WIM System Field Calibration and Validation Summary Report

California SPS-2
SHRP ID – 060200

Validation Date: November 29, 2011
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1 Executive Summary

A WIM validation was performed on November 29 and 30, 2011 at the California SPS-2 site located on route SR-99 at milepost 32.5, 0.6 miles north of the Collier Road exit.

This site was installed on November 30, 2007. The in-road sensors are installed in the northbound, righthand driving lane. The site is equipped with bending plate WIM sensors and IRD iSINC WIM controller. The LTPP lane is identified as lane 1 in the WIM controller. From a comparison between the report of the most recent validation of this equipment on March 26, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

The equipment is in working order. Electronic and electrical checks of the WIM components determined that the the equipment is operating within the manufacturer's tolerances. The damaged solar panel reported after the last validation visit remains in place. Further equipment discussion is provided in Section 3.

During the on-site pavement evaluation, There were no pavement distresses noted that may affect the accuracies of the WIM system. A visual observation of the trucks as they approach, traverse, and leave the sensor area did not indicate any adverse dynamics that would affect the accuracy of the WIM system. The trucks appear to track down the center of the lane. Further pavement condition discussion is provided in Section 4.

Based on the criteria contained in the LTPP Field Operations Guide for SPS WIM Sites, Version 1.0 (05/09), this site is providing research quality loading data. The summary results of the validation are provided in Table 1-1 below.

Table 1-1 – Post-Validation Results – 30-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.4 ± 5.5%	Pass
Single Axles	±20 percent	0.3 ± 6.1%	Pass
Tandem Axles	±15 percent	0.1 ± 4.8%	Pass
GVW	±10 percent	0.3 ± 3.0%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	0.1 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Truck speeds were manually collected for each test run by a radar gun and compared with the speed reported by the WIM equipment. For this site, the error in speed measurement was 0.2 ± 2.8 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Operations Guide for SPS WIM Sites. However, since the site is measuring axle spacing length with a mean error of 0.0 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

This site is providing research quality vehicle classification data for heavy trucks (Class 6 – 13). The heavy truck misclassification rate of 0.0% is within the 2.0% acceptability criterion for LTPP SPS WIM sites. The overall misclassification rate of 5.7% from the 100 truck sample (Class 4 – 13) was due to the misclassification of one Class 4 vehicle as a Class 5 vehicle.

There were two test trucks used for the post-validation. They were configured and loaded as follows:

- The *Primary* truck was a Class 9 vehicle with air suspension on the tractor and trailer tandems, and standard (4 feet) tandem spacings. It was loaded with plywood.

- The *Secondary* truck was a Class 9 vehicle with air suspension on the tractor tandem, air suspension on the trailer tandem, standard tandem spacing on the tractor and split tandem on the trailer. The Secondary truck was loaded with plywood.

Prior to the validation, the test trucks were weighed and measured, cold tire pressures were taken, and photographs of the trucks, loads and suspensions were obtained (see Section 7). Axle length (AL) was measured from the center hub of the first axle to the center hub of the last axle. Axle spacings were measured from the center hub of the each axle to the center hub of the subsequent axle. Overall length (OL) was measured from the edge of the front bumper to the edge of the rear bumper. The test trucks were re-weighed at the conclusion of the validation. The average post-validation test truck weights and measurements are provided in Table 1-2.

Table 1-2 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.5	12.0	16.6	16.6	15.6	15.6	14.3	4.3	32.0	4.0	54.6	59.3
2	67.4	10.6	14.4	14.4	14.0	14.0	19.5	4.3	26.7	10.2	60.6	66.5

The posted speed limit at the site is 55 mph. During the testing, the speed of the test trucks ranged from to 49 to 60 mph, a range of 11 mph. The running of test trucks above the speed limit was approved prior to the validation by the local law enforcement agency.

During test truck runs, pavement temperature was collected using a hand-held infrared temperature device. The post-validation pavement surface temperatures varied from 48.9 to 60.5 degrees Fahrenheit, a range of 11.6 degrees Fahrenheit. Fog in the morning and overcast skies in the afternoon prevented the desired 30 degree range in temperatures.

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. This site requires at least 1 additional year of data to meet the minimum of five years of research quality data.

2 WIM System Data Availability and Pre-Visit Data Analysis

To assess the quality of the current traffic data, a pre-visit analysis was conducted by comparing a two-week data sample from October 24, 2011 (Data) to the most recent Comparison Data Set (CDS) from August 19, 2010. The assessments performed prior to the site visits are used to develop reasonable expectations for the validation. The results of further investigations performed as a result of the analyses are provided in Section 5 of this report.

2.1 LTPP WIM Data Availability

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level "E" WIM data for this site. Table 2-1 provides a breakdown of the available data for years 2008 to 2011.

Table 2-1 – LTPP Data Availability

Year	Total Number of Days in Year	Number of Months
2008	339	12
2009	344	12
2010	342	12
2011	253	9

As shown in the table, this site requires one additional year of data to meet the minimum of five years of research quality data. The data meets the 210-day minimum requirement for a calendar year for years 2008 through 2011.

Table 2-2 provides a monthly breakdown of the available data for years 2008 through 2011.

Table 2-2 – LTPP Data Availability by Month

Year	Month												No. of Months
	1	2	3	4	5	6	7	8	9	10	11	12	
2008	4	29	31	30	31	30	31	31	30	31	30	31	12
2009	31	28	31	30	31	30	31	31	30	31	30	10	12
2010	21	28	31	30	31	28	20	31	30	31	30	31	12
2011	31	28	30	30	31	23	31	31	18				9

2.2 Classification Data Analysis

The traffic data was analyzed to determine the expected truck distributions. This analysis provides a basis for the classification distribution study that was conducted on site. Figure 2-1 provides a comparison of the truck type distributions for the two datasets.

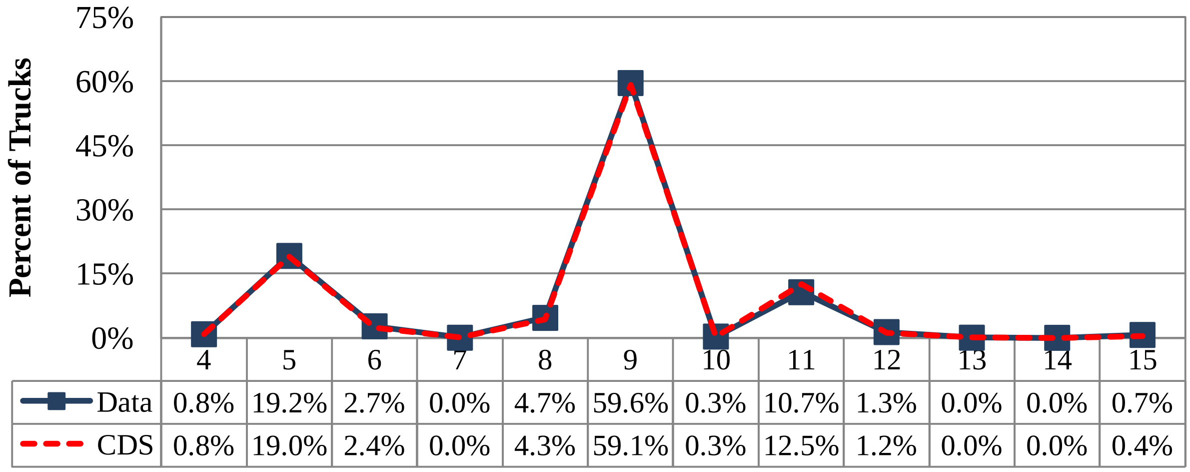


Figure 2-1 – Comparison of Truck Distribution

Table 2-3 provides statistics for the truck distributions at the site for the two periods represented by the two datasets. The table shows that according to the most recent data, the most frequent truck types crossing the WIM scale are Class 9 (59.6%) and Class 5 (19.2%). Table 2-3 also provides data for vehicle Classes 14 and 15. Class 14 vehicles are vehicles that are reported by the WIM equipment as having irregular measurements and cannot be classified properly, such as negative speeds from vehicles passing in the opposite direction of a two-lane road. Class 15 vehicles are unclassified vehicles. The table indicates that 0.7 percent of the vehicles at this site are unclassified.

Table 2-3 – Truck Distribution from W-Card

Vehicle Classification	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
4	424	0.8%	619	0.8%	0.0%
5	10150	19.0%	14098	19.2%	0.2%
6	1256	2.4%	1983	2.7%	0.3%
7	15	0.0%	16	0.0%	0.0%
8	2291	4.3%	3432	4.7%	0.4%
9	31557	59.1%	43853	59.6%	0.5%
10	143	0.3%	219	0.3%	0.0%

Vehicle Classification	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
11	6695	12.5%	7853	10.7%	-1.9%
12	634	1.2%	989	1.3%	0.2%
13	13	0.0%	25	0.0%	0.0%
14	0	0.0%	0	0.0%	0.0%
15	235	0.4%	494	0.7%	0.2%

From the table it can be seen that the percentage of Class 9 vehicles has increased by 0.5 percent from August 2010 to October 2011. Changes in the percentage of heavier trucks may be attributed to seasonal variations in truck distributions and to natural variations in truck volumes. During the same time period, the percentage of Class 5 trucks increased by 0.2 percent. These differences may be attributed to changes in the use of the roadway for local deliveries, cross-classifications of type 3 and 5 vehicles, as well as natural variations in truck volumes.

2.3 Speed Data Analysis

The traffic data received from the Phase II Contractor was analyzed to determine the expected truck speed distributions. This will provide a basis for determining the speed of the test trucks during validation testing. The CDS distribution of speeds is shown in Figure 2-2.

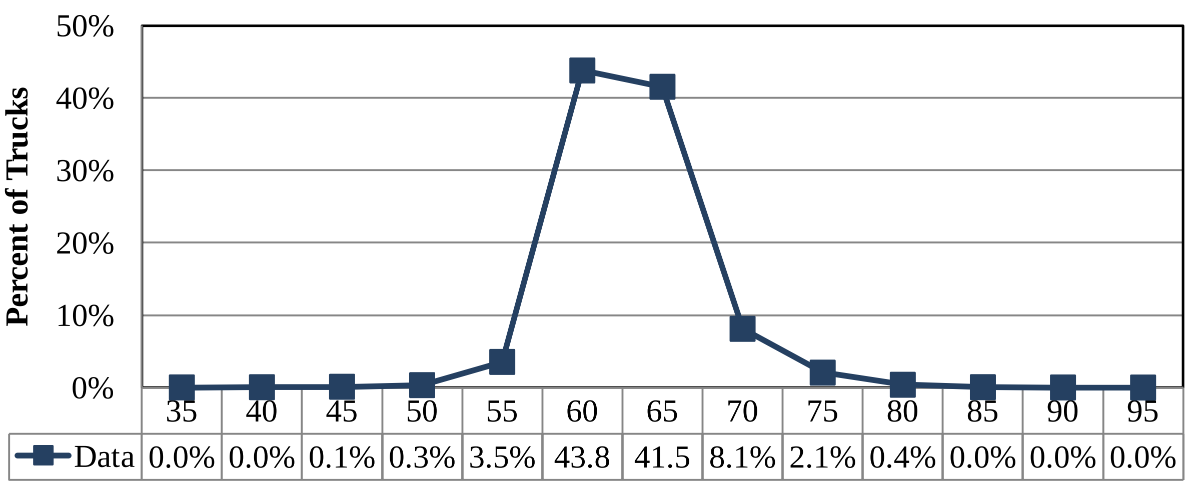


Figure 2-2 – Truck Speed Distribution – 31-Oct-11

As shown in Figure 2-2, the majority of the trucks at this site are traveling between 60 and 65 mph. The posted speed limit at this site is 55 and the 85th percentile speed for trucks at this site is 65 mph. The range of truck speeds for the validation will be 50 to 60 mph.

2.4 GVW Data Analysis

The traffic CDS data received from the Regional Support Contractor was analyzed to determine the expected Class 9 GVW distributions. Figure 2-3 shows a comparison between GVW plots generated using a two-week W-card sample from October 2011 and the Comparison Data Set from August 2010.

As shown in Figure 2-3, there is a slight downward shift for the loaded peak and increase in overloads between the August 2010 Comparison Data Set (CDS) and the October 2011 two-week sample W-card dataset (Data).

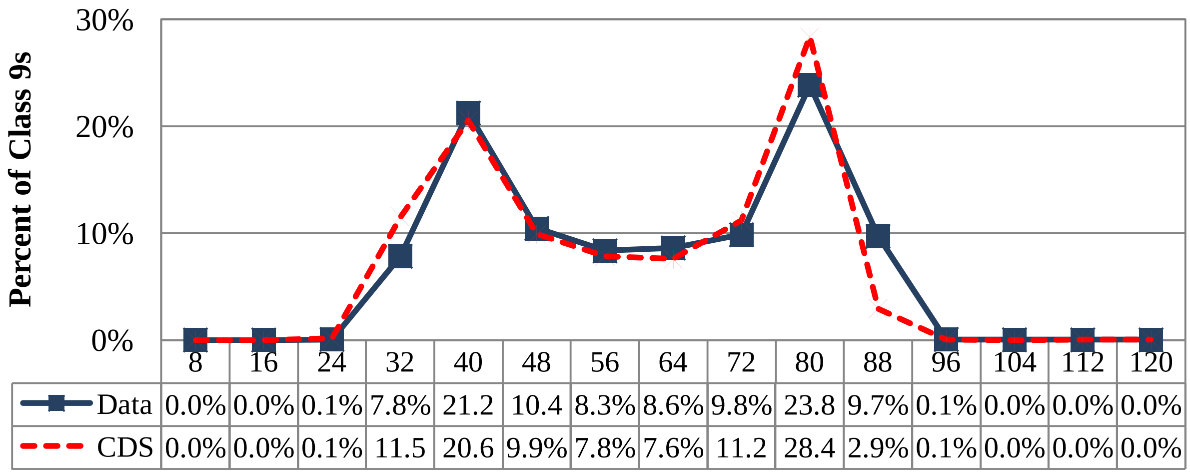


Figure 2-3 – Comparison of Class 9 GVW Distribution

Table 2-4 is provided to show the statistical comparison for Class 9 GVW between the Comparison Data Set and the current dataset.

Table 2-4 – Class 9 GVW Distribution from W-Card

GVW weight bins (kips)	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
8	0	0.0%	0	0.0%	0.0%
16	0	0.0%	0	0.0%	0.0%
24	36	0.1%	20	0.1%	-0.1%
32	2983	11.5%	2961	7.8%	-3.7%
40	5328	20.6%	8025	21.2%	0.7%
48	2565	9.9%	3944	10.4%	0.5%
56	2028	7.8%	3152	8.3%	0.5%
64	1959	7.6%	3257	8.6%	1.1%

GVW weight bins (kips)	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
72	2895	11.2%	3722	9.8%	-1.3%
80	7353	28.4%	9013	23.8%	-4.5%
88	761	2.9%	3665	9.7%	6.8%
96	14	0.1%	22	0.1%	0.0%
104	0	0.0%	7	0.0%	0.0%
112	1	0.0%	3	0.0%	0.0%
120	1	0.0%	3	0.0%	0.0%
Average =	55.2 kips		56.8 kips		1.6 kips

As shown in the table, the percentage of unloaded class 9 trucks in the 32 to 40 kips range increased by 0.7 percent while the percentage of loaded class 9 trucks in the 72 to 80 kips range decreased by 4.5 percent. During this time period the percentage of overweight trucks increased by 6.8 percent. Based on the average Class 9 GVW values from the per vehicle records, the GVW average for this site increased by 2.9 percent, from 55.2 kips to 56.8 kips kips. These results indicate that increasing percentage of trucks may be carrying overweight loads or the equipment overestimates heavy weights.

2.5 Class 9 Front Axle Weight Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average front axle weight. This will provide a basis for the evaluation of the quality of the data by comparing the average front axle weight from the current data sample set with the expected average front axle weight from the Data Comparison Set.

Figure 2-4 shows a comparison between Class 9 front axle weight plots generated by using the two week W-card sample from October 2011 and the Comparison Data Set from August 2010.

