Interlaboratory Study to Determine the Precision of the MIT Scan T2 for PCC Pavement Thickness

Final Report
for
MLR-14-01

February 2015

Highway Division

IOWA DOT

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February 2015

TECHNICAL REPORT TITLE PAGE

1. REPORT NO.

MLR-14-01

2. REPORT DATE

February 2015

3. TITLE AND SUBTITLE

Interlaboratory Study to Determine the Precision of the MIT Scan T2 for PCC Thickness

4. TYPE OF REPORT & PERIOD COVERED

Final Report, October 2014 to December 2014

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7. ACKNOWLEDGMENT OF COOPERATING ORGANIZATIONS/INDIVIDUALS

8. ABSTRACT

The MIT Scan T2 device has been implemented in Iowa as a new method for determining PCC pavement thickness compliance. The T2 device utilizes a magnetic pulse induction technology to measure the distance from a sensor to a metal target. The objective of this project was to conduct an interlaboratory study (ASTM C802) to determine the precision of the test.

Fifteen MIT Scan T2 gauges and fifteen operators performed testing on three reference platforms and nine pavement locations of varying thicknesses. The testing was conducted on October 29, 2014 at two sites near Ames, Iowa. Usable data was obtained from every operator at all locations.

The results of the ASTM C802 analysis on the nine pavement locations are:

	Within Laboratory	**Between Laboratory**
COV of a Single Test	0.3%	0.5%
Two tests on the same target should not differ by	0.8%	1.3%
Maximum Allowable Range	0.9%	1.6%

9. KEY WORDS

PCC Pavement thickness
Non-destructive testing

10. NO. OF PAGES

13

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DISCLAIMER

INTRODUCTION

The MIT Scan T2 Device has been implemented in Iowa as a new method for determining PCC pavement thickness compliance. The T2 device utilizes a magnetic pulse induction technology to measure the distance from a sensor to a metal target. Whenever a new AASHTO or ASTM test procedure is developed, a determination of the precision is expected. The Iowa DOT is performing both verification and independent assurance on each project where the T2 device is used. The precision information will be submitted to AASHTO and will also be used to help the Iowa DOT determine if the verification testing is being done correctly.

OBJECTIVE

The objective of the project was to conduct an interlaboratory study to determine the precision of the MIT Scan T2 device and the Iowa test procedure for PCC pavement thickness in Iowa.

INTERLABORATORY STUDY PLAN

Two sites were chosen near Ames, Iowa for the testing (Figure 1). One site, a rest area under construction, had sections of both 8.5 inch and 10.5 inch pavement on a modified aggregate subbase. The other site was the Central Iowa Expo Site in Boone County. The pavement sections are 6inches thick on a modified aggregate subbase and were designed and constructed for research. The Iowa targets are fabricated to the following requirements:

- 24 gage galvanized ASTM A653LFQ, CS-B, G90.
- Sheet steel from Nucor Steel at Crawfordsville, IN and AK Steel at Middletown, OH.
- Laser cut to produce clean burr free edge.
- 300 mm (11.811"+/-0.01" diameter).
- 3/16" hole cut in the center.

