Incorporating On-Board Diagnostics into Fleet Preventive Maintenance Practices (Paper 15-3474)

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Background

- Texas Department of Transportation's fleet – on-road and off-road vehicles and equipment

Research Question

- Can we enhance fleet management through the use of OBD data
  - Cost savings
  - Better preventive maintenance practices

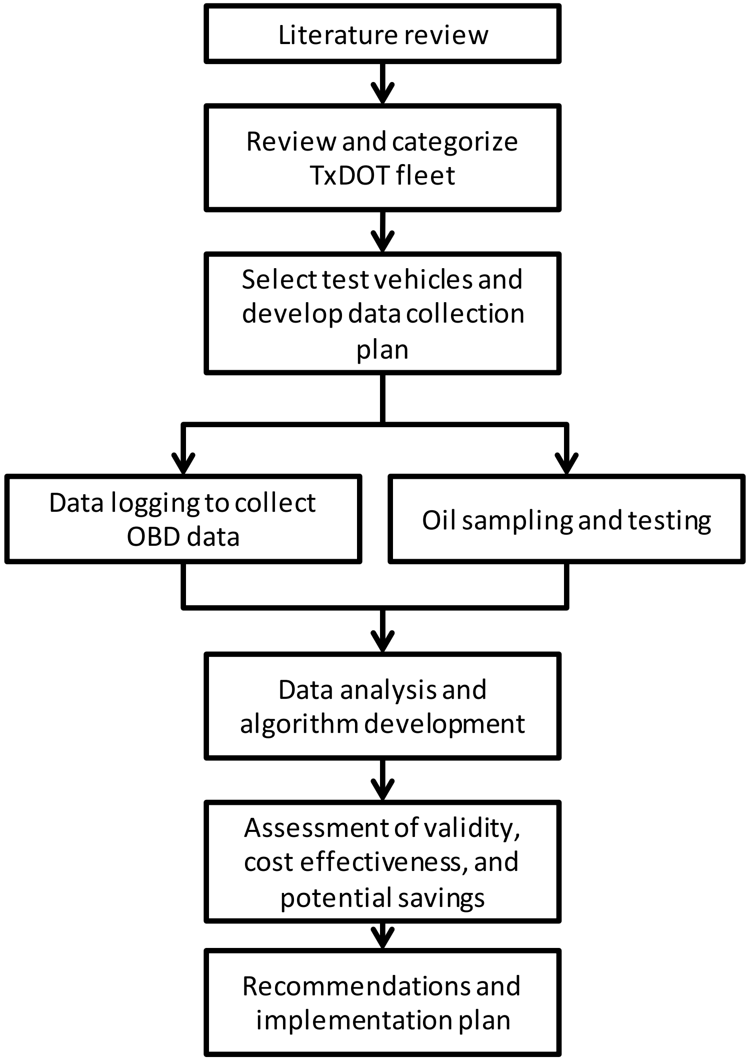
Our Approach

- Provide "proof of concept"
  - Focus on a single category of vehicle
  - Oil change practices
  - Statistical approach based on engine data collection and oil sampling
  - Identify if predictive intervals can improve practices and save money

Multidisciplinary Research Team

- Texas A&M Transportation Institute
  - Michael Kader, Tara Ramani, Jeremy Johnson, Joe Zietsman
- Texas A&M University Mechanical Engineering
  - Dr. Timothy Jacobs
- Texas A&M University Statistics
  - Dr. Clifford Spiegelman

Project Activities



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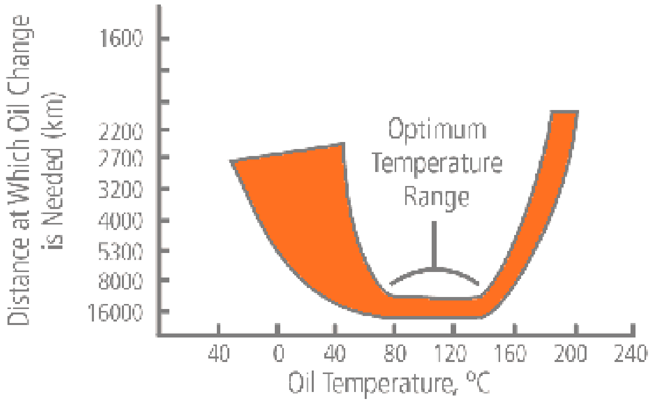
Engine Operations and Oil Life

