MESILLA VALLEY TRANSPORTATION SOLUTIONS
CERTIFIED
Fuel Economy Experts

Test Report

Alcoa ULT36
Aluminum Wheels
Steer, Drive, Trailer

MVT SOLUTIONS CERTIFIED™ FUEL ECONOMY TEST

October 2021

Fuel Savings

0.89	0.08	0.86%
gal/1000 miles	MPG	percent

1.0: INTRODUCTION

The purpose of this test was to conduct MVTS Certified tests on Howmet Aerospace's Alcoa brand ULT36 aluminum wheels in the Steer, Drive, and Trailer wheel positions. Testing was conducted on a closed-circuit track at 65 mph with Class-8 vehicles.

Mesilla Valley Transportation Solutions (MVTS) certifies the fuel savings from this product are as described in this report. **Note:** this report was designed for carriers and providing information relevant to their needs. Therefore, the format varies from traditional fuel economy and technical reports. The report Summary provides the reader a quick synopsis of the product's fuel savings. Following the Summary is the body of the report and further details on the subjects. This fuel economy test was performed using MVTS proprietary fuel economy test methods. These test methods were developed from race car engineering and advanced vehicle test methods, which Mesilla Valley Transportation (fleet) has relied on since 2012 to identify substantial fuel savings. The MVTS methods provide highly accurate and reliable answers on real-world fuel savings in comparison to other test methods, which enables carriers to make the best decisions for their company.

Contact MVTS with any questions regarding the test.

Note: blue text indicates a link to the topic. Click to follow. Alt + ← returns the reader to the initial location.

2.0: TEST SUMMARY

MVTS performed fuel economy testing comparing Alcoa ULT36 aluminum wheels to competitor steel wheels.

The **ULT36 wheels showed a fuel savings of 0.99 gal/1000 miles (0.95%) in the Steer position.**

The **ULT36 wheels showed a fuel savings of 0.64 gal/1000 miles (0.61%) in the Steer and Drive position.**

The **ULT36 wheels showed a fuel savings of 0.89 gal/1000 miles (0.86%) in the Steer, Drive, and Trailer position.**

The ULT36 wheels had 48% less Radial Runout than the steel wheels and produced a 26% better wheel and tire balance.

Testing was conducted on a 9-mile test track at 65 miles per hour and with a Gross Vehicle Weight (GVW) of approximately 45,200 lbs. Vehicles were modern Class-8 Sleeper Cabs with 53-ft dry van trailers.

Statistical bell curves for all results are show in Figure 1 below. Test results can be found below in Table 1.

Figure 1: Statistical Bell Curves of All Test Results

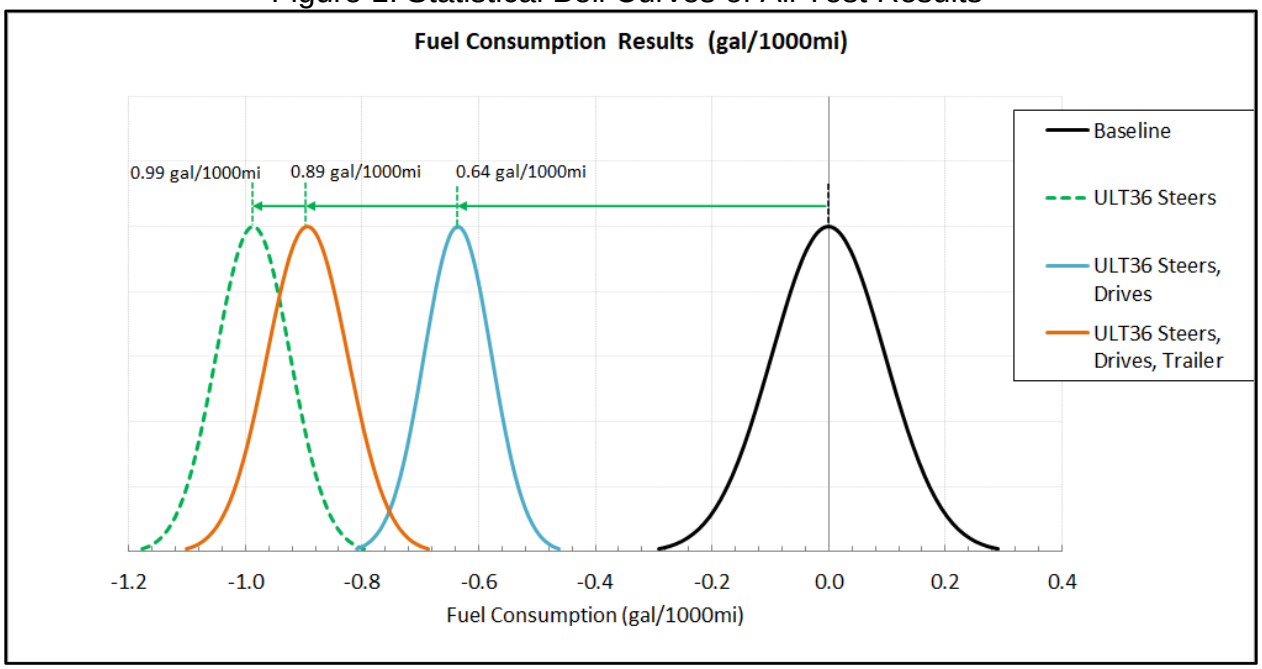

Table 1: Fuel Economy Test Results

Product	Fuel Economy Improvement		
	Gal/1000 miles	MPG	Percent
ULT36 Aluminum Wheels (S)	**0.99**	0.09	0.95%
ULT36 Aluminum Wheels (S,D)	**0.64**	0.06	0.61%
ULT36 Aluminum Wheels (S,D,T)	**0.89**	0.08	0.86%

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3.0: TEST PROCEDURE

The two (2) vehicles ran simultaneously at 65 mph on the 9-mile circle track near Pecos, Texas. The vehicles were 1-minute apart, avoiding any aerodynamic influence on either vehicle during testing. The vehicles were termed “Compare Vehicle” and “Test Vehicle”. The Compare Vehicle remained unchanged throughout testing; it was used solely for comparison. The Test Vehicle had modifications made during the test (*i.e.* Alcoa wheels installed). More details on the testing procedure can be found Section 3.2.

The test procedure may appear similar to the SAE J1321 method traditionally used in the trucking industry; however, the MVTS methods are a much more advanced and precise form of on-road and track testing. The vehicles are equipped with sensors and data recording systems that collect data on fuel consumption, aerodynamics, rolling resistance, driver behavior and many other variables that affect fuel consumption. The data is analyzed using MVTS proprietary methods, which provide very accurate answers on fuel savings. Additionally, the test results can be scientifically translated to a carrier’s real-world daily operations and long-term savings, which is a feature unique to these methods. Overall, the MVTS test methods are a much more advanced and reliable tool for predicting fuel savings than the trucking industry has used previously.

3.1: TEST VEHICLES

Test vehicles were 2019 International LT 625’s with Cummins X15 15-Liter engines and Eaton Endurant 12-speed AMT transmissions. Trailers were 53-foot Hyundai Dry Vans. Gross Vehicle Weight (GVW) was approximately 45,200 lbs. Both trucks were equipped with Ex-Guard grill guards, which were previously tested and showed no negative influence on fuel consumption. The Compare Vehicle remained unchanged for the duration of testing. The Test Vehicle configuration was changed between test runs. Trucks and trailers used dual tires. Tire pressures were initially set at 100 psi (cold) in the morning, prior to incurring any effect of daytime heat. Vehicle configuration information can be found in the Appendix.

Vehicles were thoroughly inspected and received regular maintenance prior to testing. It should also be noted, for the reader’s peace of mind, Mesilla Valley Transportation (MVT) and MVT Solutions are 100% confident in the reliable condition of the test vehicles and MVT relies on the same test results for their purchase decisions.

Figure 2: Test Vehicle (A), Compare Vehicle (B)

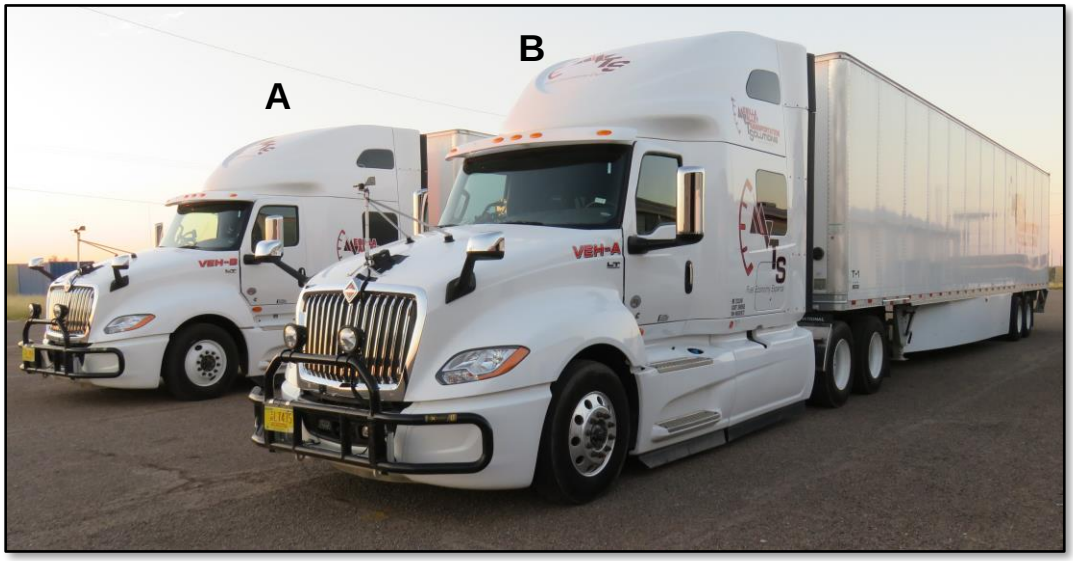


Figure 3: Compare Vehicle and Trailer

Figure 4: Trailer Gap (Test and Compare Vehicles)

Test runs were conducted in the order as shown in Table 2 below. **Note:** test runs are cumulative, therefore each run description is in addition to the changes made during the previous run(s). Other test runs occurred prior to Run 3 that were not applicable to this report. All aluminum wheels tested were Alcoa ULT36 aluminum wheels (Figure 5 and Figure 6).

