

## **DRAFT GUIDANCE FOR IN-USE, ON-BOARD DATA COLLECTION FOR HYBRID OFF-ROAD EQUIPMENT EVALUATIONS**

### **Objective**

The ultimate data analysis objective is to be able to make meaningful comparisons between the new hybrid technology and the existing conventional diesel engine technology it is replacing. ARB staff understands that the collection and analysis of in-use data from off-road equipment for comparative purposes will present challenges, and the guidance below is written with this in mind.

### **Methods**

For the purposes of this program, in-use engine/equipment testing is considered essential, and proposals that do not propose some element in-use data collection, including emissions, will be considered to be non-responsive.

Data shall be collected (and ultimately reported) in units of both mass/time (e.g., g/hour), as well as brake-specific, mass/work-done units (e.g., g/bhp-hr). Calculation of overall and 'modal' (explained below) load factor is also a project deliverable.

All emissions and engine parameter data collected are project deliverables, and will be structured in an ARB-approved format, agreed upon before data collection.

The ideal comparison would be the 'base case' and hybrid, otherwise identical equipment (i.e., same engine size and manufacturer, hp rating, certification tier, etc.), operating simultaneously, side-by-side, but it is recognized that this is very unlikely to be the case.

Instead, it is expected that dissimilar data sets will be collected, and hence data collection and analytical methods must be structured such that selected portions of the total data collected can be analyzed. This is the reason for the requirement for real-time (i.e., second-by-second) data collection listed below.

While it is recognized and understood that the 'ideal' comparison cannot likely be made achieved, bidders should nevertheless strive to maximize similarities while minimizing differences.

For example, the same equipment category and broad hp rating should be compared, such as '175 hp excavators' (understanding that the '175 hp' category spans a range between 121 and 175 hp), comparative testing should occur at the same time and location, etc.

The ratings section outlines and describes the 'most responsive' test plan approach. Proposals able to satisfy all criteria will be awarded the maximum

possible score, with fewer points awarded in proportion to deviations from the 'most responsive' case.

#### Summary of Data Collection and Data Analysis Requirements

- Collection of real-time (1 Hz minimum) gaseous pollutant emissions data, including NO<sub>x</sub>, THC, CO and CO<sub>2</sub>.
- Collection of real-time (1 Hz minimum) PM emissions data.
- Collection of real-time engine parameter data (1 Hz minimum), including at a minimum engine speed, torque(s), and fuel delivery rate, ideally, collected from the on-board engine electronic control unit.
- Collection of ambient data such as ambient temperature, humidity, barometric pressure, and other ambient conditions such as wind speed, precipitation, etc.
- Collection, analysis and reporting of equipment activity data for the candidate equipment type(s) for a period of approximately one month of usage during the peak of the usage season. Values should be comparable to ARB off-road emissions inventory annual hours of use for the candidate equipment category. Collection, analysis and reporting of these data would precede emissions testing.
- Based on previously analyzed equipment activity data (see bullet above), collection of at least ten hours of emissions and activity data each, for the 'base case' and hybrid equipment, utilizing duty cycles representative of the previously-determined activity patterns, load factors, etc.
- Ideally, during emissions testing, different types of equipment operations will be distinguished from each other (e.g., idling, trenching, moving materials, etc.). This would require an observer to record information and data about the different operations (e.g., using a video recording) that could then be paired with emissions data to aid in subsequent data analyses.
- Utilization of ARB staff approved portable emissions measurement systems (PEMS) - candidate instruments should be Code of Federal Regulations (CFR) Part 1065 compliant, or equivalent.
- Calculation and reporting of overall gaseous and PM emissions in units of g/hour for the 'base case' and hybrid.
- Calculation and reporting of overall gaseous and PM emissions in units of g/bhp-hr for the 'base case' and hybrid.
- Calculation and reporting of gaseous and PM emissions in units of g/hour for 'similar' engine/equipment activity for the 'base case' and hybrid ('similar' engine/equipment activity will be defined based on a parameter such as engine load factor).
- Calculation and reporting of gaseous and PM emissions in units of g/bhp-hr for 'similar' engine/equipment activity for the 'base case' and hybrid ('similar' engine/equipment activity will be defined based on a parameter such as engine load factor).
- Preparation and submission to ARB staff a detailed emissions sampling test plan that must be approved by ARB staff prior to beginning emissions testing.