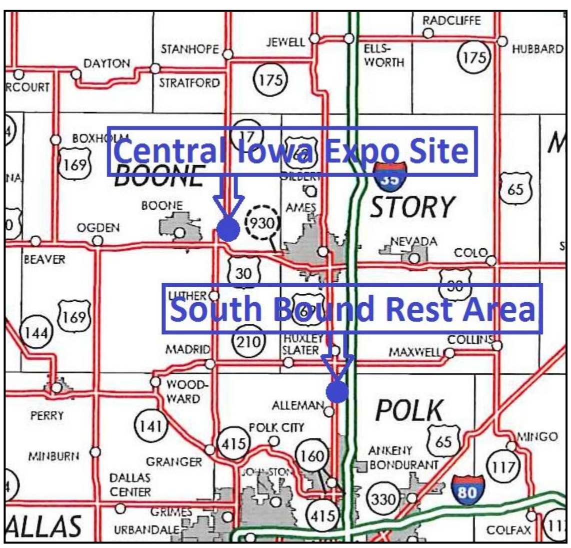


Figure 1. Site Locations

Figure 2. Example of the Target Placement on a Modified Aggregate Subbase

Figure 3. Verification Platforms

The targets were fastened down to the subbase with a single 3.5 inch galvanized siding nail (Figure 2). Both sites worked very well because there was no vehicle traffic. Verification platforms were constructed to check the gauges before going to the sites (Figure 3). The platform heights were approximately 150, 225, and 300 mm. The specific target locations are in Appendix A.

Fifteen devices and operators participated in the study. The FHWA came with 2 units and 2 operators. Kessler Soils Engineering Products, Inc.; the US distributor of the MIT device; sent one unit. The Iowa DOT provided 12 devices and 13 operators. Nine of the operators were experienced. The other 6 were inexperienced on this test but were engineers or experienced materials testing technicians. Eleven of the Iowa DOT devices are calibrated to an "Iowa style" target. The other 4 units in the study are calibrated to the German target. A correlation equation developed by Dan Ye of Fugro Roadware was used to adjust the data from those 4 units:

$$y = -0.00003723x^2 + 1.0163x + 1.45$$

The instructions to the operators were:

1. Test at the 3 platforms using the starting line and following the guide line.
2. Test at 9 different target locations.
3. Run each location 5 times and save all readings unless there is an obvious error in the testing.
4. Locate the target center in the pavement panel and use a plastic chip to mark the target location so the repeat runs follow the same path.

The operators were split into several groups of 2 to 4 people. All testing was done on October 29, 2014 from 8:00 A.M. to 3:00 P.M.. Temperatures ranged from about 45^o to 55^o F with a gusty NW wind most of the day. Figure 3 and 4 are operators testing at the two sites. There was a person assigned to each site to make sure that the operators labeled the data as instructed. The operators were to show up at different times and at the different locations so that no one had to wait to perform testing.

Figure 4. Testing at the South Bound Rest Area Car Parking

Figure 5. Testing at the Central Iowa Expo Site

DATA ANALYSIS

Analysis procedures from ASTM C802 were used to determine the precision. The overall averages for the platforms and pavement locations are in table 1. The individual results are in Appendix B. No data was removed from the analysis and the results of all 15 operators were used for all nine locations. The range of thicknesses used in the study, 6.2 inches to 11.7 inches, covers the majority of the pavement and shoulder design thicknesses used in Iowa currently.

Table 1 Overall Average Thickness Readings

Location	**Avg. (mm)**	**Std. Dev. (mm)**
Platform 1	150.5	0.90
Platform 2	223.6	0.66
Platform 3	299.6	0.77
Expo (A1)	158.6	0.76
Expo (A2)	157.7	0.85
Expo (A3)	157.3	0.83
Rest Area (B1)	297.7	1.48
Rest Area (B2)	295.5	0.98
Rest Area (B3)	288.7	0.67
Rest Area (C1)	246.5	1.20
Rest Area (C1)	218.5	0.51
Rest Area (C1)	245.4	0.60

The results of the ASTM C802 analysis on the nine pavement locations are:

	Within Laboratory	**Between Laboratory**
COV of a Single Test	0.3%	0.5%
Two tests on the same target should not differ by	0.8%	1.3%
Maximum Allowable Range	0.9%	1.6%

Precision statements can be based on a constant standard deviation or on a constant coefficient of variation (COV). The data did not indicate a strong tendency either way. Since the manufacturer’s accuracy is stated as a percentage of the gauge reading, the COV was chosen. These coefficients of variation results are very low considering that the stated accuracy of the gauge is ±(0.005×gauge reading + 1 mm). The COV are also lower than what is typical of a laboratory test. A couple possible reasons for the low COV:

1. Every operator was actually testing the same sample. For most ILS testing, each lab receives a different portion of a material.
2. The 5 replicate tests were done at the same time from the same target center location. More variation may have occurred if the same operator left the target location and then come back each time and located the center.
3. Everyone was testing on the same day in about the same weather conditions.
4. With the exception of one target location, there was no longitudinal or transverse texture.