Table 2: Test Run Sequence

Run	Test Name/Description	Start	End
3	Baseline - Steel Wheels	12:27 PM	2:49 PM
4	ULT36 Aluminum Steer Wheels	3:14 PM	5:36 PM
5	ULT36 Aluminum Drive Wheels	6:30 PM	9:02 PM
6	ULT36 Aluminum Trailer Wheels	9:57 PM	12:09 AM

Figure 5: ULT36 Alcoa Aluminum Wheel, 1 of 2

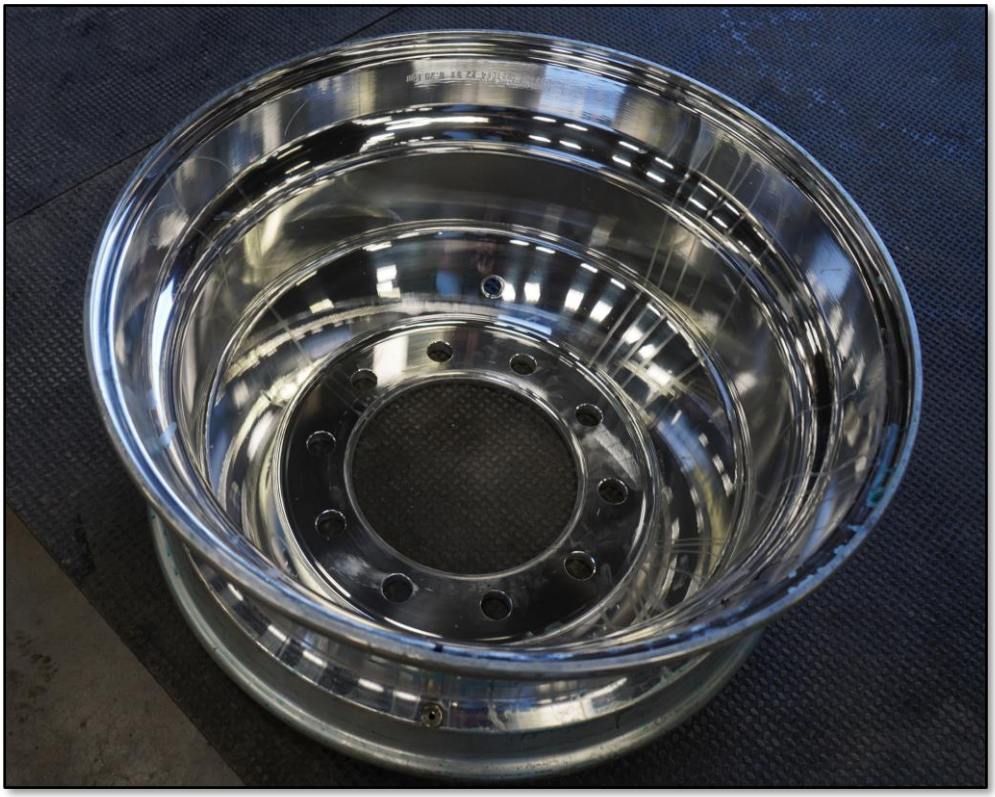


Figure 6: ULT36 Alcoa Aluminum Wheel, 2 of 2

3.2: Wheel Changes, Tire Installs and Pressure Testing Procedure

A primary reason for this test was to determine the fuel economy difference between Alcoa's ULT36 aluminum wheels and steel wheels from another supplier. Since tires and rolling resistance also affect fuel economy, tires remained consistent in their respective wheel position throughout all tests. Therefore, tires were changed each time from the standard steel wheels to the Alcoa ULT36 aluminum wheels to eliminate the effect of tires on the test results (Figure 7). Wheel and tire balance was measured on Hunter balancing equipment and recorded prior to testing at the MVTS shop (Figure 8). Radial Runout of the wheels was also measured using the same Hunter equipment and recorded. Balance and Radial Runout values can be found in Section 5.4. All tires were marked to consistently align the tire on each wheel with the valve stem (Figure 9). This ensured balance consistency during testing when tires were changed between the steel wheels and the Alcoa aluminum wheels. Tires and wheels were also labelled for vehicle position to ensure consistency during testing (Figure 10).

Figure 7: Tire Change

Figure 8: Wheel & Tire Balance

Figure 9: Alignment Mark

Figure 10: Position Label (Right-Rear-Outer)

To ensure consistent tire pressures, tires were inflated to 100.0 psi cold pressure in the morning prior to testing and prior to incurring any effect of sunlight. Cold pressures were also set after each tire/wheel change; however, these 'cold' pressures varied based on the status of the Compare vehicle tires since pressures changed throughout the day when some wheel changes occurred. These pressure differences were accounted for in a 5-lap warmup and adjusted accordingly.

The vehicles were driven 5 laps (45 miles) on the track as a warmup to allow tire pressures and temperatures to stabilize. After 5 laps, the vehicles were stopped on the track and tire pressures were checked, recorded, and adjusted accordingly. In most cases, the tire pressures of the Test Vehicle were matched to the Compare Vehicle in any position where the wheel was changed. Wheel positions that did not have wheel changes were not adjusted in most cases to remain consistent to the previous run. These steps were taken to ensure tire pressures did not affect fuel economy results after remounting the tires.

Following the warmup, 11 additional laps were completed and data from those laps were analyzed to provide the test results. Data from the five (5) warm-up laps was not used for calculating fuel economy. Tire pressures were recorded at the conclusion of the 16 laps to verify consistent tire pressures. Information on tire pressures can be found in Section 5.5.

3.3: Day 1, Run 3: Baseline – Steel Wheels

Testing began with the Test Vehicle in the Baseline configuration. This configuration consisted of conventional steel wheels in all positions (Figure 11). **Note:** all steel wheels tested were white in color and aluminum wheels were finished aluminum.

Figure 11: Test Vehicle in Baseline Configuration with Steel Wheels

Figure 12: Steel Steer Wheel (Left Side)

Figure 13: Weight of Steel Wheel (68.0 lbs)

Figure 14: Steel Drive Wheels (Left Side)

Figure 15: Steel Trailer Wheels (Left Side)

3.4: Day 1, Run 4: Aluminum Steer Wheels

Run 4 consisted of removing the steel Steer wheels from the Test Vehicle, dismounting the tires, and re-installing them on Alcoa ULT36 aluminum wheels. The aluminum wheels were then installed on the Test Vehicle. Tires and wheels were installed according to the procedure described in Section 3.2. Steel wheels remained in the Drive and Trailer positions.

Figure 16: Test Vehicle with ULT36 Aluminum Steer Wheels

Figure 17: Installing Left Side ULT36 Aluminum Steer Wheel

Figure 18: ULT36 Aluminum Steer Wheel (Left Side)

Figure 19: Weight of ULT36 Aluminum Wheel (36.2 lbs)

3.5: Day 1, Run 5: Aluminum Drive Wheels

Run 5 consisted of removing the steel Drive wheels from the Test Vehicle, dismounting the tires, and installing them on Alcoa ULT36 aluminum wheels. The aluminum wheels were then installed on the Test Vehicle. Tires and wheels were installed according to the procedure described in Section 3.2. Steel wheels remained in the Trailer position.

Figure 20: Test Vehicle with Aluminum Steer + Drive Wheels

Figure 21: Installing Tires on Aluminum Drive Wheels

Figure 22: Installing Aluminum Drive Wheels

Figure 23: Aluminum Drive Wheels (Right Side)

3.6: Day 1, Run 6: Aluminum Trailer Wheels

Run 6 consisted of removing the steel Trailer wheels from the Test Vehicle, dismounting the tires, and reinstalling on Alcoa ULT36 aluminum wheels. The aluminum wheels were then installed on the Test Vehicle. Tires and wheels were installed according to the procedure described in Section 3.2. The Test Vehicle consisted of Alcoa aluminum wheels installed in the Steer, Drive, and Trailer positions.

Figure 24: Aluminum Trailer Wheels (Right Side)

Figure 25: Aluminum Trailer Wheel (Left Side)

4.0: VEHICLE FUEL ECONOMY TEST EQUIPMENT

MVT Solutions fuel economy testing utilizes a data acquisition system and sensors specifically for this testing. This style of testing is derived from race car engineering where reliable sensor data is critical to understanding vehicle modifications.

MVTS test sensors include:

- Data acquisition system (records sensor data)
- Fuel flow meter (accurate to 0.2%)
- Fuel temperature sensor
- Tire temperature sensor (infrared, mounted on left-front Drive tire)
- Ground/road temperature sensor (infrared, mounted ahead of left-front Drive tire)
- Wind speed air pressure sensor (truck hood)
- Wind direction sensor (truck hood)
- Ambient air temperature sensor (truck hood)
- Ambient air pressure sensor (truck cab)
- High Precision GPS (latitude, longitude, altitude, time)

Figure 26: Aerodynamic Sensors

Figure 27: Data Acquisition System

Figure 28: Fuel Flow Meter

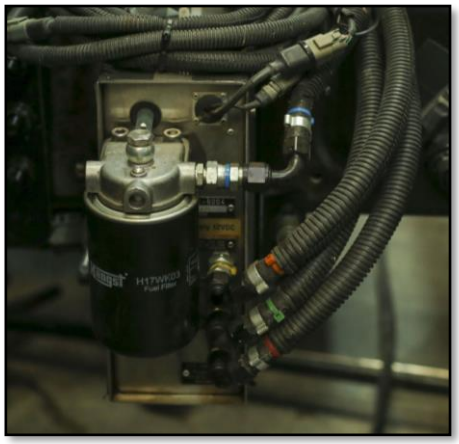


Figure 29: Tire Temp. Sensor

Click this link to see a video of MVTS sensors and testing: How We Test

5.0: TEST RESULTS

All testing was conducted using 6x4 sleeper cab tractors and 53-ft dry van trailers. All results can be found in Table 3 and Figure 30 through Figure 31.

Comparing Run 3 and 4 showed the ULT36 aluminum wheels in the Steer positions saved 0.99 gal/1000 miles (0.95%). This included tire changes, as all steel versus Alcoa aluminum wheel tests did. The level of consistency when changing a tire is somewhat unknown, which is why MVTS conducted many steps to provide consistency. This included tire position marked on the wheels (matched with valve stems), vehicle position (001 through 018) and tire pressures (checked after 5-lap warmup and at end of test run).

Comparing Run 3 and 5, the ULT36 aluminum wheels in the Steer and Drive positions combined saved 0.64 gal/1000 miles (0.61%).

Comparing Run 3 and 6, the ULT36 aluminum wheels in all positions, saved 0.89 gal/1000 miles (0.86%) over steel wheels in all positions.

Table 3: Test Results with Accuracy

Product	Fuel Economy Improvement		
	Gal/1000 miles	MPG	Percent
ULT36 Aluminum Wheels (S)	**0.99**	0.09	0.95%
Accuracy	**+/- 0.50**	+/- 0.05	+/- 0.48%
ULT36 Aluminum Wheels (S,D)	**0.64**	0.06	0.61%
Accuracy	**+/- 0.48**	+/- 0.05	+/- 0.47%
ULT36 Aluminum Wheels (S,D,T)	**0.89**	0.08	0.86%
Accuracy	**+/- 0.53**	+/- 0.05	+/- 0.51%

Note: (S), (D), and (T) above refers to the Steer, Drive, and Trailer Wheel Positions.

