AIR HYGIENE INTERNATIONAL, INC.

STANDARD OPERATION PROCEDURES FOR COMBUSTION ENGINE TESTING

Parameters/Pollutants include:
QA/QC = EPA Method 6c
Oxygen = EPA Method 3a
NOx = EPA Method 7e (20 for turbines)
CO = EPA Method 10
Exhaust Flow = EPA Method 19

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INSTRUMENT CONFIGURATION AND OPERATIONS FOR GAS ANALYSIS

The sampling and analysis procedures used during tests conform in principle with the methods outlined in the Code of Federal Regulations, Title 40, Part 60, Appendix A, Methods 3a, 6c, 7e, 10, 19, and 20 (turbines NOx & Oxygen).

The following flowchart depicts the sample system used for NOx, CO, and O_2 tests. A heated stainless steel probe is inserted into the sample ports of the stack to extract gas measurements from the emission stream. The gas sample is continuously pulled through the probe and transported via 3/8 inch heat-traced Teflon® tubing to a stainless steel minimum-contact condenser designed to dry the sample and through Teflon® tubing via a stainless steel/Teflon® diaphragm pump and into the sample manifold within the mobile laboratory. From the manifold, the sample is partitioned to the NOx, CO, and O_2 analyzers through glass and stainless steel rotameters that control the flow rate of the sample.

The attached flowchart shows that the sample system is also equipped with a separate path through which a calibration gas can be delivered to the probe and back through the entire sampling system. This allows for convenient performance of system bias checks as required by the testing methods.

All instruments are housed in an air-conditioned trailer (or van)-mounted mobile laboratory. Gaseous calibration standards are provided in aluminum cylinders with the concentrations certified by the vendor. EPA Protocol No. 1 is used to determine the cylinder concentrations where applicable (i.e. NO_x calibration gases).

Table 1 provides a description of the analyzers used for the instrument portion of the tests. All data from the continuous monitoring instruments are recorded on a Logic Beach Hyperlogger which retrieves calibrated electronic data from each instrument every 1 second and reports an average of the collected data every 30 seconds.

The number of test runs, test loads, and length of runs is based upon federal and state requirements for the facility. Typically, three test runs of at least 20 minutes each are performed on the source in the as-found operating condition.

The stack gas analysis for O_2 concentrations is performed in accordance with procedures set forth in EPA Method 3a. The O_2 analyzer uses a paramagnetic cell detector.

EPA Method 7e is used to determine concentrations of NO_x. A chemiluminescence analyzer is used to determine the nitrogen oxides concentration in the gas stream.

CO emission concentrations are quantified in accordance with procedures set forth in EPA Method 10. A continuous nondispersive infrared (NDIR) analyzer is used for this purpose.

TABLE 1
ANALYTICAL INSTRUMENTATION

Parameter	Model & Manufacturer	Max. Range	Sensitivity	Response Time (sec.)	Detection Principle
NOx	API 200AH API 200 Thermo 42H	User may select any range up to 5,000 ppm	0.1 ppm	30	Thermal reduction of NO_2 to NO Chemiluminescence of reaction of NO with O_3. Detection by PMT. Inherently linear for listed ranges.
CO	API 300 Thermo 48 Thermo 48C	User may select any range up to 5,000 ppm	0.1 ppm	30	Infrared absorption, gas filter correlation detector, microprocessor based linearization.
O_2	CAI Model 300 Servomex 1400	0-10% or 0-25%	0.1%	10	Paramagnetic cell, inherently linear.

Emission Calculations

Stack Gas Flow Rate via EPA Method 19 (F-Factor)

Q_f = fuel flow (SCFH)
F_{BTU} = high heating value of gas - dry (Btu/SCF)
F = F factor (SCF/MMBTU)
O_2 = concentration of O_2 (%)

Qd = stack flow rate on dry basis at standard conditions (SCFH)
= $Q_f \times F_{BTU} \times 10^{-6} \times F \times 20.9 / (20.9 - CO_2)$

NO_x Mass Emission Rate Calculations

NO_x = corrected concentration of NO_x (ppmvd)
MW = 46.01 lb/lb-mole
for ideal gas, 385.322 SCF = 1.0 lb/mole

Qd = SCFH (from EPA Method 19 flow data)
E_{NOx} = mass emission rate of NO_x (lb/hr)
= $NO_x \times 10^{-6} \times Qd \times MW / 385.322$
E_{NOx} = mass emission rate of NO_x (ton/yr)
= NO_x (lb/hr) x 8760 (hr/yr)/2000 (lb/ton)

CO Mass Emission Rate Calculations

CO = corrected concentration of CO (ppmvd)
MW = 28 lb/lb-mole
Use same formula as for NO_x mass emission rates

Qd = SCFH (from EPA Method 19 flow data)
E_{CO} = mass emission rate of CO (lb/hr)
= $CO \times 10^{-6} \times Qd \times MW / 385.322$
E_{CO} = mass emission rate of CO (ton/yr)
= CO (lb/hr) x 8760 (hr/yr)/2000 (lb/ton)

Turbines Only

NOx Adjustment to 15% Oxygen

NOx @ 15% O_2 = NOx measured (ppm) x (5.9/(20.9 – O_2% measured))

