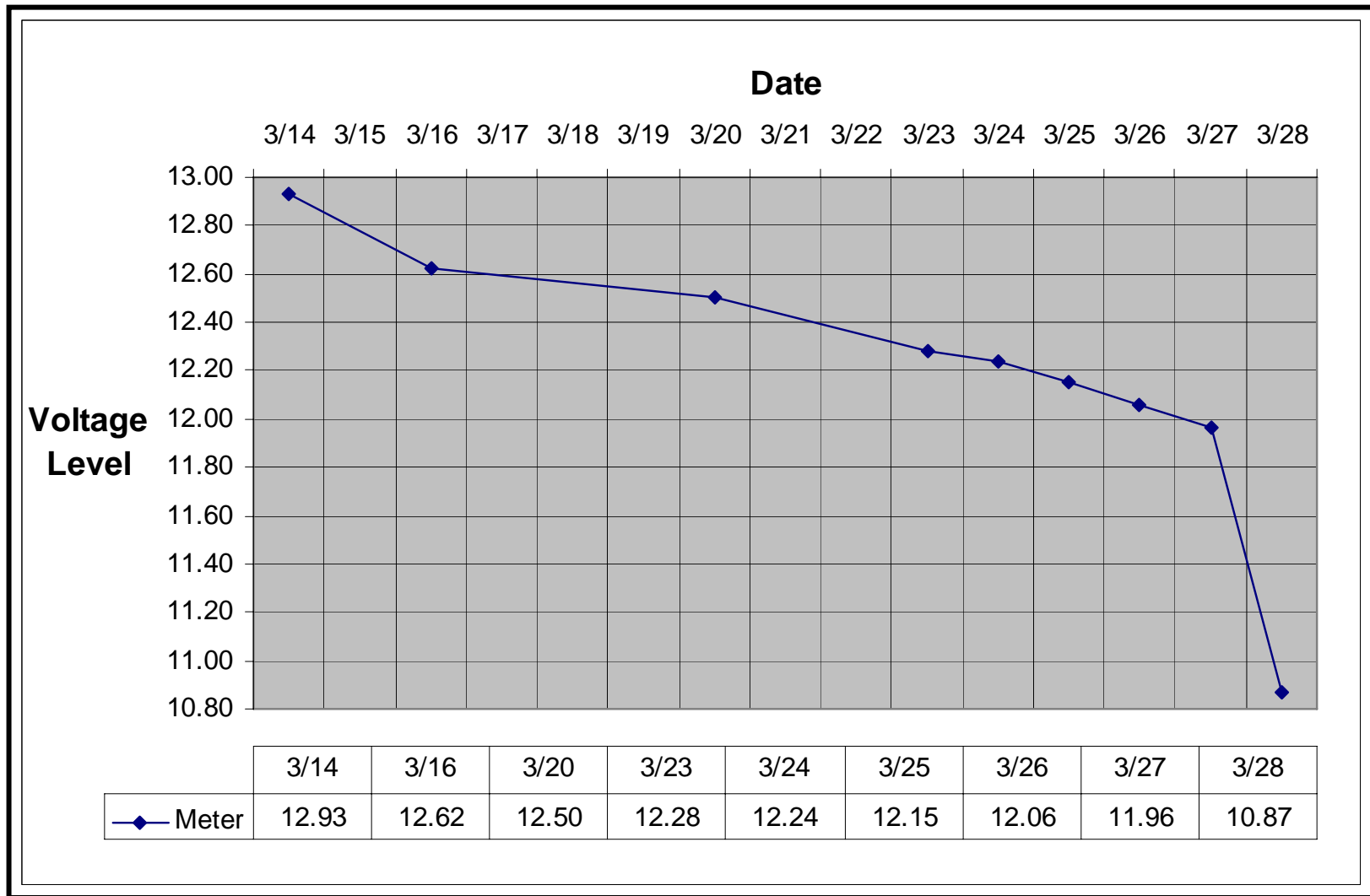


Figure 3 – PCMS(2006)- 03 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2006)- 03
Sign Panel
<ul style="list-style-type: none"> • MUTCD panel type: Type C, 25 lamps
<ul style="list-style-type: none"> • Lamp type: LED Par 46
<ul style="list-style-type: none"> • Available display modes: Left and Right Single Flashing Arrow, Double Flashing Arrow, Left and Right Chevron, Left and Right Stem Arrow, Left and Right Sequential Arrow, Alternating Diamond Caution, Center Bar Caution, Four-Corner Caution
<ul style="list-style-type: none"> • Optional alignment-sighting device
Power System
<ul style="list-style-type: none"> • Available solar array wattage outputs: 50 (tested), 70, 100, 120
<ul style="list-style-type: none"> • Standard battery-bank: Two 12 V Heavy-duty batteries, 430 Ah @ 12 Vdc (20 hr. rating)
<ul style="list-style-type: none"> • 55 amp battery charger is optional
<ul style="list-style-type: none"> • Recharge time of standard battery-bank: 24 hours
<ul style="list-style-type: none"> • AC power capability is optional
<ul style="list-style-type: none"> • Battery-bank is stored in a lockable weather-resistant enclosure
<ul style="list-style-type: none"> • Solar panels cannot be tilted for normal operation
Controller System
<ul style="list-style-type: none"> • Control display is neither backlit nor external lighted
<ul style="list-style-type: none"> • Manual dimming capability
<ul style="list-style-type: none"> • Battery-bank status indicator
<ul style="list-style-type: none"> • Controller is stored in lockable weather-resistant enclosure
General
<ul style="list-style-type: none"> • Operating temperature: – 40 to +158 degrees F
<ul style="list-style-type: none"> • Nominal operating height: 7 ft. to bottom of sign
<ul style="list-style-type: none"> • Maximum wind load: n/a
<ul style="list-style-type: none"> • Maximum towing speed: 65 mph
<ul style="list-style-type: none"> • Transport dimensions: 107 in. length x 68 in. width x 84 in. height
<ul style="list-style-type: none"> • Weight: 850 lb.

