



Quality Control/Quality Assurance Plan for Characterizing Vehicular Contributions to PM_{2.5} in Fairbanks

prepared for:

Alaska Department of Environmental Conservation

2010 and 2011

prepared by:

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**QUALITY CONTROL/QUALITY ASSURANCE PLAN FOR
CHARACTERIZING VEHICULAR CONTRIBUTIONS TO PM_{2.5}
IN FAIRBANKS**

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1. SUMMARY

1.1 Scope of this Plan

This quality control/quality assurance plan applies to test procedures, calibration procedures, and data collection procedures relevant to motor vehicle exhaust emissions tests conducted for the Alaska Department of Environmental Conservation (“DEC”) by Sierra Research as part of “Characterizing Vehicular Contributions to PM_{2.5} in Fairbanks” in 2010/2011 at Fairbanks North Star Borough’s (FNSB’s) Cold Temperature Vehicle Emissions Test Facility in Fairbanks, Alaska (“the facility”). The QC/QA plan is intended to cover: (1) measurements and determinations of the effects of ambient temperatures and block heater usage on mass emissions of PM_{2.5} and specified gaseous pollutants based on chassis dynamometer testing with dilute exhaust sampling, and (2) measurements and determinations of PM_{2.5} and CO₂ concentrations and their ratio as related to “plume following.”

1.2 Organization of the Plan

Following this summary, section 2 discusses quality assurance policy and responsibility; section 3 discusses quality assurance goals; section 4 discusses sampling, analysis, and calibration procedures; section 5 discusses data reduction, validation, and reporting; section 6 describes internal checks and corrective actions; and section 7 discusses operation and maintenance. References cited throughout this document are listed in Section 8.

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2. QUALITY ASSURANCE POLICY AND RESPONSIBILITY

2.1 Commitment to Quality Assurance

Sierra Research will devote all resources necessary* to ensure that the test data developed and reported as a result of its operation of the test facility meets the standards of precision and accuracy that are generally accepted in the emissions testing industry.

2.2 Quality Assurance Policy

It is the policy of Sierra Research, Inc. to ensure that all services performed for clients and all test data furnished to clients conform to specified requirements of applicable codes, regulations, standards and contracts, and to good engineering practice.

2.3 Quality Assurance Authority and Responsibility

Sierra's overall approach to data quality assurance relies upon: (1) knowledgeable and experienced test personnel who are assigned a high level of authority for testing and responsibility for data integrity; (2) an in-depth knowledge of the measurement system and the Fairbanks test facility; (3) a thoughtful study design, including carefully prescribed procedures for testing and record-keeping; and (4) a thorough technical review of data and computations.

Sierra maintains a library of current testing procedures and practices, and each responsible test engineer at Sierra is familiar with 40CFR86 and other specifications for commonly performed vehicle exhaust emissions tests. In addition, Sierra test engineers and project managers are very familiar with those factors^{†,1,2,3} that give rise to variation in test results, and are committed to designing and executing studies that minimize undue testing variability.

In Sierra's work for ADEC, at least one experienced test engineer or Qualified Environmental Professional (QEP) will be responsible for and directly participate in

* DEC's Request for Proposals for the subject research effort provided, and Sierra's response assumed, that elements of the project would use certain DEC equipment and Fairbanks North Star Borough test facilities and staff (i.e. resources outside of Sierra's control). Contingencies are specified in our resulting mutual agreement, and nothing in this report is intended to modify that agreement.

† Superscript numbers denote references provided in Section 8.

every laboratory function, including calibration and setup, test execution, and data reduction.

To help ensure rigorous test procedures, Sierra has developed and will rely upon standard operating procedures⁴ (SOPs) for the operation of the facility's dynamometer and analytical bench; for its dynamometer-based driving; and for daily service and diagnostic activities performed by the project's technician. Detailed test conditions and test results are recorded in laboratory and technician's test logs, along with the initials of the responsible test engineers and technician. The name(s) of all the technical personnel that conducted testing are also documented with test results in Sierra's final reports.

The draft test report from each project is reviewed for accuracy, precision, and completeness by the Laboratory Director, a QEP certified by the Institute of Professional Environmental Practice (IPEP),* and by a Sierra Research Senior Partner. This quality assurance review certifies the reliability of the test data to within the accuracy and precision targets for the laboratory, based on conformance of the laboratory's testing procedures to generally accepted practices and to the testing specifications that Sierra has committed to the client to follow. This review also reflects an in-depth knowledge of standardized test procedures and the specifications and performance of Sierra's test equipment, plus familiarity with the project's objectives.

