

# Kansas City PM Characterization Study

## Final Report

### Appendix M

### Offsite Quality Assurance and Analysis

Assessment and Standards Division  
Office of Transportation and Air Quality  
U.S. Environmental Protection Agency

#### Sponsors:

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## PEMS Data integrity and quality check queries

ID	Query	Pre-test fields	Test record columns	Criteria
1	Collect test times	"Test Start Time" and "Test End Time"	N/A	These will be used in audit queries
2	If MY > 1995, has VI been collected?	"Vehicle Interface Type"	"Vehicle Responding"	If enabled/collected, OK Else, flag
3	Are transport delays appropriate?	"AMBI Delay(s)", "NDUV Delay(s)", "SCB Delay(s)", "THC FID Delay(s)", "Methabe FID Delays", "Flow Meter Delay(s)"	N/A	Values should be 6,6,0,5,5,0, respectively
4	Is test duration appropriate?	N/A – NOTE: don't use "Test Duration(s)" field	Test time (i.e., total # of seconds after CO + CO <sub>2</sub> is > 5)	For Precond runs: If duration is < 1000, flag For Dyne testing: If duration is < 2340, flag For Driveaways: If duration is < 18000, flag
5	Is correct speed used?	iVEH_SPEED_USED	N/A	For Precond runs: If not equal to "iGPS_GROUND_SPEED", flag For Dyne testing: N/A For Driveaways: If not equal to "iGPS_GROUND_SPEED", flag
6	Is test distance appropriate?	"Total Distance Traveled (mi)" (for Precond runs and driveaways)	"External Analog Input 3" (for dyne testing)	For Precond runs: if "Total Distance Traveled (mi)" < 7.5, flag For Dyne testing: if total distance determined using converted "External Analog Input 3" < 9.7 miles For Driveaways: If "Total Distance Traveled (mi)" < 10, flag
7	Does the test have faults/warnings?	"Faults:", "Warnings:"	N/A	If yes, list faults and warnings by test id
8	Is test preceded by a "passed" audit?	"Audit"	N/A	Using test times previously collected, find last audit immediately before test. If no audit, or audit has a failure, flag
9	Is test followed by a "passed" audit?	"Audit"	N/A	For precond runs and dyne testing, using test times previously collected, find audit performed after test. If no audit, or audit has a failure, flag. Disregard for driveaways.
10	Are pre-test and post-test gas audit values correct?	"Audit"	N/A	Ensure gas bottle values are within range for all pollutants (CO=200 ± 5, CO <sub>2</sub> =6 ± 0.1, NOx=300 ± 5, THC = 50 ± .2)
11	Is dilution reasonable?	N/A	"CO", "CO <sub>2</sub> " % (wet corrected)	If CO + CO <sub>2</sub> < 13, flag
12	Is flow collected?	N/A	"Exhaust Mass Flow Rate"	If all = zero or null, flag



<b>ID</b>	<b>Query</b>	<b>Pre-test fields</b>	<b>Test record columns</b>	<b>Criteria</b>
13	Is post-processor version correct?	"Post-Processor DLL Version"	N/A	5.4
14	Max, avg, mean mass flow rate by displacement plots and output file	"Engine Displacement"	"Corrected mass flow rate (kg/hr)", "iGPS_ground_speed" (control, precond, dway), "iSCB_EAI3" (dyne)	For each test record, drop all obs with speed < 1 mph Calculate max, avg, and mean mass flow rate for each test Print 3 scatter plots, x-axis is displacement (L), y-axis is mass flow rate. Output CSV file with test ID, max, avg, mean mass flow rates, displacement (to find records that should be manually reviewed)
15	Avg mpg by displacement and output plots	"Engine Displacement", "Overall Fuel Economy (mpg)"	N/A	For each test record, either use mpg from pre-test, or the one we calculate with independent equation. Print scatter plot with x-axis displacement, y-axis is fuel economy. Output CSV file with test ID, fuel economy, displacement.



ID	Query	Pre-test fields	Test record columns	Criteria
16	Test value output for tests with suspect mileage values	"Engine Displacement", "Overall Fuel Economy (mpg)", "Total Distance Traveled (mi)"	"iGPS_ground_speed" (control, precondition, dway), "iSCB_EAI3" (dyne)	<p>For each test record, either use mpg from pre-test info, or the one we calculate with independent equation. Then, for various engine size groupings, we'll do a mpg range screening. If the values fall outside the screening range, we'll want to do some calcs and output test info and the calculated values to a CSV file for manual review.</p> <p>Record suspect if <math>A &lt; \text{disp} &lt; B</math> and <math>\text{MPG} &lt; Y</math> or <math>\text{MPG} &gt; Z</math>,  . Perhaps for 1<sup>st</sup> groups, then do the following:  &lt;2 L, 20 mpg to 30 mpg  2L to 2.5L, 15 mpg to 25 mpg  2.5L to 3L, 10 mpg to 20 mpg  3L to 3.5L, 10 mpg to 20 mpg  3.5L to 4L, 10 mpg to 20 mpg  4L to 4.5L, 10 mpg to 20 mpg  4.5L to 5L, 10 mpg to 20 mpg  &gt;5L, 10 mpg to 20 mpg  We will need to tweak engine/mpg groupings to set appropriate screening limits. Maybe do a proc freq of mpg by displacement group to get initial settings.</p> <p>For each record that falls outside limits, drop all obs with speed &lt; 1 mph and with a corrected exhaust flow rate column (icMASS_FLOW, kg/hr) less than 10 kg/hr. Calculate/output to CSV test ID, MY, make, model, displacement, mpg, total dist traveled, and then max and averages for: iCO2zw (%) + iCOzw (%), icMASS_FLOW, iFLOW_EX_TEMP, iFLOW_UP_PRESS, AF_Calc, Lambda.</p>