CONCLUSIONS AND RECOMMENDATIONS

Based on this study with the MIT Scan T2 gauges, the following conclusions and recommendations can be stated:

1. The test procedure using the gauge is relatively easy to learn and perform.
2. The verification platforms were a quick and effective way to check gauge operation and calibration.
3. The criteria in the Iowa test procedure that requires all 3 readings at a location to be 3 mm or less is close to the within laboratory criteria determined in this study.
4. Rather than using a percent tolerance, a single tolerance of 0.15 inches or less should be placed in Materials IM 216 and used in the Independent Assurance Program for this test.

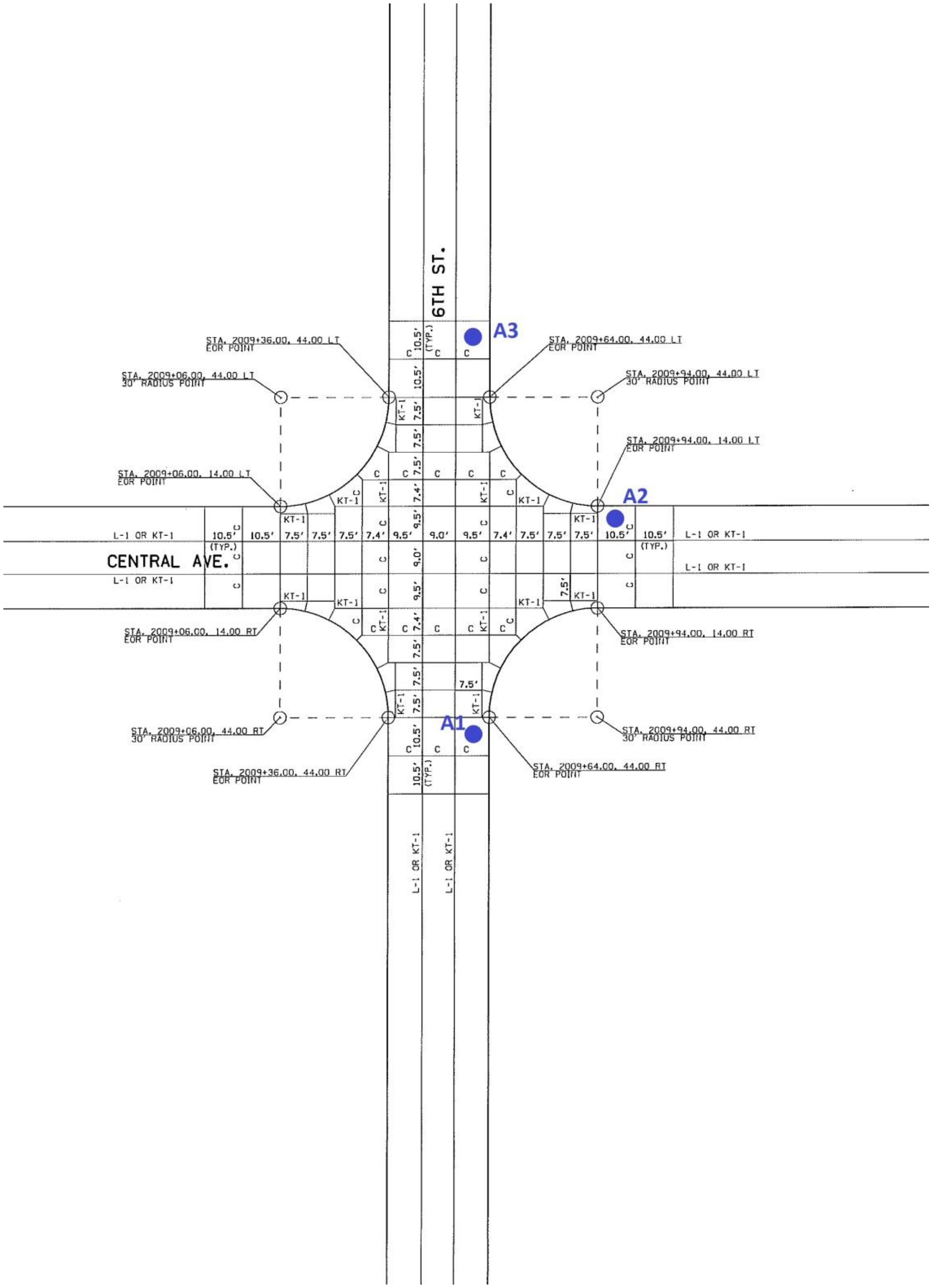
ACKNOWLEDGEMENT