To provide a final assurance of data quality, all laboratory test reports produced by Sierra are, prior to release as draft or final reports, reviewed by one or more Senior Partners. This level of review ensures that the final work product, including all data collected and any analysis performed, meets the company's standards for technical excellence.

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* The IPEP is the independent, not-for-profit certifying organization for the QEP and the Environmental Professional Intern certifications. IPEP's objectives are "to improve the practice and educational standards of environmental professionals and to administer the QEP and EPI application, examination, and certification process." IPEP, One Gateway Center, Third Floor, Pittsburgh, PA, 15222.

3. QUALITY ASSURANCE GOALS FOR MEASUREMENTS AND DATA

This section discusses Sierra's QA goals in terms of measurement precision and accuracy, and data completeness. Terms are defined, procedures are explained, and a detailed table presents equipment specifications.

3.1 Overall Goal

Sierra's overall QA goal is to provide the most complete data and best measurement precision and accuracy possible using well-operated and high quality laboratory equipment, high quality calibration gases, and rigorous test procedures.

3.2 Definitions

Measurement Precision – Measurement precision, as used here, means repeatability of measurements.

Measurement Accuracy – Accuracy, as used here, means absence of bias in measurements or, where specified, sensitivity.

Data Completeness – Data completeness, as used here, means the ratio of the amount of valid data obtained to the total amount of data expected to be obtained in the test plan for the project, and is expressed as a percentage. Data completeness is determined for each project on the basis of the entire series of tests planned.

3.3 Routine Procedures Used to Assure Consistency in Measurement Precision and Accuracy and in Data Completeness

Testing will be performed as specified in the Sierra Technical Proposal and/or Vehicle Test Program Plan for this project. Test data will be studied for trends, or similarities to previous experience. Means and standard deviations will be calculated as appropriate. If a particular test or segment of data appears to be an outlier, the test will be repeated where possible, identified and qualified (i.e. "flagged") as appropriate, or excluded from the analysis as appropriate. If required by the Test Program Plan, Sierra will employ the

SAS⁵ statistical package to determine relationships among emissions variables and test parameters, whether they were intentionally varied or not.

Variability in driver behavior on the dynamometer can be a significant source of test-to-test variability in emissions.⁶ Accordingly, Sierra will rely upon experienced dynamometer drivers for its testing to the extent practicable, and on the use of standard operating procedures for the drivers in order to help ensure consistent operation. Dynamometer roll speed that is recorded for each test will be evaluated, in accordance with 40CFR86, Appendix I, to determine how closely it follows the target speeds. Depending upon the test plan, significant departures from the target drive can be cause for flagging or invalidating, and/or (where practicable) rerunning a test.

3.4 Precision and Accuracy of Measurement Equipment

The manufacturers' specifications for precision and accuracy of the major items of equipment that are used in FNSB's laboratory and plume following are documented elsewhere^{7,8,9,10,11,12,13}.

For gas mixing ratio measurements, overall measurement accuracy and precision are dependent upon not only instrument capabilities, but also the quality of the gases used for calibration and calibration procedures, both of which are discussed in Chapter 4.

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4. SAMPLING, ANALYSIS, AND CALIBRATION PROCEDURES

4.1 Dynamometer-Based Emissions Measurement

The cold temperature test facility in Fairbanks has the capability to measure those data required to compute integrated (filter-based) PM_{2.5} concentrations by test phase, second by second concentrations of PM_{2.5}, and mixing ratios of carbon monoxide (CO), total hydrocarbons (THC), carbon dioxide (CO₂), and nitrogen oxides (NO_x). More particularly, as designed and operated by Sierra, the system consisting of the RealTime dynamometer, Horiba IM240 system, TSI DustTrak, Thermo Fisher Scientific DataRAM4000, Sartorius balance system, and all appurtenances can measure and record the following:

- Test time
- Phase
- CVS Flow Rate
- Roll Speed and Distance
- HC, NO_x, CO, and CO₂ grams and mixing ratios
- PM_{2.5} second by second mass concentrations by DataRAM4000 and by DustTrak II and phase-integrated mass concentrations by filter measurement

4.2 Plume Following Concentration Measurements

The plume following vehicle has the capability to record the following:

- Time and date-stamped second by second data;
- On-road PM_{2.5} concentrations (by DataRAM4) and CO₂ mixing ratios (by LICOR Model 820);
- Vehicle speed and position by GPS;
- On-road Temperature;
- Selected manual data entry information; and
- Audio and/or video recorded information.

