U.S. Environmental Protection Agency
Environmental Technology Verification Program
Advanced Monitoring Systems Center

and

The Canadian Environmental Technology Verification Program

Joint Test/QA Plan for Verification of Airborne Leak Detection Systems

JOINT TEST/QA PLAN

for

Verification of Airborne Leak Detection Systems

Version 1.0

September 30, 2010

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This joint verification test/quality assurance plan was developed through a collaboration between the Environmental Technology Verification (ETV) programs of the United States and Canada and is intended for use by both Canada and the United States either individually or together in jointly verifying technologies which will be recognized by both countries. This joint plan can also be used by a vendor who would like to receive verification from either or both countries.

VENDOR APPROVAL PAGE

U.S. EPA ETV Advanced Monitoring Systems Center

and

ETV Canada

Test/QA Plan for Verification of
Airborne Leak Detection Systems

Version 1.0

September 30, 2010
APPROVAL:

Name ________________________________

Company _____________________________

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Disclaimer

The U.S. Environmental Protection Agency, through its Office of Research and Development, partially funded, managed, and collaborated in the research described herein. It has been subjected to the Agency's peer and administrative review. Any opinions expressed in this report are those of the author(s) and do not necessarily reflect the views of the Agency, therefore, no official endorsement should be inferred. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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ABBREVIATIONS/ACRONYMS

ADQ	audit of data quality
AMS	Advanced Monitoring Center
DQI	data quality indicator
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
ETV	Environmental Technology Verification
FID	flame ionization detection
GFCR	Gas-Filter Correlation Radiometry
GPS	global positioning system
GVP	General Verification Protocol
LEL	lower explosive limit
LRB	laboratory record book
m	meter
NIST	National Institute of Standards and Technology
nm	nanometer
PEA	performance evaluation audit
QA	quality assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QC	quality control
QMP	Quality Management Plan
RMOTC	Rocky Mountain Oilfield Testing Center
scfh	standard cubic feet per hour
Tg	terragrams
TQAP	test/quality assurance plan
TSA	Technical systems audit
VTC	Verification Test Coordinator

SECTION A

PROJECT MANAGEMENT

A1 VERIFICATION TEST ORGANIZATION

This test/quality assurance plan (TQAP) describes specific procedures for the performance of a joint verification test of airborne leak detection technologies for the inspection of natural gas pipelines. The verification test described in this document will be conducted under the United States Environmental Protection Agency (EPA) Environmental Technology Verification (ETV) Program and the Canadian ETV Program. The verification test will be coordinated and directed jointly by Battelle and ETV Canada. The intent is for the results of this test to be recognized by both the U.S. and Canadian ETV programs. This TQAP reflects the requirements of a U.S. EPA Quality category III project.

Testing will be performed at the Rocky Mountain Oilfield Testing Center (RMOTC) and involve a field testing campaign under potentially challenging measurement conditions. As described in this TQAP, testing will involve manned flights over a predefined virtual pipeline that includes a number of intentional natural gas leaks that will serve as targets for the leak detection technologies. Ground-based measurements will confirm the rates and geospatial coordinates of the leaks as well as provide estimates of airborne concentrations of natural gas (ethane/methane) in the vicinity of the leaks. Meteorological measurements will be recorded to establish conditions during testing.

The ETV Advanced Monitoring Systems (AMS) Center will facilitate the necessary reviews and audits, coordinate stakeholders and quality assurance (QA) personnel, develop the TQAP, lead the testing activities, and prepare the verification reports and statements. This role will provide the necessary oversight for the U.S. ETV program to ensure a quality process of evaluation, data collection, and reporting for this project. ETV Canada will facilitate the necessary activities by Environment Canada program management, stakeholders, and QA personnel including reviews of the TQAP and the verification reports and statements, and audit of the testing activities. This will provide the necessary oversight for the Canadian ETV program to ensure a quality process of evaluation, data collection, and reporting. QA oversight will be provided jointly by the Battelle AMS Center Quality Manager and the ETV Canada

Quality Assurance Manager (QAM). Additional QA oversight will be provided by the EPA AMS Center Quality Manager at her discretion.

The organization chart in Figure 1 identifies the responsibilities of the organizations associated with the verification test. Roles and responsibilities are defined further below.