The authors wish to extend appreciation Kessler Soils Engineering Products, Inc. for the use of their gauge and to following people for participating as operators in this study and making it successful:

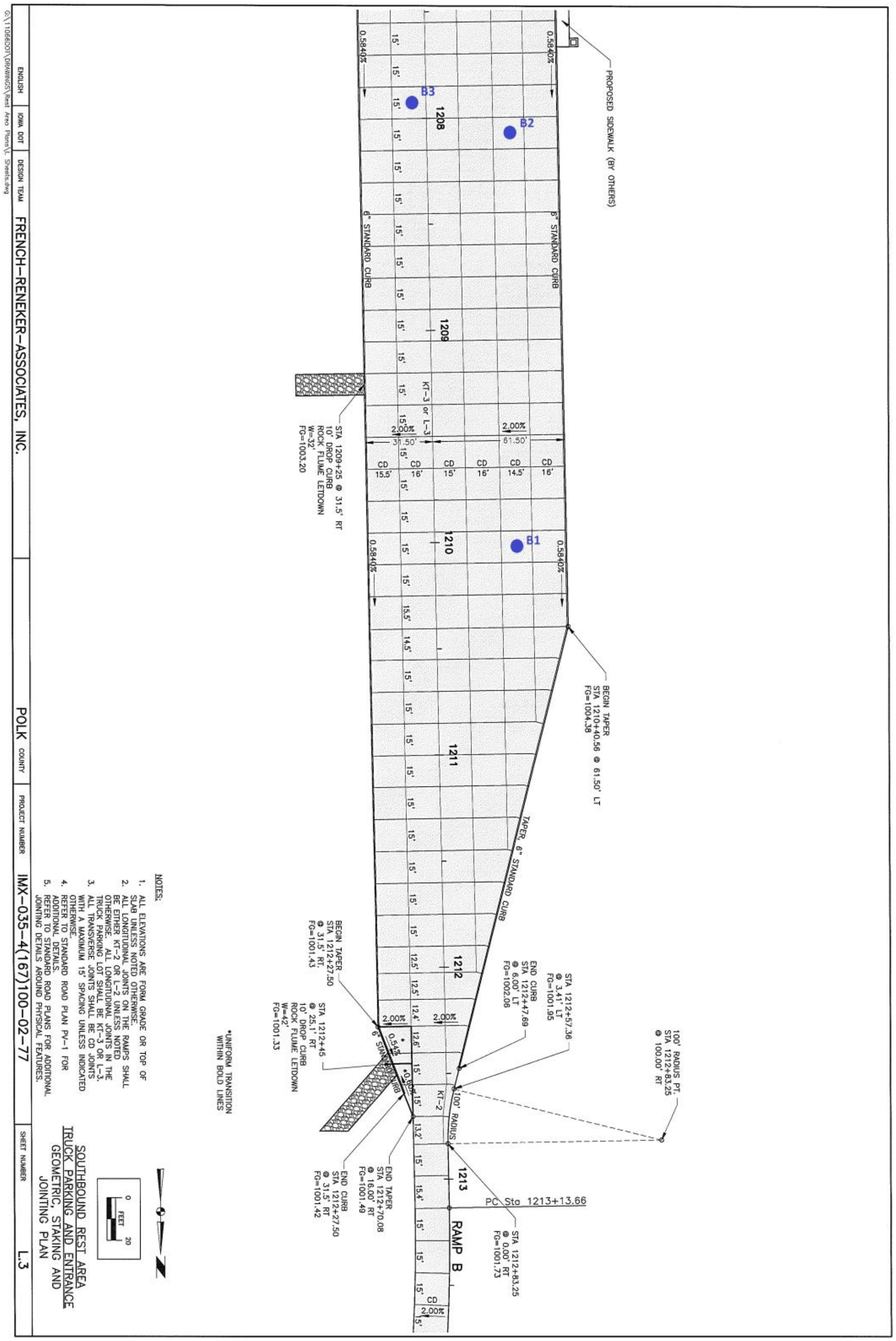
Jon Anderson, FHWA
Jim Grove, FHWA
Kevin Merryman, Construction and Materials Office
Jeff Devries, District 1 Materials
Brian Burr, District 1 Materials
Adam Knier, District 1 Materials
Todd Eichhorst, Marshalltown Construction Residency
Baron Hannah, District 3 Materials
Josh Cedar, Cherokee Construction Residency
Burt Chaska, Central Materials Laboratory
Ron Stephens, Central Materials Laboratory
Dustin Wilkinson, Central Materials Laboratory
Kendall Gustafson, Central Materials Laboratory