Figure 30: Test Results (gal/1000 miles)

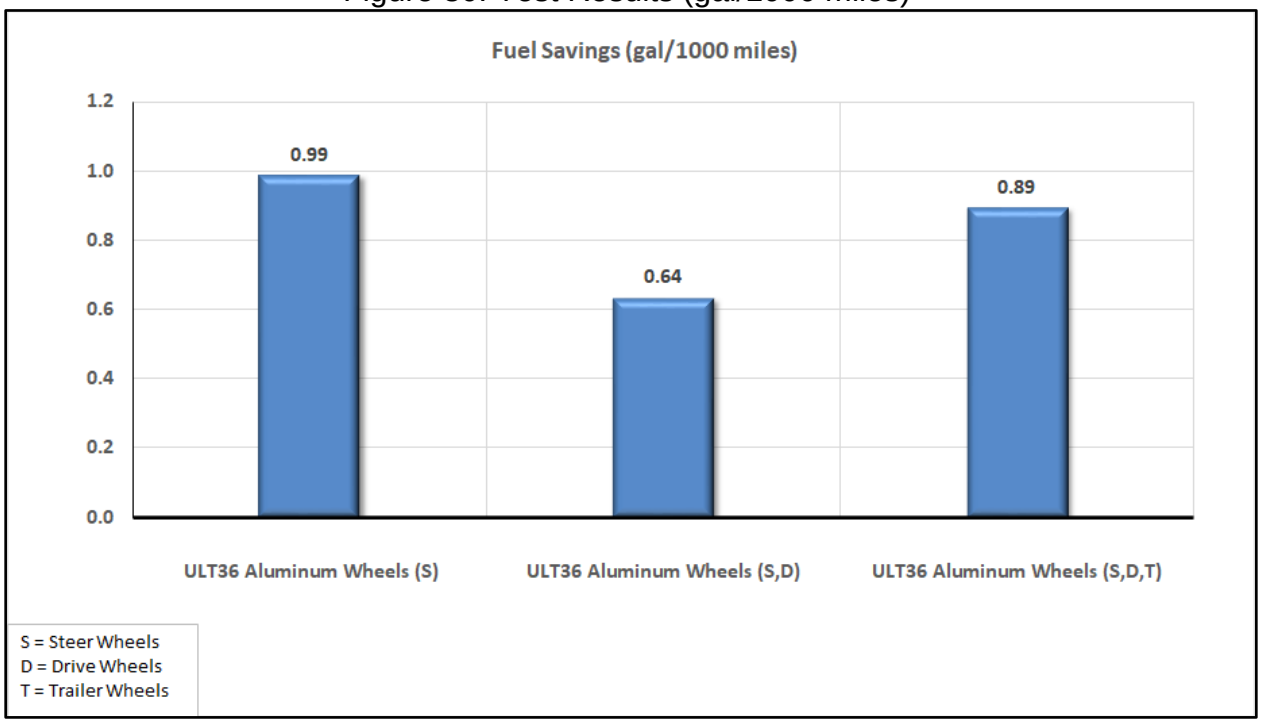
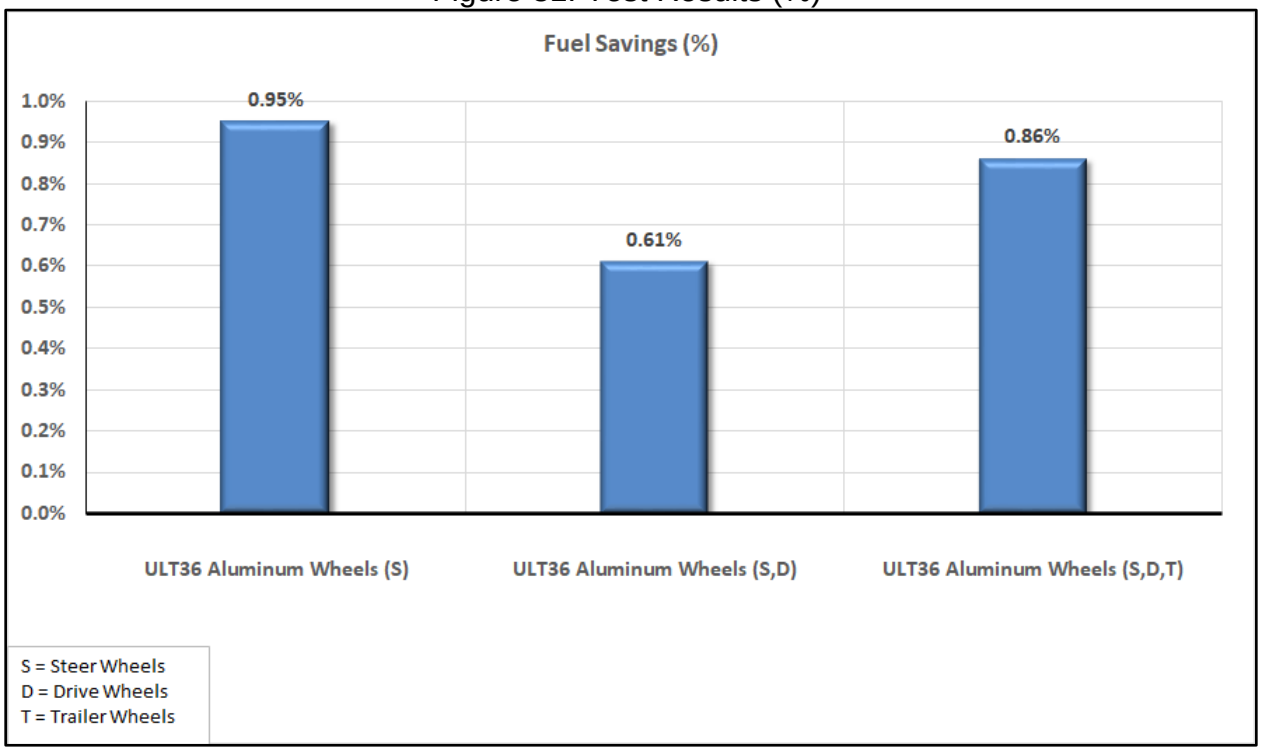


Figure 31: Test Results (%)



5.1: UNITS OF MEASUREMENT

The reader may not be familiar with units of gal/1000 miles (gallons per 1000 miles) since it is not traditionally used in the trucking industry. The following paragraphs briefly explain the reasons for these units and how they help carriers better calculate fuel savings.

Units of gal/1000 miles more reliably calculate fuel savings when compared to other units such as miles-per-gallon (MPG) and percent (%). Those units are prone to error from changing variables such as vehicle baseline fuel economy, load, driver behavior, and duty cycle. For example, gal/1000 miles values are not affected by load for an aerodynamic product. Any empty Class-8 unit at 34,000 lbs. will save the same fuel in gal/1000 miles as one loaded to 80,000 lbs. However, when viewed in percent (%) or MPG the values change with load. This causes a carrier to experience varied results in real-world operation and difficulty predicting the financial benefits of the product unless units of gal/1000 miles are used.

Units of gal/1000 miles are the most reliable units of measurement for aerodynamic fuel savings due to their scientific and mathematical relationship to fuel consumption. Further detail is beyond the scope of this report and the reader is encouraged to contact MVT Solutions if more information is desired.

5.2: WEATHER CONDITIONS SUMMARY

Ambient temperature during testing ranged from 64°F to 90°F with winds ranging from 0-9 mph. Weather data was acquired from a local Weather Underground weather station and complete data can be found in the Appendix.

The reader should be aware that MVTS methods include instantaneous and constant weather data acquisition on each vehicle, and this testing has minimal dependency on external weather data collection. MVTS test data accounts for changes in wind, temperature, and other pertinent variables instantaneously.

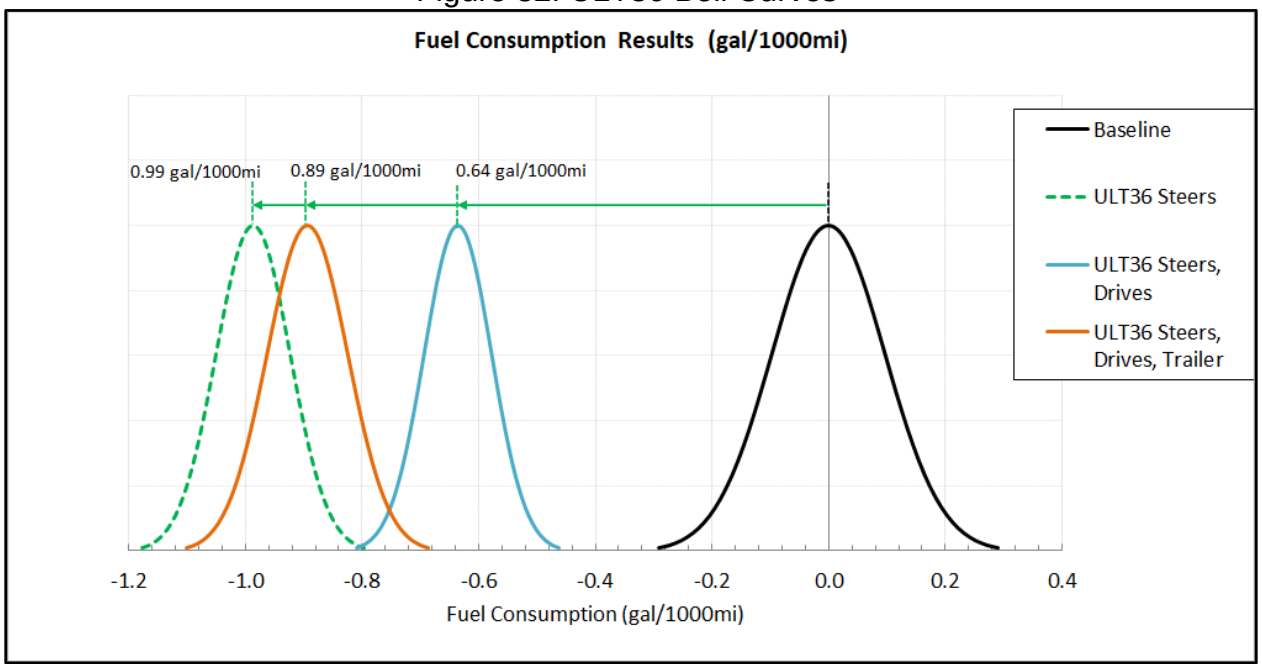
5.3: MEASUREMENT ACCURACY

The accuracy of fuel economy measurements is critical in determining the trustworthiness of test results. Historically, this has been a major difficulty in the trucking industry with fuel economy testing, which has led to confusion and misleading results. The MVTS test methods overcome this issue by achieving better accuracy, which is one of the ways it provides more reliable test results.

Accuracy for all the tests was calculated using a 95% confidence interval, a common standard for testing measurement. 95% confidence interval indicates that if the test were repeated 100 times, values would fall within the range in 95 out of the 100 tests (*i.e.* the reader would be 95% confident the value would be within that range).

Figure 32 below shows the statistical bell curves of for all test runs. The arrows pointing to the left illustrate less fuel used with the aluminum wheels (*i.e*. fuel savings).

Figure 32: ULT36 Bell Curves



The results are broken down into individual test runs and their respective bell curves below. **Note**: (S), (D), and (T) in the graphs below refer to the Steer, Drive, and Trailer wheel positions, respectively.

Figure 33 below illustrates the statistical bell curves of the ULT36 aluminum wheels installed in the Steer positions. The graph shows two very distinct curves, indicating a confident difference in fuel economy. The arrow pointing to the left illustrates less fuel used with the aluminum wheels (*i.e*. fuel savings). The distance between the peaks of the bell curves is the test result average, which was 0.99 gal/1000 miles. Minimum and maximum values were calculated as the test result plus or minus the accuracy values (0.99 +/- 0.5), which were 0.49 and 1.49 gal/1000 miles.