(Blank)



PCMS(2006)- 04

Product Information
Product Name/Model: KKMB3L-240
Company: K&K Systems
Address: 687 Palmetto Road, Tupelo, MS 38801
Phone: (662) 566-2025, FAX (662) 566-7123
Web Site: www.k-ksystems.com

3.0 Sight Tests Results – PCMS(2006)- 04	
Visibility Results –	
Daytime:	2456 feet
Nighttime:	4800 feet
Legibility Results –	
Daytime “Word”:	886 feet
Daytime “Eye Chart”:	678 feet
Nighttime “Word”:	982 feet
Nighttime “Eye Chart”:	740 feet
Angularity Results –	
Daytime:	137 feet / 10.4 degrees (half-angle calculation)
Nighttime:	67 feet / 20.6 degrees (half-angle calculation) (Rear-view mirror affected result)

4.0 Operation Performance Tests Results – PCMS(2006)- 04	
Power System Configuration as Tested –	
Solar Array output:	240 W
Battery-bank:	Four Crown 8D-1475 12 V Heavy-duty batteries, 860 Ah @ 12 Vdc (20 hr. rate)
Durability Results –	
Testing period:	2/10/06 through 3/13/06
Beginning Voltage:	13.0 V per sign’s diagnostics, 13.05 V per voltmeter
Ending Voltage:	12.7 V per sign’s diagnostics, 12.78 V per voltmeter
Testing Comments:	<ul style="list-style-type: none"> – 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:	3/14/06
Date found non-operational:	3/24/06
Days of operation:	10 days (see Figure 4)
Sign’s “shutdown” voltage setting:	11.4 V
Voltage measured at shutdown:	11.9 V per sign’s diagnostics, 12.00 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2006)- 04

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck on 3/24 to find the display message off. Even though the sign's voltage reading was 11.9 V (12.0 V per the voltmeter), it is the team's opinion that the sign did cease operation at the 11.4 V voltage setting. By reviewing the voltage readings shown in Figure 4, the sign was approaching 11.4 V on 3/23. The 11.9 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 programmed message was still in the controller memory and the sign functioned properly.

Failures or Significant Problems –

There were no failures or significant problems found during testing.