APPENDIX A
Target Locations

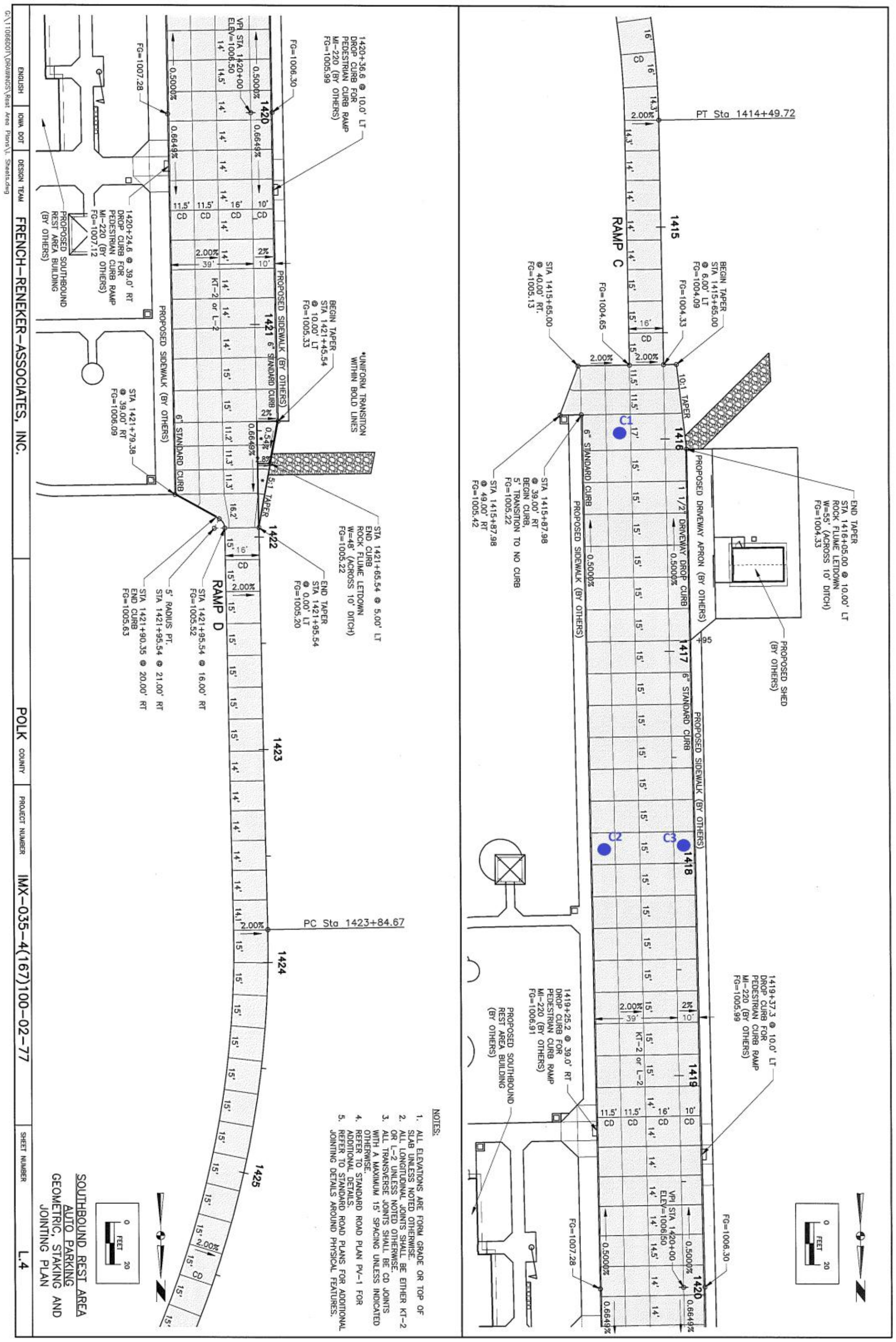
Target Locations at the Central Iowa Expo Site