Figure 33: ULT36 Steer Wheels Bell Curve

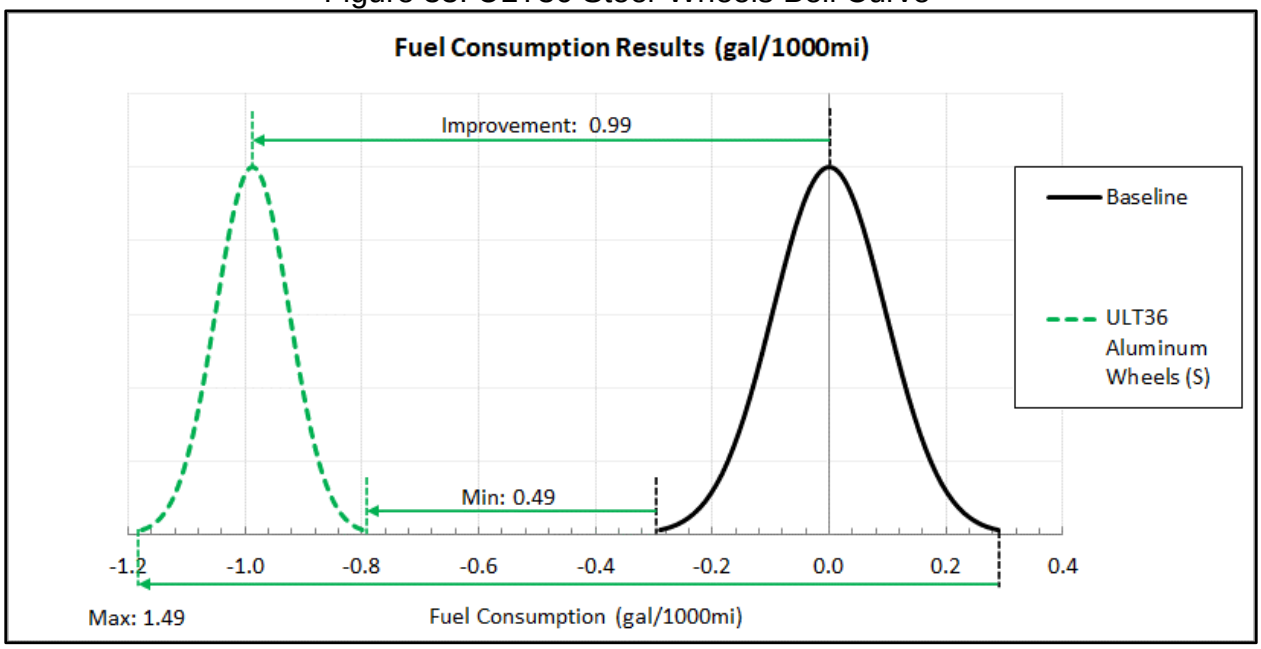


Figure 34 below illustrates the statistical bell curves of the ULT36 aluminum wheels in the Steer and Drive positions. The arrow pointing to the left illustrates less fuel used with the aluminum wheels installed (*i.e*. fuel savings). The test result average was 0.64 gal/1000 miles saved. Minimum and maximum values were calculated as the test result plus or minus the accuracy values (0.64 +/- 0.49), which were 0.15 and 1.13 gal/1000 miles.

Figure 34: ULT36 Steer and Drive Wheels Bell Curve

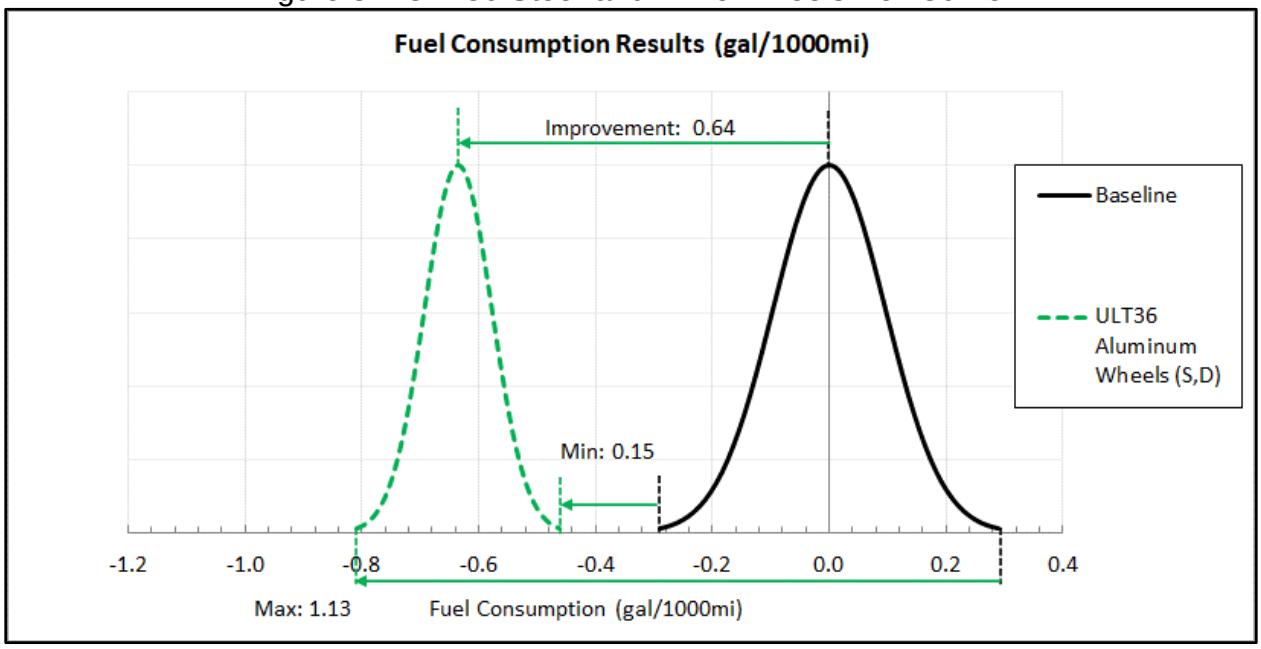
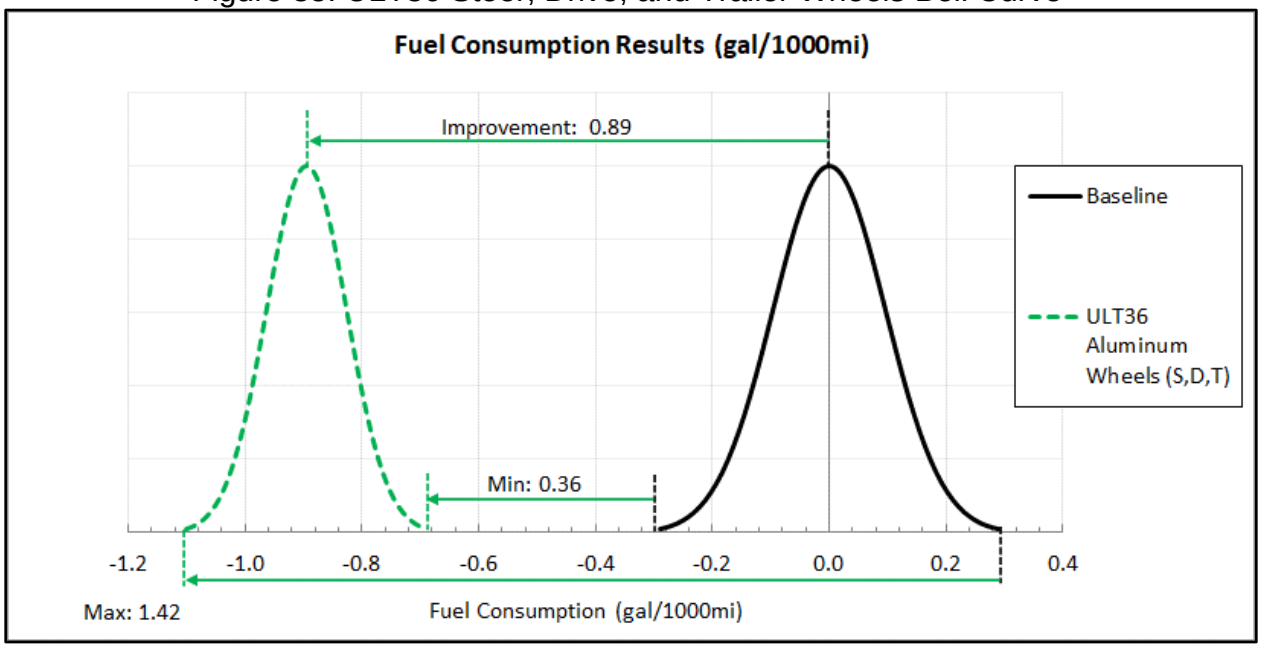


Figure 35 below illustrates the statistical bell curves of the ULT36 aluminum wheels in the Steer, Drive, and Trailer positions. The arrow pointing to the left illustrates less fuel used with the aluminum wheels installed (*i.e*. fuel savings). The test result average was 0.89 gal/1000 miles saved. Minimum and maximum values were calculated as the test result plus or minus the accuracy values (0.89 +/- 0.53), which were 0.36 and 1.42 gal/1000 miles.

Figure 35: ULT36 Steer, Drive, and Trailer Wheels Bell Curve



5.4: BALANCE AND RUNOUT

Wheels were labelled by their installation position on the vehicle and numbered 001 through 018 as shown in Figure 36. Since the Alcoa aluminum wheels and comparison steel wheels were easily identified by color (aluminum and white, respectively) they were similarly numbered 001 through 018. Table 4 below lists the Radial Runout and Balance for the steel and aluminum wheels. **Note:** Radial Runout was measured without tires installed whereas Balance included tires. Weights were not added to any wheels for testing. A Hunter brand tire machine was used to measure Runout and Balance.

Table 4: Radial Runout and Wheel Balance

Serial #	Vehicle Position	Steel Wheels			Alcoa ULT36 Aluminum Wheels		
		Radial Runout (in)	Inner Balance (oz)	Outer Balance (oz)	Radial Runout (in)	Inner Balance (oz)	Outer Balance (oz)
001	*001*	0.063	3.00	8.00	0.015	2.00	0.00
002	*002*	0.023	3.00	6.00	0.007	2.00	6.00
003	*003*	0.016	6.00	4.00	0.011	3.00	3.00
004	*004*	0.018	4.00	8.00	0.017	3.00	7.00
005	*005*	0.015	3.00	3.00	0.01	1.00	5.00
006	*006*	0.02	3.00	0.00	0.016	0.00	7.00
007	*007*	0.039	4.00	0.00	0.017	6.00	0.00
008	*008*	0.035	0.00	7.00	0.009	3.00	0.00
009	*009*	0.006	7.00	0.00	0.017	0.00	5.00
010	*010*	0.034	6.00	5.00	0.013	3.00	6.00
011	*011*	0.012	4.00	0.00	0.012	1.00	5.00
012	*012*	0.016	2.00	4.00	0.01	2.00	0.00
013	*013*	0.009	0.00	0.00	0.004	4.00	0.00
014	*014*	0.002	2.00	6.00	0.005	0.00	6.00
015	*015*	0.027	2.00	6.00	0.014	0.00	4.00
016	*016*	0.025	1.00	6.00	0.005	0.00	0.00
017	*017*	0.022	0.00	5.00	0.015	0.00	3.00
018	*018*	0.037	0.00	3.00	0.014	0.00	0.00
Average		**0.023**	**2.78**	**3.94**	**0.012**	**1.67**	**3.17**
Total Average Balance			**3.36**			**2.42**	

Figure 36: Wheel Position Diagram

Overall, the average Radial Runout of the steel wheels was 0.023 inches. The Alcoa ULT36 aluminum wheel was 0.012 inches. Therefore, the Alcoa aluminum wheels had 48% less Radial Runout than the steel wheels. The average balance of the steel wheels with tires mounted was 2.78 ounces and 3.94 ounces for the inner and outer, respectively, which averaged 3.36 ounces. By comparison, the Alcoa ULT36 aluminum wheel balance was 1.76 ounces and 3.17 ounces for the inner and outer, respectively, which averaged 2.47 ounces. Therefore, the Alcoa aluminum wheels resulted in 26% better balanced tire and wheel combination.

