COLLECTION OF ACTIVITY DATA FROM ON-ROAD HEAVY DUTY DIESEL VEHICLES

I. OBJECTIVE

The objective of this research is to characterize the heavy-duty truck activity profiles (e.g., duty cycles, starts and soak time) for different types of vocational uses (line haul, drayage, delivery, etc.) with the specific goal of identifying what fraction of the vehicle operation may be such that Selective Catalytic Reduction (SCR) functionality is challenged. The research should also put these results in context of the emission certification test cycle and provide an analysis of the representativeness of the certification cycle to real world emissions of nitrogen oxide (NO_X) for the different types of heavy duty vehicles. The results will be used to improve heavy duty NO_X emissions models, and to take a critical look at whether certification and compliance procedures need to be updated to account for the functionality of SCR.

I. BACKGROUND

For the State of California to meet upcoming ambient air quality standards for ozone and PM, considerable reductions in NO_X emissions are needed. To achieve some of these reductions the NO_X emission standard for heavy-duty on-road engines was reduced by 90 percent in 2010. Diesel engine manufacturers are in most cases using advanced engine exhaust aftertreatment, specifically SCR, to meet the new standard. SCR reduces NO_X in the exhaust stream, but requires adequate temperatures for the reduction to take place. Typically the SCR needs to be at least 200°C before significant NO_X reduction is achieved. However, there will be times when this temperature requirement is not met, such as right after engine start and during low loads experienced when the engine is idling, or when the vehicle is moving slowly on flat terrain. The frequency of low temperature and low duty operations varies for a truck depending on its type of vocation. In line-haul application a truck operates mostly with high load to maintain high-speed cruise, while the other trucks operate with frequent stops in local goods delivery application. As a truck activity changes, SCR functionality of the truck changes with implications for NO_X reduction using SCR. Therefore, it is critical to characterize heavy-duty diesel truck activity profiles including duty cycles, number of engine starts, and engine soak time distributions, for trucks by vocation. The heavy-duty diesel truck activity profiles are fundamental for updating emission inventories, quantifying real-world NO_X emissions from trucks meeting the new 2010 NO_X certification standard, and determining if the certification standard should be revised.

I. SCOPE OF WORK

The contractor should create a fully developed research plan and perform all tasks as described below.

Task 1. Screening analysis of identifying the magnitude of NO_X emissions by types of vocational uses for heavy-duty diesel trucks

California motor vehicle emission inventory model, EMFAC2011, categorizes medium (T6) and heavy (T7) heavy-duty diesel trucks by a combination of their geological operation boundaries and vocational uses (APPENDIX A). Further truck class categorization by the type of vocation is critical to understand truck activity profiles to estimate SCR functionality and to quantify emissions. For instance, current T6 instate heavy-duty trucks operate in multiple vocations including beverage distribution, mail delivery, local goods delivery and others. It is believed that activity profiles from a mail delivery truck, which may include multiple short trips (short soak time) with low exhaust temperature, will be different from a beverage distribution truck making longer soak duration while loading and unloading. Although the two trucks are in the same T6 instate truck category, the difference of their activity profiles may be statistically significant. The contractor should investigate types of vocations for each truck class in EMFAC2011, and conduct a screening analysis of identifying truck vocational use types by the magnitude of NO_X emissions. Based on this screening analysis results, Tasks 2 and 3 will be conducted.

Task 2. Conduct truck travel diary survey, and quantify number of engine starts and soak time distribution

This task requests that the contractor conducts a truck travel diary survey, and quantifies the number of engine starts per day and soak time distribution per day for each truck use type by vocation. The contractor should conduct a truck travel diary survey to collect truck, engine and activity information for as many trucks as feasible. Table 1 shows the list of information that shall be included in a developed truck travel diary survey form.

Table 1. Information Included in Truck Travel Diary Survey

Vehicle and Engine Information	Vehicle and Engine Activity Information
Vocational use	Engine start time
Vehicle type	Engine stop time
Axle configuration	Trip purpose
Vehicle model year	Odometer reading at the first engine start
VIN number	Odometer reading at each engine stop
Vehicle weight	PTO use time (if applicable)
Engine make	

Engine size Engine model Engine model year	

Task 3. Collect ECU/OBD data and develop truck activity profiles for each truck use type by vocation