Decreases Oil Life	Extends Oil Life
Short Trip Intervals	Long Trip Intervals
Excessive Idling	Continuous Intervals (Steady RPM)
Extreme High Temperature Operation	Operating at Moderate Temperatures
Low Temperature Operation	Good Maintenance Procedures
Poor Maintenance	

Figure 2 - A Temperature-Based Model of Engine Oil Life



Selected Oil Parameters

- Viscosity Performance – Main source of lubrication.
- Total Base Number – Alkaline additives that neutralizes contaminating acids.
- Additives – Designed to increase lubrication, inhibit corrosion and clean engine. Includes Zinc, Phosphorus, Boron, Calcium, Magnesium, etc…
- Wear Metals – High levels inhibit lubrication. Includes Copper, Iron, Aluminum, etc…
- Insolubles – Percentage of solids in oil test sample

Degradation
Viscosity Performance
Additives Concentration
Total Base Number

Contamination
Oxidation/Nitration
Metals Concentrations (Wear Particles)
Total Acid Number
Insolubles

Selected Engine Parameters

- Focus on dynamic engine parameters
  - Engine speed (RPM)
  - Engine load
  - Oil and Coolant Temperatures
  - Oil pressure
  - Distance traveled/hours in operation *(currently used by TxDOT)*

Selection of Vehicle Category

- EOS Database
  - Engine Type and Number of Units.
  - Average Model Year.
  - Total and Average Oil Expense
  - Total and Average Usage
- Data logging considerations

	A	B	C	D	E	F	G	H	I
1	EQUIP-NO	CLASS-CODE	DISTRI(	MAKE-CODE	MODEL-NAME	MODEL-YEAR-[	COUNTY-NO	MENG-MAKE	MENG-FUEL-TYPE
2	09838G	75010	1	363	XL3100	2003	190	216	D
118	09836G	75010	2	363	XL3100	2003	220	216	D
119	09837G	75010	11	363	XL3100 4X	2003	3	216	D
120	09839G	75010	16	363	XL3100	2004	178	216	D
121	09840G	75010	16	363	XL3100	2004	178	216	D
122	09841G	75010	11	363	XL3100 4X	2004	202	216	D
123	09842G	75010	13	363	XL3100 4X	2004	241	216	D
124	09843G	75010	13	363	XL3100 4X	2004	121	216	D
125	09844G	75010	13	363	XL3100 4X	2004	8	216	D
126	09846G	75010	19	363	XL3100	2004	19	216	D
127	09848G	75010	24	363	XL3100	2004	72	216	D
128	09850G	75010	12	363	XL3100	2004	102	216	D
129	09852G	75010	13	363	XL3100	2005	62	216	D
130	09853G	75010	10	363	XL3100	2005	250	214	D
131	09854G	75010	10	363	XL3100	2005	37	214	D

Excavator / Grader / Loader / Car / Truck / HD Truck

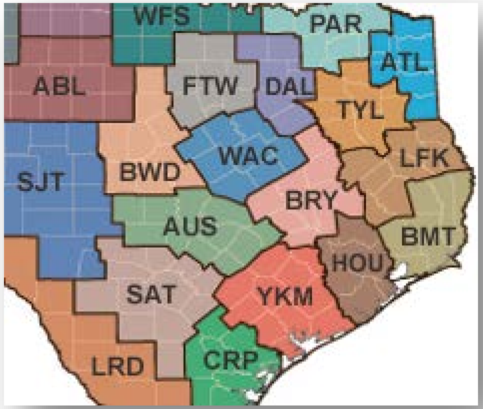
Final Selection

Engine Type	Vehicle Type	Make	Typical Model	Number of Units	Average Year Model
MBE4000	Truck	Sterling	LT9500	355	2006

