

Michelin NA Cross Country Fuel Economy Tests Summer 2011



NACFE Overview

- The NACFE is a non-profit organization dedicated to doubling the freight efficiency of transportation industry.
- We pursue this goal in two ways:
 - By improving the quality of information
 - And by highlighting the success of high efficiency technologies



5000 mile Over the Road Fuel Test

Design of Experiment and Analysis of Variance
Approach to Fuel Efficiency Testing and Analysis

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Our Partnership

On behalf of the entire Michelin Team, we would like to thank NACFE for your support of this test as a third party evaluator and look forward to expanding our future partnership.

History

- Market Demands
 - Cost of Fuel
- Product Evolution and Improvement
 - e.g XZA1, XZA2, XZA3, XZA3+
- Establishing the Rolling Resistance Advantage
- SAE Testing Methodology
- Fleet Testing and Usage disparity

Objective

- Use a statistical matrix approach to test variables that influence efficient fuel usage on commercial heavy truck
- Identify the influence of known test variables on mile per gallon.
- Analyze the results by building models to explain clearly the variables that has an effect within the test

SAE FUEL TESTS

- RP 1102 SAE J1326 TYPE II Fuel Test
- RP 1103 SAE J1526 TYPE III Fuel Test
- RP 1109 TYPE IV Fuel Test

**Do you know the
Difference?**

What is Design of Experiment and Analysis of Variance?

Design of Experiment

(DOE) :Is a statistical approach of structuring an experiment before it is conducted to make the analysis clearer and more precise.

- **Analysis of Variance (ANOVA)**: Is the method of explaining the observed means of each variable being tested.

Why DOE and ANOVA

- Reduced bias in unequal testing condition
- Variation of any comparison is greatly reduced
- More concise testing model
- **Precise analysis of the interacting variables**
- Importance of each background factor may be assessed

SAE Fuel Test Limitations

- Allow only for one variable testing at a time
- Noise within the test condition is not detected
- Variation within the test process is not detected
- Test results are not always repeatable

5000 Mile Test Structure

- Three identical 4x2 trucks in make, model, age and mileage
- Three identical Drivers with similar driving experience
- Five thousand mile route
- Three different treads (All Michelin)
 - Truck #1: XZA3, XDA5, and XT1
 - Truck #2: XZA3, X1 XDA Energy, X1 XTA
 - Truck #3: XZA3, X1 XDN2, X1 XTE
- Three identical 28ft double trailers equally loaded
- 12 segment stops to make changes