This task requests that the contractor collect instantaneous engine operation data and develop truck activity profiles for each vocational use. Instantaneous engine operation data can be acquired by engine control unit (ECU) or on-board diagnostic (OBD) data loggers, and should be collected on at least five trucks. As the contractor collects ECU/OBD data from a truck, it is required to collect vehicle and engine information from the truck and to conducta truck travel diary survey for the truck. In addition to ECU/OBD data, if applicable, it is suggested to collect vehicle position data by global positioning system (GPS), which are time-synchronized with ECU/OBD data. Table 2 shows vehicle and engine information, and ECU/OBD/GPS data to be collected in this task. The contractor should develop truck activity profiles, which include duty cycles, the number of starts per day and the soak time duration per day for each truck use type by vocation, by using the vehicle and engine information and ECU/OBD data, and conduct comparison analysis of the truck activity profiles to the truck diary survey results obtained from the task 2. If GPS data can be collected, the contractor should develop GPS data-based duty cycles and vehicle operation time and speed profiles by road facility type. GPS data-based duty cycles can be developed through a modal modeling concept such as physical emission rate estimator (PERE) applied to U.S. EPA motor vehicle emissions simulator (MOVES).

Table 2. Vehicle and Engine Information, ECU/OBD/GPS Data

Vehicle and Engine Information	ECU/OBD/GPS Data
Vocational use	Vehicle speed
Vehicle type	Engine horsepower
Axle configuration	Engine RPM
Vehicle model year	Fuel rate
VIN number	Exhaust temperature
Vehicle weight	Truck location (optional)
Engine make	
Engine size	
Engine model	
Engine model year	

Task 4. Analysis of the representativeness of the certification cycle to developed duty cycles for each vocational use

The contractor should conduct the analysis of the representativeness of the certification cycle by comparing to the duty cycles developed in Task 3 for truck use types by vocation. The contractor should deliver the difference between the certification cycle and the duty cycle with statistics including speed, travel duration, acceleration, deceleration and others.

APPENDIX A. EMFAC2011 T6 and T7 Diesel Vehicle Categories

Truck Category	Description
T6 Ag	Medium-Heavy Duty Diesel Agriculture Truck
T6 CAIRP heavy	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR>26000 lbs
T6 CAIRP small	Medium-Heavy Duty Diesel CA International Registration Plan Truck with GVWR<=26000 lbs
T6 instate construction heavy	Medium-Heavy Duty Diesel instate construction Truck with GVWR>26000 lbs
T6 instate construction small	Medium-Heavy Duty Diesel instate construction Truck with GVWR<=26000 lbs
T6 instate heavy	Medium-Heavy Duty Diesel instate Truck with GVWR>26000 lbs
T6 instate small	Medium-Heavy Duty Diesel instate Truck with GVWR<=26000 lbs
T6 OOS heavy	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR>26000 lbs
T6 OOS small	Medium-Heavy Duty Diesel Out-of-state Truck with GVWR<=26000 lbs
T6 Public	Medium-Heavy Duty Diesel Public Fleet Truck
T6 utility	Medium-Heavy Duty Diesel Utility Fleet Truck
T7 Ag	Heavy-Heavy Duty Diesel Agriculture Truck
T7 CAIRP	Heavy-Heavy Duty Diesel CA International Registration Plan Truck
T7 CAIRP construction	Heavy-Heavy Duty Diesel CA International Registration Plan Construction Truck

T7 NNOOS	Heavy-Heavy Duty Diesel Non-Neighboring Out-of-state Truck
T7 NOOS	Heavy-Heavy Duty Diesel Neighboring Out-of-state Truck
T7 other port	Heavy-Heavy Duty Diesel Drayage Truck at Other Facilities
T7 POAK	Heavy-Heavy Duty Diesel Drayage Truck in Bay Area
T7 POLA	Heavy-Heavy Duty Diesel Drayage Truck near South Coast
T7 Public	Heavy-Heavy Duty Diesel Public Fleet Truck
T7 Single	Heavy-Heavy Duty Diesel Single Unit Truck
T7 single construction	Heavy-Heavy Duty Diesel Single Unit Construction Truck
T7 SWCV	Heavy-Heavy Duty Diesel Solid Waste Collection Truck
T7 tractor	Heavy-Heavy Duty Diesel Tractor Truck
T7 tractor construction	Heavy-Heavy Duty Diesel Tractor Construction Truck
T7 utility	Heavy-Heavy Duty Diesel Utility Fleet Truck
PTO	Power Take Off

IV. DELIVERABLES

- Quarterly progress reports
- Final report
- All data and analyses generated through the course of this project

V. TIMELINE

It is anticipated this project will be completed in 24 months from the start date. Note that this allows 18 months for completion of all work through delivery of a draft final report; the last 6 months are for ARB and RSC review of the draft final report and delivery of a revised final report and data files to the ARB.