- High oil expenses incurred
- Well-represented in overall fleet
- High usage category
- High average model year

Identification of Test Units

- Random selection of ten units (plus 2 alternates) after applying geographical constraints
- Selected from Bryan, Houston, Austin and Waco districts



Data Collection – Oil Sampling

- Extracted through engine dipstick tube via vacuum pump
- Small quantity (<100ml) – comparable to oil burn rate.
- Analysis performed by third party laboratory
- Operators maintain log sheet

Parameter	Standard Number	Standard/Test Name
Viscosity	Modified ASTM D445	Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids
Oxidation	ASTM E2412	Standard Practice for Condition Monitoring of Used Lubricants by Trend Analysis Using Fourier Transform Infrared (FT-IR) Spectrometry
Nitration		
Total Acid Number	Modified ASTM D664	Standard Test Method for Acid Number of Petroleum Products by Potentiometric Titration
Total Base Number	Modified ASTM D4739	Standard Test Method for Base Number Determination by Potentiometric Hydrochloric Acid Titration
Wear Metals	Modified ASTM D5185	Standard Test Method for Determination of Additive Elements, Wear Metals, and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
Soot	ASTM E2412	Standard Practice for Condition Monitoring of Used Lubricants by Trend Analysis Using Fourier Transform Infrared (FT-IR) Spectrometry
Fuel Dilution	-	Fuel Dilution by Gas Chromatography

Data Collection – Engine Data

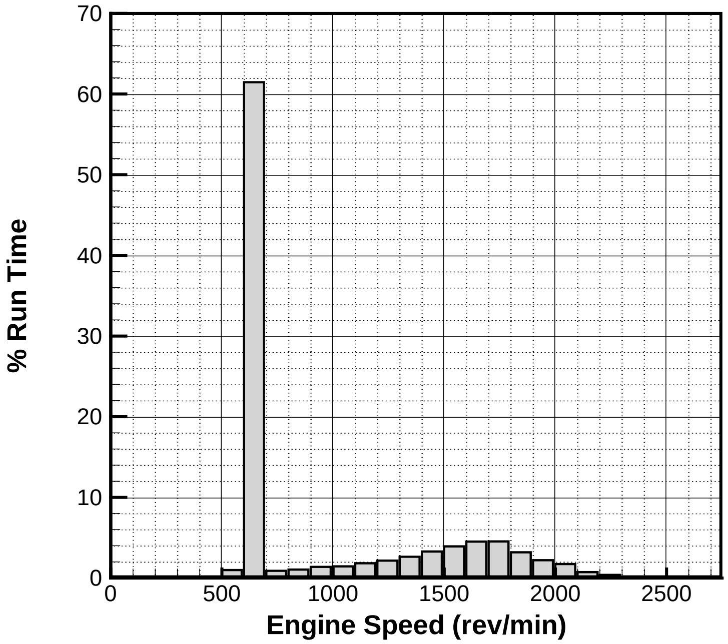
- J1939 port using Caflor IOSiX data logger
- Transferred to a laptop from memory card
- Data downloaded biweekly

Data Collection and Analysis

- Data collected from ~ July/August 2011 through October 2012
  - Oil change intervals extended in select vehicles
- Data analysis conducted concurrently
  - Oil and engine data and trends
  - Stepwise methods, component plots and other statistics
- Overall findings
  - Low levels of oil degradation
  - Engine operations predominantly low load, with high levels of idling