Figure 37: Measuring Wheel and Tire Balance

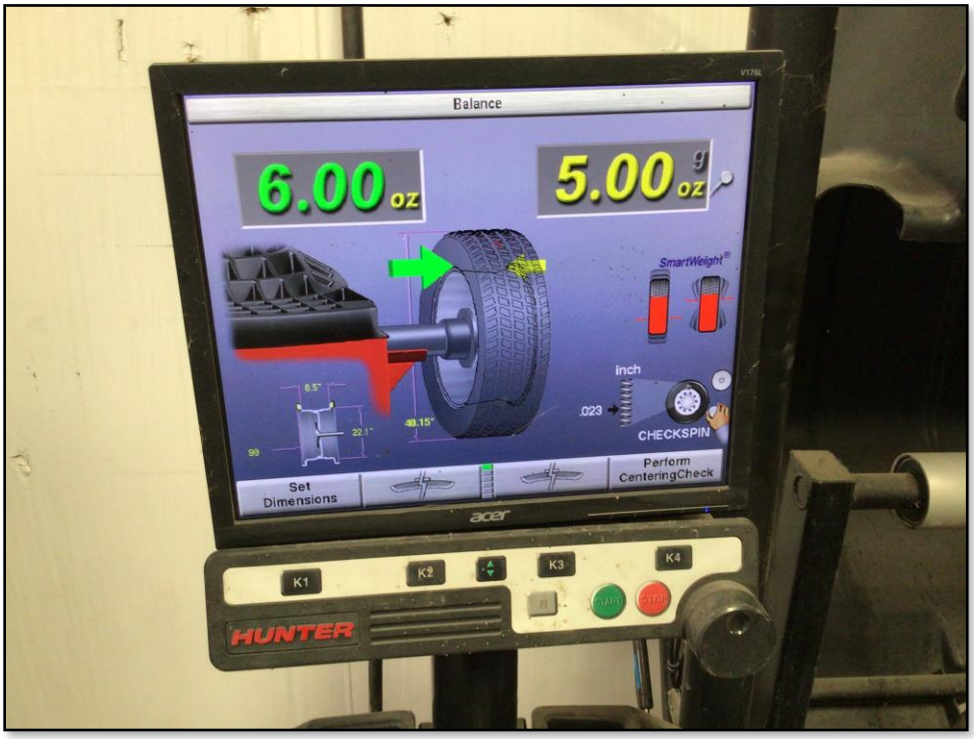
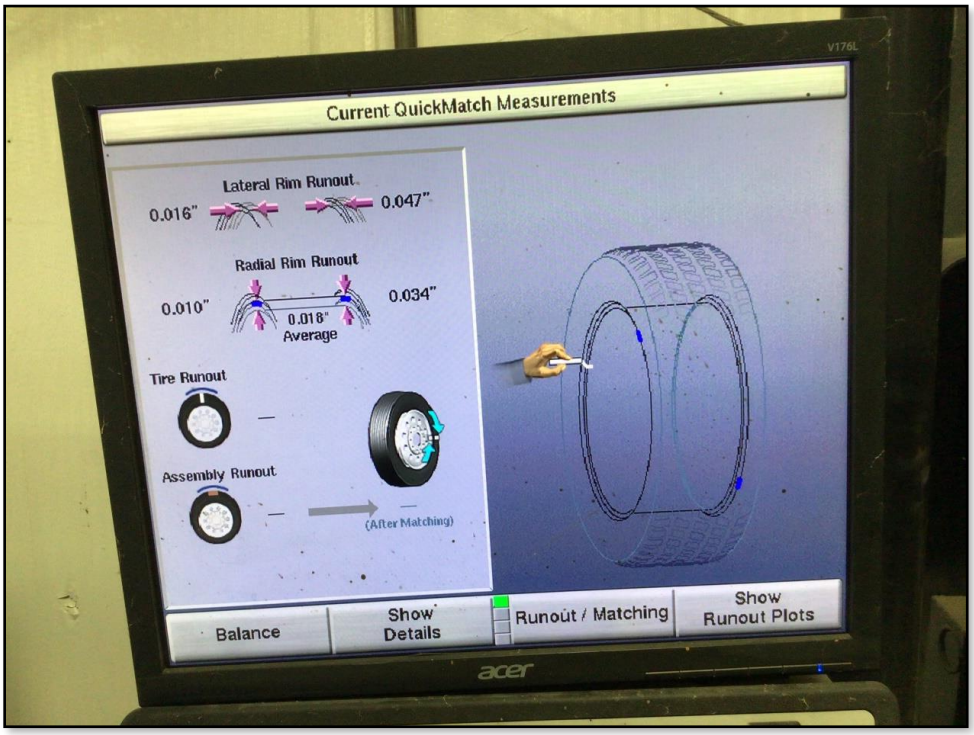


Figure 38: Measuring Wheel Radial Runout



5.5: TIRE PRESSURE RESULTS

Tire pressures were analyzed for variances between the vehicles during runs that included wheel changes. Test runs that did not experience wheel or tire changes were not included in pressure changes or analysis. Information for the wheel change runs is shown below in Figure 39 to Figure 46.

Figure 39: Tire Pressures and Wheel Information, Test Vehicle (Run 3)

Veh. B (Test)								
				Truck	Veh. B			
LF:				Front Axle Tires				RF: Same
Michelin X Line Energy				Type				Michelin X Line Energy
275/80R22.5	Steel			Size			Steel	275/80R22.5
18/32				Tread Depth (32nds)				18/32
118.0				End Warmup (psi)				118.5
118.0				Bled to (psi)				118.5
119.0				End Run (psi)				119.0
118.5				**Pressure (psi) Avg**				**118.8**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:		RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
18/32	18/32			Tread Depth (32nds)		18/32		18/32
111.5	114.5			End Warmup (psi)		113.0		110.5
111.5	114.5			Bled to (psi)		113.0		110.5
112.5	115.5			End Run (psi)		115.0		112.0
112.0	**115.0**		Steel	**Pressure (psi) Avg.**	Steel	**114.0**		**111.3**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:		RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
17/32	18/32			Tread Depth (32nds)		19/32		18/32
112.5	114.0			End Warmup (psi)		112.5		113.0
112.5	114.0			Bled to (psi)		112.5		113.0
113.0	115.5			End Run (psi)		113.0		114.5
112.8	**114.8**			**Pressure (psi) Avg.**		**112.8**		**113.8**
				Trailer	T-2			
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer		RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
12/32	12/32			Tread Depth (32nds)		11/32		11/32
111.5	112.5			End Warmup (psi)		113.0		113.5
111.5	112.5			Bled to (psi)		113.0		113.5
111.5	114.0			End Run (psi)		114.0		114.5
111.5	**113.3**		Steel	**Pressure (psi) Avg.**	Steel	**113.5**		**114.0**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer		RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
12/32	12/32			Tread Depth (32nds)		12/32		12/32
111.0	111.5			End Warmup (psi)		112.5		112.5
111.0	111.5			Bled to (psi)		112.5		112.5
112.0	113.0			End Run (psi)		114.0		113.5
111.5	**112.3**			**Pressure (psi) Avg.**		**113.3**		**113.0**

Figure 40: Tire Pressures and Wheel Information, Compare Vehicle (Run 3)

Veh. A (Compare)								
				Truck	Veh. A			
LF:				Front Axle Tires				RF: Same
Michelin X Line Energy				Type				Michelin X Line Energy
275/80R22.5	Aluminum			Size			Aluminum	275/80R22.5
17/32				Tread Depth (32nds)				17/32
116.5				End Warmup (psi)				117.0
116.5				Bled to (psi)				117.0
118.0				End Run (psi)				118.5
117.3				**Pressure (psi) Avg**				**117.8**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:		RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
19/32	18/32			Tread Depth (32nds)		19/32		19/32
110.5	113.0			End Warmup (psi)		113.5		113.0
110.5	113.0			Bled to (psi)		113.5		113.0
113.0	114.5			End Run (psi)		116.0		113.5
111.8	**113.8**		Steel	**Pressure (psi) Avg.**	Steel	**114.8**		**113.3**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:		RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
18/32	19/32			Tread Depth (32nds)		19/32		19/32
111.5	111.0			End Warmup (psi)		113.0		113.0
111.5	111.0			Bled to (psi)		113.0		113.0
113.5	113.5			End Run (psi)		116.5		114.4
112.5	**112.3**			**Pressure (psi) Avg.**		**114.8**		**113.7**
				Trailer	T-1			
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer		RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
11/32	11/32			Tread Depth (32nds)		11/32		10/32
111.0	110.5			End Warmup (psi)		111.0		111.0
111.0	110.5			Bled to (psi)		111.0		111.0
113.0	113.0			End Run (psi)		113.0		113.0
112.0	**111.8**		Steel	**Pressure (psi) Avg.**	Steel	**112.0**		**112.0**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer		RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
10/32	11/32			Tread Depth (32nds)		10/32		10/32
110.5	111.0			End Warmup (psi)		111.0		112.0
110.5	111.0			Bled to (psi)		111.0		112.0
113.0	113.5			End Run (psi)		113.0		114.0
111.8	**112.3**			**Pressure (psi) Avg.**		**112.0**		**113.0**

Table 5: Comparison of Tire Pressure Avg, Growth, and Variance (Run 3)

Average Tire Pressure Comparison (Test Vehicle - Compare Vehicle)						Tire Pressure Growth Comparison (End psi - Start psi) of (Test Vehicle - Compare Vehicle)				
1.3	Steers (psi)			1.0		-0.5	Steers (psi)			-1.0
0.3	1.3	Drives-Front (psi)	-0.8	-2.0		-1.5	-0.5	Drives-Front (psi)	-0.5	1.0
0.3	2.5	Drives-Rear (psi)	-2.0	0.0		-1.5	-1.0	Drives-Rear (psi)	-3.0	0.1
-0.5	1.5	Trailer-Front (psi)	1.5	2.0		-2.0	-1.0	Trailer-Front (psi)	-1.0	-1.0
-0.3	0.0	Trailer-Rear (psi)	1.3	0.0		-1.5	-1.0	Trailer-Rear (psi)	-0.5	-1.0
0.4		Average Pressure Variance (psi)				-1.0		Average Pressure Variance (psi)		
-2.0		Minimum Pressure Variance (psi)				-3.0		Minimum Pressure Variance (psi)		
2.5		Maximum Pressure Variance (psi)				1.0		Maximum Pressure Variance (psi)		

The tire pressure tables show how the two vehicles related to one another, providing the ability to quantify the consistency in tire pressure. Values are calculated as Test Vehicle subtract Compare Vehicle. Average Tire Pressure Comparison (left side of table) showed Average Pressure Variance was 0.4 psi, which indicates the average tire pressures on the Test increased 0.4 psi more than the Compare vehicle. This can be considered a relatively small value and indicates consistency between the two vehicles. Tire Pressure Growth Comparison (right side of table), which is the 'End psi' subtract the 'Start psi' (*i.e.* lap 16 pressures subtract lap 5 adjusted pressures), the value was -1.0 psi. This indicates the Compare vehicle tire pressures increased an average of 1.0 psi more than the Test Vehicle. A difference of 1.0 psi can also be considered a small value and indicates consistent pressures between the vehicles.

Minimum and Maximum values relate to individual wheel positions. In the case of the Average Tire Pressure Comparison, a minimum of -2.0 psi relates to the Drives-Rear right-inside position. The maximum value of 2.5 psi relates to the Drives-Rear left-inside position.