Target Locations at the SB Rest Area Truck Parking



Target Locations at the SB Rest Area Car Parking



Appendix B
Individual Test Data

Gauge #	Operator	T1	T2	T3	A1	A2	A3	B1	B2	B3	C1	C2	C3
10	Todd E.	151	224	299	158	158	157	300	297	289	248	218	246
		150	224	298	158	158	157	298	297	289	247	218	245
		151	223	300	158	158	157	299	297	289	247	218	245
		150	224	297	158	157	157	299	296	288	248	218	245
		151			158	157	157	300	298	288	247	218	246
	Avg.	150.6	223.8	298.5	158.0	157.6	157.0	299.2	297.0	288.6	247.4	218.0	245.4
	Std. Dev.	0.55	0.50	1.29	0.00	0.55	0.00	0.84	0.71	0.55	0.55	0.00	0.55
63	John FHWA	151	224	301	159	159	159	299	295	289	247	219	246
		151	224	301	159	159	159	299	295	289	248	219	247
		151	224	300	160	159	159	299	296	289	248	219	247
		151	224	302	160	159	159	299	296	290	248	219	247
		151	224	302	159	159	159	299	296	290	248	219	246
	Avg.	151.0	224.2	301.2	159.5	159.1	159.1	299.0	295.6	289.5	248.0	219.2	246.8
	Std. Dev.	0.00	0.00	0.83	0.55	0.00	0.00	0.00	0.54	0.54	0.45	0.00	0.55
35	Jim FHWA	150	223	299	158	156	157	298	296	291	246	219	245
		150	223	302	158	157	159	298	295	288	246	219	245
		150	223	298	158	157	157	298	295	289	246	218	247
		149	223	299	158	157	157	297	295	289	246	219	245
		150	223	301	158	157	157	297	295	288	247	219	246
	Avg.	149.8	223.2	299.8	158.1	156.9	157.5	297.6	295.2	289.1	246.4	219.0	245.8
	Std. Dev.	0.45	0.00	1.63	0.00	0.45	0.90	0.54	0.44	1.22	0.45	0.45	0.89
8	Adam	150	224	300	158	156	156	296	295	287	246	218	245
		150	223	299	158	157	156	297	295	288	246	218	245
		150	223	300	158	157	156	297	295	288	246	218	245
		150	223	298	158	157	157	296	294	288	246	218	245
		150	223	299	158	157	157	297	294	288	246	218	244
	Avg.	150.0	223.2	299.2	158.0	156.8	156.4	296.6	294.6	287.8	246.0	218.0	244.8
	Std. Dev.	0.00	0.45	0.84	0.00	0.45	0.55	0.55	0.55	0.45	0.00	0.00	0.45
11	Brian	150	223	299	157	157	156	297	296	288	245	218	245
		150	222	301	157	157	156	296	296	288	245	217	245
		150	223	299	157	157	156	297	296	288	245	218	245
		150	223	298	157	157	156	297	296	288	245	218	245
		150	223	300	157	157	156	297	297	288	245	218	245
	Avg.	150.0	222.8	299.4	157.0	157.0	156.0	296.8	296.2	288.0	245.0	217.8	245.0
	Std. Dev.	0.00	0.45	1.14	0.00	0.00	0.00	0.45	0.45	0.00	0.00	0.45	0.00
3	Burt	150	225	298	159	159	157	297	294	288	245	218	245
		150	225	299	160	158	157	297	294	288	247	218	245
		150	223	297	159	159	157	297	294	289	245	219	245
		150	223	300	158	158	157	296	294	288	246	218	245
		150	223	299	158	158	157	297	294	290	245	219	245
	Avg.	150.0	223.8	298.6	158.8	158.4	157.0	296.8	294.0	288.6	245.6	218.4	245.0