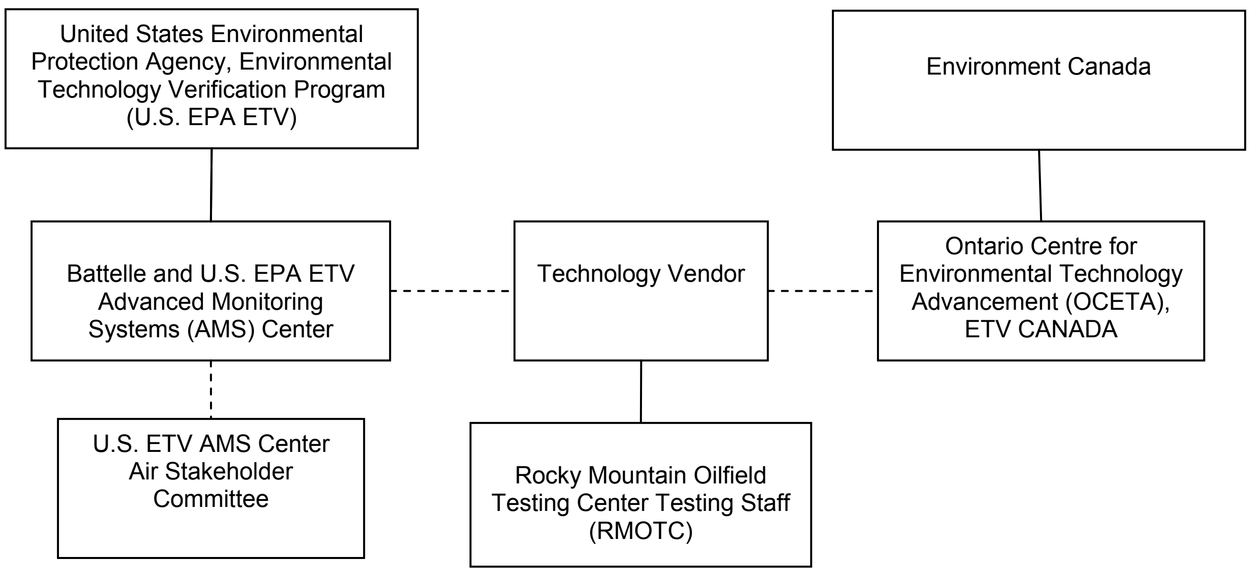

Figure 1. Organizational Chart

A1.1 Battelle

Dr. Kenneth Cowen is the AMS Center Verification Test Coordinator (VTC) for this test. In this role, Dr. Cowen will have overall responsibility for ensuring that the technical, schedule, and cost goals established for the verification test are met. Specifically, he will:

- Serve as the primary point of contact for vendor representatives and collaborators;
- Hold a kick-off meeting approximately one week prior to the start of the verification test to review the critical logistical, technical, and administrative aspects of the verification test;
- Be responsible, or assign responsibility, for each aspect of the verification test;
- Direct the team (Battelle testing staff and vendors) in performing the verification test in accordance with this TQAP;

- Ensure that all quality procedures specified in the TQAP and in the AMS Center Quality Management Plan[1] (QMP) are followed;
- Maintain real-time communication with the Battelle AMS Center Manager and EPA AMS Center Project Officer and QAM on any potential or actual deviations from the TQAP;
- Coordinate with testing staff to ensure that the planned testing will not interfere with the test site operations;
- Provide test data, including data from the first day of testing, to the Battelle AMS Center Manager and EPA AMS Center Project Officer and QAM;
- Prepare the draft and final TQAP, verification report(s), and verification statement(s);
- Conduct a technical review of all test data. Designate an appropriate Battelle technical staff member to review data generated by the VTC;
- Revise the draft TQAP, verification report(s), and verification statement(s) in response to reviewers' comments;
- Respond to any issues raised in assessment reports and audits, including instituting corrective action as necessary;
- Serve as the primary point of contact for vendor representatives and collaborators;
- Coordinate distribution of the final TQAP, verification report(s), and statement(s); and
- Establish a budget for the verification test and manage staff to ensure the budget is not exceeded.

<u>Ms. Amy Dindal</u> is Battelle's manager for the AMS Center. Ms. Dindal will:

- Review the draft and final TQAP;
- Review the draft and final verification report(s) and verification statement(s);
- Ensure that necessary Battelle resources, including staff and facilities, are committed to the verification test;
- Ensure that confidentiality of sensitive vendor information is maintained;
- Maintain communication with EPA's AMS Center Project Officer and Quality Manager; and

- Facilitate a stop-work order if Battelle or EPA QA staff discover adverse findings that will compromise data quality or test results.