Figure 41: Tire Pressures and Wheel Information, Test Vehicle (Run 4)

Veh. B (Test)							
				Truck	Veh. B		
LF:				**Front Axle Tires**			RF: Same
Michelin X Line Energy				Type			Michelin X Line Energy
275/80R22.5				Size			275/80R22.5
18/32				Tread Depth (32nds)			18/32
120.0				End Warmup (psi)			119.5
118.0				Bled to (psi)			118.5
119.0				End Run (psi)			119.0
118.5	**Aluminum**			**Pressure (psi) Avg**		**Aluminum**	**118.8**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:	RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
18/32	18/32			Tread Depth (32nds)		18/32	18/32
113.0	116.0			End Warmup (psi)		114.0	112.0
113.0	116.0			Bled to (psi)		114.0	112.0
113.0	115.5			End Run (psi)		113.0	111.0
113.0	**115.8**	**Steel**		**Pressure (psi) Avg.**	**Steel**	**113.5**	**111.5**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:	RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
17/32	18/32			Tread Depth (32nds)		19/32	18/32
113.5	116.0			End Warmup (psi)		112.5	114.5
113.5	116.0			Bled to (psi)		112.5	114.5
113.0	116.0			End Run (psi)		111.0	113.5
113.3	**116.0**			**Pressure (psi) Avg.**		**111.8**	**114.0**
				Trailer	T-2		
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer	RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
12/32	12/32			Tread Depth (32nds)		11/32	11/32
112.0	114.0			End Warmup (psi)		114.0	114.5
112.0	114.0			Bled to (psi)		114.0	114.5
112.0	114.0			End Run (psi)		113.5	114.0
112.0	**114.0**	**Steel**		**Pressure (psi) Avg.**	**Steel**	**113.8**	**114.3**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer	RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
12/32	12/32			Tread Depth (32nds)		12/32	12/32
112.5	113.0			End Warmup (psi)		113.5	113.0
112.5	113.0			Bled to (psi)		113.5	113.0
112.0	113.0			End Run (psi)		113.0	113.0
112.3	**113.0**			**Pressure (psi) Avg.**		**113.3**	**113.0**

Figure 42: Tire Pressures and Wheel Information, Compare Vehicle (Run 4)

Veh. A (Compare)								
				Truck	Veh. A			
LF:				Front Axle Tires				RF: Same
Michelin X Line Energy	Aluminum			Type			Aluminum	Michelin X Line Energy
275/80R22.5				Size				275/80R22.5
17/32				Tread Depth (32nds)				17/32
118.5				End Warmup (psi)				119.0
118.5				Bled to (psi)				119.0
119.0				End Run (psi)				119.5
118.8				**Pressure (psi) Avg**				**119.3**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:		RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
19/32	18/32			Tread Depth (32nds)		19/32		19/32
113.5	113.5			End Warmup (psi)		115.5		113.5
113.5	113.5			Bled to (psi)		115.5		113.5
113.0	114.5			End Run (psi)		115.0		113.5
113.3	**114.0**		Steel	**Pressure (psi) Avg.**	Steel	**115.3**		**113.5**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:		RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
18/32	19/32			Tread Depth (32nds)		19/32		19/32
113.5	113.5			End Warmup (psi)		115.5		114.0
113.5	113.5			Bled to (psi)		115.5		114.0
114.0	113.0			End Run (psi)		115.5		113.5
113.8	**113.3**			**Pressure (psi) Avg.**		**115.5**		**113.8**
				Trailer	T-1			
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer		RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
11/32	11/32			Tread Depth (32nds)		11/32		10/32
113.5	113.0			End Warmup (psi)		113.0		113.0
113.5	113.0			Bled to (psi)		113.0		113.0
113.5	113.0			End Run (psi)		112.5		112.5
113.5	**113.0**		Steel	**Pressure (psi) Avg.**	Steel	**112.8**		**112.8**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer		RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5		275/80R22.5
10/32	11/32			Tread Depth (32nds)		10/32		10/32
113.5	114.0			End Warmup (psi)		113.0		113.5
113.5	114.0			Bled to (psi)		113.0		113.5
113.0	114.0			End Run (psi)		113.0		113.0
113.3	**114.0**			**Pressure (psi) Avg.**		**113.0**		**113.3**

Table 6: Comparison of Tire Pressure Avg, Growth, and Variance (Run 4)

Average Tire Pressure Comparison (Test Vehicle - Compare Vehicle)						Tire Pressure Growth Comparison (End psi - Start psi) of (Test Vehicle - Compare Vehicle)				
-0.3	Steers (psi)			-0.5		0.5	Steers (psi)			0.0
-0.3	1.8	Drives-Front (psi)	-1.8	-2.0		0.5	-1.5	Drives-Front (psi)	-0.5	-1.0
-0.5	2.8	Drives-Rear (psi)	-3.8	0.3		-1.0	0.5	Drives-Rear (psi)	-1.5	-0.5
-1.5	1.0	Trailer-Front (psi)	1.0	1.5		0.0	0.0	Trailer-Front (psi)	0.0	0.0
-1.0	-1.0	Trailer-Rear (psi)	0.3	-0.3		0.0	0.0	Trailer-Rear (psi)	-0.5	0.5
-0.2		Average Pressure Variance (psi)				-0.3		Average Pressure Variance (psi)		
-3.8		Minimum Pressure Variance (psi)				-1.5		Minimum Pressure Variance (psi)		
2.8		Maximum Pressure Variance (psi)				0.5		Maximum Pressure Variance (psi)		

During Day 1, Run 4, the Average Pressure Variances were -0.2 psi and -0.3 psi for the Average Tire Pressure Comparison and the Tire Pressure Growth Comparisons, respectively. These can be considered very consistent. The Minimum and Maximum values were greater than the previous run; however, can still be considered consistent.

Figure 43: Tire Pressures and Wheel Information, Test Vehicle (Run 5)

Veh. B (Test)							
				Truck	Veh. B		
LF:				**Front Axle Tires**			RF: Same
Michelin X Line Energy				Type			Michelin X Line Energy
275/80R22.5	Aluminum			Size		Aluminum	275/80R22.5
18/32				Tread Depth (32nds)			18/32
118.0				End Warmup (psi)			117.5
118.0				Bled to (psi)			117.5
115.0				End Run (psi)			115.0
116.5				**Pressure (psi) Avg**			**116.3**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:	RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
18/32	18/32			Tread Depth (32nds)		18/32	18/32
117.0	118.5			End Warmup (psi)		116.0	116.0
110.5	110.5			Bled to (psi)		113.0	111.5
110.0	110.0			End Run (psi)		111.5	110.0
110.3	**110.3**	Aluminum		**Pressure (psi) Avg.**	Aluminum	**112.3**	**110.8**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:	RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
17/32	18/32			Tread Depth (32nds)		19/32	18/32
112.0	116.0			End Warmup (psi)		119.0	118.5
112.0	110.0			Bled to (psi)		113.0	111.5
109.5	109.5			End Run (psi)		112.5	110.0
110.8	**109.8**			**Pressure (psi) Avg.**		**112.8**	**110.8**
				Trailer	T-2		
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer	RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
12/32	12/32			Tread Depth (32nds)		11/32	11/32
110.5	112.5			End Warmup (psi)		113.0	112.5
110.5	112.5			Bled to (psi)		113.0	112.5
107.5	109.5			End Run (psi)		109.5	109.0
109.0	**111.0**	Steel		**Pressure (psi) Avg.**	Steel	**111.3**	**110.8**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer	RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
12/32	12/32			Tread Depth (32nds)		12/32	12/32
111.0	111.5			End Warmup (psi)		112.0	111.5
111.0	111.5			Bled to (psi)		112.0	111.5
106.5	108.5			End Run (psi)		109.0	108.0
108.8	**110.0**			**Pressure (psi) Avg.**		**110.5**	**109.8**

Figure 44: Tire Pressures and Wheel Information, Compare Vehicle (Run 5)

Veh. A (Compare)							
				Truck	Veh. A		
LF:				**Front Axle Tires**			RF: Same
Michelin X Line Energy				Type			Michelin X Line Energy
275/80R22.5				Size			275/80R22.5
17/32				Tread Depth (32nds)			17/32
117.0				End Warmup (psi)			117.0
117.0				Bled to (psi)			117.0
114.5				End Run (psi)			114.0
115.8	Aluminum			**Pressure (psi) Avg**		Aluminum	**115.5**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:	RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
19/32	18/32			Tread Depth (32nds)		19/32	19/32
111.0	111.5			End Warmup (psi)		113.5	111.5
111.0	111.5			Bled to (psi)		113.5	111.5
108.5	109.0			End Run (psi)		110.0	108.5
109.8	**110.3**	Steel		**Pressure (psi) Avg.**	Steel	**111.8**	**110.0**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:	RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
18/32	19/32			Tread Depth (32nds)		19/32	19/32
112.0	110.5			End Warmup (psi)		113.5	111.5
112.0	110.5			Bled to (psi)		113.5	111.5
109.0	107.5			End Run (psi)		110.0	108.0
110.5	**109.0**			**Pressure (psi) Avg.**		**111.8**	**109.8**
				Trailer	T-1		
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer	RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
11/32	11/32			Tread Depth (32nds)		11/32	10/32
111.5	111.0			End Warmup (psi)		111.0	111.0
111.5	111.0			Bled to (psi)		111.0	111.0
108.0	108.5			End Run (psi)		107.7	107.0
109.8	**109.8**	Steel		**Pressure (psi) Avg.**	Steel	**109.4**	**109.0**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer	RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5	275/80R22.5
10/32	11/32			Tread Depth (32nds)		10/32	10/32
111.0	112.0			End Warmup (psi)		111.0	111.5
111.0	112.0			Bled to (psi)		111.0	111.5
108.0	109.0			End Run (psi)		108.0	108.0
109.5	**110.5**			**Pressure (psi) Avg.**		**109.5**	**109.8**

Table 7: Comparison of Tire Pressure Avg, Growth, and Variance (Run 5)

Average Tire Pressure Comparison (Test Vehicle - Compare Vehicle)					Tire Pressure Growth Comparison (End psi - Start psi) of (Test Vehicle - Compare Vehicle)				
0.8	Steers (psi)			0.8	-0.5	Steers (psi)			0.5
0.5	0.0	Drives-Front (psi)	0.5	0.8	2.0	2.0	Drives-Front (psi)	2.0	1.5
0.3	0.8	Drives-Rear (psi)	1.0	1.0	0.5	2.5	Drives-Rear (psi)	3.0	2.0
-0.8	1.3	Trailer-Front (psi)	1.9	1.8	0.5	-0.5	Trailer-Front (psi)	-0.2	0.5
-0.8	-0.5	Trailer-Rear (psi)	1.0	0.0	-1.5	0.0	Trailer-Rear (psi)	0.0	0.0
0.6		Average Pressure Variance (psi)			0.8		Average Pressure Variance (psi)		
-0.8		Minimum Pressure Variance (psi)			-1.5		Minimum Pressure Variance (psi)		
1.9		Maximum Pressure Variance (psi)			3.0		Maximum Pressure Variance (psi)		

Average Pressure Variances of 0.6 psi and 0.8 psi are small values and the Minimum and Maximum values are also relatively small, which indicate consistency throughout the test run.