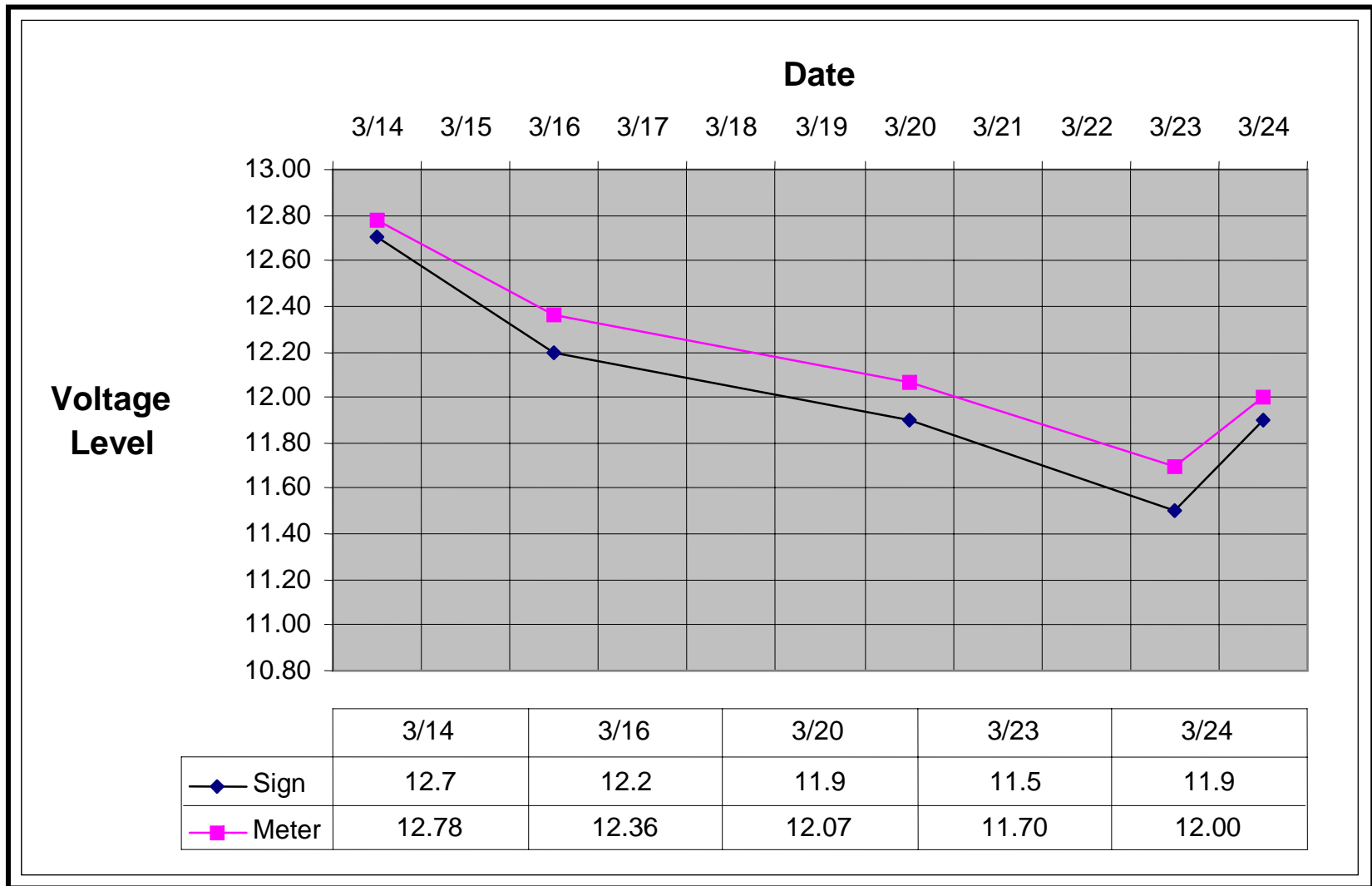


Figure 4 – PCMS(2006)-04 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2006)- 04

Sign Panel

- Display type: Three Line LED Character Matrix
- Panel size: 132 in. wide x 78 in. high
- Maximum number of 5 x 7 characters per line: Eight
- 5 x 7 element character size: 18.2 in. high x 13 in. wide
- 5 x 7 element character spacing: 4 in.
- LEDs (pixels) per element: Four
- LED angularity specification tested: 15 degrees
- Optional alignment-sighting device
- 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: 170, 240 (tested), 300, and 480
- Standard battery-bank: Four 12 V Heavy-duty batteries, 860 Ah @ 12 Vdc (20 hr. rating)
- 55 amp battery charger is standard
- Recharge time of standard battery-bank: 24 hours
- AC power capable
- Battery-bank is stored in a lockable weather-resistant enclosure
- Solar panels can be tilted for normal operation

Controller System

- Input device: keyboard with no external lighting
- Backlit display
- Menu driven programming
- Single password protection with multi-level password protection via laptop software
- Automatic test function for pixels
- Quick-program feature
- Programmable default message
- “Auto-resume” feature after power interruption with user defined message
- 215 pre-programmed messages (upgraded with additional memory)
- 99 user programmed messages (upgraded with additional memory)

5.0 Technical Desk Audit and Verification – PCMS(2006)- 04

Controller System (continued)

- Six messages can be displayed sequentially
- Message display time intervals: 0.1 to 25.5 seconds per 0.1 second increments
- Message flash time: 0.1 to 25.5 seconds per 0.1 second increments
- Manual dimming capability
- Controller software upgrades per laptop or interchangeable controller
- Controller is stored in lockable weather proof enclosure

General

- Operating temperature: – 40 to +158 degrees F
- Optional surge or electric trailer brakes
- Tongue wheel is standard
- Nominal operating height: 184 in. as tested, new version will be 164 in.
- Maximum wind load: (Information not supplied)
- Maximum towing speed: 65 mph
- Transport dimensions: 180 in. length x 80 in. width x 136 in. height
- Weight: 2180 lb.
- Tongue weight: 350 lb.