Ms. Rosanna Buhl is Battelle's Quality Manager for the AMS Center. Ms. Buhl will:

- Review the draft and final TQAP;
- Assign a Quality Assurance Officer (QAO) for this verification test;
- Delegate to other Battelle quality staff any QAO responsibilities assigned below as needed to meet project schedules;
- Review any audit checklists prepared by the QAO for completeness and detail;
- Review draft and final audit reports prior to release to the VTC and/or EPA for clarity and appropriate assessment of findings;
- Review audit responses for appropriateness;
- Review and approve TQAPs and deviations;
- Review draft and final verification report(s) and verification statement(s);
- Maintain real-time communication with the QAO on QA activities, audit results, and concerns;
- Work with the QAO, VTC, and Battelle's AMS Center Manager to resolve data quality concerns and disputes; and
- Recommend a stop-work order if audits indicate that data quality or safety is being compromised.

A1.2 ETV Canada

During this joint verification test, John Neate of ETV Canada will:

- Provide a person from ETV Canada to be the point of contact for Battelle and the vendors;
- Provide input, review, and comment on the TQAP, Verification Report, Verification Statement, and other documents pertaining to verification of the vendor technologies;

- Coordinate review of the TQAP, Verification Report, Verification Statement, and other documents pertaining to verification of the vendor technologies with Environment Canada and Canadian expert reviewers as needed;
- Participate in a (virtual) joint kick-off meeting, led by Battelle prior to test initiation;
- Inform Environment Canada of the final TQAP, Verification Report, including the Verification Statement; and
- Comply with all quality procedures and program requirements specified in the TQAP, and ETV Canada General Verification Protocol (GVP)[2], as follows:
    - Review the TQAP;
    - Review test data;
    - Provide summary of review; and
    - Conduct on-site field audit.

A1.3 Vendors

The responsibilities of the airborne leak detection system vendors are as follows:

- Review and provide comments on the draft TQAP;
- Approve the final TQAP prior to test initiation;
- Provide a complete leak detection system for evaluation during the verification test;
- Provide all other equipment/supplies/reagents/consumables needed to operate their leak detection system for the duration of the verification test;
- Supply a representative to operate and maintain their technology, including the airborne platform, during the verification test;
- Provide the data from the vendor's leak detection system to the Battelle field testing staff at the end of each day of testing; and
- Review and provide comments on the draft Verification Report and Statement for their leak detection system.

A1.4 EPA

EPA's responsibilities in the AMS Center are based on the requirements stated in the U.S. ETV Program QMP.[3] The roles of specific EPA staff are as follows:

Michelle Henderson is the EPA AMS Center QAM. For the verification test, Ms. Henderson will:

- Review the draft and approve the final TQAP;
- Attend the verification kickoff meeting, as available;
- Review checklists, reports, report responses, and closure statements of the technical systems audit (TSA), performance evaluation audit (PEA), and audits of data quality (ADQs) conducted by Battelle and/or ETV Canada;
- Perform at her option an external TSA of testing activities, and/or an ADQ during the verification test;
- Notify the EPA AMS Center Project Officer of the need for a stop-work order if evidence indicates that data quality is being compromised;
- Prepare and distribute an assessment report summarizing results of the external audit performed;
- Review the first day of data from the verification test and provide immediate comments if concerns are identified; and
- Review the draft and approve the final Verification Reports and Verification Statements.

John McKernan is EPA's Project Officer for the AMS Center. Dr. McKernan will:

- Review the draft TQAP;
- Approve the final TQAP;
- Attend the verification kickoff meeting, as available;
- Be available during the verification test to authorize any TQAP deviations by phone and provide the name of a delegate to the Battelle AMS Center Manager should he not be available during the testing period. Review the first day of data from the verification test and provide immediate comments if concerns are identified;
- Review the draft verification reports and verification statements;
- Oversee the EPA review process for the TQAP, verification reports, and verification statements;
- Coordinate the submission of Verification Reports and Verification Statements for final EPA approval; and
- Post the TQAP, Verification Reports, and Verification Statements on the ETV Web site.

A1.5 Environment Canada

The Canadian ETV program is delivered by ETV Canada under a license agreement from Environment Canada. ETV Canada will consult with Environment Canada as required.