Figure 45: Tire Pressures and Wheel Information, Test Vehicle (Run 6)

Veh. B (Test)							
			Truck	Veh. B			
LF:			**Front Axle Tires**				RF: Same
Michelin X Line Energy			Type				Michelin X Line Energy
275/80R22.5	Aluminum		Size			Aluminum	275/80R22.5
18/32			Tread Depth (32nds)				18/32
114.5			End Warmup (psi)				114.5
114.5			Bled to (psi)				114.5
114.0			End Run (psi)				114.0
114.3			**Pressure (psi) Avg**				**114.3**
LF-Outer Drive:	LF-Inner Drive:		**Drive Axle Tires**		RF-Inner Drive:		RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +		Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5		275/80R22.5
18/32	18/32		Tread Depth (32nds)		18/32		18/32
108.5	109.5		End Warmup (psi)		110.0		109.5
108.5	109.5		Bled to (psi)		110.0		109.5
108.0	109.0	Aluminum	End Run (psi)	Aluminum	109.5		109.0
108.3	**109.3**		**Pressure (psi) Avg.**		**109.8**		**109.3**
LR-Outer Drive:	LR-Inner Drive:		**Drive Axle Tires**		RR-Inner Drive:		RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +		Type		Michelin X Line XDA Energy +		Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5		275/80R22.5
17/32	18/32		Tread Depth (32nds)		19/32		18/32
108.5	108.5		End Warmup (psi)		111.0		109.0
108.5	108.5		Bled to (psi)		111.0		109.0
107.0	108.5		End Run (psi)		110.5		109.0
107.8	**108.5**		**Pressure (psi) Avg.**		**110.8**		**109.0**
			Trailer	T-2			
LF-Outer Trailer:	LF-Inner Trailer:		**Tandem Front**		RF-Inner Trailer		RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +		Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5		275/80R22.5
12/32	12/32		Tread Depth (32nds)		11/32		11/32
111.5	116.0		End Warmup (psi)		113.0		113.5
107.0	107.0		Bled to (psi)		106.0		105.5
108.0	109.5	Aluminum	End Run (psi)	Aluminum	108.0		107.5
107.5	**108.3**		**Pressure (psi) Avg.**		**107.0**		**106.5**
LR-Outer Trailer:	LR-Inner Trailer:		**Tandem Rear**		RR-Inner Trailer		RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +		Type		Michelin X Line Energy +		Michelin X Line Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5		275/80R22.5
12/32	12/32		Tread Depth (32nds)		12/32		12/32
114.0	115.5		End Warmup (psi)		114.5		115.0
107.0	107.0		Bled to (psi)		106.5		106.5
108.0	109.0		End Run (psi)		108.0		108.0
107.5	**108.0**		**Pressure (psi) Avg.**		**107.3**		**107.3**

Figure 46: Tire Pressures and Wheel Information, Compare Vehicle (Run 6)

Veh. A (Compare)									
				Truck	Veh. A				
LF:				Front Axle Tires					RF: Same
Michelin X Line Energy				Type					Michelin X Line Energy
275/80R22.5	Aluminum			Size				Aluminum	275/80R22.5
17/32				Tread Depth (32nds)					17/32
114.5				End Warmup (psi)					115.0
114.5				Bled to (psi)					115.0
112.5				End Run (psi)					111.5
113.5				**Pressure (psi) Avg**					**113.3**
LF-Outer Drive:	LF-Inner Drive:			**Drive Axle Tires**		RF-Inner Drive:			RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +			Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5			275/80R22.5
19/32	18/32			Tread Depth (32nds)		19/32			19/32
109.0	110.0			End Warmup (psi)		110.5			110.0
109.0	110.0			Bled to (psi)		110.5			110.0
107.0	106.5			End Run (psi)		108.0			106.5
108.0	**108.3**		Steel	**Pressure (psi) Avg.**	Steel	**109.3**			**108.3**
LR-Outer Drive:	LR-Inner Drive:			**Drive Axle Tires**		RR-Inner Drive:			RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +			Type		Michelin X Line XDA Energy +			Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5			275/80R22.5
18/32	19/32			Tread Depth (32nds)		19/32			19/32
109.0	109.0			End Warmup (psi)		111.5			109.5
109.0	109.0			Bled to (psi)		111.5			109.5
106.5	104.5			End Run (psi)		108.0			106.0
107.8	**106.8**			**Pressure (psi) Avg.**		**109.8**			**107.8**
				Trailer	T-1				
LF-Outer Trailer:	LF-Inner Trailer:			**Tandem Front**		RF-Inner Trailer			RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +			Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5			275/80R22.5
11/32	11/32			Tread Depth (32nds)		11/32			10/32
107.5	105.5			End Warmup (psi)		106.5			106.0
107.5	105.5			Bled to (psi)		106.5			106.0
106.0	106.0			End Run (psi)		105.5			105.0
106.8	**105.8**		Steel	**Pressure (psi) Avg.**	Steel	**106.0**			**105.5**
LR-Outer Trailer:	LR-Inner Trailer:			**Tandem Rear**		RR-Inner Trailer			RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +			Type		Michelin X Line Energy +			Michelin X Line Energy +
275/80R22.5	275/80R22.5			Size		275/80R22.5			275/80R22.5
10/32	11/32			Tread Depth (32nds)		10/32			10/32
107.5	107.5			End Warmup (psi)		107.0			107.0
107.5	107.5			Bled to (psi)		107.0			107.0
105.5	106.5			End Run (psi)		105.0			105.5
106.5	**107.0**			**Pressure (psi) Avg.**		**106.0**			**106.3**

Table 8: Comparison of Tire Pressure Avg, Growth, and Variance (Run 6)

Average Tire Pressure Comparison (Test Vehicle - Compare Vehicle)					Tire Pressure Growth Comparison (End psi - Start psi) of (Test Vehicle - Compare Vehicle)				
0.8	Steers (psi)			1.0	1.5	Steers (psi)			3.0
0.3	1.0	Drives-Front (psi)	0.5	1.0	1.5	3.0	Drives-Front (psi)	2.0	3.0
0.0	1.8	Drives-Rear (psi)	1.0	1.3	1.0	4.5	Drives-Rear (psi)	3.0	3.5
0.8	2.5	Trailer-Front (psi)	1.0	1.0	2.5	2.0	Trailer-Front (psi)	3.0	3.0
1.0	1.0	Trailer-Rear (psi)	1.3	1.0	3.0	3.0	Trailer-Rear (psi)	3.5	3.0
1.0		Average Pressure Variance (psi)			2.7		Average Pressure Variance (psi)		
0.0		Minimum Pressure Variance (psi)			1.0		Minimum Pressure Variance (psi)		
2.5		Maximum Pressure Variance (psi)			4.5		Maximum Pressure Variance (psi)		

Pressure Variances of 1.0 and 2.7 psi were higher than previous runs. The Maximum Pressure Variances of 2.5 and 4.5 psi were also higher than previous runs. The higher variances were a result of many variables. Ambient air temperature and ground temperature was at the lowest of the day when Run 6 started and continued to decrease until the end of the run. After the warmup laps, the amount of air that was removed from the trailer tires on the test vehicle may have lowered the tire air temperature to a point where, despite the cooling ambient conditions, the air inside the tire was affected by the heat generated during the rest of the run and resulted in a tire pressure higher than the 'bled to' pressure at the end of the run. Figure 45 shows higher end of the run pressures occurred only for the trailer tires, while the other tires experienced a slight decrease in pressure or no change at all.

5.6: Drive Tire Temperature Results

Drive tire temperature (left-front, inner tire) and ground temperature were recorded during each run and analyzed for variances between steel and ULT36 wheels. Figure 47 below illustrates an observable Drive tire temperature difference between the Test and Compare vehicles during D1R5 and D1R6, when the ULT36 Aluminum wheels were installed on the Drive positions. Drive tire temperature results can be found in Table 9 below.

Figure 47: Drive Tire Temperature During Test Runs

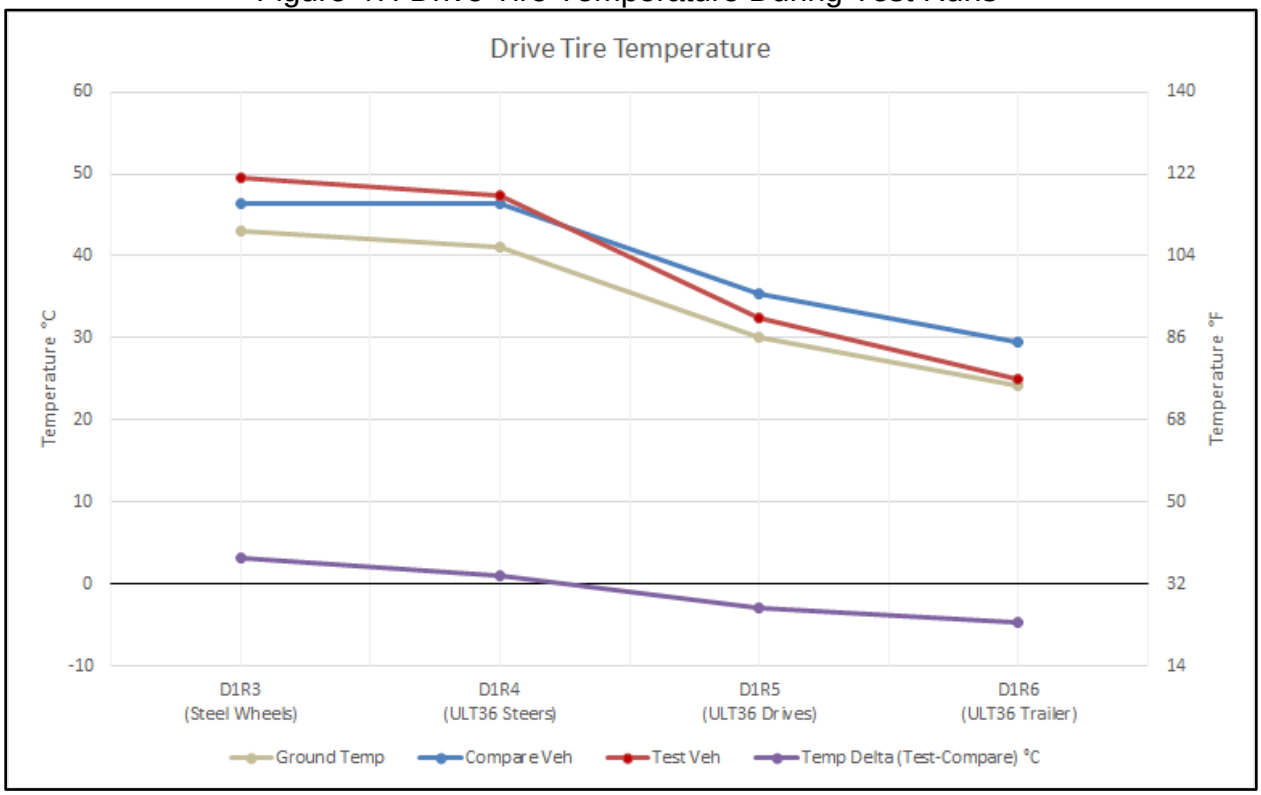


Table 9: Average Drive Tire Temperature Results

Average Drive Tire Temperature Comparison Day 1					
(Test Vehicle - Compare Vehicle)					
Run	**Veh B**	**Veh A**	**Delta**		
R3	49.5	46.4	3.2		
R4	47.4	46.4	1.0		
R5	32.4	35.4	-3.0		
R6	24.9	29.6	-4.7		
-0.9	Average Temp Delta °C				
-4.7	Minimum Avg Temp Delta °C				
3.2	Maximum Avg Temp Delta °C				

D1R4 consisted of ULT36 Aluminum wheels installed on the Test Vehicle in the Steer positions only. Steel wheels were still installed on the Drive positions of both vehicles and experienced an average tire temperature difference of 1.0°C (1.8°F) during this test run.

During the next two test runs (D1R5 and D1R6), ULT36 Aluminum wheels were installed on the Test Vehicle in the Drive positions, while steel wheels remained on the Compare Vehicle. Test vehicle tire temperatures decreased by -3.0°C (5.4°F) and -4.7°C (8.5°F), respectively, compared to steel wheels on the Compare Vehicle.