PCMS(2006)- 05

Product Information
Product Name/Model: WTLMB-SLL(A)06
Company: Wanco, Inc.
Address: 5870 Tennyson Street, Arvada, CO, 80003
Phone: (303) 427-5700, FAX (303) 427-5725
Web Site: www.wanco.com

3.0 Sight Tests Results – PCMS(2006)- 05	
Visibility Results –	
Daytime:	4800 feet
Nighttime:	4800 feet
Legibility Results –	
Daytime “Word”:	1349 feet
Daytime “Eye Chart”:	1042 feet
Nighttime “Word”:	1295 feet
Nighttime “Eye Chart”:	853 feet
Angularity Results –	
Daytime:	67 feet / 20.6 degrees (half-angle calculation) (Rear-view mirror affected result)
Nighttime:	73 feet / 19 degrees (half-angle calculation) (Rear-view mirror affected result)

4.0 Operation Performance Tests Results – PCMS(2006)- 05	
Power System Configuration as Tested –	
Solar Array output:	250 W
Battery-bank:	Ten Exide GC-135 6 V Deep-cycle batteries, 1125 Ah @12 Vdc (20 hr. rate)
Durability Results –	
Testing period:	2/10/06 through 3/13/06
Beginning Voltage:	12.48 V per sign’s diagnostics, 12.87 V per voltmeter
Ending Voltage:	12.45 V per sign’s diagnostics, 12.78 V per voltmeter
Testing Comments:	<ul style="list-style-type: none"> – The sign’s voltage diagnostics was approximately 0.5 V less than what was read per the voltmeter. Disregarding the sign’s diagnostics and only using the voltmeter’s reading for the evaluation, it is the opinion of the team that the sign’s charging system kept the battery-bank properly charged during testing.
Reliability Results –	
Solar array disconnect date:	3/14/06
Date found non-operational:	3/29/06
Days of operation:	15 days (see Figure 5)
Sign’s “shutdown” voltage setting:	11.3 V
Voltage measured at shutdown:	11.28 V per sign’s diagnostics, 11.83 V per voltmeter

4.0 Operation Performance Tests Results – PCMS(2006)- 05

Reliability Results (continued)–

Testing Comments:

- The team arrived at the test deck and witnessed the sign ceasing operation as it fell below the 11.3 V “shutdown” setting.
- Since the sign’s voltage diagnostics was approximately 0.5 V less than what was read per the voltmeter (see above Testing Comments), it is the team’s opinion that the discrepancy in the sign diagnostics resulted in the sign ceasing operation several days sooner than it should have.
- The sign’s “startup” voltage setting was 11.5 V. The testers found that the sign would startup within minutes of shutdown because of battery recovery and then shutdown again as the battery voltage fell to the 11.3 V shutdown voltage. The resulting “on/off” of the display gave the appearance that the sign was flashing the message. The result is not a detriment to the sign’s performance since the startup voltage can be adjusted. It is suggested to review the “startup” voltage setting with Wanco, Inc. when purchasing the sign.
- The sign’s solar array was reconnected and the battery-bank charged to operational voltage. The programmed message was still in the controller memory and the sign functioned properly.

Failures or Significant Problems –

On 3/10 during Durability Testing, hydraulic fluid was found leaking onto the mast mounting plate. Wanco, Inc was notified about the problem and it was determined that the leak was not significant enough to halt the test and repair.

On 3/28 during Reliability Testing, the team found an element not operational in the character “D” on the third line of the message.

On 4/01 after the sign had been recharged and checked for normal operation, the team found an element not operational in the character “T” on the second line of the message.

The team decided to give Wanco, Inc. an opportunity to explain the above problems. The following is their response:

- Hydraulic leak: The fitting that was installed on the pump output has an O-Ring. This O-Ring was found to be damaged on the test unit and was replaced to prevent future problems.
- Element problems: Failure was due to bad solder joints. Resoldering using a wave soldering process cured the problem.