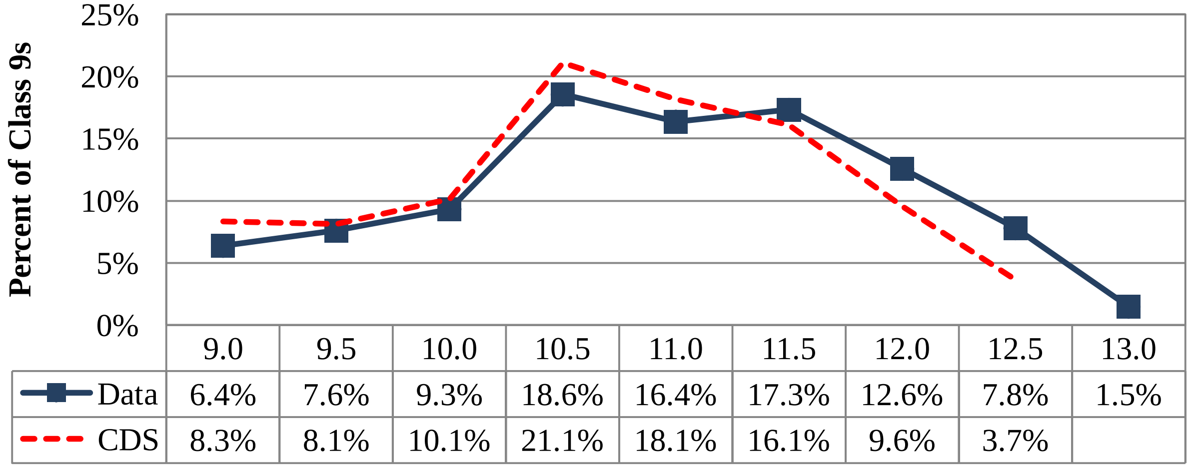


Figure 2-4 – Distribution of Class 9 Front Axle Weights

It can be seen in the figure that the greatest percentage of trucks have front axle weights between 10.5 and 11.5 kips. The percentage of trucks in this range has decreased between the August 2010 Comparison Data Set (CDS) and the October 2011 dataset (Data). The percentages of light axles (10.0 to 10.5 kips) decreased by approximately 0.8% and the percentages of heavy axles (12.0 to 12.5 kips) increased by approximately 3.0%, indicating a heavier truck population or a possible positive bias (overestimation of loads) in front axle measurement.

Table 2-5 provides the Class 9 front axle weight distribution data for the August 2010 Comparison Data Set (CDS) and the October 2011 dataset (Data).

Table 2-5 – Class 9 Front Axle Weight Distribution from W-Card

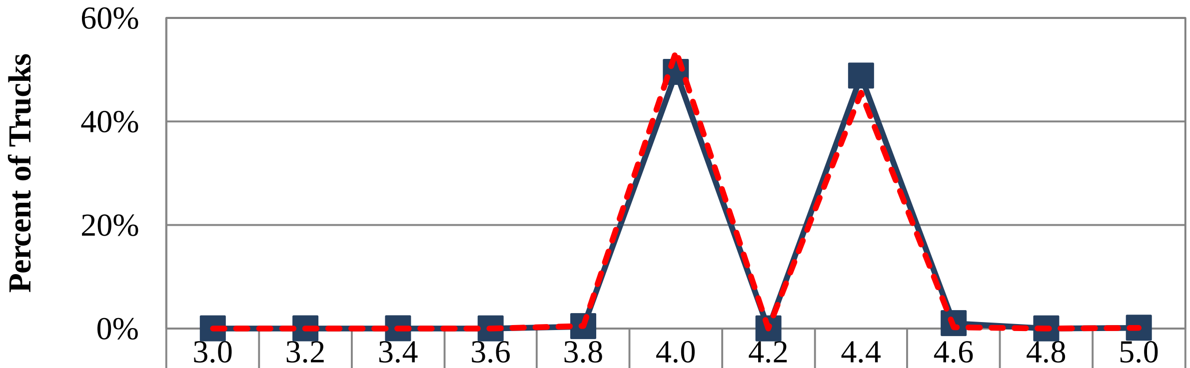
F/A weight bins (kips)	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
9.0	1141	4.4%	955	2.5%	-1.9%
9.5	2153	8.3%	2391	6.4%	-2.0%
10.0	2104	8.1%	2849	7.6%	-0.5%
10.5	2616	10.1%	3497	9.3%	-0.8%
11.0	5445	21.1%	6953	18.6%	-2.5%
11.5	4688	18.1%	6136	16.4%	-1.8%
12.0	4163	16.1%	6492	17.3%	1.2%
12.5	2475	9.6%	4714	12.6%	3.0%
13.0	949	3.7%	2922	7.8%	4.1%
13.5	104	0.4%	555	1.5%	1.1%
Average =	10.9 kips		11.1 kips		0.2 kips

The table shows that the average front axle weight for Class 9 trucks has increased by 0.2 kips, or 1.8 percent. According to the values from the per vehicle records, the average front axle weight for Class 9 trucks is 11.1 kips.

2.6 Class 9 Tractor Tandem Spacing Data Analysis

The CDS data received from the Regional Support Contractor was analyzed to determine the expected average tractor tandem spacing. This will provide a basis for the evaluation of the accuracy of the equipment distance and speed measurements by comparing the observed average tractor tandem spacing from the sample data (Data) with the expected average tractor tandem spacing from the comparison data set (CDS).

The Class 9 tractor tandem spacing plot in Figure 2-5 is provided to indicate possible shifts in WIM system distance and speed measurement accuracies.



	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0
Data	0.0%	0.0%	0.0%	0.0%	0.4%	49.5%	0.0%	48.8%	1.0%	0.0%	0.1%
CDS	0.0%	0.0%	0.0%	0.0%	0.5%	53.5%	0.0%	45.5%	0.3%	0.0%	0.1%

Figure 2-5 – Comparison of Class 9 Tractor Tandem Spacing

As seen in the figure, the Class 9 tractor tandem spacings for the August 2010 Comparison Data Set and the October 2011 Data are nearly identical.

Table 2-6 shows the Class 9 axle spacings between the second and third axles.

Table 2-6 – Class 9 Axle 2 to 3 Spacing from W-Card

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
3.0	0	0.0%	2	0.0%	0.0%
3.2	0	0.0%	4	0.0%	0.0%
3.4	4	0.0%	8	0.0%	0.0%

Tandem 1 spacing bins (feet)	CDS		Data		Change
	Date				
	8/19/20010		10/24/2011		
3.6	0	0.0%	0	0.0%	0.0%
3.8	139	0.5%	166	0.4%	-0.1%
4.0	13882	53.5%	18725	49.5%	-4.0%
4.2	0	0.0%	0	0.0%	0.0%
4.4	11797	45.5%	18457	48.8%	3.3%
4.6	67	0.3%	384	1.0%	0.8%
4.8	0	0.0%	0	0.0%	0.0%
5.0	35	0.1%	50	0.1%	0.0%
Average =	4.1 feet		4.1 feet		0.0 feet

From the table it can be seen that the drive tandem spacing of Class 9 trucks at this site is between 3.8 and 4.6 feet. Based on the average Class 9 drive tandem spacing values from the per vehicle records, the average tractor tandem spacing is 4.1 feet, which is identical to the expected average of 4.1 feet from the CDS per vehicle records. Further axle spacing analyses are performed during the validation and post-validation analysis.

2.7 Data Analysis Summary

Historical data analysis involved the comparison of the most recent Comparison Data Set (August 2010) based on the last calibration with the most recent two-week WIM data sample from the site (October 2011). Comparison of vehicle class distribution data indicates a 0.5 percent increase in the percentage of Class 9 vehicles. Analysis of Class 9 weight data indicates that the average front axle weight has increased by 0.2 kips and average GVW has increased by 2.9 percent for the October 2011 data, indicating a positive drift in the WIM system calibration. The data indicates an average truck tandem spacing of 4.1 feet, which is identical the expected average of 4.1 feet.

3 WIM Equipment Discussion

From a comparison between the report of the most recent validation of this equipment on March 26, 2008 and this validation visit, it appears that no changes have occurred during this time to the basic operating condition of the equipment.

3.1 Description

This site was installed on November 30, 2007 by International Road Dynamics. It is instrumented with bending plate weighing sensors and IRD iSINC WIM Controller. As the installation contractor, IRD also performs routine equipment maintenance and data quality checks of the WIM data.

3.2 Physical Inspection

Prior to the pre-validation test truck runs, a physical inspection of all WIM equipment and support services equipment was conducted. It was noted that the *solar panel has a crack in it as reported in the prvious validation, as shown in the photo below.*

Photo 3-1 - Solar Panel Damage

No other deficiencies were noted. Photographs of all system components were taken and are presented after Section 7.

3.3 Electronic and Electrical Testing

Electronic and electrical checks of all system components were conducted prior to the pre-validation test truck runs. Dynamic and static electronic checks of the in-road sensors were performed. All values for the WIM sensors and inductive loops were within tolerances. Electronic tests of the power and communication devices indicated that they were operating normally. Electronic readings for the damaged solar panel indicated that it was working properly.

3.4 Equipment Troubleshooting and Diagnostics

The WIM system appeared to collect, analyze and report vehicle measurements normally. No troubleshooting actions were taken.

3.5 Recommended Equipment Maintenance

It is recommended that the solar panel be replaced.

4 Pavement Discussion

4.1 Pavement Condition Survey

During a visual distress survey of the pavement conducted from the shoulder, no areas of pavement distress that may affect the accuracy of the WIM sensors were noted.

4.2 Profile and Vehicle Interaction

Profile data was collected on November 23, 2010 by the Western Regional Support Contractor using a high-speed profiler, where the operator measures the pavement profile over the entire one-thousand foot long WIM Section, beginning 900 feet prior to WIM scales and ending 100 feet after the WIM scales. Each pass collects International Roughness Index (IRI) values in both the left and right wheel paths. For this site, 10 profile passes were made, 4 in the center of the travel lane and 6 that were shifted to the left and to the right of the center of the travel lane.

From a pre-visit review of the IRI values for the center, right, and left profile runs, the highest IRI value within the 1000 foot WIM section is 528 in/mi and is located approximately 587 feet prior to the WIM scale. The highest IRI value within the 400 foot approach section was 150 in/mi and is located approximately 387 feet prior to the WIM scale. These areas of the pavement were closely investigated during the validation visit, and truck dynamics in this area were closely observed. There were no distresses observed at these locations that would influence truck dynamics in the WIM scale area.

Additionally, a visual observation of the trucks as they approach, traverse and leave the sensor area did not indicate any visible motion of the trucks that would affect the performance of the WIM scales. Trucks appear to track down the center of the lane.

4.3 LTPP Pavement Profile Data Analysis

The IRI data files are processed using the WIM Smoothness Index software. The indices produced by the software provide an indication of whether or not the pavement roughness may affect the operation of the WIM equipment. The recommended thresholds for WIM Site pavement smoothness are provided in Table 4-1.

Table 4-1 – Recommended WIM Smoothness Index Thresholds

Index	Lower Threshold (m/km)	Upper Threshold (m/km)
Long Range Index (LRI)	0.50	2.1
Short Range Index (SRI)	0.50	2.1
Peak LRI	0.50	2.1
Peak SRI	0.75	2.9

When all values are less than the lower threshold shown in Table 4-1, it is unlikely that pavement conditions will significantly influence sensor output. Values between the threshold values may or may not influence the accuracy of the sensor output and values above the upper threshold would lead to sensor output that would preclude achieving the research quality loading data.

The profile analysis was based on four different indices: Long Range Index (LRI), which represents the pavement roughness starting 25.8 m prior to the scale and ending 3.2 m after the scale in the direction of travel; Short Range Index (SRI), which represents the pavement roughness beginning 2.74 m prior to the WIM scale and ending 0.46 m after the scale; Peak LRI – the highest value of LRI within 30 m prior to the scale; and Peak SRI – the highest value of SRI between 2.45 m prior to the scale and 1.5 m after the scale. The results from the analysis for each of the indices for the right wheel path (RWP) and left wheel path (LWP) values for the 3 left, 3 right and 4 center profiler runs are presented in Table 4-2.

Table 4-2 – WIM Index Values

Profiler Passes			**Pass 1**	**Pass 2**	**Pass 3**	**Pass 4**	**Avg**
Left	LWP	LRI (m/km)	0.882	0.842	0.910		0.878
		SRI (m/km)	0.851	0.721	0.661		0.744
		Peak LRI (m/km)	1.117	1.195	1.047		1.120
		Peak SRI (m/km)	0.923	0.860	0.837		0.873
	RWP	LRI (m/km)	1.016	1.078	1.006		1.033
		SRI (m/km)	1.039	1.292	1.323		1.218
		Peak LRI (m/km)	1.016	1.078	1.009		1.034
		Peak SRI (m/km)	**1.112**	**1.492**	**1.427**		**1.344**
Center	LWP	LRI (m/km)	0.813	0.690	0.661	0.784	0.737
		SRI (m/km)	0.786	0.674	0.475	0.771	0.677
		Peak LRI (m/km)	0.826	0.856	0.781	0.843	0.827
		Peak SRI (m/km)	1.290	1.137	*0.688*	1.294	1.102
	RWP	LRI (m/km)	0.845	0.923	0.791	0.878	0.859
		SRI (m/km)	1.145	1.076	0.813	1.108	1.036
		Peak LRI (m/km)	0.845	0.923	0.932	0.976	0.919
		Peak SRI (m/km)	1.462	1.286	1.058	1.345	1.288
Right	LWP	LRI (m/km)	1.146	0.701	0.686		0.844
		SRI (m/km)	0.842	0.452	0.489		0.594
		Peak LRI (m/km)	1.150	0.814	0.768		0.911
		Peak SRI (m/km)	0.928	0.813	0.977		0.906
	RWP	LRI (m/km)	0.782	0.971	0.995		0.916
		SRI (m/km)	0.803	0.815	0.553		0.724
		Peak LRI (m/km)	0.971	0.973	0.995		0.980
		Peak SRI (m/km)	1.105	1.418	1.436		1.320

From Table 4-2 it can be seen that with one exemption the indices computed from the profiles are between the upper and lower threshold values. One value was under the lower threshold. The value that is below the lower threshold is shown in italics. The highest values are the Peak SRI values in the right wheel path of the left shift passes (shown in bold).

4.4 Recommended Pavement Remediation

No pavement remediation is recommended.

5 Statistical Reliability of the WIM Equipment

The following section provides summaries of data collected during the pre-validation, the calibration, and the post-validation test truck runs, as well as information resulting from the classification and speed studies. All analyses of test truck data and information on necessary equipment adjustments are provided.

5.1 Pre-Validation

The first set of test runs provides a general overview of system performance prior to any calibration adjustments for the given environmental, vehicle speed and other conditions.

The 40 pre-validation test truck runs were conducted on November 29, 2011, beginning at approximately 9:18 AM and continuing until 4:06 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with sheets of plywood, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.
- A Class 9, 5-axle truck, loaded with sheets of plywood, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and split tandem spacing on the trailer.

The test trucks were weighed prior to the pre-validation and were re-weighed at the conclusion of the pre-validation. The average test truck weights and measurements are provided in Table 5-1.

Table 5-1 - Pre-Validation Test Truck Weights and Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.6	12.2	16.6	16.6	15.6	15.6	14.3	4.3	32.0	4.0	54.6	59.3
2	67.4	10.7	14.3	14.3	14.1	14.1	19.5	4.3	26.7	10.2	60.6	66.5

Test truck speeds varied by 14 mph, from 49 to 63 mph. The measured pre-validation pavement temperatures varied 4.3 degrees Fahrenheit, from 48.4 to 52.7. The cloudy weather conditions prevented achieving the desired 30 degree temperature range. Table 5-2 provides a summary of the pre-validation results.

As shown in Table 5-2, the site did not meet the LTPP requirements for Vehicle Length measurement as a result of the pre-validation test truck runs.

Table 5-2 – Pre-Validation Overall Results – 29-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	+20 percent	0.7 ± 5.0%	Pass
Single Axles	+20 percent	1.0 ± 6.2%	Pass
Tandem Axles	+15 percent	1.5 ± 5.1%	Pass
GVW	+10 percent	1.4 ± 3.3%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	1.8 ± 1.0 ft	FAIL
Axle Length	+ 0.5 ft [150mm]	0.3 ± 0.2 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement over all speeds was 0.3 ± 3.6 mph, which is greater than the +1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.3 feet, and the speed and axle spacing measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.1.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is *55* mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-3.

Table 5-3 – Pre-Validation Results by Speed – 29-Nov-11

Parameter	95% Confidence Limit of Error	Low	Medium	High
		49.0 to 53.7 mph	53.8 to 58.4 mph	58.5 to 63.0 mph
Steering Axles	+20 percent	0.4 ± 3.5%	1.6 ± 6.6%	-0.4 ± 4.4%
Single Axles	+20 percent	0.0 ± 4.5%	1.2 ± 6.6%	2.1 ± 7.6%
Tandem Axles	+15 percent	1.3 ± 4.7%	2.0 ± 6.0%	0.2 ± 6.8%
GVW	+10 percent	1.0 ± 2.0%	1.4 ± 4.4%	2.0 ± 3.5%
Vehicle Length	±3.0 percent (1.9 ft)	1.8 ± 0.8 ft	1.8 ± 1.0 ft	1.9 ± 1.5 ft
Vehicle Speed	± 1.0 mph	0.3 ± 2.9 mph	0.4 ± 2.9 mph	0.2 ± 6.4 mph
Axle Length	+ 0.5 ft [150mm]	0.3 ± 0.1 ft	0.3 ± 0.1 ft	0.3 ± 0.4 ft

From the table, it can be seen that, on average, the WIM equipment overestimated weights at all speeds. For single and tandem axles, the range in error appears to increase as speed increases. For GVW and steering axles, the range in error is greater at the medium speeds when compared with the low and high speeds.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following sections.