4.3 Data Custody

Sierra's laboratory data collection procedures rely upon both automated and, where necessary, manual data entry. For each test, the responsible engineer completes a test

log, which identifies and describes the test vehicle, conditions of the test (including vehicle preconditioning), and background where applicable. The responsible personnel's certification documents the authenticity of these data.

In addition to manual recording of certain test data (and as noted earlier), Sierra normally collects second-by-second data in an automated fashion using a data-logging program. These computer-readable data are, on the same day of collection, compressed and copied both to a portable non-volatile memory device ("thumb drive" as required), and to Sierra's in-house computer system, where they are incrementally archived every weeknight. Original data on the data logging PC are also stored on a PC's (nonvolatile) hard disk.

For the Sartorius balance operation, filter chamber environmental measurements, verification of weight standards, and weight of filters are recorded on a regular basis, consistent with good engineering practice.

For plume following, data collection is performed by FNSB staff under Sierra direction, with training provided by Sierra.

4.4 Calibration Gases

Sierra has specified compressed gases for the facility that conform to Horiba's and LICOR's specifications for all gas analyzers (see reference 8 and 13).

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5. DATA REDUCTION, VALIDATION, AND REPORTING

For each project, all emissions test data and computations are handled directly by a test engineer or by Sierra's Laboratory Director. Results from each test are reviewed by at least one knowledgeable professional who was not directly involved in the testing. Review of the data includes examination of more detailed information than is normally included in final emission testing reports.

Unlike some other CVS testing laboratories, Sierra routinely operates the test facility and collects data in such a manner as to produce modal (second-by-second) test data in addition to integrated results (averaged over the entire test).

Draft reports of test results are prepared by the test engineer or project engineer. Unless otherwise requested, test reports contain only essential information about the conditions of the test and results.

Prior to distribution, draft test reports are reviewed by at least one knowledgeable professional—either the Laboratory Director, a Senior Partner, or a Qualified Environmental Professional (QEP) certified by the Institute of Professional Environmental Practice.

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6. INTERNAL CHECKS AND CORRECTIVE ACTION

A high degree of test automation and (where practical) redundant data collection, along with detailed standard operating procedures, assist test personnel in ensuring the reliability and high capture rate of emissions-related data.

In addition to automated checks, the results from every test conducted by Sierra in the test facility are reviewed by at least one professional that was not involved in performing the test. Separate quality assurance reports produced for each test will assist the test engineer and the professional reviewing the test results in assessing the validity of the test. If it is determined in consultation with the test engineer that the result is invalid, it will be deleted; otherwise, the test result will be reported.

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7. OPERATION AND MAINTENANCE

As a general principle, all Sierra-owned equipment used by Sierra for emissions testing for DEC is operated and maintained in accordance with good engineering practice in order to ensure the optimal accuracy, reliability, and completeness of measurements. In the case of equipment owned by DEC or FNSB, Sierra will make all reasonable efforts, consistent with contractual agreement with DEC, to ensure likewise that equipment is maintained in accordance with good engineering practice in order to ensure the optimal accuracy, reliability, and completeness of measurements.

7.1 Chassis Dynamometer

The chassis dynamometer is maintained consistent with the manufacturer's recommended procedures. Parasitic losses are checked after every dynamometer warm-up and are revised as required.* Dynamometer roll speed at 50 mph (nominal setting of the dynamometer controller) is independently checked using a Strobotachometer prior to the start of each project.

7.2 Constant Volume Sampling (CVS) System

Continuous dilution sample lines to the analyzer contain in-line filters both upstream and downstream of the sample pump. These filters, which protect the analyzers from excessive plugging, are checked regularly and replaced when necessary.

The CVS system flow is checked by propane injection before and after each testing project, to the extent feasible and consistent with project requirements.

7.3 Gas Analyzers and Analytical Bench

For the CVS system, gas analyzers are zeroed and spanned immediately prior to testing each day, and at least once for every 4-6 hours of testing. Analyzer calibrations are, consistent with 40CFR86, checked not more than one month before the start of every project using a gas divider and ten-point calibration, and are recalibrated as necessary.

* These functions are performed in an automated fashion by Realtime software.

Comparable specifications do not yet exist for plume following, which is an emerging field of environmental measurement. The plume following gas analyzer is zeroed and spanned prior to each drive.

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8. REFERENCES

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