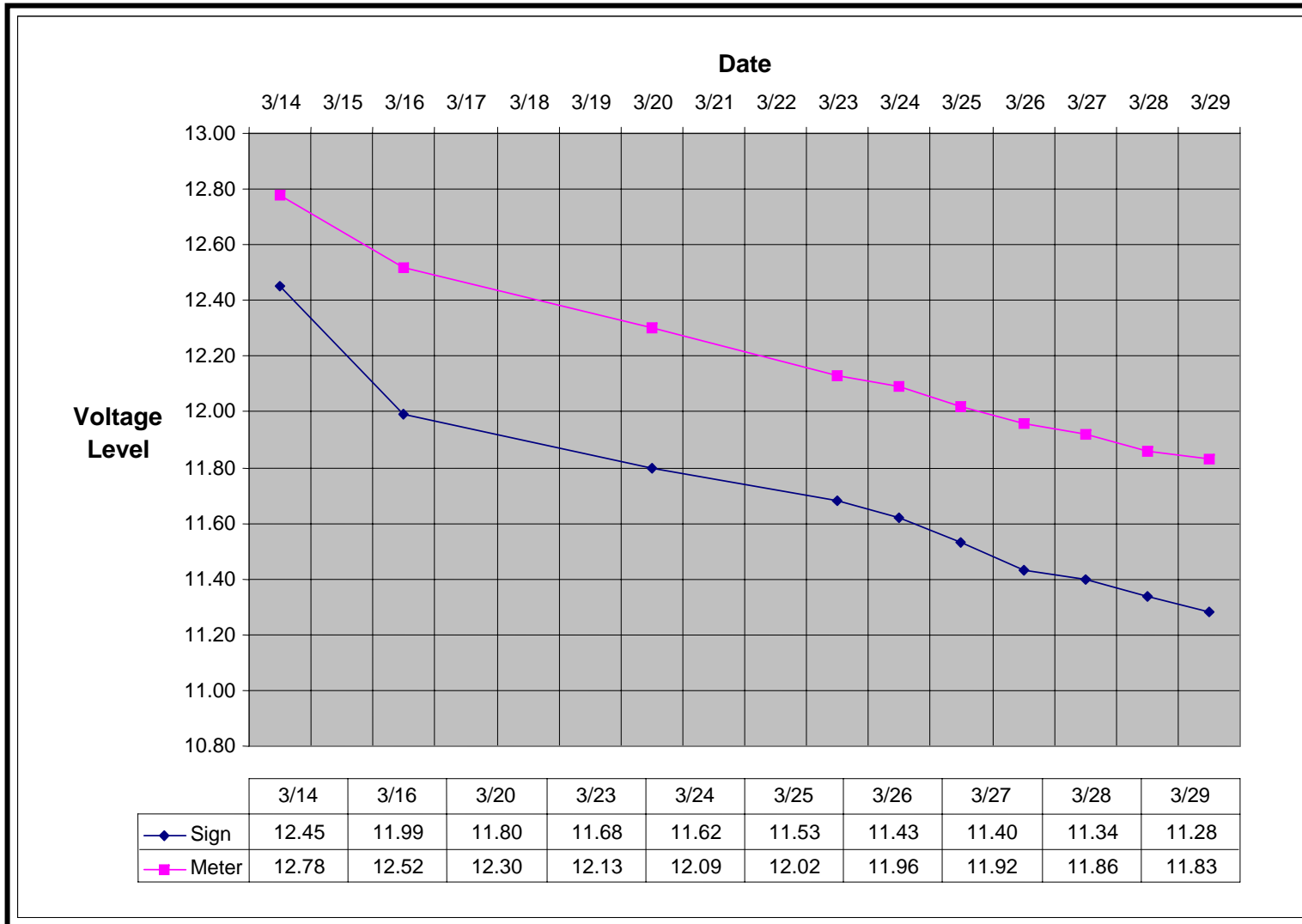


Figure 5 – PCMS(2006)-05 Reliability Results

5.0 Technical Desk Audit and Verification – PCMS(2006)- 05

Sign Panel

- Display type: Three Line LED Character Matrix
- Panel size: 137 3/4 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 11 5/8 in. wide
- 5 x 7 element character spacing: 5 3/4 in.
- LEDs (pixels) per element: Four
- LED angularity specification tested: 23 degree LED with custom lens that increased effective angularity to 50 degrees
- Alignment sighting tube mounted on panel mast
- 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: 160, 250 (tested), 520
- Standard battery-bank: Ten 6 V Deep-cycle batteries, 1125 Ah @ 12 Vdc (20 hr. rating)
- 45 amp battery charger is standard
- Recharge time of standard battery-bank: 45 – 50 hours
- 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

- Input device: IBM compatible keyboard with external lighting
- Backlit display
- Menu driven programming
- Multilevel password protection
- Automatic test function
- Quick-program feature
- Default “low battery” message
- “Auto-resume” feature after power interruption
- 94 pre-programmed messages
- 100 user programmed messages, 10 temporary messages

5.0 Technical Desk Audit and Verification – PCMS(2006)- 05

Controller System (continued)

- Six messages can be displayed sequentially
- Message display time intervals: 0.1 to 25.0 seconds per 0.1 second increments
- Message flash time: 1.0 to 25.0 seconds per 0.1 second increments
- Manual dimming capability
- Controller software upgrades via chip replacement
- Controller is stored in lockable weather-resistant enclosure

General

- Operating temperature: – 5 to +150 degrees F
- Optional surge or electric trailer brakes
- Tongue wheel is standard
- Nominal operating height: 156 in.
- Maximum wind load: 98 mph with optional outrigging
- Maximum towing speed: 70 mph
- Transport dimensions: 190 in. length x 95 in. width x 107 in. height
- Weight: 2640 lb.
- Tongue weight: 170 lb.

NTPEP ID# & Product	Company	Daytime					Nighttime				
		Visibility (ft)	Legibility (ft)		Angularity (ft/∅)		Visibility (ft)	Legibility (ft)		Angularity (ft/∅)	
			Word	Eye Chart				Word	Eye Chart		
PCMS(2006)- 01 Silent Messenger MB-1548	Solar Technology, Inc.	4800	1398	992	116	12.2°	4800	1202	893	67	20.6°
PCMS(2006)- 02 Silent Messenger MB-4048	Solar Technology, Inc.	4800	1113	836	79	17.7°	4800	1115	909	64	21.3°
PCMS(2006)- 04 KKMB3L-240	K&K Systems	2456	886	678	137	10.4°	4800	982	740	67	20.6°
PCMS(2006)- 05 WTLMB-SLL(A)06	Wanco, Inc.	4800	1349	1042	67	20.6°	4800	1295	853	73	19°

Figure 6 – PCMS Sight Tests Results Comparison

Note: The Angularity data reported is an “one-half” angle calculation. All results shown for Angularity that are highlighted were affected by the car’s rear-view mirror.