## PEMS results analysis

- Query A:

The intent of this query is to distinguish between the preconditioning portion and the actual driveaway portion of the driveaway files (when precondition and driveaway both exist and are in the same test file)

***Precond run start time:***

Start of precondition run should first second by second records where  $CO+CO_2 > 5$  and speed  $> 1$

***Precond run end time:***

The first observation where

If “Cumulative Distance (actual)” (iCALCSUM\_Dc) is greater than 7

And if “Ground Speed” (iGPS\_GROUND\_SPEED) has been ***less than 1*** for at least 5 seconds

And if “iGPS\_LAT (deg) is between 39.08999 and 39.0908,

And if “iGPS\_LON (deg) is between -94.731 and -94.734,

The preceding portion of the test is the preconditioning run, and the remaining portion of the test is the driveaway

Please provide precondition start time, precondition end time, precondition miles, and precondition time duration for each run.

Please provide a plot of speed vs. # of seconds for each of the above tests (one plot for each test record, not broken into segments).

Please also provide the plots with only the first 6000 seconds plotted.

- Query B:

The intent of this query is to determine the fuel economy and emissions for the preconditioning segment of driveaway runs. Then, determine fuel economy and emissions for the remainder (driveaway portion) of the test.

For tests that meet the conditions of Query A, please list the test file name, and then for each segment (precondition and driveaway) please list total number of seconds, cumulative distance (iCALCSUM\_Dc), cumulative fuel economy (iCALCSUM\_Wc mpg) and cumulative emissions (iCALCSUM\_CO2cm, iCALCSUM\_Cocm, iCALCSUM\_kNOcm, iCALCSUM\_HCcm) that is listed on the last valid line of the test segment. In other words, the above values will be listed for both the preconditioning segment and the driveaway segment as determined using Query A.

Note that since cumulative driveaway value includes precondition segment, this is being differentiated using the following eqn:

$$\begin{aligned} FE_{\text{driveaway}} &= [\text{Miles}_{\text{total}} \times FE_{\text{overall}}] - [\text{Miles}_{\text{precond}} \times FE_{\text{precond}}] / [\text{Miles}_{\text{total}} - \text{Miles}_{\text{precond}}] \\ &= [\text{Gallons}_{\text{total}} - \text{Gallons}_{\text{precond}}] / [\text{Miles}_{\text{driveaway}}] \\ &= [\text{Gallons}_{\text{driveaway}}] / [\text{Miles}_{\text{driveaway}}] \end{aligned}$$



- Query C:

The intent of this query is to independently calculate fuel economy from the SEMTECH record fields and compare it with the pre-test SEMTECH mpg values for each SEMTECH test record (Round 2 dyne SEMTECH, Round 2 precond, Round 2 driveaway, Round 1.5 )

$$\begin{aligned}\text{Fuel Economy} &= 2421 / ((\text{CO}_2 \times 0.273) + (\text{HC} \times 0.866) + (\text{CO} \times 0.429)) \\ &= 2421 / ((\text{iCALCSUM\_CO2cm} \times 0.273) + (\text{iCALCSUM\_HCcm} \times 0.866) + (\text{iCALCSUM\_COcm} \times 0.429)) \text{ where iCALCSUM} \\ &\text{units are taken from the last valid line of the test record and are in g/mi.}\end{aligned}$$

For each record, please list the record name, fuel economy calculated above and the fuel economy listed in the pre-test info.

- Query D:

Please read in the control vehicle runs (located at G:\KansasCity\SEMTECH\Round1\_5\ControlVehicle\KC Rnd 15 control run csvs). Should be same format as what you've already read in.

Please determine the preconditioning start and end times using the logic defined above. Then, for these control runs, please provide a csv file that lists for each test record the test ID, vehicle ID, "SEMTECH Serial Number" (from pre-test info), HC, CO, CO2, NOx g/mile emissions, cumulative distance, and fuel economy (mpg) for the preconditioning run.

Please provide a line plot of fuel economy (left axis) by control run # (horizontal axis test date as label) for all the control runs (one plot with 37 data points).

Please provide plots (by pollutant) of g/mi emissions (left axis) by control run # (horizontal axis with test date as label) for all control runs (four plots with 37 data points each)