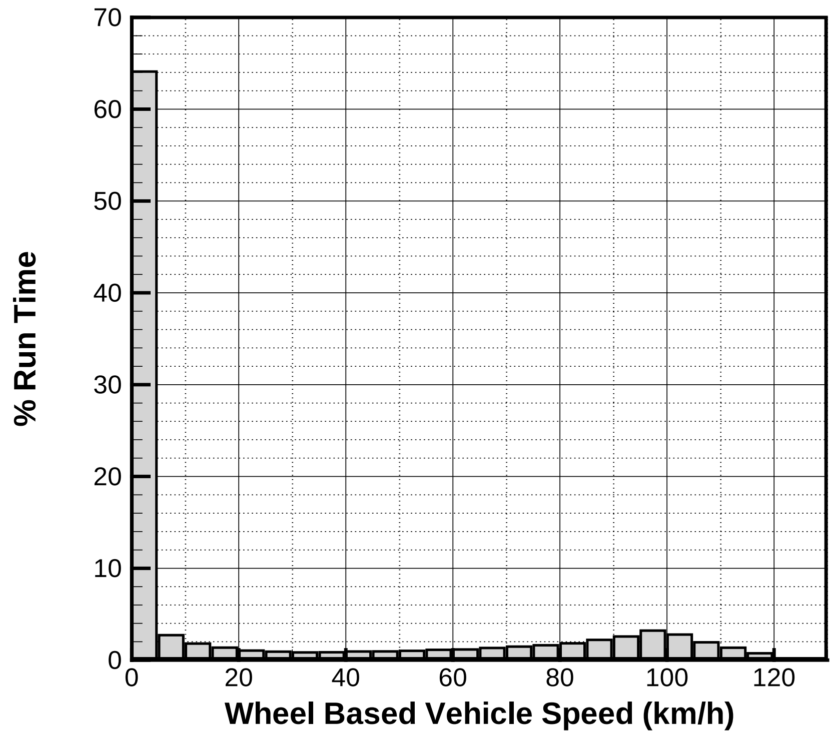
Engine Speed (All Vehicles)

- 60% of run time at idle
- 98% of idle speed time is spent at torque levels less than 10%