5.1.1.1 GVW Errors by Speed

As shown in Figure 5-1, the equipment generally overestimated GVW at all speeds. The range in error was higher at medium speeds when compared to low and high speeds.

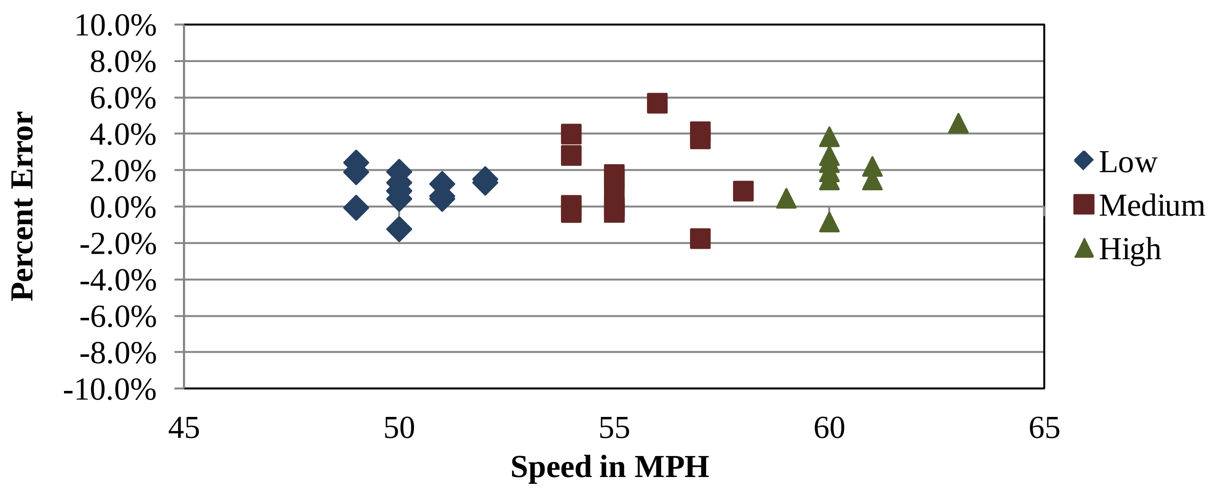


Figure 5-1 – Pre-Validation GVW Error by Speed – 29-Nov-11

5.1.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-2, the equipment generally overestimates steering axle weights. The range in error appears to be greater at the medium speeds.

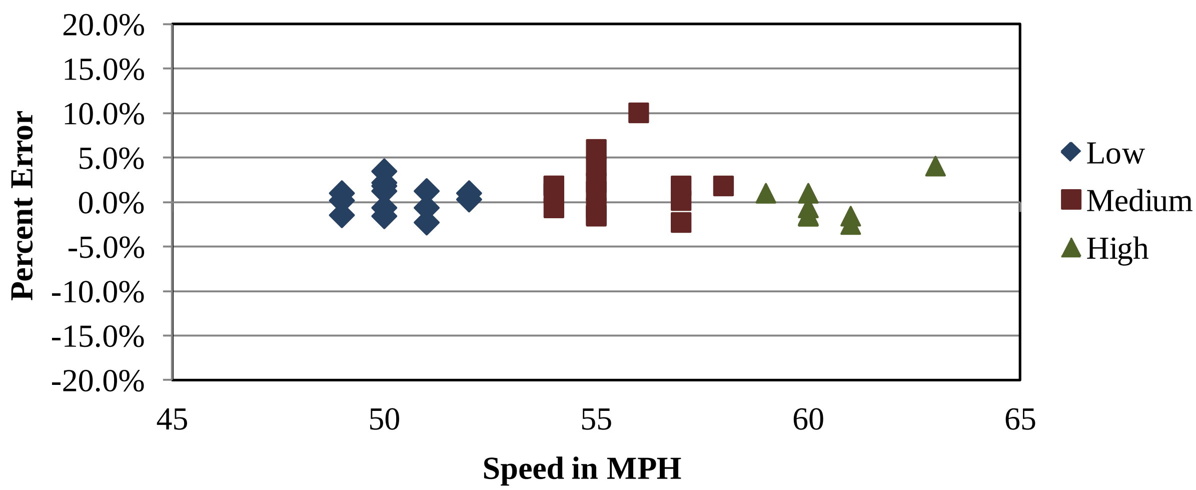


Figure 5-2 – Pre-Validation Steering Axle Weight Errors by Speed – 29-Nov-11

5.1.1.3 Single Axle Weight Errors by Speed

As shown in Figure 5-4, the equipment overestimates single axle weights at the medium and high speeds. The bias appears to increase as speed increases. The range in error appears to increase as speed increases. There appears to be a correlation between speed and single axle measurements for this site.

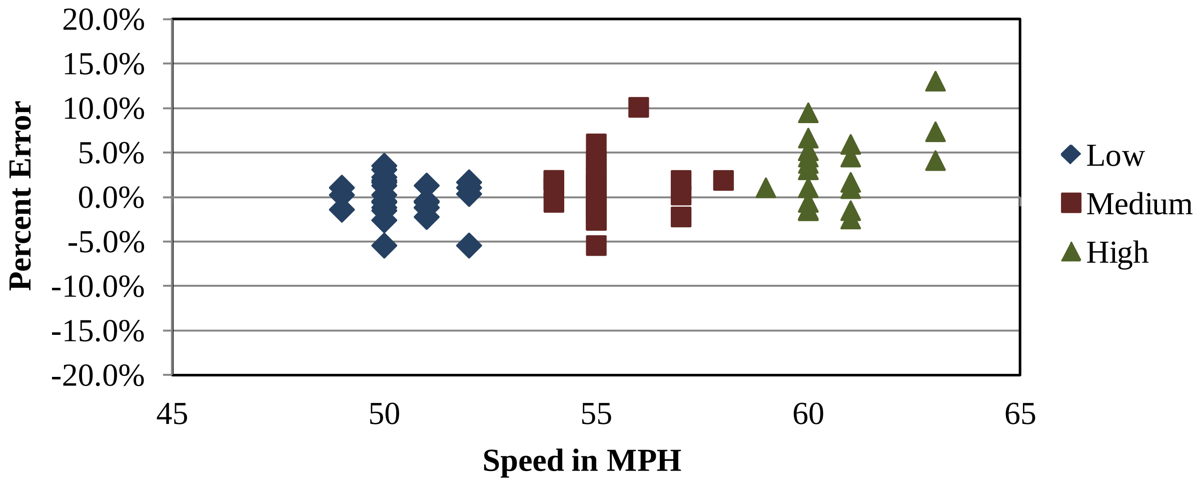


Figure 5-3 – Pre-Validation Single Axle Weight Errors by Speed – 29-Nov-11

5.1.1.4 Tandem Axle Weight Errors by Speed

As shown in Figure 5-4, the equipment generally overestimates tandem axle weights. The range in error appears to greater at the medium speeds when compared with low and high speeds.

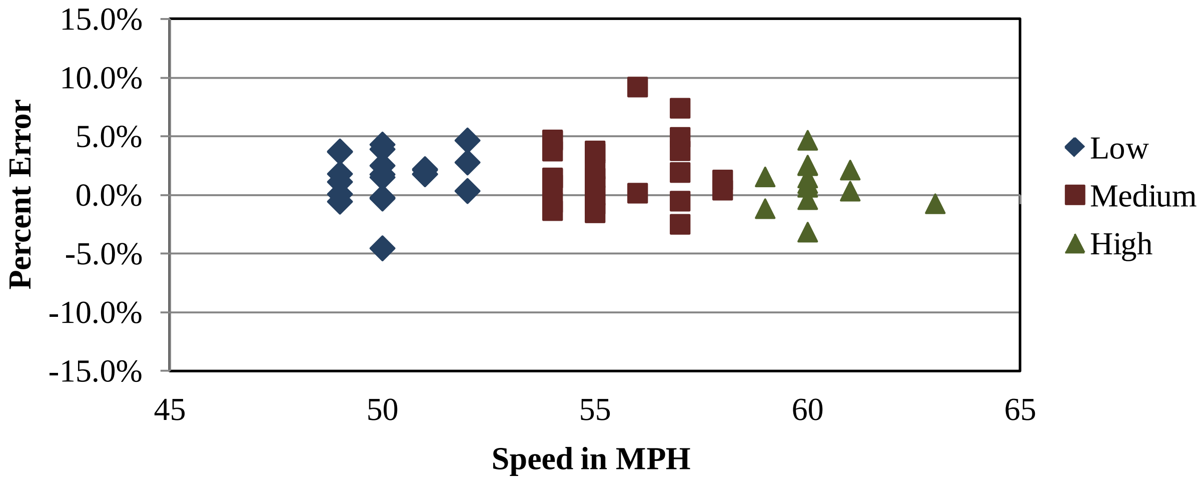


Figure 5-4 – Pre-Validation Tandem Axle Weight Errors by Speed – 29-Nov-11

5.1.1.5 GVW Errors by Speed and Truck Type

When the GVW error for each truck is analyzed as a function of speed, it can be seen that the WIM equipment bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. The range in error at the medium speed appears to be greater for the Primary truck. Distribution of errors is shown graphically in Figure 5-5.

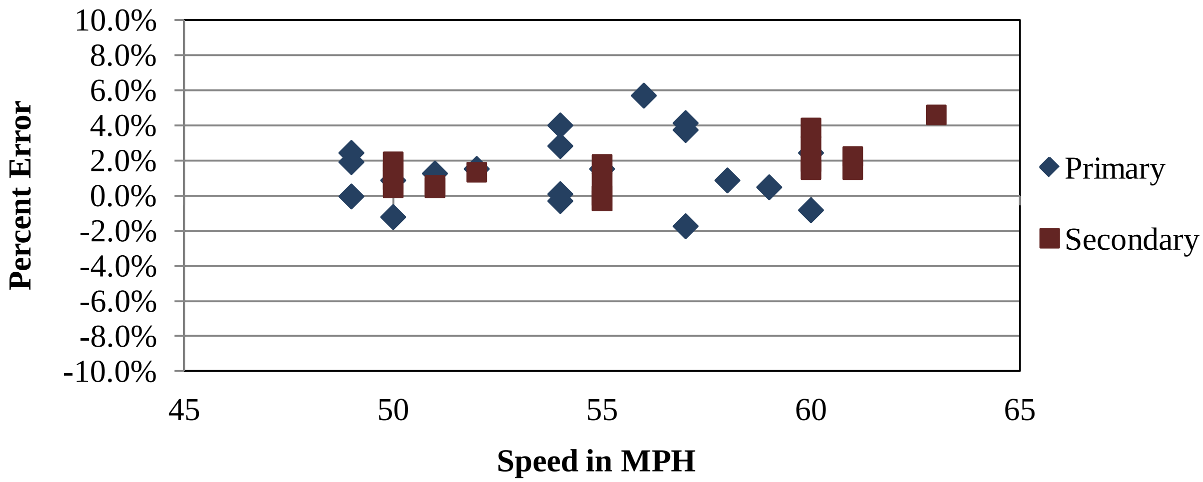


Figure 5-5 – Pre-Validation GVW Errors by Truck and Speed – 29-Nov-11

5.1.1.6 Axle Length Errors by Speed

For this site, the overestimation of axle length measurement was consistent at all speeds. The range in axle length measurement error ranged from 0.1 feet to 0.4 feet. Distribution of errors is shown graphically in Figure 5-6.

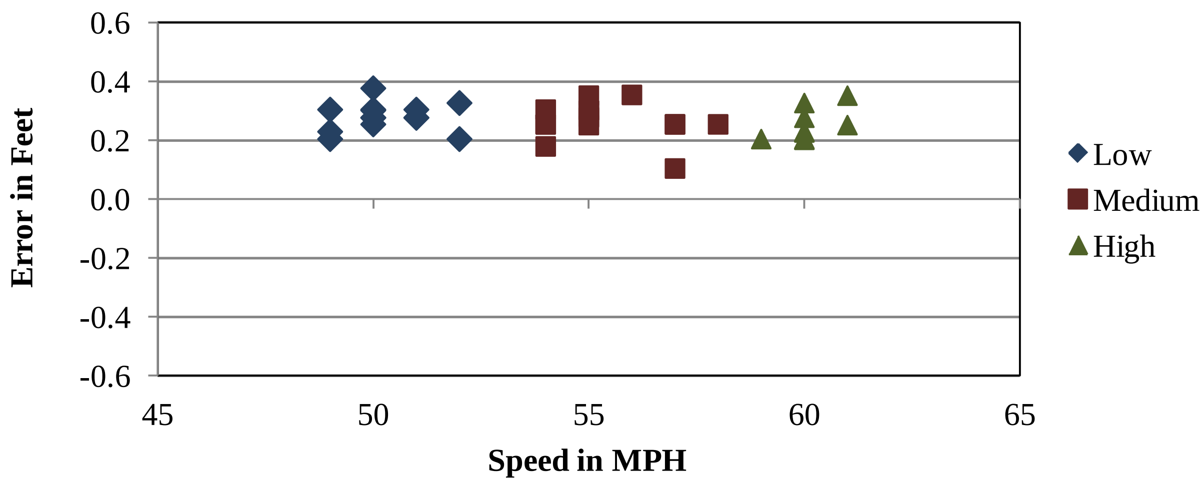


Figure 5-6 – Pre-Validation Axle Length Errors by Speed – 29-Nov-11

5.1.1.7 Overall Length Errors by Speed

For this system, the WIM equipment overestimated overall vehicle length consistently over the entire range of speeds, with an error range of 1.5 to 3.5 feet. Distribution of errors is shown graphically in Figure 5-7.

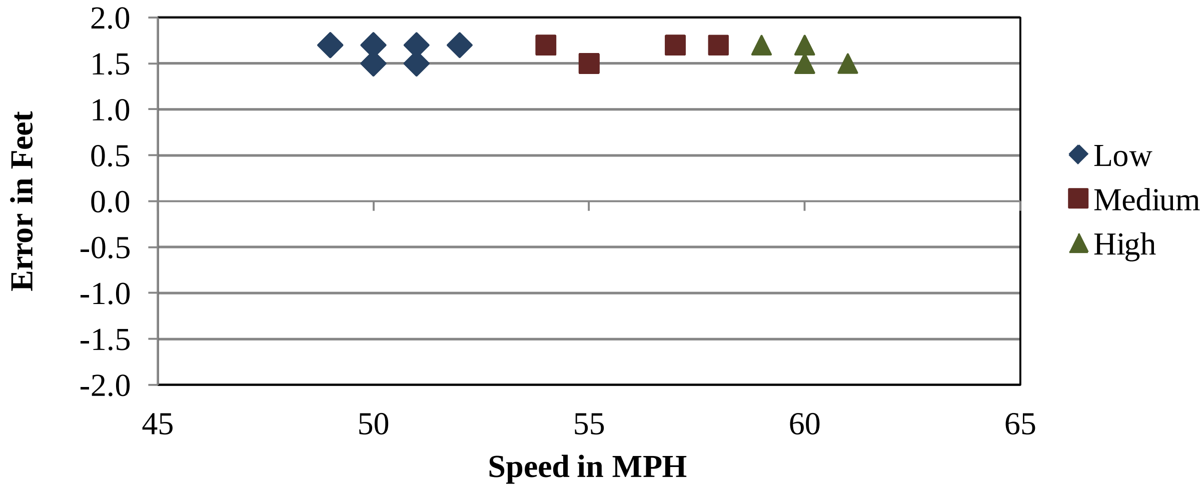


Figure 5-7 – Pre-Validation Overall Length Error by Speed – 29-Nov-11

5.1.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. Due to fog and overcast skies, the range of pavement temperatures only varied 4.3 degrees, from 48.4 to 52.7 degrees Fahrenheit. Since the desired 30 degree temperature range was not met, the pre-validation test runs are being reported under one temperature groups, as shown in Table 5-4.

Table 5-4 – Pre-Validation Results by Temperature – 29-Nov-11

Parameter	**95% Confidence Limit of Error**	**Medium**
		48.4 to 52.7 degF
Steering Axles	±20 percent	0.7 ± 5.0%
Single Axles	±20 percent	1.0 ± 6.2%
Tandem Axles	±15 percent	1.5 ± 5.1%
GVW	±10 percent	1.4 ± 3.3%
Vehicle Length	±3.0 percent (1.9 ft)	1.8 ± 1.0 ft
Vehicle Speed	± 1.0 mph	0.3 ± 3.6 mph
Axle Length	± 0.5 ft [150mm]	0.3 ± 0.2 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle, and axle group weights.

5.1.2.1 GVW Errors by Temperature

From Figure 5-8, it can be seen that the equipment generally overestimates GVW across the range of temperatures observed in the field.