	Std. Dev.	0.00	1.10	1.14	0.84	0.55	0.00	0.45	0.00	0.89	0.89	0.55	0.00

Gauge #	Operator	T1	T2	T3	A1	A2	A3	B1	B2	B3	C1	C2	C3
5	Baron	150	224	302	158	157	156	295	297	287	247	218	245
		149	223	299	158	157	156	296	297	289	247	218	245
		149	223	298	158	157	156	295	298	289	246	218	245
		149	223	301	159	156	156	296	298	288	246	218	246
		149	222	301	157	157	156	296	298	288	247	218	245
	Avg.	149.2	223.0	300.2	158.0	156.8	156.0	295.6	297.6	288.2	246.6	218.0	245.2
	Std. Dev.	0.45	0.71	1.64	0.71	0.45	0.00	0.55	0.55	0.84	0.55	0.00	0.45
Kessler	Dustin	152	223	300	158	159	158	298	295	289	249	219	245
		152	223	297	158	159	157	297	294	288	247	219	245
		152	223	299	158	159	157	309	295	288	255	218	245
		152	223	297	158	159	157	297	295	289	249	219	245
		152	223	301	158	158	157	298	296	290	247	219	245
	Avg.	152.0	223.2	298.8	158.1	158.9	157.3	299.8	295.0	288.9	249.6	219.0	245.2
	Std. Dev.	0.00	0.00	1.78	0.00	0.45	0.45	5.14	0.70	0.83	3.28	0.45	0.00
6	Jeff	149	223	299	159	156	158	297	294	289	246	218	245
		150	223	301	159	156	158	297	295	289	247	218	245
		149	224	300	159	156	158	297	296	289	246	218	245
		149	223	299	159	156	158	297	295	289	246	218	245
		149	223	298	159	157	158	297	295	289	246	218	245
	Avg.	149.2	223.2	299.4	159.0	156.2	158.0	297.0	295.0	289.0	246.2	218.0	245.0
	Std. Dev.	0.45	0.45	1.14	0.00	0.45	0.00	0.00	0.71	0.00	0.45	0.00	0.00
1	Josh	152	223	299	160	158	159	296	295	288	245	217	245
		152	223	298	160	158	156	296	295	288	245	218	244
		152	223	299	160	158	159	296	294	287	245	217	245
		152	222	299	160	159	156	296	295	287	244	218	244
		152	222	299	160	159	159	296	294	288	245	218	245
	Avg.	152.0	222.8	298.8	160.1	158.5	157.9	296.0	294.6	287.7	245.0	217.8	244.8
	Std. Dev.	0.00	0.55	0.44	0.00	0.55	1.65	0.00	0.54	0.55	0.45	0.55	0.55
2	Kendall	150	224	299	159	157	157	297	295	289	246	219	245
		150	225	299	159	157	158	298	295	287	246	218	246
		150	224	299	159	157	157	297	293	288	246	218	245
		150	224	300	158	157	157	297	295	288	245	219	245
		150	224	301	159	157	157	297	295	289	245	219	245
	Avg.	150.0	224.2	299.6	158.8	157.0	157.2	297.2	294.6	288.2	245.6	218.6	245.2
	Std. Dev.	0.00	0.45	0.89	0.45	0.00	0.45	0.45	0.89	0.84	0.55	0.55	0.45
12	Kevin M	151	222	301	159	158	158	297	295	288	247	219	245
		151	224	300	159	158	158	297	295	288	247	219	245
		151	224	300	159	158	158	297	295	288	247	219	245
		151	222	299	159	158	158	298	295	289	248	219	245
		151	224	298	159	157	158	297	295	289	248	218	245
	Avg.	151.0	223.2	299.6	159.0	157.8	158.0	297.2	295.0	288.4	247.4	218.8	245.0
	Std. Dev.	0.00	1.10	1.14	0.00	0.45	0.00	0.45	0.00	0.55	0.55	0.45	0.00