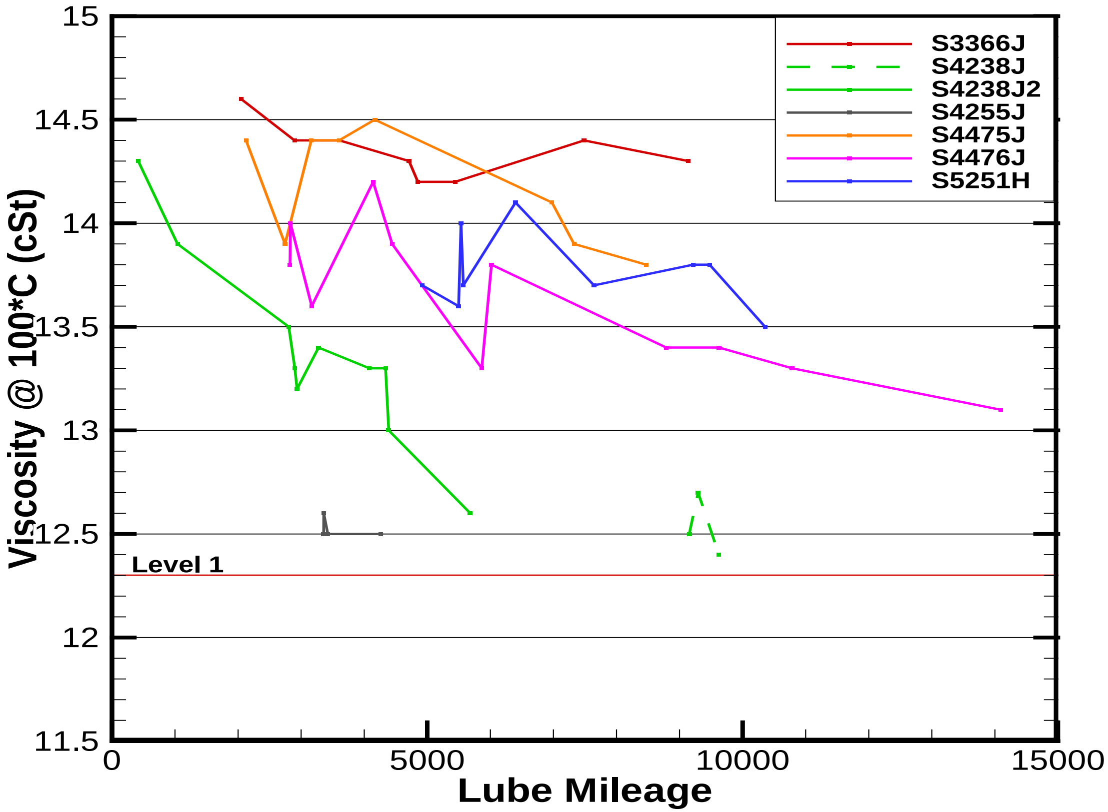


Vehicle Speed (All Vehicles)

- 64 percent of run time at speeds under 3.1 mph



Example Oil Results – Viscosity Tests



Spreadsheet Tool and Guide

- Data logger setup instructions
- Database setup instructions
- Data analysis features


Product 0-6626-P1

Spreadsheet-Based Engine Data Analysis Tool - User's Guide

Project 0-6626
Project Title: Fleet Equipment Performance Measurement Preventive Maintenance Model

Authors:
Jeremy Johnson
Tara Ramani
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Texas A&M Transportation Institute

TxDOT Project 0-6626: Fleet Equipment Performance Measurement Preventive Maintanence Model

Spreadsheet-Based Engine Data Analysis Tool

This analysis tool was developed as part of TxDOT Research Project 0-6626: Fleet Equipment Performance Measurement Preventive Maintenance Model and is intended for use with data extracted from heavy-duty (HD) fleet vehicles using data loggers that follow SAEJ1939 to communicate with their on-board diagnostic (OBD) port. Basic instructions to operate this spreadsheet can be accessed from the main menu. For futher information, please refer to the User's Guide document.