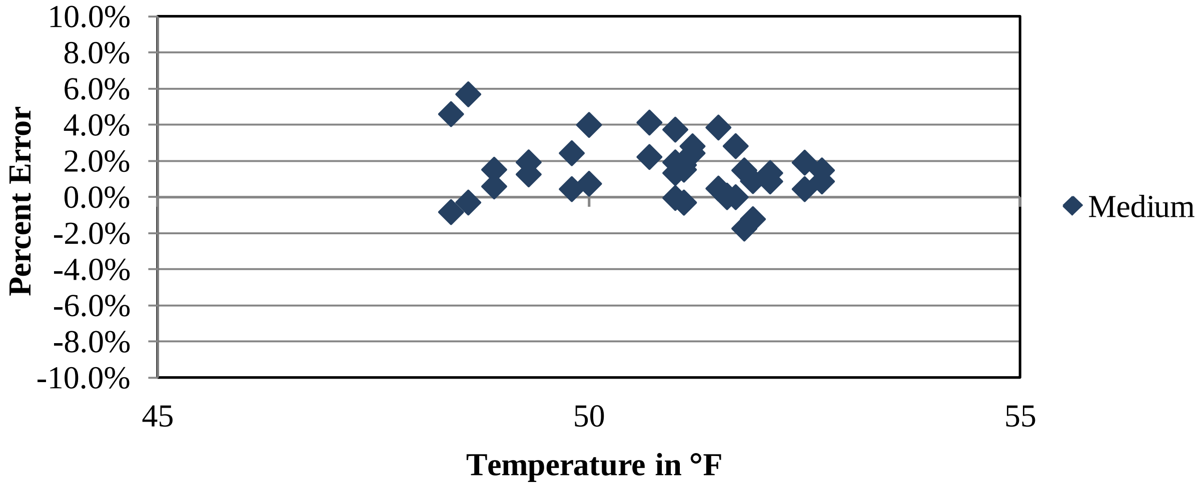


Figure 5-8 – Pre-Validation GVW Errors by Temperature – 29-Nov-11

5.1.2.2 Steering Axle Weight Errors by Temperature

Figure 5-9 illustrates that for steering axles, the WIM equipment estimates weights with similar accuracy at all temperatures.

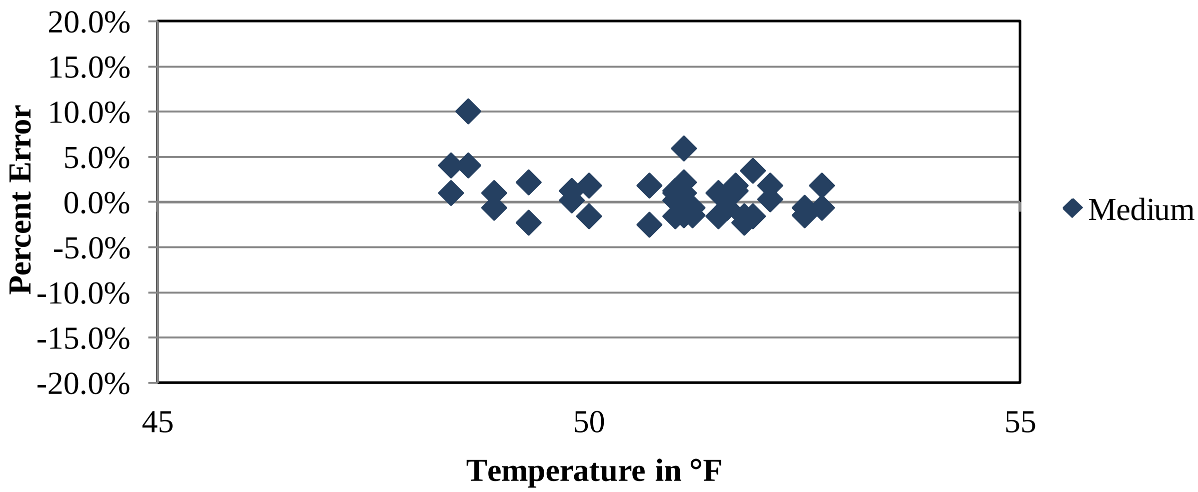


Figure 5-9 – Pre-Validation Steering Axle Weight Errors by Temperature – 29-Nov-11

5.1.2.3 Single Axle Weight Errors by Temperature

Figure 5-10 illustrates that for single axles, the WIM equipment generally estimates weights with similar accuracy at all temperatures.

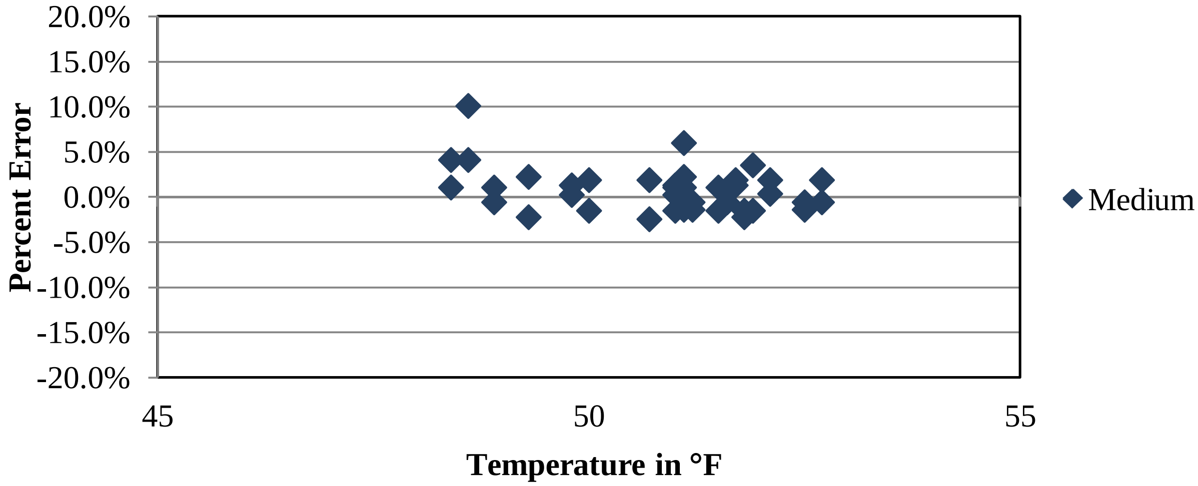


Figure 5-10 – Pre-Validation Single Axle Weight Errors by Temperature – 29-Nov-11

5.1.2.4 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-11, the WIM equipment generally overestimates tandem axle weights across the range of temperatures observed in the field.

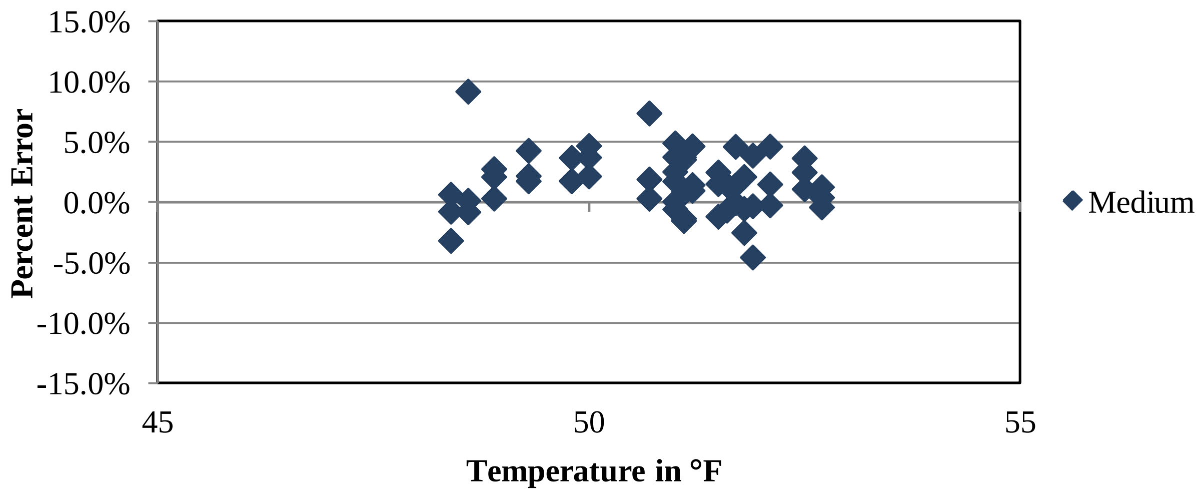


Figure 5-11 – Pre-Validation Tandem Axle Weight Errors by Temperature – 29-Nov-11

5.1.2.5 GVW Errors by Temperature and Truck Type

When analyzed for each test truck, it can be seen that the WIM equipment precision and bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. For both trucks, the range of errors and bias are consistent over the range of temperatures. Distribution of errors is shown graphically in Figure 5-12.

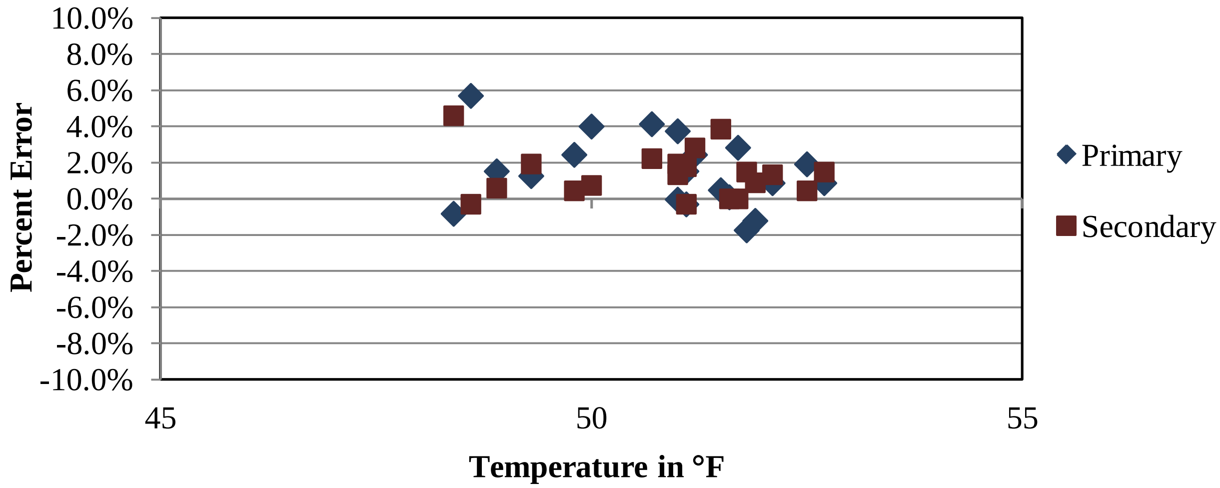


Figure 5-12 – Pre-Validation GVW Error by Truck and Temperature – 29-Nov-11

5.1.3 Classification and Speed Evaluation

The pre-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the pre-validation classification study at this site, a manual sample of 107 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Table 5-5 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. Misclassified vehicles are defined as those vehicles that are manually classified by observation as one class of vehicle but identified by the WIM equipment as another class of vehicle. As shown in Table 5-5, three Class 3 vehicles were misclassified as Class 5s, one class 3 vehicle was misclassified as a Class 8 vehicle, and one Class 4 vehicle was misclassified as a Class 5 vehicle by the equipment. Additionally, one Class 5 vehicle was identified as a Class 8 and one Class 5 was identified as a Class 9.

Table 5-5 – Pre-Validation Classification Study Results – 29-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	3	6/4	0	9/5	0
3/8	1	6/7	0	9/8	0
4/5	1	6/8	0	9/10	0
5/3	0	6/9	0	10/9	0
5/4	0	6/10	0	10/13	0
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	1	8/5	0	13/10	0
5/9	1	8/9	0	13/11	0

As shown in the table, a total of 7 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. The combined results produced an undercount of four Class 3 vehicles and one Class 4 vehicle, and an overcount of two Class 5 vehicles, 2 Class 8 vehicles, and one Class 9 vehicle, as shown in Table 5-6. The cause of the misclassifications was not investigated in the field. More detailed post-visit investigations of misclassified vehicles may be performed using the collected video.

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-6.

Table 5-6 – Pre-Validation Misclassifications by Pair – 29-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	7	1	13	8	0	4	63	0	9	2	0
WIM Count	3	0	15	8	0	6	64	0	9	2	0
Observed Percent	6.5	0.9	12.1	7.5	0.0	3.7	58.9	0.0	8.4	1.9	0.0
WIM Percent	2.8	0.0	14.0	7.5	0.0	5.6	59.8	0.0	8.4	1.9	0.0
Misclassified Count	4	1	2	0	0	0	0	0	0	0	0
Misclassified Percent	57.1	100	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Based on the vehicles observed during the pre-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 6.5%.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-7.

Table 5-7 – Pre-Validation Unclassified Trucks by Pair – 29-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 1.7 mph; the range of errors was 1.6 mph.

5.2 Calibration

The WIM equipment required one calibration iteration between the pre- and post-validations. Information regarding the basis for changing equipment compensation factors, supporting data for the changes, and the resulting WIM accuracies from the calibrations are provided in this section.

The operating system weight compensation parameters that were in place prior to the pre-validation are shown in Table 5-8.

Table 5-8 – Initial System Parameters – 29-Nov-11

Speed Point	MPH	Left	Right
		1	2
80	50	3092	3478
88	55	3269	3678
96	60	3180	3578
104	65	3172	3567
112	70	3004	3377
Axle Distance (cm)		310	
Dynamic Comp (%)		104	
Loop Width (cm)		250	

5.2.1 Equipment Adjustments

For GVW, the pre-validation test truck runs produced an overall error of 1.4% and errors of 1.0%, 1.4%, and 2.0% at the 50, 55 and 60 mph speed points respectively. The errors for the 50 mph and 60 mph speed points were extrapolated to derive new compensation factors for the 65 mph and 70 mph speed points. To compensate for these errors, the changes in Table 5-9 were made to the compensation factors.

Table 5-9 – Calibration 1 Equipment Factor Changes – 30-Nov-11

Speed Points		Old Factors		New Factors	
		Left	Right	Left	Right
KPH	MPH	1	2	1	2
80	50	3314	3314	3277	3277
88	55	3314	3314	3262	3262
96	60	3333	3333	3273	3273
104	65	3229	3229	3171	3171
112	70	3229	3229	3171	3171
Axle Distance (cm)		277		272	
Dynamic Comp (%)		100		101	
Loop Width (cm)		300		314	

5.2.2 Calibration Results

The results of the 14 calibration verification runs are provided in Table 5-10 and Figure 5-13. As can be seen in the table, the mean error of all weight estimates was reduced as a result of the first calibration iteration.

Table 5-10 – Calibration Results – 30-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	1.3 ± 4.9%	Pass
Single Axles	±20 percent	0.6 ± 6.9%	Pass
Tandem Axles	±15 percent	-0.3 ± 6.7%	Pass
GVW	±10 percent	0.2 ± 3.5%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	0.0 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Figure 5-13 shows that the WIM equipment is estimating GVW with similar accuracy at all speeds.

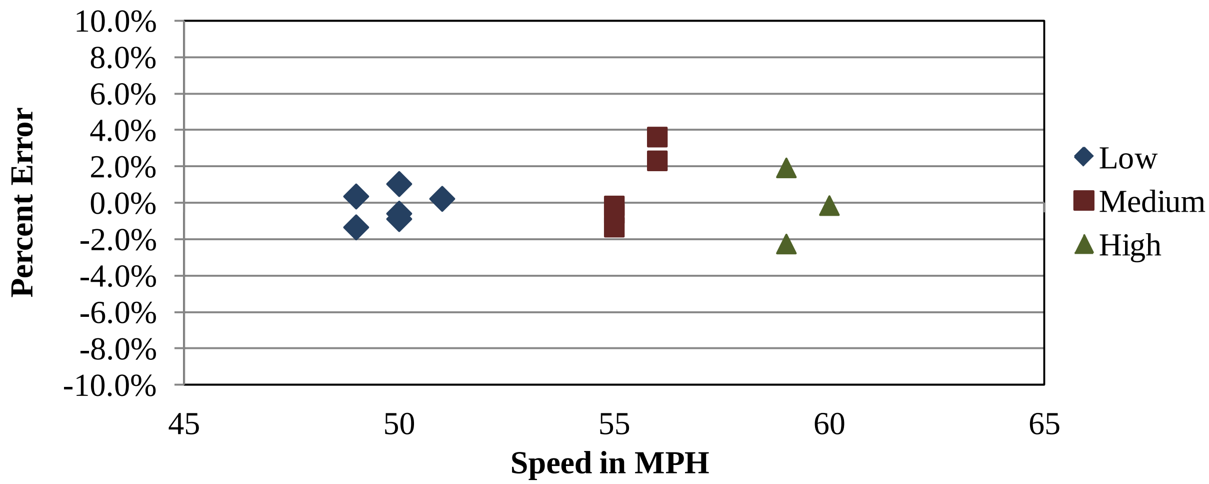


Figure 5-13 – Calibration GVW Error by Speed – 30-Nov-11

Based on the results of the first calibration, where GVW estimate bias decreased to 0.2 percent, a second calibration was not considered to be necessary. The 14 calibration runs were combined with 26 additional post-validation runs to complete the WIM system validation.