NOx Concentration @ 15% Oxygen and ISO Standard Day Conditions

NOx (EPA Corrected): Predicted NOx emission concentration at ISO Conditions & 15% Oxygen
NOx @ 15% O_2: Predicted NOx concentrations with 15% Oxygen in the exhaust
P_{ref}: Absolute pressure (psia) at combuster inlet (PCD) at 29.95 in.Hg ambient pressure
P_{obs}: Gauge pressure (psig) at combuster inlet (PCD) at ambient pressure test conditions
in. Hg: Atmospheric pressure at test conditions
H: Ambient specific humidity at test conditions (lbs moisture/lb dry air)
T: Ambient temperature at test conditions (°F)
Standard ISO Day Conditions: Temperature = 519 °R
Humidity = 0.00633 lbs/lbs dry air
Pressure = 29.92 in. Hg

$NOx = (NOx @15\% O_2) \times (P_{ref}/((in.Hg/2.036) + P_{obs})^{0.5} \times 2.718^{(19 \times (H - 0.00633))} \times (519/(460 + T)^{1.53}$

ENGINE QUALITY ASSURANCE PROGRAM SUMMARY

Air Hygiene Incorporated ensures the quality and validity of its emission measurement and reporting procedures through a rigorous quality assurance (QA) program. The program is developed and administered by an internal QA team and encompasses five major areas:

1. QA reviews of reports, laboratory work, and field testing;
2. Equipment calibration and maintenance;
3. Chain-of-custody;
4. Training; and
5. Knowledge of current test methods.

QA Reviews

Air Hygiene Incorporated's review procedure includes review of each source test report, along with laboratory and fieldwork, by the QA Team.

The most important review is the one that takes place before a test program begins. The QA Team works closely with technical division personnel to prepare and review test protocols. Test protocol review includes selection of appropriate test procedures, evaluation of interferences or other restrictions that might preclude use of standard test procedures, and evaluation and/or development of alternate procedures.

Equipment Calibration and Maintenance

The equipment used to conduct the emission measurements is maintained according to the manufacturer's instructions to ensure proper operation. In addition to the maintenance program, calibrations are carried out on each measurement device according to the schedule outlined by the Environmental Protection Agency. Quality control checks are also conducted in the field for each test program.

Chain-of-Custody

Air Hygiene Incorporated maintains full chain-of-custody documentation on all samples and data sheets. In addition to normal documentation of changes between field sample custodians, laboratory personnel, and field test personnel, Air Hygiene Incorporated documents every individual who handles any test component in the field (e.g., probe wash, impinger loading and recovery, filter loading and recovery, etc.). Samples are stored in a locked area to which only Air Hygiene Incorporated personnel have access. Field data sheets are secured at Air Hygiene Incorporated's offices upon return from the field.

Training

Personnel's training is essential to ensure quality testing. Air Hygiene Incorporated has formal and informal training programs, which include:

1. Attendance at EPA-sponsored training courses;
2. Enrollment in EPA correspondence courses;
3 A requirement for all technicians to read and understand Air Hygiene Incorporated's QA manual;
4. In-house training and QA meetings on a regular basis; and
5. Maintenance of training records.

Knowledge of Current Test Methods

With the constant updating of standard test methods and the wide variety of emerging test procedures, it is essential that any qualified source tester keep abreast of new developments. Air Hygiene Incorporated subscribes to services, which provide updates on EPA reference methods, rules, and regulations. Additionally, source test personnel regularly attend and present papers at testing and emission-related seminars and conferences. Air Hygiene Incorporated personnel maintain membership in the Air and Waste Management Association and the American Industrial Hygiene Association.

ENGINE TESTING QUALITY ASSURANCE ACTIVITIES

A number of quality assurance activities are undertaken before, during, and after engine testing projects. This section describes each of those activities.

Each instrument's response is checked and adjusted in the field prior to the collection of data via multi-point calibration. The instrument's linearity is checked by first adjusting its zero and span responses to zero nitrogen and an upscale calibration gas in the range of the expected concentrations. The instrument response is then challenged with other calibration gases of known concentration and accepted as being linear if the response of the other calibration gases agreed within ± 2 percent of range of the predicted values.

NO2 to NO conversion is checked via direct connect with a EPA Protocol certified concentration of NO2 in a balance of nitrogen. Conversion is verified to be above 90%.

Instruments are both factory tested and periodically field challenged with interference gases to verify the instruments have less than a 2% interference from CO_2, SO_2, CO, NO, and Oxygen.

After each test run, the analyzers are checked for zero and span drift. This allows each test run to be bracketed by calibrations and documents the precision of the data collected. The criterion for acceptable data is that the instrument drift is no more than 3 percent of the full-scale response. Quality assurance worksheets summarize all multipoint calibration linearity checks and the zero to span checks performed during the tests are included in the test report.

The sampling systems is leak-checked by demonstrating that a vacuum greater than 10 in Hg can be held for at least 1 minute with a decline of less than 1 in. Hg. A leak test is conducted after the sample system is set up and before the system is dismantled. This test is conducted to ensure that ambient air does not dilute the sample. Any leakage detected prior to the tests is repaired and another leak check conducted before testing will commence.

The absence of leaks in the sampling system is also verified by a sampling system bias check. The sampling system's integrity is tested by comparing the responses of the analyzers to the responses of the calibration gases introduced via two paths. The first path is directly into the analyzer and the second path via the sample system at the sample probe. Any difference in the instrument responses by these two methods was attributed to sampling system bias or leakage. The criterion for acceptance is agreement within 5% of the span of the analyzer.

The control gases used to calibrate the instruments are analyzed and certified by the compressed gas vendors to ± 1% accuracy for all gases. EPA Protocol No. 1 is used, where applicable, to assign the concentration values traceable to the National Institute of Standards and Technology (NIST), Standard Reference Materials (SRM's). The gas calibration sheets as prepared by the vendor are included in the test report.