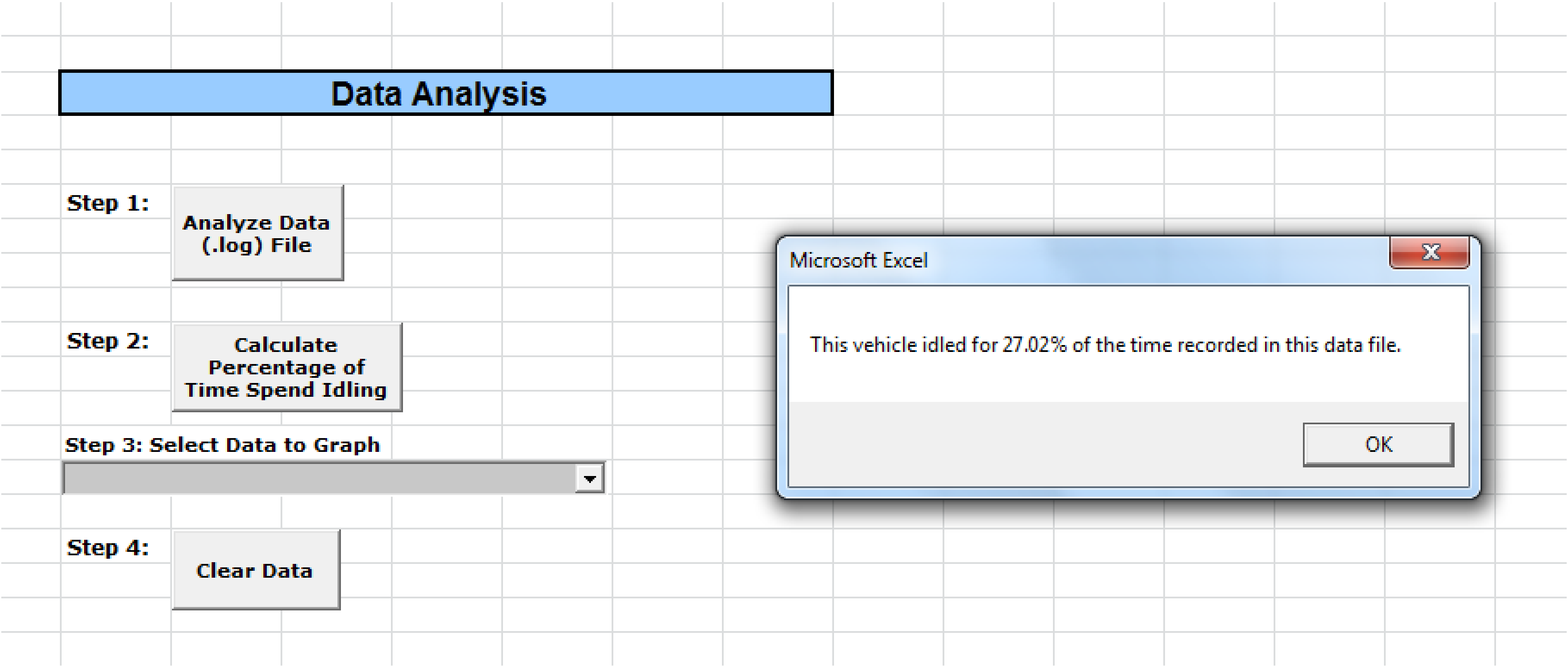
Menu

Click on hyperlinks to go to individual worksheets

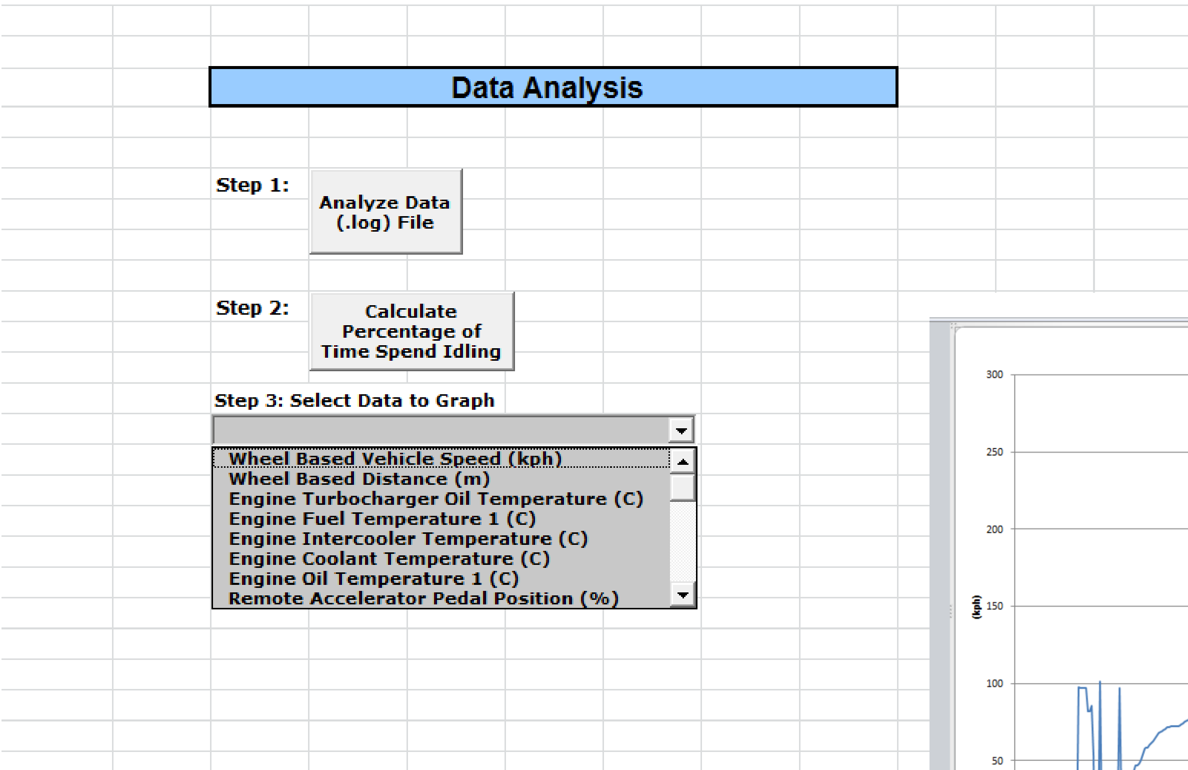
Click 'Return to Menu' (top left on each individual sheet) to return