5.3 Post-Validation

The 42 post-validation test truck runs were conducted on November 30, 2011, beginning at approximately 8:32 AM and continuing until 4:46 PM.

The two test trucks consisted of:

- A Class 9 truck, loaded with sheets of plywood, and equipped with air suspension on truck and trailer tandems and with standard tandem spacings on both the tractor and trailer.

- A Class 9, 5-axle truck, loaded with sheets of plywood, and equipped with air suspension on the tractor, air suspension on the trailer, with standard tandem spacing on the tractor and split tandem spacing on the trailer.

The test trucks were weighed prior to the post-validation and re-weighed at the conclusion of the post-validation. The average test truck weights and measurements are provided in Table 5-11.

Table 5-11 – Post-Validation Test Truck Measurements

Test Truck	Weights (kips)						Spacings (feet)					
	GVW	Ax1	Ax2	Ax3	Ax4	Ax5	1-2	2-3	3-4	4-5	AL	OL
1	76.5	12.0	16.6	16.6	15.6	15.6	14.3	4.3	32.0	4.0	54.6	59.3
2	67.4	10.6	14.4	14.4	14.0	14.0	19.5	4.3	26.7	10.2	60.6	66.5

Test truck speeds varied by 11 mph, from 49 to 60 mph. The measured post-validation pavement temperatures varied 11.6 degrees Fahrenheit, from 48.9 to 60.5. Fog in the morning and overcast skies in the afternoon prevented the desired minimum 30 degree temperature range. Table 5-12 is a summary of post validation results.

Table 5-12 – Post-Validation Overall Results – 30-Nov-11

Parameter	95% Confidence Limit of Error	Site Values	Pass/Fail
Steering Axles	±20 percent	0.4 ± 5.5%	Pass
Single Axles	±20 percent	0.3 ± 6.1%	Pass
Tandem Axles	±15 percent	0.1 ± 4.8%	Pass
GVW	±10 percent	0.3 ± 3.0%	Pass
Vehicle Length	±3.0 percent (1.9 ft)	0.1 ± 1.3 ft	Pass
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	Pass

Truck speed was manually collected for each test run using a radar gun and compared with the speed reported by the WIM equipment. For this site, the average error in speed measurement for all speeds was 0.2 ± 2.8 mph, which is greater than the ±1.0 mph tolerance established by the LTPP Field Guide. However, since the site is measuring axle spacing length with a mean error of 0.0, and the speed and axle spacing length measurements are based on the distance between the axle detector sensors, it can be concluded that the distance factor is set correctly and that the speeds being reported by the WIM equipment are within acceptable ranges.

5.3.1 Statistical Speed Analysis

Statistical analysis was conducted on the test truck run data to investigate whether a relationship exists between speed and WIM equipment weight and distance measurement accuracy. The posted speed limit at this site is 55 mph. The test runs were divided into three speed groups - low, medium and high speeds, as shown in Table 5-13.

Table 5-13 – Post-Validation Results by Speed – 30-Nov-11

Parameter	95% Confidence Limit of Error	Low 49.0 to 52.7 mph	Medium 52.8 to 56.4 mph	High 56.5 to 60.0 mph
Steering Axles	±20 percent	1.9 ± 4.5%	-0.3 ± 6.3%	-1.1 ± 4.9%
Single Axles	±20 percent	0.5 ± 5.3%	-0.3 ± 6.8%	1.0 ± 6.7%
Tandem Axles	±15 percent	-0.2 ± 4.2%	0.5 ± 6.1%	-0.4 ± 5.2%
GVW	±10 percent	0.5 ± 1.6%	-0.1 ± 4.0%	0.9 ± 4.0%
Vehicle Length	±3.0 percent (1.9 ft)	0.1 ± 1.7 ft	0.0 ± 1.1 ft	0.2 ± 1.2 ft
Vehicle Speed	± 1.0 mph	-0.1 ± 1.8 mph	0.2 ± 3.6 mph	0.7 ± 3.6 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft	0.0 ± 0.1 ft	0.0 ± 0.1 ft

From the table, it can be seen that the WIM equipment estimates all weights with similar accuracy at all speeds. The range in error for single and tandem axles appears to be greater at the medium and high speeds. For steering axles and GVW, the range in error appears to be greater at the medium speeds. There does not appear to be a significant relationship between weight estimates and speed at this site.

To aid in the speed analysis, several graphs were developed to illustrate the possible effects of speed on GVW, single axle, and axle group weights, and axle and overall length distance measurements, as discussed in the following paragraphs.

5.3.1.1 GVW Errors by Speed

As shown in Figure 5-14, the equipment estimated GVW with similar accuracy at all speeds. The range in error appears to greater at the medium speeds.

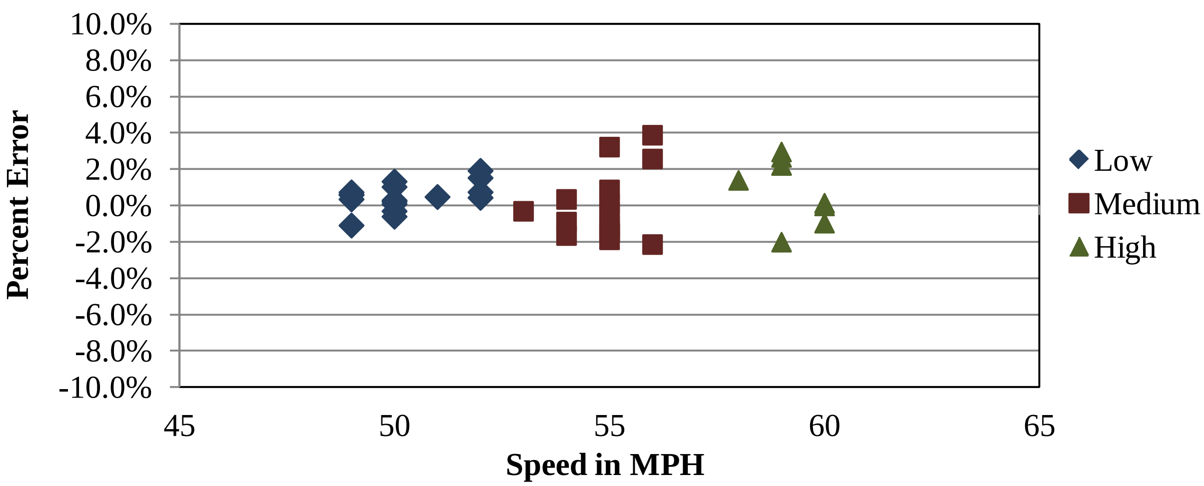


Figure 5-14 – Post-Validation GVW Errors by Speed – 30-Nov-11

5.3.1.2 Steering Axle Weight Errors by Speed

As shown in Figure 5-15, the range in error for steering axle weights is similar throughout the entire speed range, although the measurement bias appears to transition from positive to negative as speed increases, and so there does appear to be a slight correlation between speed and steering axle weight estimates at this site.

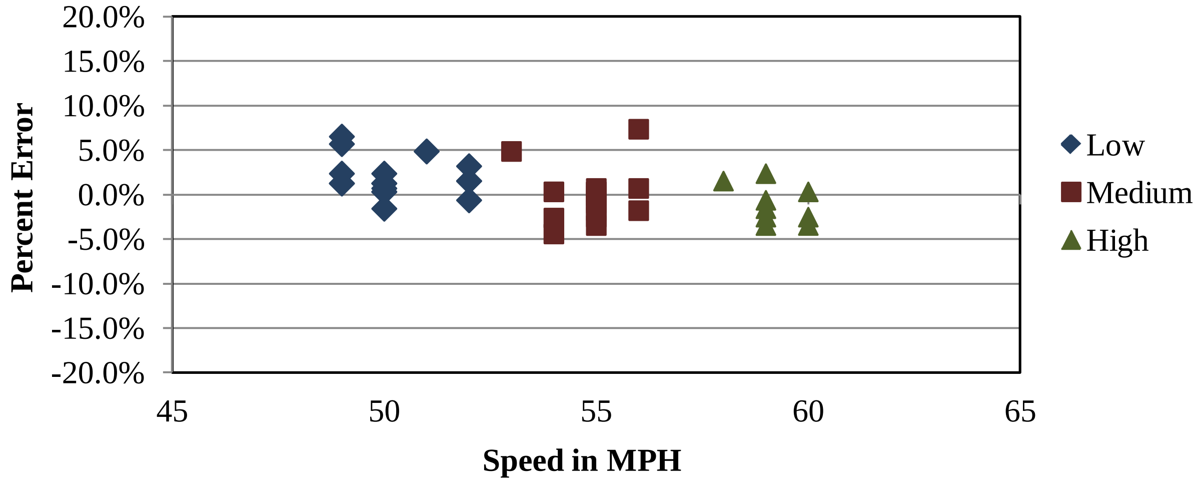


Figure 5-15 – Post-Validation Steering Axle Weight Errors by Speed – 30-Nov-11

5.3.1.3 Single Axle Weight Errors by Speed

As shown in Figure 5-16, the equipment estimated single axle weights with similar accuracy at all speeds. The range in error and bias is similar throughout the entire speed range.

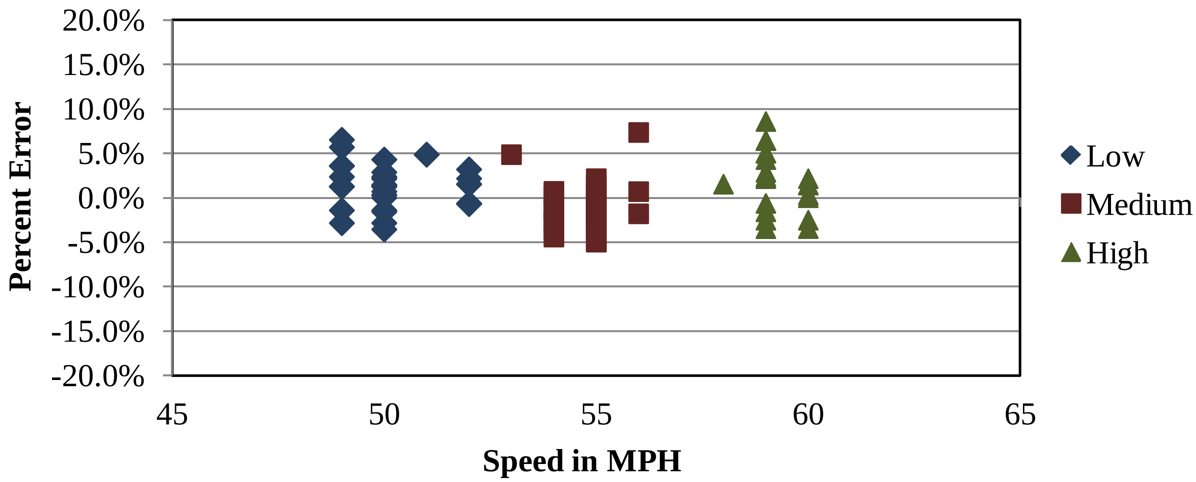


Figure 5-16 – Post-Validation Single Axle Weight Errors by Speed – 30-Nov-11

5.3.1.4 Tandem Axle Weight Errors by Speed

As shown in Figure 5-17, the equipment estimated tandem axle weights with similar accuracy at all speeds. The range in error appears to be grater at the medium speeds.

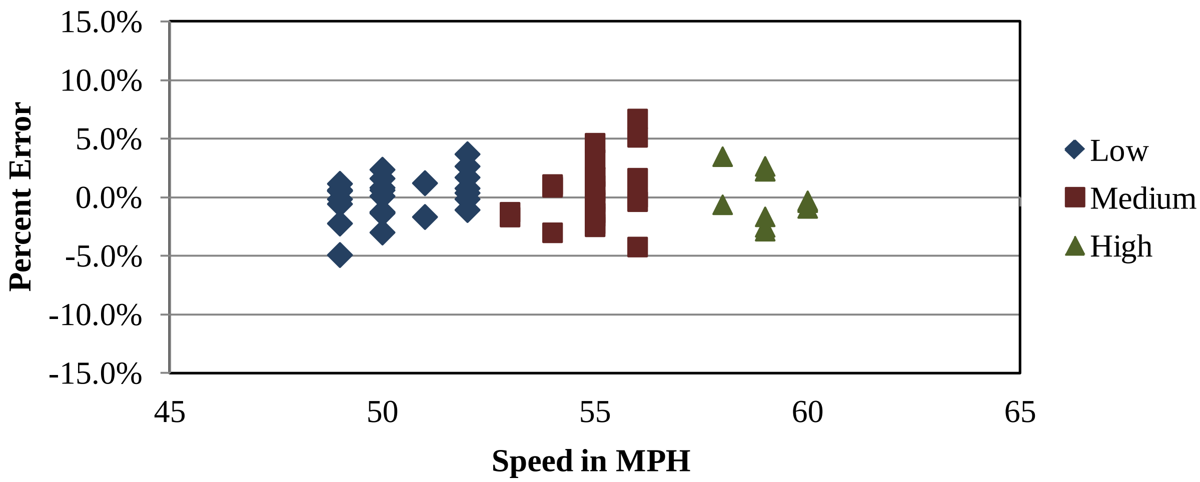


Figure 5-17 – Post-Validation Tandem Axle Weight Errors by Speed – 30-Nov-11

5.3.1.5 GVW Errors by Speed and Truck Type

It can be seen in Figure 5-18 that when the GVW errors are analyzed by truck type, the WIM equipment bias is similar for both the heavily loaded (Primary) truck and the partially loaded (Secondary) truck. The range in GVW error appears to greater for the Primary truck at the medium speeds.

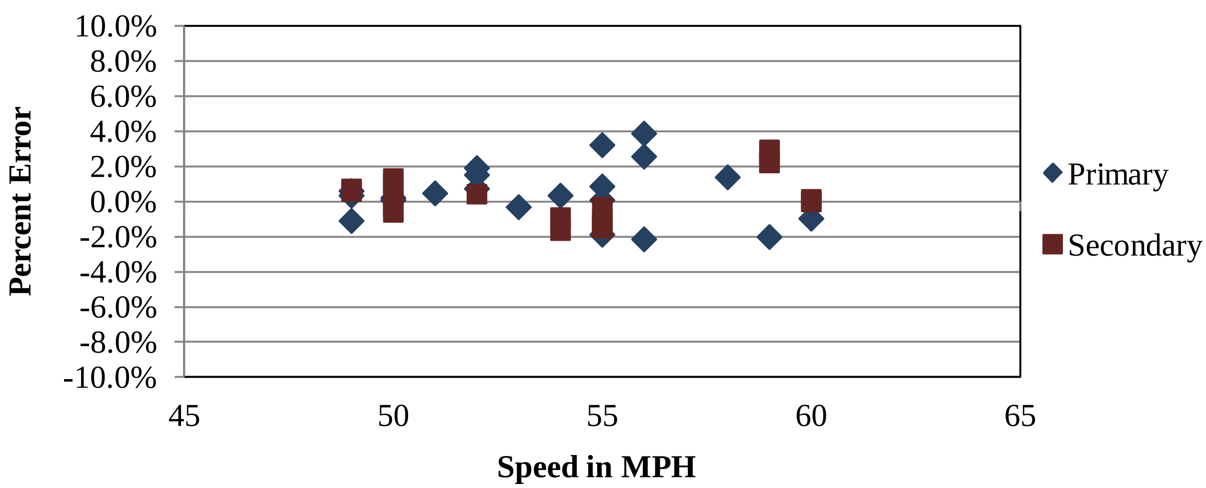


Figure 5-18 – Post-Validation GVW Error by Truck and Speed – 30-Nov-11

5.3.1.6 Axle Length Errors by Speed

For this site, the error in axle length measurement was consistent at all speeds. The range in axle length measurement error was from -0.1 feet to 0.1 feet. Distribution of errors is shown graphically in Figure 5-19.