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Test Deck Pictures

(Blank)

Section 3.0- Sight Tests Pictures



Evaluation vehicle approaching sign



Sight test message



Sight test mode



Sight test message

Section 4.0- Operational Performance Tests Pictures



Test message



Test mode



Test deck sign setup



Signs under test

Appendix A

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

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NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM (NTPEP)

PROJECT WORK PLAN FOR PORTABLE CHANGEABLE MESSAGE SIGNS (PCMS)

2006

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.*

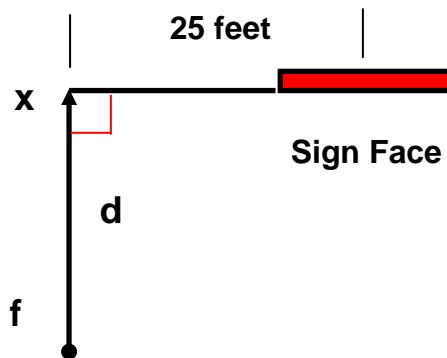


Figure 1

(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.*

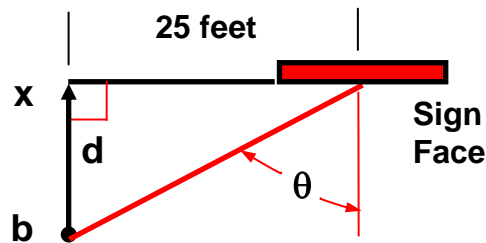


Figure 2

(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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NATIONAL TRANSPORTATION PRODUCT EVALUATION PROGRAM (NTPEP)

PROJECT WORK PLAN FOR FLASHING ARROW PANELS (FAP)

2006

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.*

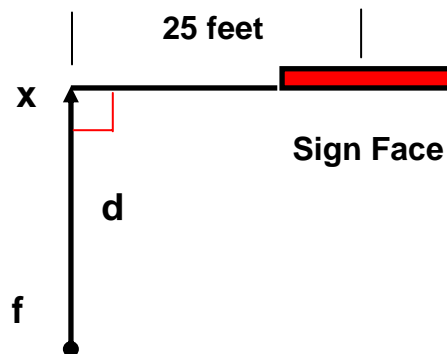


Figure 1

(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.*

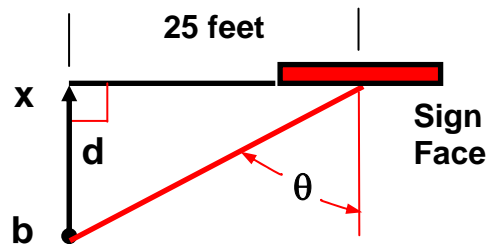


Figure 2

(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?