Test Variables

- Tires
- Drivers
- Trucks
- Segments



Matrix

	Segment 1 - Out		
Truck	A	B	C
Driver	1	2	3
Tires	Config 1	Config 2	Config 3

	Segment 1 - Back		
Truck	A	B	C
Driver	1	2	3
Tires	Config 1	Config 2	Config 3

	Segment 2 - Out		
Truck	A	B	C
Driver	3	1	2
Tires	Config 2	Config 3	Config 1

	Segment 2 - Back		
Truck	A	B	C
Driver	3	1	2
Tires	Config 2	Config 3	Config 1

	Segment 3 - Out		
Truck	A	B	C
Driver	2	3	1
Tires	Config 3	Config 1	Config 2

	Segment 3 - Back		
Truck	A	B	C
Driver	2	3	1
Tires	Config 3	Config 1	Config 2

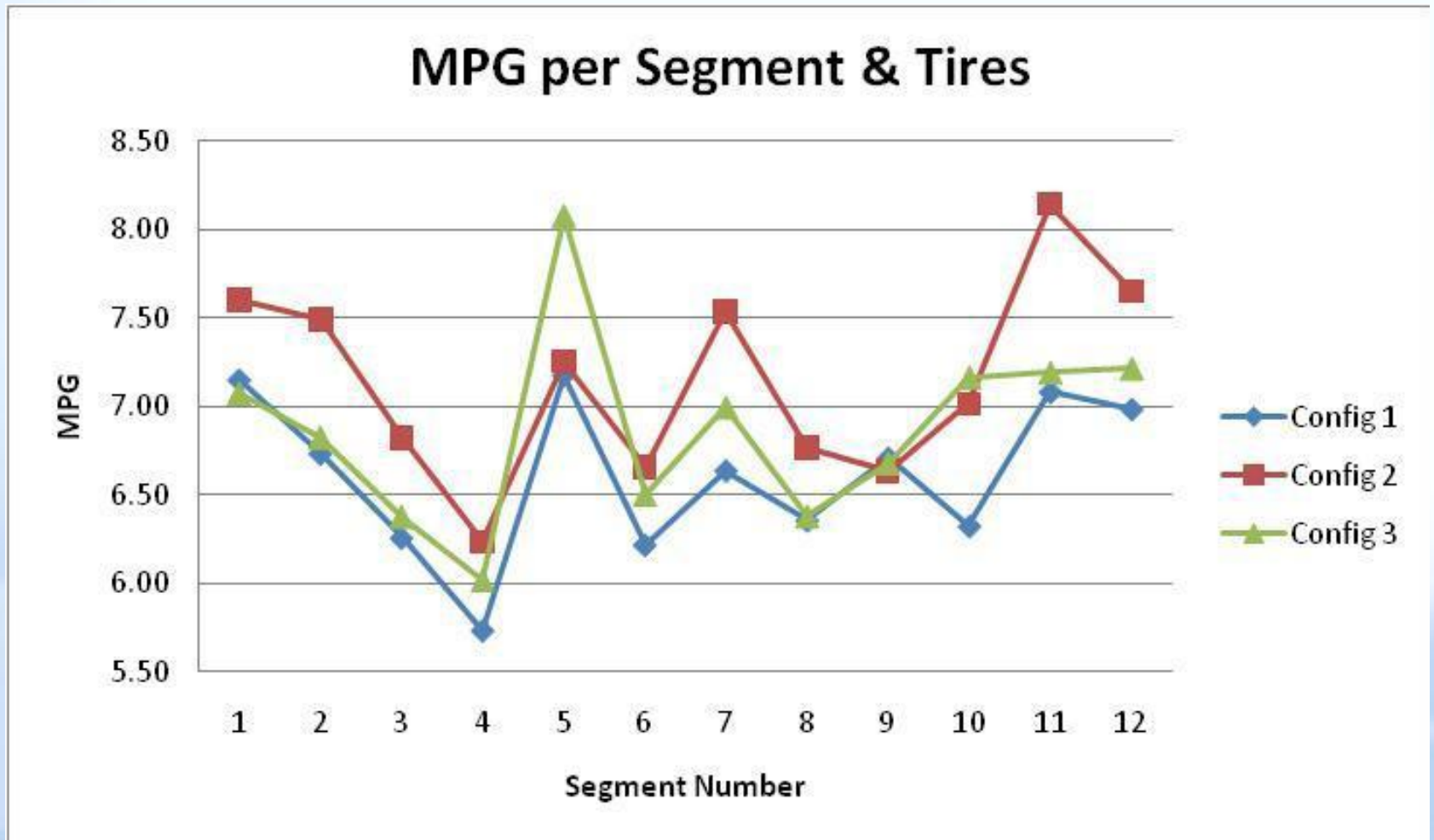
Test Procedure

- Route is from Greenville, LPG, Southern California and back.
- The turnaround is at I-10 Los Angeles.
- Drivers should drive each truck 4 times during the test – an average of 400 miles.
- Tires should be rotated each 400 miles during the trip to see each truck.
- Air pressure is 100 psi on each position and should be checked and adjusted each morning prior to the next leg.
- Load each vehicle as close as possible to GVW (80K) with driver and full fuel tanks.

Test Procedure

- Record weight.
- Fuel stops need to be equi-distant and not dependent on fuel gauge
- The fuel receipt will be the official record of fuel pumped
- Logged driving is to comply with normal DOT hours of operations.
- Each driver will need a calibrated air gauge to check tires cold each day of the trip prior to departure.
- Idle time will be recorded and consistent across trucks

Results of Test by Segment



Summary Table

Source	DF	Squares	Mean Square	F Value	Pr > F
Model	17	9.51706886	0.55982758	10.29	<.0001
Error	18	0.97919696	0.05439983		
Corrected Total	35	10.49626582			

R-Square	Coeff Var	Root MSE	mpg Mean
0.906710	3.389881	0.233238	6.880410

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Segment	11	7.25032567	0.65912052	12.12	<.0001
Truck	2	0.04960355	0.02480178	0.46	0.6410
Driver	2	0.35868128	0.17934064	3.30	0.0603
Config	2	1.90028887	0.95014444	17.47	<.0001

Means Comparison - Config

Alpha	0.05
Error Degrees of Freedom	18
Error Mean Square	0.0544
Critical Value of Std Range	3.60930
Minimum Significant Difference	0.243

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	config
A	7.15581	12	2
B	6.87732	12	3
C	6.60809	12	1

Percentage Comparison

- Truck #1: XZA3, XDA5, and XT1
 - Config 1
- Truck #2: XZA3, X1 XDA Energy, X1 XTA
 - Config 2 was 8.13% better than Config 1
- Truck #3: XZA3, X1 XDN2, X1 XTE
 - Config 3 was 3.93% better than Config 1

Means - Segment

Tukey Grouping	Mean	N	segment
A	7.5046	3	5
A	7.4737	3	11
A B	7.2846	3	12
A B	7.2769	3	1
A B C	7.0560	3	7
A B C	7.0187	3	2
A B C	6.8350	3	10
B C D	6.6733	3	9
C D	6.5019	3	8
C D	6.4849	3	3
C D	6.4601	3	6
D	5.9954	3	4

Comments on Study

- Study is valid based on the test model
- Conclusions are that all three configurations can be statistically separated at 95% confidence
- Config 2 is best for mpg with config 3 being second and config 1 being worst

Other Interesting Results

- Segment differences were significant with a range greater than that of config
- Differences between segment pairs (1,12), (2,10) etc. were large and (5,8) significant
- Configuration ranking agreed 67% of segments

THANK YOU!!!

Get Engaged

- Become a Member.
- Purchase the Adoption Study and ask questions.
- Sponsor one of the projects, support them through information or be a subject matter expert on the team.
- Become engaged in our committee work
- Attend DI Meetings and Encourage others to get involved.

Comments

- What went well today? Was intriguing insightful, helpful.
- What do we need to do more of?

Please fill out the Evaluation & Volunteer Form.

The Next Driving Innovation Meeting – During MATS –
March 2013.

Thanks for coming!

We ARE the People We Have Been Looking For!