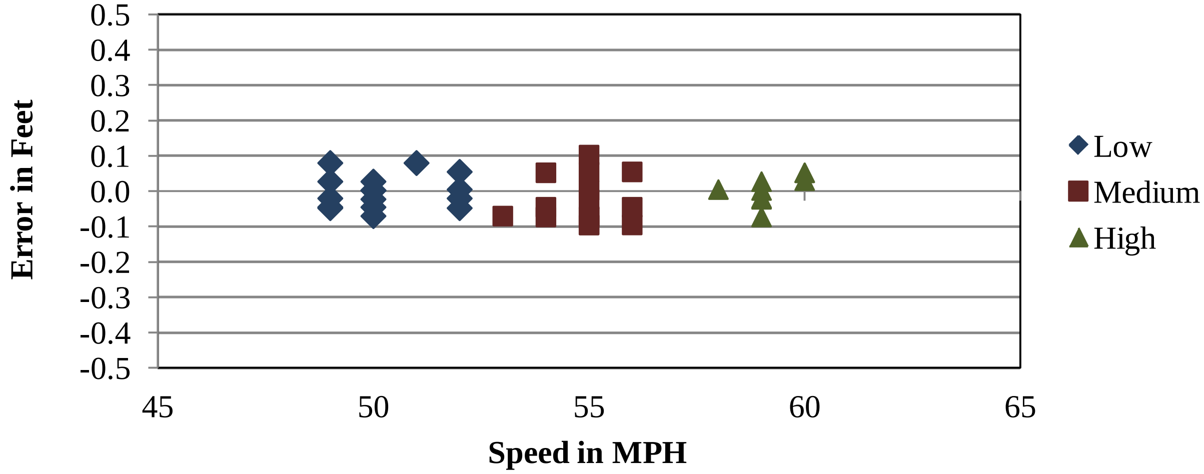


Figure 5-19 – Post-Validation Axle Length Error by Speed – 30-Nov-11

5.3.1.7 Overall Length Errors by Speed

For this system, the WIM equipment measures overall length consistently over the entire range of speeds, with errors ranging from -0.5 to 0.7 feet. Distribution of errors is shown graphically in Figure 5-20.

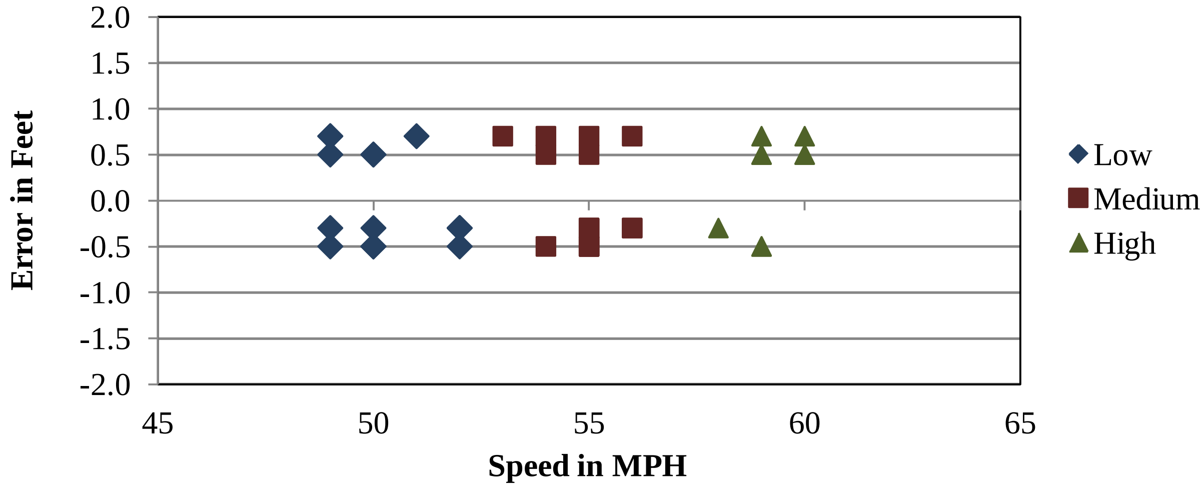


Figure 5-20 – Post-Validation Overall Length Error by Speed – 30-Nov-11

5.3.2 Statistical Temperature Analysis

Statistical analysis was performed for the test truck run data to investigate whether a relationship exists between pavement temperature and WIM equipment weight and distance measurement accuracy. Due to fog and overcast skies, the range of pavement temperatures was only 11.6 degrees, from 48.9 to 60.5 degrees Fahrenheit. The post-validation test runs are reported under one temperature group, as shown in Table 5-14.

Table 5-14 – Post-Validation Results by Temperature – 30-Nov-11

Parameter	95% Confidence Limit of Error	Medium
		48.9 to 60.5 degF
Steering Axles	±20 percent	0.4 ± 5.5%
Single Axles	±20 percent	0.3 ± 6.1%
Tandem Axles	±15 percent	0.1 ± 4.8%
GVW	±10 percent	0.3 ± 3.0%
Vehicle Length	±3.0 percent (1.9 ft)	0.1 ± 1.3 ft
Vehicle Speed	± 1.0 mph	0.2 ± 2.8 mph
Axle Length	± 0.5 ft [150mm]	0.0 ± 0.1 ft

To aid in the analysis, several graphs were developed to illustrate the possible effects of temperature on GVW, single axle weights, and axle group weights.

5.3.2.1 GVW Errors by Temperature

From Figure 5-21, it can be seen that the equipment appears to estimate GVW with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and weight estimates at this site.

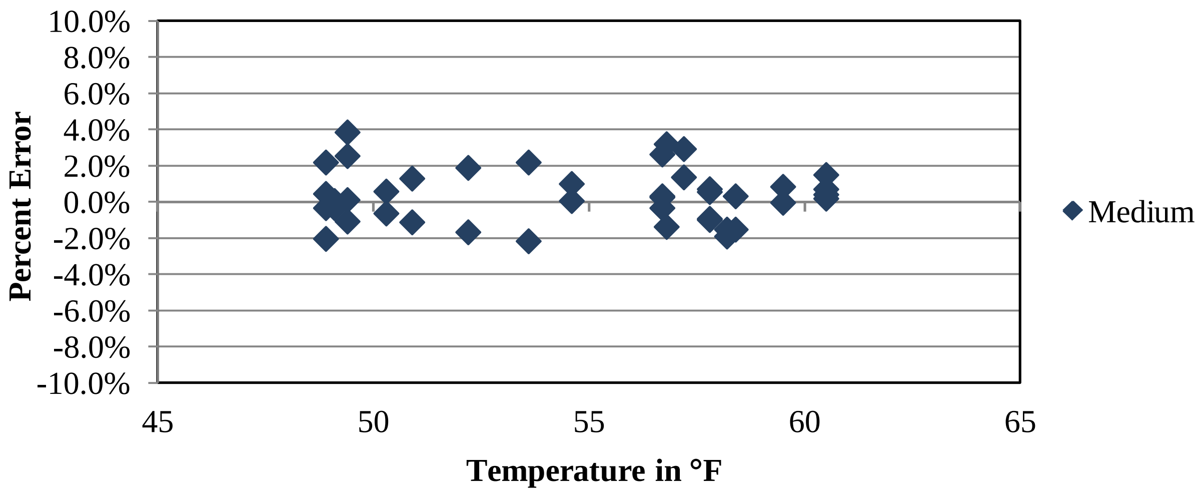


Figure 5-21 – Post-Validation GVW Errors by Temperature – 30-Nov-11

5.3.2.2 Steering Axle Weight Errors by Temperature

Figure 5-22 demonstrates that for steering axles, the WIM equipment appears to estimate weights with similar accuracy across the range of temperatures observed in the field. There does not appear to be a correlation between temperature and steering axle weight estimates at this site.

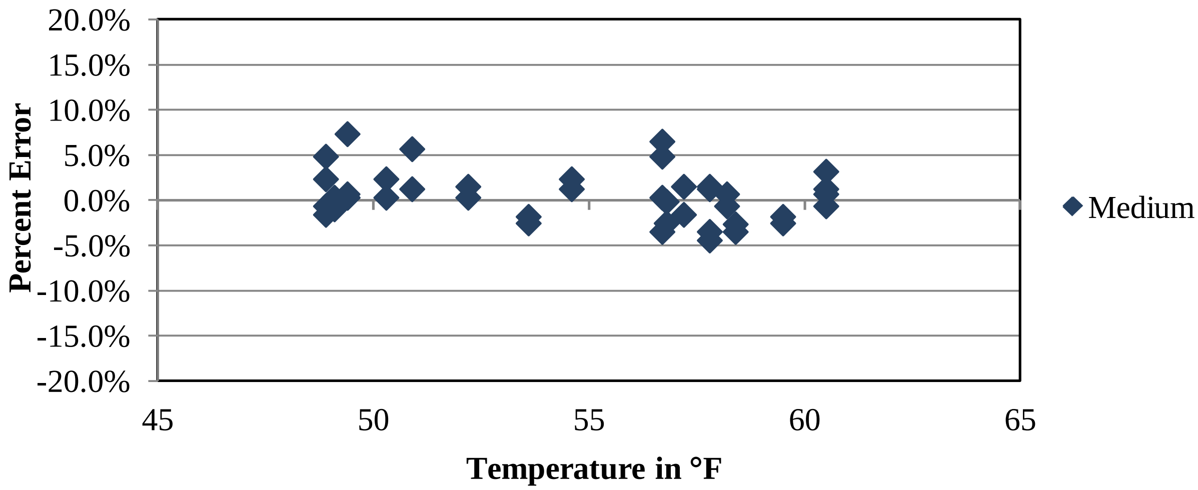


Figure 5-22 – Post-Validation Steering Axle Weight Errors by Temperature – 30-Nov-11

5.3.2.3 Single Axle Weight Errors by Temperature

Figure 5-23 demonstrates that for loaded single axles, the WIM equipment appears to estimate single axle weights with similar accuracy across the range of temperatures observed in the field.

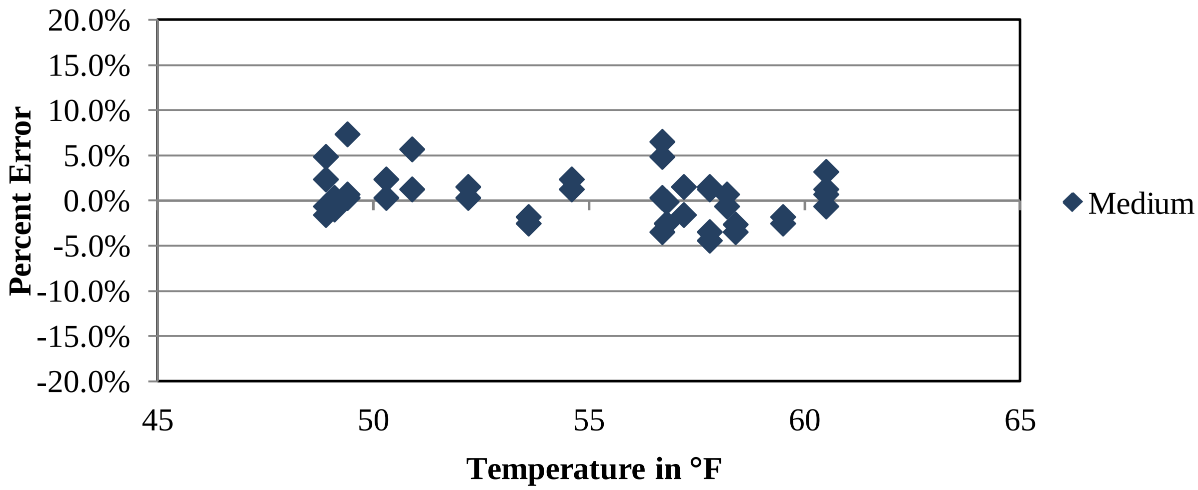


Figure 5-23 – Post-Validation Single Axle Weight Errors by Temperature – 30-Nov-11

5.3.2.4 Tandem Axle Weight Errors by Temperature

As shown in Figure 5-24, the WIM equipment appears to estimate tandem axle weights with similar accuracy across the range of temperatures observed in the field.

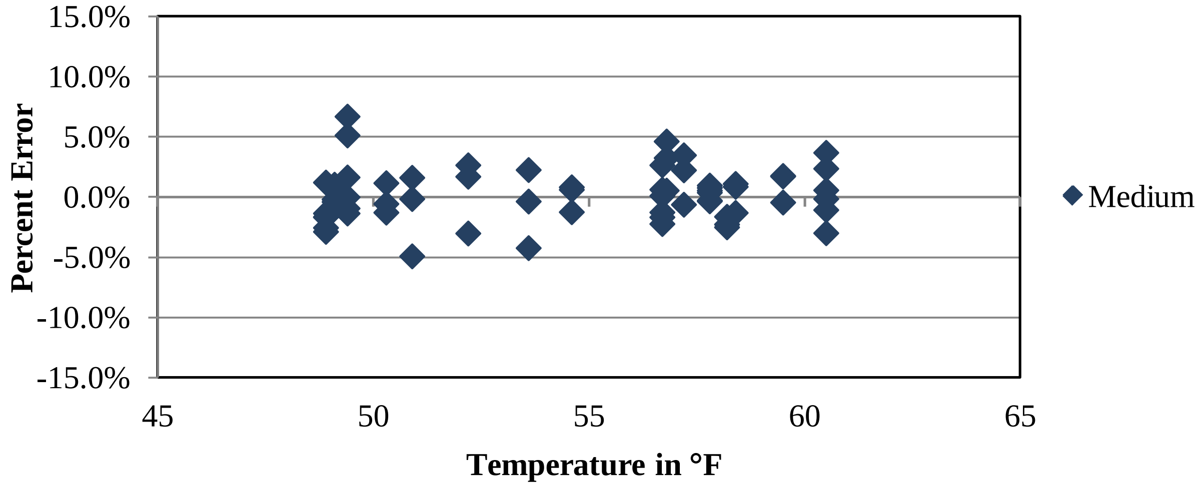


Figure 5-24 – Post-Validation Tandem Axle Weight Errors by Temperature – 30-Nov-11

5.3.2.5 GVW Errors by Temperature and Truck Type

As shown in Figure 5-25, when analyzed by truck type, GVW measurement errors for both trucks are similar at all temperatures. For both trucks, the range of errors and bias are reasonably consistent over the range of temperatures.

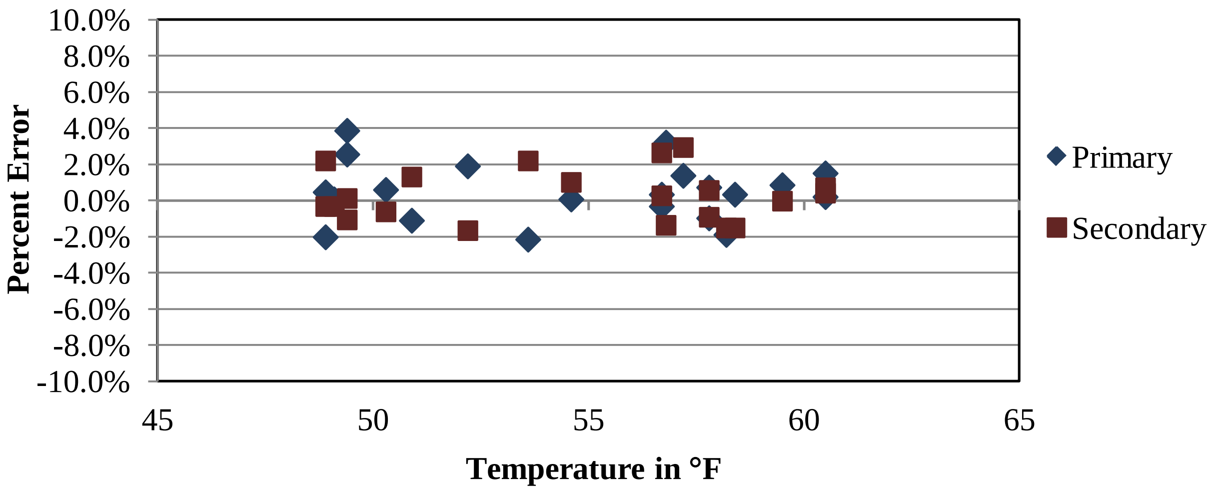


Figure 5-25 – Post-Validation GVW Error by Truck and Temperature – 30-Nov-11

5.3.3 GVW and Steering Axle Trends

Figure 5-26 is provided to illustrate the predicted GVW error with respect to the post-validation errors by speed.

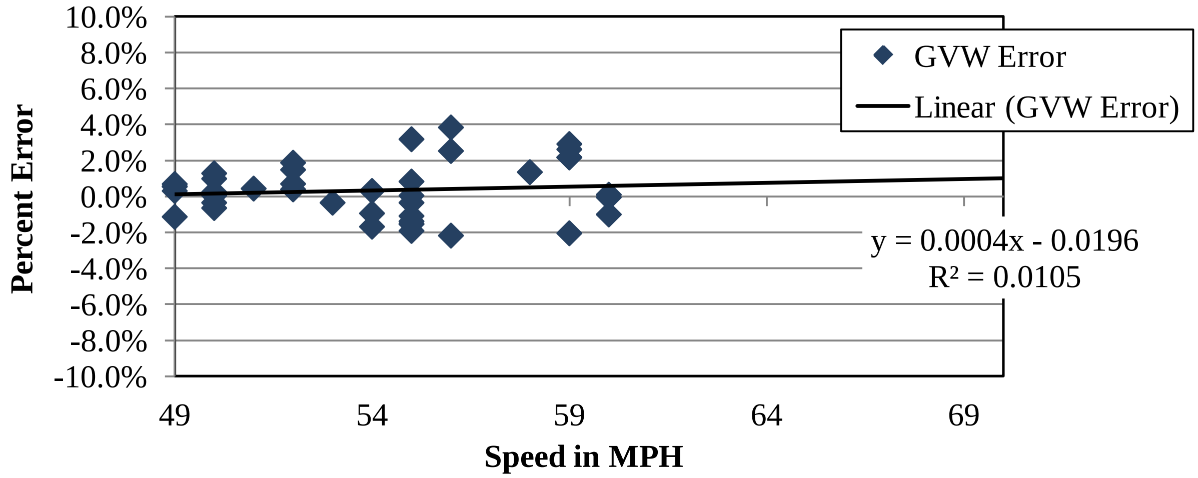


Figure 5-26 – GVW Error Trend by Speed

Figure 5-27 is provided to illustrate the predicted Steering Axle error with respect to the post-validation errors by speed.