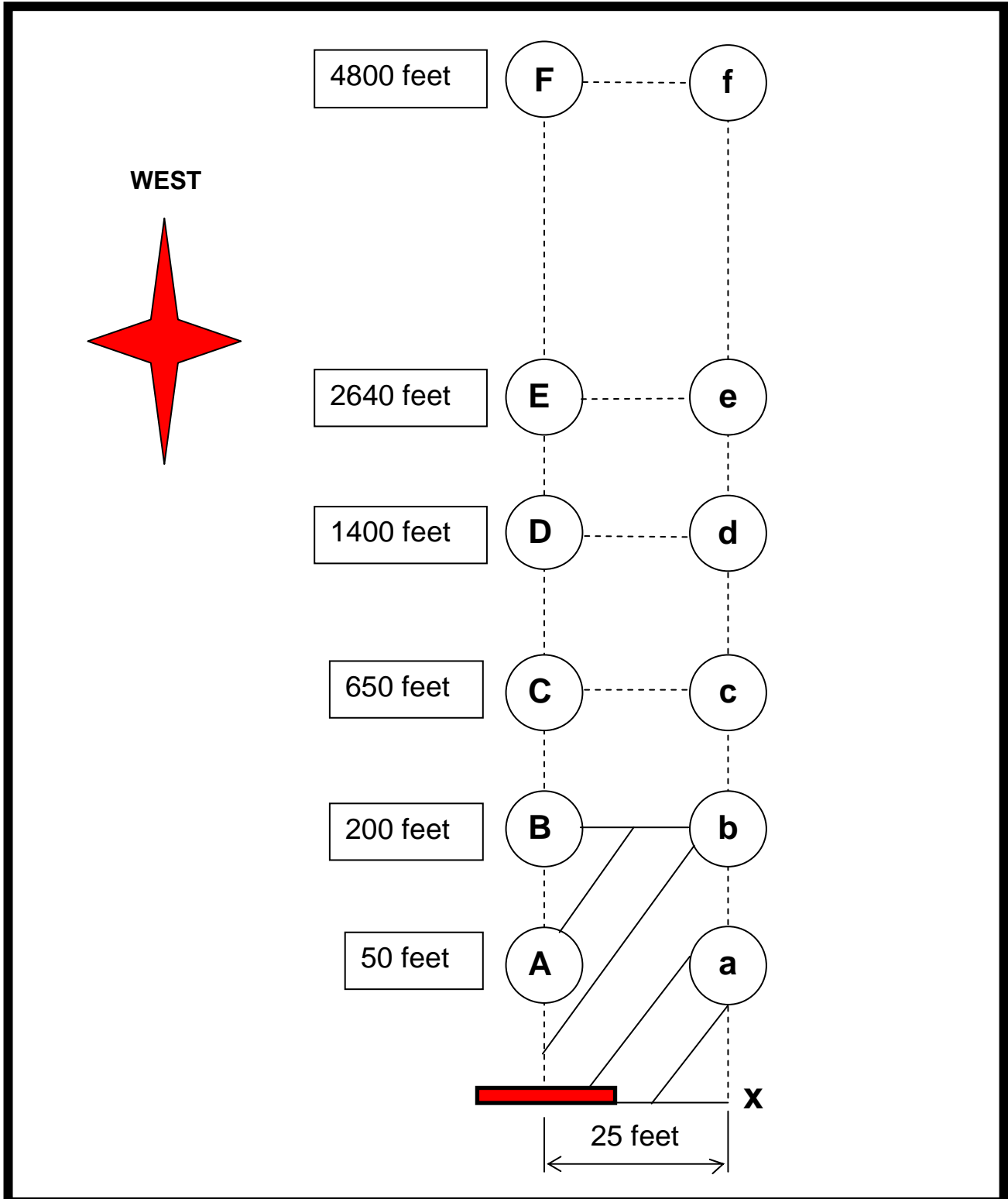
5.4 Controller System

- 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).