Worksheet	***Description***	***Type***
Menu	Menu	Menu
Spreadsheet Instructions	Instructions for using this spreadsheet	Instructions
Data Logger Instructions	Instructions for setting up and using the data loggers.	Instructions
Database Setup Instructions	Instructions for updating the database.	Instructions
Database	Database tab containing parameters to be analyzed from collected data.	Database
User Input	User input worksheet	Data Entry
Analyzed Data	Output tab for analyzed data collected with data loggers.	Data Output

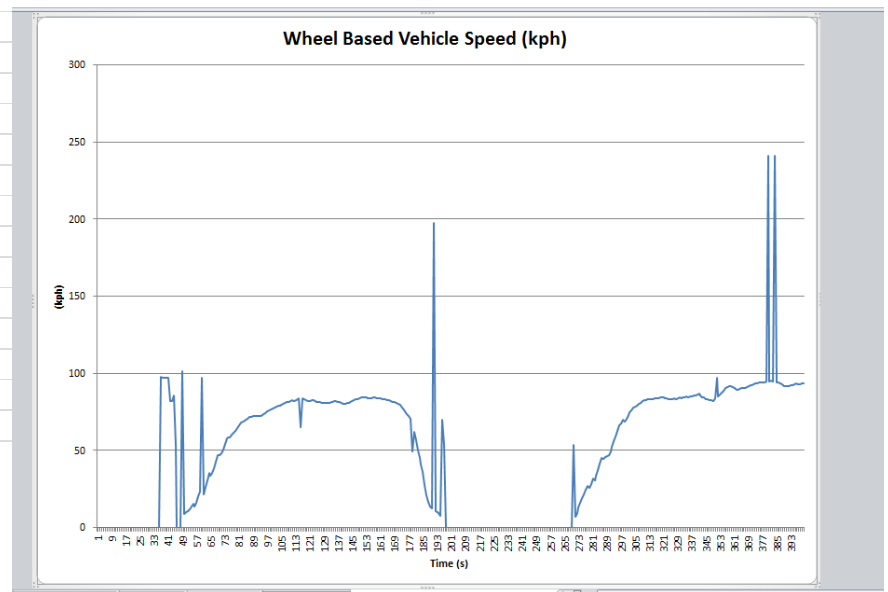
Example Analysis



Graphs



Data Analysis
Step 1:
Analyze Data (.log) File
Step 2:
Calculate Percentage of Time Spend Idling
Step 3: Select Data to Graph
Wheel Based Vehicle Speed (kph)
Wheel Based Distance (m)
Engine Turbocharger Oil Temperature (C)
Engine Fuel Temperature 1 (C)
Engine Intercooler Temperature (C)
Engine Coolant Temperature (C)
Engine Oil Temperature 1 (C)
Remote Accelerator Pedal Position (%)



Wheel Based Vehicle Speed (kph)
300
250
200
150
100
50
0
(kph)
Time (s)

Conclusions

- Methodology and procedures established successfully
- Data collection and analysis produced interesting results
- However low oil degradation levels limited scope of findings

Conclusions (contd.)

- Support replacing 10,000 mile oil change guidance (current TxDOT practice) with manufacturer recommendations
  - 15,000 miles for annual use of 6,000-60,000 miles
  - Estimated cost savings of $ 16,000 per year

Contact

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