Gauge #	Operator	T1	T2	T3	A1	A2	A3	B1	B2	B3	C1	C2	C3
14	Kevin J	151	224	298	159	158	158	298	296	289	246	219	246
		151	225	299	159	158	157	297	296	289	246	219	246
		151	225	299	159	158	158	297	295	289	247	219	246
		151	225	302	159	158	158	298	295	289	246	219	246
		151	225	302	159	158	158	298	296	289	247	219	246
	Avg.	151.0	224.8	300.0	159.0	158.0	157.8	297.6	295.6	289.0	246.4	219.0	246.0
	Std. Dev.	0.00	0.45	1.87	0.00	0.00	0.45	0.55	0.55	0.00	0.55	0.00	0.00
13	Todd H.	151	225	301	159	158	158	301	296	289	246	219	246
		150	224	300	159	158	158	303	296	289	247	219	246
		151	225	300	159	158	158	301	295	289	246	219	246
		151	225	300	159	158	158	300	297	289	246	219	247
		151	224	302	159	158	158	300	295	289	247	219	247
	Avg.	150.8	224.6	300.6	159.0	158.0	158.0	301.0	295.8	289.0	246.4	219.0	246.4
	Std. Dev.	0.45	0.55	0.89	0.00	0.00	0.00	1.22	0.84	0.00	0.55	0.00	0.55
7	Ron				159	158	157	298	297	291	246	218	245
					159	158	157	299	296	290	246	218	245
					159	158	157	298	295	290	246	218	245
					159	158	157	298	298	290	246	219	245
					159	158	157	298	296	290	246	219	245
	Avg.	N/A	N/A	N/A	159.0	158.0	157.0	298.2	296.4	290.2	246.0	218.4	245.0
	Std. Dev.	N/A	N/A	N/A	0.00	0.00	0.00	0.45	1.14	0.45	0.00	0.55	0.00

Pink highlighted has been adjusted to the Iowa style target using the equation: y = -0.00003723x2 + 1.0163x + 1.45