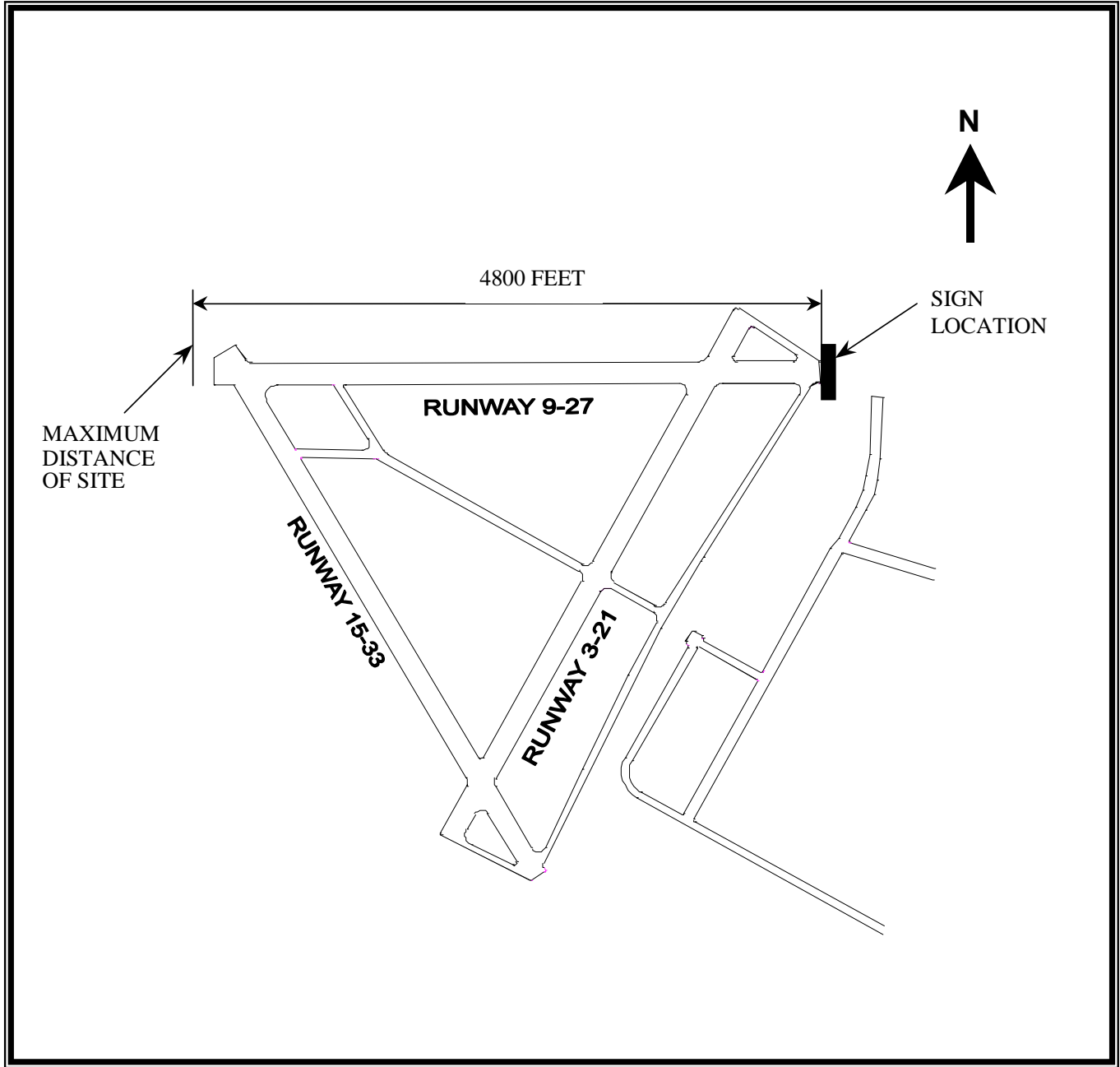
APPENDIX B

- Wilson Industrial Air Center
- Weather Data

(Blank)

Wilson Industrial Air Center

Wilson, NC



Weather Data

Weather data was provided by the Federal Aviation Administration

3.0 Sight Tests Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
05/01/06	71°	57°	43°	52	0.00	

4.0 Operational Performance Tests- Durability Daily Weather Data						
Date	Temperature (°F)			Average Humidity(%)	Precipitation Sum (in.)	Weather Events
	High	Avg	Low			
02/10/06	53°	37°	20°	53	0.00	
02/11/06	44°	40°	35°	77	0.39	Rain
02/12/06	44°	37°	30°	63	Trace	Snow
02/13/06	44°	34°	24°	52	0.00	
02/14/06	57°	41°	24°	51	0.00	
02/15/06	65°	50°	35°	45	0.00	
02/16/06	70°	56°	41°	51	0.00	
02/17/06	74°	61°	48°	59	0.00	
02/18/06	48°	40°	32°	62	0.07	Rain, Snow
02/19/06	37°	29°	20°	48	0.00	
02/20/06	49°	40°	31°	56	Trace	Snow
02/21/06	62°	49°	36°	62	0.00	
02/22/06	50°	44°	38°	83	0.42	Fog, Rain
02/23/06	60°	48°	36°	62	0.24	Fog, Rain
02/24/06	59°	47°	35°	48	0.00	
02/25/06	60°	47°	34°	60	0.00	
02/26/06	51°	40°	28°	52	0.00	
02/27/06	53°	37°	20°	40	0.00	
02/28/06	69°	56°	42°	40	0.00	
03/01/06	77°	60°	43°	54	0.00	
03/02/06	79°	66°	53°	52	0.00	
03/03/06	64°	50°	36°	37	0.00	
03/04/06	53°	39°	25°	44	0.00	
03/05/06	58°	42°	26°	43	0.00	
03/06/06	51°	46°	40°	64	0.11	Rain
03/07/06	55°	44°	32°	56	0.01	Rain
03/08/06	65°	46°	27°	54	0.00	
03/09/06	73°	59°	45°	53	0.00	
03/10/06	76°	67°	57°	64	Trace	Rain
03/11/06	81°	67°	52°	63	0.01	Fog, Rain
03/12/06	83°	71°	59°	70	0.00	
03/13/06	82°	72°	62°	66	0.00	

Durability Daily Weather Data Summary			
Temperature	Maximum	Average	Minimum
High Temperature (°F)	83°	61°	37°
Mean Temperature (°F)	72°	49°	29°
Low Temperature (°F)	62°	36°	20°

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			
03/14/06	69°	60°	50°	44	0.06	Rain
03/15/06	61°	51°	41°	29	0.00	
03/16/06	67°	53°	38°	45	0.00	
03/17/06	66°	55°	44°	45	Trace	Rain
03/18/06	57°	48°	38°	37	0.00	
03/19/06	56°	44°	32°	34	0.00	
03/20/06	54°	42°	30°	62	0.48	Rain
03/21/06	42°	40°	38°	91	0.51	Rain
03/22/06	52°	44°	35°	60	0.00	
03/23/06	54°	42°	29°	50	0.00	
03/24/06	52°	45°	38°	57	Trace	Rain
03/25/06	49°	41°	33°	76	0.07	Rain
03/26/06	52°	41°	29°	62	0.00	
03/27/06	60°	45°	29°	57	0.00	
03/28/06	63°	51°	38°	58	0.00	
03/29/06	66°	53°	39°	62	0.00	Fog

Reliability Daily Weather Data Summary			
Temperature	Maximum	Average	Minimum
High Temperature (°F)	69°	58°	42°
Mean Temperature (°F)	60°	47°	40°
Low Temperature (°F)	50°	36°	29°

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“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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