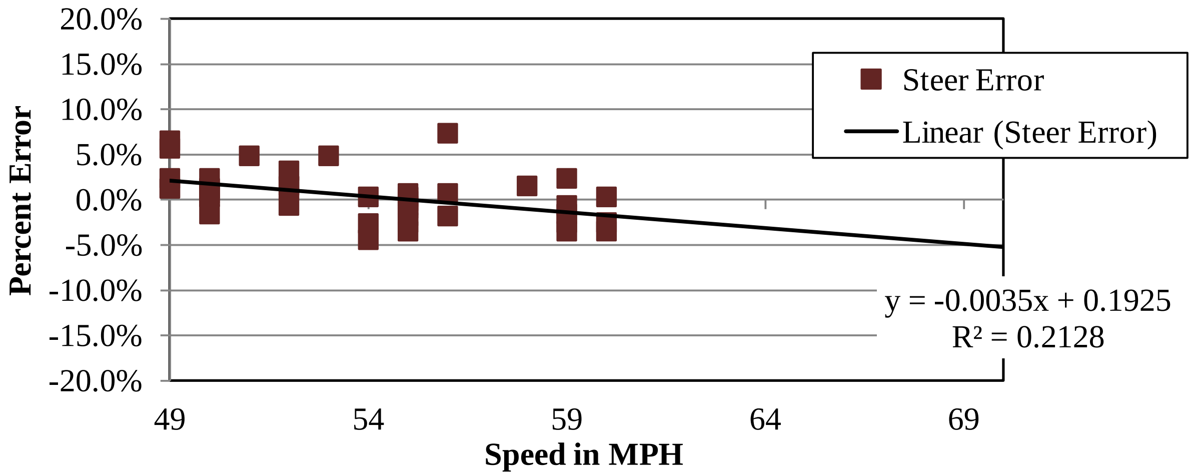


Figure 5-27 – Steering Axle Trend by Speed

5.3.4 Multivariable Analysis

This section provides additional results for the analysis carried out to determine the influence of truck type, speed and pavement temperature on WIM measurement errors. Multivariable linear regression analysis was applied to WIM data collected during calibration procedures. The same calibration data analyzed and discussed previously was used for this analysis; however a more comprehensive statistical methodology was applied. The objective of the additional analysis is to investigate if the trends identified using previous analyses are statistically significant, and to quantify these trends.

Multivariable analysis provides additional insight on how factors like speed, temperature, and truck type may affect weight measurement errors for a specific WIM site. It is expected that multivariable analysis done systematically for many sites may reveal overall trends.

5.3.4.1 Data

All errors from the weight measurement data collected by the equipment during the validation were analyzed. The percent error is defined as percentage difference between the weight measured by the WIM system and the static weight. Compared to analysis described previously, the weight of "axle group" was evaluated separately for tandem axles on tractors and on trailers. The separate evaluation was carried out because the tandem axles on trailers may have different dynamic response to loads than tandem axles on tractors.

In this case, the tandem axle on the trailer of the Secondary truck was a split tandem axle with the spacing of 10.2 feet. Because the spacing of the split tandem axle exceeded 10 feet, and there was no effective weight equalization between the axles of the split tandem axle, the split tandem axle was assumed to consist of two single axles.

The measurement errors were statistically attributed to the following variables or factors:

- Truck type. Primary truck and secondary truck.
- Truck test speed. Truck test speed ranged from 49 to 60 mph.
- Pavement temperature. Pavement temperature ranged from 48.9 to 60.5 degrees Fahrenheit.

5.3.4.2 Results

For analysis of GVW weights, the value of regression coefficients and their statistical properties are summarized in Table 5-15. The value of regression coefficients defines the slope of the relationship between the % error in GVW and the predictor variables (speed, temperature, and truck type). The values of the t-distribution (for the regression coefficients) given in Table 5-15 are for the null hypothesis that assumes that the regression coefficients are equal to zero. The p-value reported in Table 5-15 is for the probability that the regression coefficient, given in Table 5-15, is equal to zero.

Table 5-15 – Table of Regression Coefficients for Measurement Error of GVW

Parameter	Regression coefficients	Standard error	Value of t-distribution	Probability value
Intercept	-1.6555	5.14077	-0.3220	0.7493
Speed	0.0482	0.07173	0.67237	0.5057
Temp	-0.0090	0.06024	-0.1493	0.8821
Truck	-0.250	0.50255	-0.4981	0.6215

The probability values given in Table 5.15 are all higher than 0.5. This means that there is more than 50 percent chance that the values of the regression coefficients in Table 5.15 can occur by chance alone. For speed, the chance was lowest at about 51 percent. In other words, speed, temperature and truck type had no statistically significant effect on the GVW measurement error.

Figure 5-28 illustrates that for GVW, speed does not have a statistically significant effect on the measurement error.

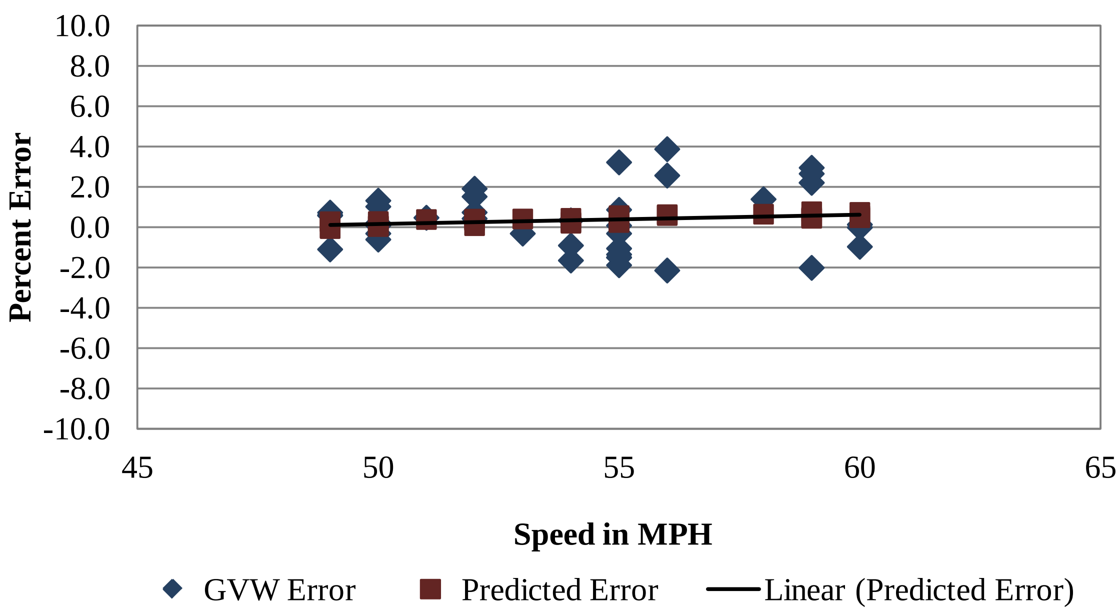


Figure 5-28 – Influence of Speed on the Measurement Error of GVW

5.3.4.3 Summary Results

Table 5-16 lists regression coefficients and their probability values for all combinations of factors and % errors evaluated. Not listed in the table are factor interactions because the interactions were not statistically significant. Entries in the table are provided only if the probability value was smaller than 0.20. The dash in Table 5-16 indicates that the relationship was not statistically significant (the probability that the relationship can occur by chance alone was greater than 20 percent).

Table 5-16 – Summary of Regression Analysis

	Factor					
	Speed		Temperature		Truck type	
Weight, % error	Regression coefficient	Probability value	Regression coefficient	Probability value	Regression coefficient	Probability value
GVW	-	-	-	-	-	-
Steering axle	-0.2961	0.0022	-0.2133	0.0076	-2.1354	0.0017
Tandem axle tractor	-	-	-	-	-	-
Single axle	-	-	-	-	-	-

Only steering axle weight measurements show statistically significant relationship with respect to speed, temperature and truck type. The relationship between speed and steering axle measurement errors is shown in Figure 5-29. The figure includes trend line for the predicted percent error. Besides the visual assessment of the relationship, Figure 5-28 provides quantification and statistical assessment of the relationship.

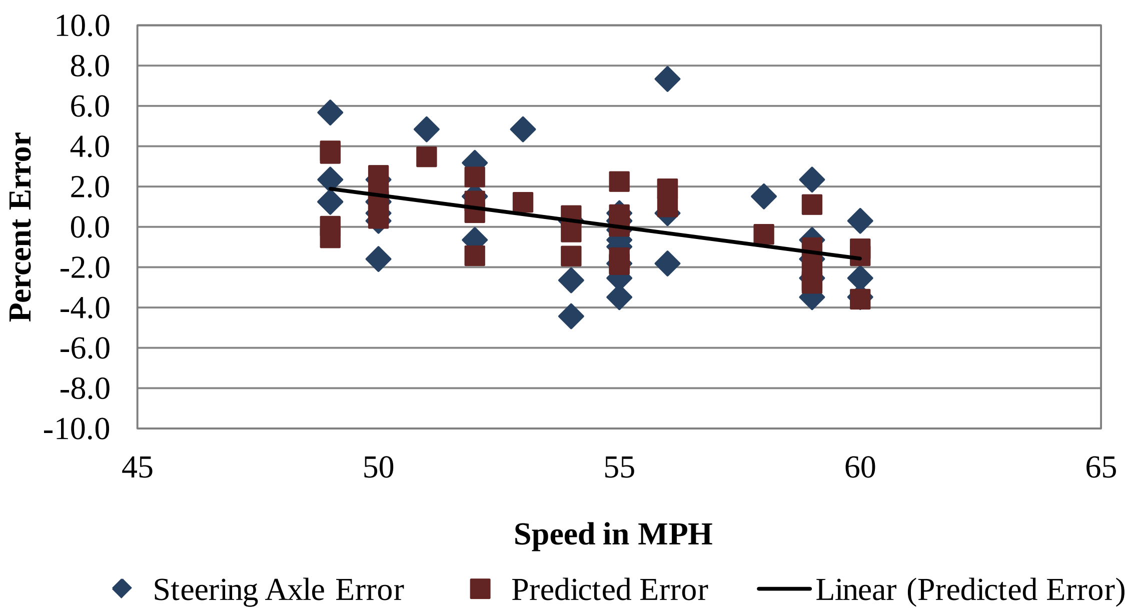


Figure 5-29 – Influence of Speed on the Measurement Error of Steering Axles

The quantification is provided by the value of the regression coefficient, in this case -0.2961 (in Table 5-16). This means, for example, that for a 10 mph increase in speed, the % error is increased by about 3 % (0.2961 x 10). The statistical assessment of the relationship is provided by the probability value of the regression coefficient for speed (0.0022 in Table 5-16). The low probability value indicates that the chance that the relationship shown in Figure 5-28 can occur by chance alone is less than 0.22 percent.

5.3.4.4 Conclusions

1. Speed, temperature, and truck type had statistically significant effect on measurement errors of steering axles only.

2. Even though speed and truck type had statistically significant effects on measurement errors of some of the parameters, the practical significance of these effects on WIM system calibration tolerances is small and does not affect the results of the validation.

5.3.5 Classification and Speed Evaluation

The post-validation classification and speed study involved the comparison of vehicle classification and speed data collected manually with the information for the same vehicles reported by the WIM equipment.

For the post-validation classification study at this site, a manual sample of 106 vehicles including 100 trucks (Class 4 through 13) was collected. Video was collected during the study to provide a means for further analysis of misclassifications and vehicles whose classifications could not be determined with a high degree of certainty in the field.

Table 5-17 illustrates the breakdown of vehicles observed and identified by the WIM equipment for the manual classification study. Misclassified vehicles are defined as those vehicles that are manually classified by observation as one type of vehicle but identified by the WIM equipment as another type of vehicle. As shown in Table 5-17, three Class 3 vehicles were identified as Class 5s, three Class 3 vehicles were misclassified as Class 8 vehicles, and one Class 4 vehicle was misclassified as a Class 5 vehicle.

Table 5-17 – Post-Validation Misclassifications by Pair – 30-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/5	2	6/4	0	9/5	0
3/8	3	6/7	0	9/8	0
4/5	1	6/8	0	9/10	0
5/3	0	6/9	0	10/9	0
5/4	0	6/10	0	10/13	0
5/6	0	7/6	0	11/12	0
5/7	0	8/3	0	12/11	0
5/8	0	8/5	0	13/10	0
5/9	0	8/9	0	13/11	0

As shown in the table, a total of 6 vehicles, including 0 heavy trucks (6 – 13) were misclassified by the equipment. The combined results of the misclassifications resulted in undercount of five Class 3 vehicles and one Class 4 vehicle, and an overcount of three Class 5 vehicles and three Class 8 vehicles, as shown in Table 5-18. The cause of the misclassifications was not investigated in the field. More detailed post-visit investigations of misclassified vehicles may be performed using the collected video.

The misclassified percentage represents the percentage of the misclassified vehicles in the manual sample. The misclassifications by pair are provided in Table 5-18.

Table 5-18 – Post-Validation Classification Study Results – 30-Nov-11

Class	3	4	5	6	7	8	9	10	11	12	13
Observed Count	6	2	21	4	0	8	56	0	9	0	0
WIM Count	1	1	24	4	0	11	56	0	9	0	0
Observed Percent	5.7	1.9	19.8	3.8	0.0	7.5	52.8	0.0	8.5	0.0	0.0
WIM Percent	1.9	0.0	22.6	3.8	0.0	10.4	52.8	0.0	8.5	0.0	0.0
Misclassified Count	5	1	0	0	0	0	0	0	0	0	0
Misclassified Percent	83.3	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unclassified Count	0	0	0	0	0	0	0	0	0	0	0
Unclassified Percent	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Based on the vehicles observed during the post-validation study, the misclassification percentage is 0.0% for heavy trucks (6 – 13), which is within the 2.0% acceptability criteria for LTPP SPS WIM sites. The overall misclassification rate for all vehicles (3 – 15) is 5.7%.

Unclassified vehicles are defined as those vehicles that cannot be identified by the WIM equipment algorithm. These are typically trucks with unusual trailer tandem configurations and are identified as Class 15 by the WIM equipment. The unclassified vehicles by pair are provided in Table 5-19.

Table 5-19 – Post-Validation Unclassified Trucks by Pair – 30-Nov-11

Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs	Observed/ WIM	Number of Pairs
3/15	0	7/15	0	11/15	0
4/15	0	8/15	0	12/15	0
5/15	0	9/15	0	13/15	0
6/15	0	10/15	0		

Based on the manually collected sample of the 100 trucks, 0.0% of the vehicles at this site were reported as unclassified during the study. This is within the established criteria of 2.0% for LTTP SPS WIM sites.

For speed, the mean error for WIM equipment speed measurement was 0.8 mph; the range of errors was 1.7 mph.

6 Previous WIM Site Validation Information

The information reported in this section provides a summary of the performance of the WIM equipment since it was installed or since the first validation was performed on the equipment. The information includes historical data on weight and classification accuracies as well as a comparison of post-validation results.

6.1 Sheet 16s

This site has validation information from five previous visits as well as the current one as summarized in the tables below and provided on the Traffic Sheet 16. Table 6-1 data was extracted from the most recent previous validation and was updated to include the results of this validation.

Table 6-1 – Classification Validation History

Date	Misclassification Percentage by Class										Pct Unclass
	4	5	6	7	8	9	10	11	12	13	
25-Mar-08	N/A	0	0	N/A	0	0	0	0	N/A	N/A	0.0
26-Mar-08	0	0	0	N/A	0	0	N/A	0	N/A	N/A	0.0
17-Aug-10	N/A	6	0	N/A	0	0	0	0	N/A	N/A	0.0
18-Aug-10	N/A	25	0	100	0	0	N/A	0	0	N/A	1.0
29-Nov-11	100	15	0	0	0	0	0	0	0	0	0.0
30-Nov-11	50	0	0	0	0	0	0	0	0	0	0.0

Table 6-2 data was extracted from the previous validation and was updated to include the results of this validation. The table provides the mean error and standard deviation for GVW, single axles and tandems for prior pre- and post-validations as reported on the LTPP Traffic Sheet 16s.

