Oil Sands Heavy Haul Truck Emissions Measurement Study

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Environment Canada is conducting a study into emissions related to surface mining of oil sands. The emissions of interest for haul truck exhaust are: carbon dioxide (CO_2), carbon monoxide (CO), total hydrocarbons (THC), and nitrogen oxides (NOx). The particulate matter (PM) substances dispersed in the exhaust are also of interest to Environment Canada (ash particulates, metallic abrasion particles, sulphates, and silicates).

The goal is to be able to quantify the pollutants in specific emissions, that is, the average grams of each pollutant per kilowatt-hour over a typical duty cycle. A measurement system is currently being built that will measure all of the parameters to be able to find the specific emissions in real time. Previous studies have reported emissions over an interval of time, and so they have not been useful for determining what best operating practices would be to achieve production requirements while controlling emissions.

A system is under development to mount in a truck for monitoring emissions during regular operating activities. The intent is to put the measurement equipment in the cab or on the deck beside the cab, with a sample line running into the exhaust line. The only modification to the vehicle will be to drill and tap two small holes into the exhaust line and to run sampling tubes up from the exhaust to where the instruments are located. While some vehicle operating variables could be monitored by connecting to the on-board controller network to read specific codes from the engine module, this is not required in the current test plan.

The gas-phase emissions will be measured via two gas analysers. A Vetronix PXA-1100 will measure the carbon dioxide (CO_2), carbon monoxide (CO), oxygen (O_2), and total hydrocarbons (THC) of the exhaust gas. A sample line will be connected from the exhaust manifold to this device. A Horiba MEXA-720NOx will be used for the NO_X emissions, as well as the Air-to-fuel ratio. A NO_X sensor will be located within the exhaust, likely using the same sampling port.

Particulate matter will be measured in two ways: total mass, and particle size. The total mass of the particulates will be measured by using a filter that captures particles in all sizes down to nanoparticles. A cyclone placed before the filter will knock out particles of diameter greater than 1μm, as they have much shorter atmospheric residence times. Because a particle mass measurement system is physically unable to filter the total exhaust gas of mining truck, a sampling probe will capture a fraction of the total exhaust mass flow. This sample will be diluted by pre-filtered air at a controlled rate. The rate of dilution air will be regulated and be a function of the exhaust flow rate. The exhaust mass flow rate will be calculated using a Pitot tube, pressure transducer, and thermocouple in the exhaust manifold.

A second system will be used to measure the size distribution of particles sampled from the exhaust. A Cambustion DMS50 machine is able to measure the size distribution of particles sampled. The device can then count the number of particles measured at each size bin, and plot a distribution for each sample.

The total system will be mounted on the truck in a 19-inch rack. The system will be powered by a small gas generator which can be strapped to the deck. The system will be controlled by a small computer using MATLAB as the data acquisition software.

Installation of the system can likely be done in less than two hours with the assistance of two heavy-duty mechanics. After installation of the system on a truck, the system will begin recording and logging data at the beginning of a typical duty cycle, according to a test plan that will be approved in advance by the company that is operating the equipment. A researcher will ride along with the equipment to record observations of what activities are being done. (This information can be verified from the dispatching system.) The system will be stopped after a certain number of duty cycles are performed; and the data will be stored for analysis. The filter for the particulate mass will be measured on a micro-balance after each test. The number of tests and the truck type will be agreed to with the operating company. Test dates will be subject to availability of equipment. After testing is complete, the equipment can be removed in less than one hour, including capping the sample ports.

The results of the testing and analysis will be discussed in detail with the company that provides access to their equipment, to assist them to interpret the results for guiding operating practices. A summary of the study results will be published in late 2012 or early 2013.

Other than in-kind contributions, the company would have no costs. Direct costs will be covered by Environment Canada. Timing for the study would preferably be late Summer 2012.

If you are interested in participating in this study, or another study related to vehicle emissions, please contact Jason Olfert (780-492-2341, jason.olfert@ualberta.ca) or Mike Lipsett (780-492-9494, mlipsett@ualberta.ca).