Note: the general downward trend in overall temperatures from D1R4 to D1R6 was due to decreasing track temperature. However, testing illustrated the ULT36 Aluminum wheels in the Drive position decreased tire temperature when compared to steel wheels. This may not be surprising due to aluminum having a higher rate of heat transfer than steel.

6.0: CONCLUSION

Alcoa's ULT36 aluminum wheels installed on the Test Vehicle produced measurable fuel savings.

The ULT36 aluminum wheels in the Steer positions saved 0.99 gal/1000 miles (0.95%).

The ULT36 aluminum wheels in the Steer and Drive positions produced a savings of 0.64 gal/1000 miles (0.61%)

The ULT36 aluminum wheels in all wheel positions produced a savings of 0.89 gal/1000 miles (0.86%).

In addition to fuel savings, the ULT36 wheels were manufactured with smaller radial runout and required less balancing when compared to conventional steel wheels.

Tire pressures were consistent and reliable throughout testing as shown in the pressure growth and variance tables. Therefore, it was not expected that tire pressures influenced test results of the wheels.

ULT36 wheels resulted in a decrease in tire temperature ranging from -3.0°C (5.4°F) and -4.7°C (8.5°F) compared to steel wheels.

For questions or inquiries please contact MVTS.

7.0: APPENDIX

7.1: TEST VEHICLE DETAILS

Figure 48: Truck and Trailer Info, Test Vehicle

Date	October 5, 2021					
Company	Mesilla Valley Transportation Solutions					
Location	Pecos, Texas					
Test Route	Pecos 9-mile Test Track					
TRUCK ID:	**Veh. B**					
Brand	International					
Date of Manufacture	2019					
Model	LT 625					
Engine	Cummins X15					
VIN	3HSDZAPR3KN562087					
Starting Mileage (miles):	16,452					
Transmission	Eaton Endurant 12-speed AMT					
Rear Gear	2.79 : 1					
Fuel Load	Full					
Fuel Type & Batch	No. 2 Diesel					
Axle Weights (S,D,T) (lbs)	11,260		17,300		16,640	
Total weight	45,200					
TRAILER ID:	**T-2**					
Model	Hyundai Translead					
VIN	3H3V532C6LR282006					
Year	2019					
Type	Dry Van					
Size	53-ft					
Trailer Gap (inches)	35" from cab extender to trailer					
Add-ons	Trailer Skirts					
	Alcoa Aluminum Wheels (Run 6)					

Figure 49: Initial Wheel and Tire Configuration, Test Vehicle

			Truck	Veh. B		
LF			**Front Axle**			RF
Michelin X Line Energy			Type			Michelin X Line Energy
275/80R22.5			Size			275/80R22.5
18/32			Tread Depth (32nds)			18/32
100			Pressure (psi)			100
Steel			Wheel Type			Steel
LF-Outer Drive	LF-Inner Drive		**Drive Axle**		RF-Inner Drive	RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +		Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
18/32	18/32		Tread Depth (32nds)		18/32	18/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel
LR-Outer Drive	LR-Inner Drive		**Drive Axle**		RR-Inner Drive	RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +		Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
17/32	18/32		Tread Depth (32nds)		19/32	18/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel
			Trailer	T-2		
LF-Outer Trailer	LF-Inner Trailer		**Tandem Front**		RF-Inner Trailer	RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +		Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
12/32	12/32		Tread Depth (32nds)		11/32	11/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel
LR-Outer Trailer	LR-Inner Trailer		**Tandem Rear**		RR-Inner Trailer	RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +		Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
12/32	12/32		Tread Depth (32nds)		12/32	12/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel

7.2: COMPARE VEHICLE DETAILS

Figure 50: Truck and Trailer Info, Compare Vehicle

Date	October 5, 2021		
Company	Mesilla Valley Transportation Solutions		
Location	Pecos, Texas		
Test Route	Pecos 9-mile Test Track		
TRUCK ID:	**Veh. A**		
Brand	International		
Date of Manufacture	2019		
Model	LT 625		
Engine	Cummins X15		
VIN	3HSDZAPR4KN562972		
Starting Mileage (miles):	19,423		
Transmission	Eaton Endurant 12-speed AMT		
Rear Gear	2.79 : 1		
Fuel Load	Full		
Fuel Type & Batch	No. 2 Diesel		
Axle Weights (S,D,T) (lbs)	11,260	17,300	16,640
Total weight	45,200		
TRAILER ID:	**T-1**		
Model	Hyundai Translead		
VIN	3H3C532C6MR248009		
Year	2020		
Type	Dry Van		
Size	53-ft		
Trailer Gap (inches)	35" from cab extender to trailer		
Add-ons	Trailer Skirts		

Figure 51: Wheel and Tire Info, Compare Vehicle

			Truck	**Veh. A**		
LF			**Front Axle**			RF
Michelin X Line Energy			Type			Michelin X Line Energy
275/80R22.5			Size			275/80R22.5
17/32			Tread Depth (32nds)			17/32
100			Pressure (psi)			100
Aluminum			Wheel Type			Aluminum
LF-Outer Drive	LF-Inner Drive		**Drive Axle**		RF-Inner Drive	RF-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +		Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
19/32	18/32		Tread Depth (32nds)		19/32	19/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel
LR-Outer Drive	LR-Inner Drive		**Drive Axle**		RR-Inner Drive	RR-Outer Drive
Michelin X Line XDA Energy +	Michelin X Line XDA Energy +		Type		Michelin X Line XDA Energy +	Michelin X Line XDA Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
18/32	19/32		Tread Depth (32nds)		19/32	19/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel
			Trailer	**T-1**		
LF-Outer Trailer	LF-Inner Trailer		**Tandem Front**		RF-Inner Trailer	RF-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +		Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
11/32	11/32		Tread Depth (32nds)		11/32	10/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel
LR-Outer Trailer	LR-Inner Trailer		**Tandem Rear**		RR-Inner Trailer	RR-Outer Trailer
Michelin X Line Energy +	Michelin X Line Energy +		Type		Michelin X Line Energy +	Michelin X Line Energy +
275/80R22.5	275/80R22.5		Size		275/80R22.5	275/80R22.5
10/32	11/32		Tread Depth (32nds)		10/32	10/32
100	100		Pressure (psi)		100	100
Steel	Steel		Wheel Type		Steel	Steel

7.3: TEST ROUTE

Pecos, Texas 9-mile circle track. Clockwise direction, middle lane (of 3).

Figure 52: Pecos Test Track

7.4: WEATHER CONDITIONS

Weather during testing was fair with winds ranging from 0-9 mph. Weather data was acquired from a local Weather Underground weather station. Source shown below.

The reader should be aware that MVTS methods include instantaneous and constant weather data acquisition on each vehicle, and this testing has minimal dependency on external weather data collection. MVTS test data accounts for changes in wind, temperature, and other pertinent variables instantaneously. **Note:** darkened rows pertain to test times.

Table 10: Day 1 Weather Data, October 5, 2021

Time	Temperature	Dew Point	Humidity	Wind	Wind Speed	Wind Gust	Pressure	Precip.	Condition
11:10 PM	65 °F	40 °F	40 %	S	6 mph	0 mph	27.38 in	0.0 in	Fair
12:10 AM	63 °F	40 °F	44 %	SSW	5 mph	0 mph	27.38 in	0.0 in	Fair
1:10 AM	62 °F	42 °F	48 %	SSW	6 mph	0 mph	27.37 in	0.0 in	Fair
2:10 AM	61 °F	41 °F	48 %	CALM	0 mph	0 mph	27.37 in	0.0 in	Fair
3:10 AM	60 °F	43 °F	53 %	CALM	0 mph	0 mph	27.36 in	0.0 in	Fair
4:10 AM	59 °F	41 °F	51 %	CALM	0 mph	0 mph	27.36 in	0.0 in	Fair
5:10 AM	55 °F	40 °F	56 %	CALM	0 mph	0 mph	27.37 in	0.0 in	Fair
6:10 AM	54 °F	39 °F	57 %	CALM	0 mph	0 mph	27.38 in	0.0 in	Fair
7:10 AM	54 °F	41 °F	62 %	NW	5 mph	0 mph	27.39 in	0.0 in	Fair
8:10 AM	60 °F	44 °F	55 %	CALM	0 mph	0 mph	27.42 in	0.0 in	Fair
9:10 AM	67 °F	45 °F	44 %	CALM	0 mph	0 mph	27.42 in	0.0 in	Fair
10:10 AM	75 °F	45 °F	34 %	N	3 mph	0 mph	27.42 in	0.0 in	Fair
11:10 AM	80 °F	45 °F	30 %	CALM	0 mph	0 mph	27.41 in	0.0 in	Fair
12:10 PM	84 °F	43 °F	24 %	SSE	5 mph	0 mph	27.39 in	0.0 in	Fair
1:10 PM	87 °F	41 °F	20 %	CALM	0 mph	0 mph	27.36 in	0.0 in	Fair
2:10 PM	87 °F	39 °F	18 %	SE	3 mph	0 mph	27.34 in	0.0 in	Fair
3:10 PM	90 °F	39 °F	16 %	ENE	9 mph	0 mph	27.32 in	0.0 in	Fair
4:10 PM	89 °F	37 °F	16 %	CALM	0 mph	0 mph	27.31 in	0.0 in	Fair
5:10 PM	88 °F	38 °F	17 %	NNE	3 mph	0 mph	27.29 in	0.0 in	Fair
6:10 PM	85 °F	39 °F	19 %	NE	3 mph	0 mph	27.30 in	0.0 in	Fair
7:10 PM	78 °F	39 °F	25 %	NE	6 mph	0 mph	27.30 in	0.0 in	Fair
8:10 PM	75 °F	39 °F	27 %	ENE	5 mph	0 mph	27.32 in	0.0 in	Fair
9:10 PM	74 °F	38 °F	28 %	E	3 mph	0 mph	27.32 in	0.0 in	Fair
10:10 PM	70 °F	37 °F	30 %	S	5 mph	0 mph	27.32 in	0.0 in	Fair
11:10 PM	69 °F	38 °F	32 %	S	5 mph	0 mph	27.32 in	0.0 in	Fair
12:10 AM	64 °F	38 °F	38 %	CALM	0 mph	0 mph	27.32 in	0.0 in	Fair

Source: https://www.wunderground.com/history/daily/us/tx/pecos/KPEQ/date/2021-10-5

7.5: PRODUCT DETAILS

- Alcoa ULT36 Aluminum Wheels

7.6: TEST PERSONNEL (ON-SITE)

7.6a: MVT SOLUTIONS

- Daryl Bear, Lead Engineer & COO
- Jacob Schwartz, Test Engineer
- Jonathan Ruppert, Test Engineer
- Amber Schwartz, Office Manager
- Garrett Patton, Technician

7.6b: MVT SOLUTIONS DRIVERS & TECHNICIANS

- Allan Dahringer, Director of Maintenance, MVT fleet
- Andrew Burnett, Shop Foreman
- Carlos Aragon
- Jack Burchell

7.6c: HOWMET AEROSPACE TECHNOLOGIES (ALCOA)

- Douglas Mason, Ph. D, Global Technical Manager, Global Accessories Manager

7.7: MVT SOLUTIONS CONTACT INFO

Daryl Bear, Lead Engineer & COO
Daryl.Bear@m-v-t-s.com
317-603-9325

Jacob Schwartz, Test Engineer
Jacob.Schwartz@m-v-t-s.com
575-288-3342

Jonathan Ruppert, Test Engineer
Jonathan.Ruppert@m-v-t-s.com
575-405-5015