Table 6-2 – Weight Validation History

Date	Mean Error and SD		
	GVW	Single Axles	Tandem
25-Mar-08	1.1 ± 1.1	1.2 ± 1.7	1.0 ± 1.4
26-Mar-08	1.2 ± 0.7	0.3 ± 1.8	1.3 ± 1.4
17-Aug-10	3.2 ± 1.2	3.0 ± 2.1	3.6 ± 2.0
18-Aug-10	-0.1 ± 1.2	-1.1 ± 2.1	0.2 ± 1.9
29-Nov-11	1.4 ± 1.6	1.0 ± 3.1	1.5 ± 2.5
30-Nov-11	0.3 ± 1.5	0.3 ± 3.0	0.1 ± 2.3

The variability of the weight errors appears to have remained reasonably consistent since the site was first validated. From this information, it appears that the system demonstrates a tendency for the equipment to move toward an overestimation of axle weights over time. The table also demonstrates the effectiveness of the validations in keeping the weight estimations within LTPP SPS WIM equipment tolerances.

6.2 Comparison of Past Validation Results

A comparison of the post-validation results from previous visits is provided in Table 6-3. The table provides the historical performance of the WIM system with regard to the 95% confidence interval tolerances.

Table 6-3 – Comparison of Post-Validation Results

Parameter	95 %Confidence Limit of Error	Site Values (Mean Error and 95% Confidence Interval)		
		26-Mar-08	18-Aug-10	30-Nov-11
Steering Axles	±20 percent	0.3 ± 3.6	-1.1 ± 4.3	0.3 ± 5.5
Tandem Axles	±15 percent	1.3 ± 2.7	0.2 ± 3.7	0.1 ± 4.8
GVW	±10 percent	1.2 ± 1.4	-0.1 ± 2.5	0.3 ± 3.0

From Table 6-3, it appears that the mean error has remained consistent and the 95% confidence intervals have increased for all weights since the equipment was installed. These trends are consistent with the expected performance of WIM systems over time. Calibration of WIM systems can maintain the mean error at the same level over time, but cannot compensate for the increase in the variance of the measurement error. Error variance is probably increasing due to the increase in dynamic axle weights as the WIM system, including the pavement, ages and deteriorates.

The final factors left in place at the conclusion of the validation are provided in Table 6-4.

Table 6-4 – Final Factors

Speed Points	Left	Right
	1	2
80	3277	3277
88	3262	3262
96	3273	3273
104	3171	3171
112	3171	3171
Axle Distance (cm)	272	
Dynamic Comp (%)	101	
Loop Width (cm)	314	

A review of the LTPP Standard Release Database 25 shows that there are 4 years of level “E” WIM data for this site. This site requires 1 additional year of data to meet the minimum of five years of research quality data.

7 Additional Information

The following information is provided in the attached appendix:

- Site Photographs
    - Equipment
    - Test Trucks
    - Pavement Condition
- Pre-validation Sheet 16 – Site Calibration Summary
- Post-validation Sheet 16 – Site Calibration Summary
- Pre-validation Sheet 20 – Classification and Speed Study
- Post-validation Sheet 20 – Classification and Speed Study

Additional information is available upon request through LTPP INFO at ltppinfo@dot.gov, or telephone (202) 493-3035. This information includes:

- Sheet 17 – WIM Site Inventory
- Sheet 18 – WIM Site Coordination
- Sheet 19 – Validation Test Truck Data
- Sheet 21 – WIM System Truck Records
- Sheet 22 – Site Equipment Assessment plus Addendum
- Sheet 24A/B – Site Photograph Logs
- Updated Handout Guide

WIM System Field Calibration and Validation - Photos

California, SPS-2
SHRP ID: 060200

Validation Date: November 30, 2011

APPLIED RESEARCH ASSOCIATES, INC.

Photo 1 – Cabinet Exterior

Photo 2 – Cabinet Interior (Front)

Photo 3 – Cabinet Interior (Back)

Photo 4 – Leading Loop

Photo 5 – Leading WIM Sensor

Photo 6 – Trailing WIM Sensor

Photo 7 – Trailing Loop Sensor

Photo 8 – Solar Panel

Photo 9 – Cellular Modem

Photo 10 – Downstream

Photo 11 – Upstream

Photo 12 – Truck 1

Photo 13 – Truck 1 Tractor

Photo 14 – Truck 1 Trailer and Load

Photo 15 – Truck 1 Suspension 1

Photo 16 – Truck 1 Suspension 2

Photo 17 – Truck 1 Suspension 3

Photo 18 – Truck 1 Suspension 4

Photo 19 – Truck 1 Suspension 5

Photo 20 – Truck 2

Photo 21 – Truck 2 Tractor

Photo 22 – Truck 2 Trailer and Load

Photo 23 – Truck 2 Suspension 1

Photo 24 – Truck 2 Suspension 2

Photo 25 – Truck 2 Suspension 3

Photo 26 – Truck 2 Suspension 5

Photo 27 – Truck 2 Suspension 4

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/29/2011

SITE CALIBRATION INFORMATION

1. DATE OF CALIBRATION {mm/dd/yy} 11/29/11

2. TYPE OF EQUIPMENT CALIBRATED: Both

3. REASON FOR CALIBRATION: LTPP Validation

4. SENSORS INSTALLED IN LTPP LANE AT THIS SITE (Select all that apply):

a. Inductance Loops c. ______
b. Bending Plates d. ______

5. EQUIPMENT MANUFACTURER: IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. CALIBRATION TECHNIQUE USED: Test Trucks

Number of Trucks Compared: ______
Number of Test Trucks Used: 2
Passes Per Truck: 20

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:			

7. SUMMARY CALIBRATION RESULTS (expressed as a %):

Mean Difference Between -

Dynamic and Static GVW:	1.4%	Standard Deviation:	1.6%
Dynamic and Static Single Axle:	1.0%	Standard Deviation:	3.1%
Dynamic and Static Double Axles:	1.5%	Standard Deviation:	2.5%

8. NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED: 3

9. DEFINE SPEED RANGES IN MPH:

			Low		High	Runs
a.	Low	-	49.0	to	53.7	14
b.	Medium	-	53.8	to	58.4	16
c.	High	-	58.5	to	63.0	10
d.		-		to		
e.		-		to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/29/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3333 | 3333

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	2.0	FHWA Class	5	-	15.0
FHWA Class 8:	50.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Cal 1

Person Leading Calibration Effort: **Kevin Trousdale**

Contact Information: Phone: 717-975-3550

E-mail: ktrousdale@ara.com

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/30/2011

SITE CALIBRATION INFORMATION

1. **DATE OF CALIBRATION** {mm/dd/yy} 11/30/11

2. **TYPE OF EQUIPMENT CALIBRATED:** Both

3. **REASON FOR CALIBRATION:** LTPP Validation

4. **SENSORS INSTALLED IN LTPP LANE AT THIS SITE** (Select all that apply):
   - a. Inductance Loops
   - b. Bending Plates
   - c.
   - d.

5. **EQUIPMENT MANUFACTURER:** IRD iSINC

WIM SYSTEM CALIBRATION SPECIFICS

6. **CALIBRATION TECHNIQUE USED:** Test Trucks

Number of Trucks Compared:
Number of Test Trucks Used: 2
Passes Per Truck: 21

	Type	Drive Suspension	Trailer Suspension
Truck 1:	9	air	air
Truck 2:	9	air	air
Truck 3:			

7. **SUMMARY CALIBRATION RESULTS** (expressed as a %):

Mean Difference Between -

	Mean		Standard Deviation
Dynamic and Static GVW:	0.3%	Standard Deviation:	1.5%
Dynamic and Static Single Axle:	0.3%	Standard Deviation:	3.0%
Dynamic and Static Double Axles:	0.1%	Standard Deviation:	2.3%

8. **NUMBER OF SPEEDS AT WHICH CALIBRATION WAS PERFORMED:** 3

9. **DEFINE SPEED RANGES IN MPH:**

		Low		High	Runs
a.	Low	49.0	to	52.7	17
b.	Medium	52.8	to	56.4	16
c.	High	56.5	to	60.0	9
d.			to		
e.			to		

Traffic Sheet 16 LTPP MONITORED TRAFFIC DATA SITE CALIBRATION SUMMARY	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/30/2011

10. CALIBRATION FACTOR (AT EXPECTED FREE FLOW SPEED) 3273 | 3273

11. IS AUTO- CALIBRATION USED AT THIS SITE? No

If yes , define auto-calibration value(s):

CLASSIFIER TEST SPECIFICS

12. METHOD FOR COLLECTING INDEPENDENT VOLUME MEASUREMENT BY VEHICLE CLASS:

Manual

13. METHOD TO DETERMINE LENGTH OF COUNT: Number of Trucks

14. MEAN DIFFERENCE IN VOLUMES BY VEHICLES CLASSIFICATION:

FHWA Class 9:	0.0	FHWA Class	5	-	14.0
FHWA Class 8:	38.0	FHWA Class		-	
		FHWA Class		-	
		FHWA Class		-	

Percent of "Unclassified" Vehicles: 0.0%

Validation Test Truck Run Set - Post

Person Leading Calibration Effort: **Kevin Trousdale**

Contact Information: Phone: 717-975-3550

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Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/29/2011

Count - 107 Time = 3:08:21 Trucks (4-15) - 100 Class 3s - 7

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
61	9	11308	60	9	60	9	11410	58	9
57	8	11310	55	8	58	9	11907	58	9
60	9	11312	58	9	59	5	11908	57	3
60	9	11318	60	9	61	9	11910	60	9
62	9	11324	57	9	58	11	11914	55	11
60	9	11326	59	9	68	5	11920	66	5
59	9	11327	57	9	62	9	11923	59	9
64	5	11340	62	5	59	6	11925	60	6
73	5	11343	69	5	59	9	11927	59	9
59	11	11345	58	11	61	3	11928	54	3
60	9	11347	58	9	60	6	11932	58	6
62	9	11348	62	9	61	11	11933	57	11
56	9	11351	56	9	54	9	11936	52	9
56	9	11352	56	9	54	9	11937	52	9
60	3	11353	57	3	53	3	11938	49	3
66	5	11360	61	5	59	9	11948	55	9
62	9	11361	62	9	63	9	11950	60	9
57	9	11368	58	9	62	11	11955	63	11
56	9	11369	53	9	58	9	11964	54	9
57	9	11373	54	9	59	9	11967	58	9
58	11	11376	58	11	58	8	11971	57	8
57	9	11378	55	9	59	5	11975	57	5
55	9	11379	54	9	57	5	11977	55	5
57	9	11407	55	9	59	6	11983	58	6
57	9	11408	54	9	54	9	11985	54	9

Sheet 1 - 0 to 50 Start: 11:40:17 Stop: 12:32:58

Recorded By: ar Verified By: kt

Validation Test Truck Run Set - Cal 1

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/29/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
60	9	13289	58	9	59	9	13389	61	9
60	9	13295	59	9	59	9	13390	58	9
59	6	13296	58	6	62	9	13392	60	9
60	6	13297	59	6	54	5	13393	52	5
59	9	13304	56	9	57	9	13396	53	9
60	**5**	**13307**	**58**	**4**	56	8	13454	54	8
61	9	13313	59	9	57	9	13462	56	9
59	9	13315	56	9	60	11	13465	59	11
56	6	13320	53	6	59	9	13476	57	9
54	9	13321	53	9	54	9	13478	53	9
58	9	13326	60	9	54	11	13479	55	11
61	9	13327	60	9	**53**	**5**	**13480**	**53**	**3**
65	5	13328	64	5	58	9	13488	59	9
59	8	13337	58	8	56	9	13491	55	9
60	**8**	**13341**	**59**	**3**	63	6	13494	59	6
60	9	13344	58	9	64	9	13506	63	9
66	5	13349	65	5	62	12	13507	59	12
57	**5**	**13353**	**57**	**3**	63	9	13513	61	9
60	9	13357	56	9	56	9	13517	56	9
60	9	13369	59	9	**66**	**8**	**13531**	**65**	**5**
58	9	13375	55	9	58	9	13533	55	9
57	11	13376	53	11	57	12	13534	55	12
61	9	13381	59	9	64	11	13542	63	11
59	9	13382	57	9	62	9	13546	57	9
63	9	13383	59	9	59	9	13548	59	9

Sheet 2 - 51 to 100 Start: 14:18:29 Stop: 14:37:19

Recorded By: ar Verified By: kt

Validation Test Truck Run Set - Cal 1

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/29/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
64	**9**	**13569**	**62**	**5**					
59	9	13577	56	9					
64	5	13584	62	5					
61	6	13594	59	6					
60	9	13599	59	9					
58	9	13605	54	9					
57	5	13607	56	5					

Sheet 3 - 101 - 150 Start: 14:38:41 Stop: 14:48:38

Recorded By: ar Verified By: kt

Validation Test Truck Run Set - Cal 1

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/30/2011

Count - 106 Time = 1:33:06 Trucks (4-15) - 100 Class 3s - 6

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
58	5	24755	58	5	68	5	25019	69	5
57	9	24756	55	9	54	5	25025	52	5
57	9	24757	56	9	64	9	25084	61	9
58	3	24760	54	4	60	11	25086	61	11
55	9	24763	55	9	54	9	25093	53	9
57	9	24765	59	9	55	5	25095	62	3
57	9	24769	58	9	58	9	25102	54	9
60	9	24775	60	9	63	9	25106	59	9
57	9	24821	55	9	57	9	25110	58	9
62	11	24823	62	11	54	9	25113	54	9
57	11	24829	55	11	54	9	25117	54	9
60	11	24831	59	11	54	5	25121	53	5
57	5	24833	55	5	68	8	25130	67	3
62	9	24834	64	9	56	9	25132	55	9
56	9	24838	54	9	57	9	25134	54	9
53	5	24841	52	5	52	8	25143	52	8
56	9	24843	55	9	55	11	25149	54	11
65	9	24845	64	9	57	5	25309	54	5
57	11	24846	57	11	57	8	25310	55	8
53	8	24847	53	8	52	6	25314	52	6
60	9	24850	60	9	60	5	25319	60	5
62	9	24887	60	9	57	9	25323	57	9
54	8	24888	54	8	55	8	25326	55	8
55	5	24890	55	3	64	5	25327	62	5
56	9	25018	54	9	54	9	25335	53	9

Sheet 1 - 0 to 50 Start: 12:22:31 Stop: 13:17:06

Recorded By: ar Verified By: kt

Validation Test Truck Run Set - Post

Traffic Sheet 20 LTPP MONITORED TRAFFIC DATA SPEED AND CLASSIFICATION STUDIES	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/30/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
55	9	25341	55	9	**55**	**8**	**25646**	**53**	**3**
55	9	25347	55	9	57	5	25651	55	5
59	9	25352	58	9	54	9	25654	54	9
59	11	25354	58	11	54	5	25656	55	5
58	9	25365	59	9	59	9	25658	58	9
57	5	25368	61	5	67	5	25664	67	5
57	9	25376	54	9	59	6	25665	59	6
63	5	25379	59	5	55	9	25669	54	9
60	9	25385	59	9	60	9	25676	61	9
62	9	25391	61	9	54	9	25678	54	9
62	8	25392	59	8	**56**	**5**	**25679**	**53**	**4**
62	8	25402	59	8	55	9	25681	55	9
60	9	25406	62	9	63	5	25686	60	5
59	9	25410	58	9	60	9	25689	55	9
70	5	25414	69	5	57	9	25691	55	9
65	5	25417	65	5	57	9	25696	55	9
58	9	25424	59	9	57	9	25700	55	9
58	6	25426	57	6	56	11	25703	54	11
57	8	25428	60	8	56	9	25707	55	9
60	6	25437	58	6	58	9	25712	56	9
59	11	25443	57	11	57	9	25718	57	9
56	9	25445	55	9	60	3	25720	61	3
60	**8**	**25450**	**60**	**3**	57	9	25723	56	9
56	9	25457	58	9	59	9	25726	59	9
62	5	25463	63	5	62	9	25730	61	9

Sheet 2 - 51 to 100 Start: 13:17:38 Stop: 13:47:44

Recorded By: ar Verified By: kt

Validation Test Truck Run Set - Post

Traffic Sheet 20 **LTPP MONITORED TRAFFIC DATA** **SPEED AND CLASSIFICATION STUDIES**	STATE CODE: 06 SPS WIM ID: 060200 DATE (mm/dd/yyyy) 11/30/2011

WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class	WIM speed	WIM class	WIM Record	Obs. Speed	Obs. Class
52	9	25804	52	9					
53	9	25805	53	9					
60	9	25815	60	9					
68	5	25819	64	5					
64	5	25820	63	5					
70	5	25823	68	5					

Sheet 3 - 101 - 150 Start: 13:53:51 Stop: 13:55:37

Recorded By: ar Verified By: kt

Validation Test Truck Run Set - Post