A1.6 RMOTC

RMOTC will provide field testing sites for this verification and will coordinate access to these sites by testing personnel, vendor representatives, and subcontractors. Specifically, RMOTC staff will:

- Ensure the Battelle testing staff, the vendors, and aircraft operators have appropriate access to the test site prior to and during the testing period;
- Coordinate the installation of the necessary equipment to generate intentional leaks at the host facility;
- Communicate needs for safety and other training of staff working at the test site;
- Provide a secure location for safe-keeping of equipment when not being used for testing;
- Provide information regarding test site features for the Verification Reports;
- Review the draft TQAP; and
- Review the draft Verification Report and Statement.

A1.7 Technical Panel

The following experts provided input to this TQAP through participation in technical panel discussions:

- Eben Thoma, EPA, Office of Research and Development;
- Phil Galvin, New York State Department of Conservation;
- Donald Stedman, University of Denver;
- Shannon Phillips, TransCanada PipeLines Limited;
- Mark Kuhl, Environment Canada; and
- Roy McArthur, Environment Canada.

Mr. Galvin and Ms. Phillips also provided peer review of this TQAP.

A2 BACKGROUND

The purpose of verification programs such as the EPA and Canadian ETV programs is to provide objective and quality-assured performance data on environmental technologies, so that users, developers, regulators, and consultants can make informed decisions about purchasing and applying these technologies. Stakeholder committees of buyers and users of such technologies recommend technology categories, and technologies within those categories, as priorities for testing. Among the technology categories recommended for testing are airborne leak detection systems for the identification of natural gas leaks in gas processing plants, distribution lines, and transmission lines.

A2.1 Technology Need

Fugitive emissions from natural gas systems have been estimated to account for approximately 18% of all methane emissions in the U.S. in 2007, and have a global warming potential equivalent to approximately 105 terragrams (Tg = 10^6metric tons) of carbon dioxide (Tg carbon dioxide equivalent, see http://www.methanetomarkets.org/documents/oil-gas_fs_eng.pdf). These emissions are the result of leaking equipment, system upsets, and deliberate flaring and venting at production fields, processing facilities, transmission lines, storage facilities, and gas distribution lines. Identifying and mitigating the sources of these fugitive emissions will benefit not only the companies who own and operate the natural gas systems but will also lessen the environmental burden introduced by greenhouse gases in the atmosphere. However, while some sources of fugitive emissions are readily detected, those along gas pipelines are generally more difficult to detect because of the extended lengths of the pipelines, their frequent remote location, and the variable terrain and vegetative cover where the pipelines are located.

A.2.2 Technology Category Description

A variety of technologies are included in the category of airborne leak detection systems. At present, this TQAP has been developed for the verification of systems that employ a remote sensing technique known as Gas-Filter Correlation Radiometry (GFCR). However, this TQAP can be used for the verification of any airborne leak detection technology whether GFCR or another technique is employed. GFCR is a remote sensing technique used to measure the amount of a gas of interest in the section of an atmosphere located within the field of view of an instrument that employs this technique. As the name suggests, a sample of the target gas fills a container, referred to as a correlation cell, located within the path of the incoming electromagnetic radiation in the form of light. Light wavelengths are in the range of 10 nanometers (nm) for ultraviolet light to 300,000 nm for infrared light. This range includes visible light, which is between 400 and 700 nm. Light incident upon the cell first passes through a narrow band-pass filter that allows only a narrow range of infrared light frequencies through. The range allowed through the filter is centered on the absorption lines of the target gas in the correlation cell. The filtered light is then split into two beams, one of which is passed through the correlation cell, and the other is passed through a "null" cell containing a radiatively inert gas (i.e., transparent to the incoming filtered light). As the light passes through the two cells, the gas in the correlation cell absorbs some of the light, thereby reducing the amount of light exiting the cell. On the other hand, the "null" cell has no effect on the light passing through it. The radiation that exits both cells is then measured by separate detectors.

By modulating and demodulating the intensity of the radiation being absorbed, the signal associated with the absorption of target gas can be isolated from the background radiation which is not modulated. This modulation can be done by manipulating the density of the gas sample in the correlation cell, thus changing the width and strength of the absorption line and, implicitly, the transmittance of the cell. The difference between the detector signals from the correlation and null cells allows determination of light intensity modulation, allowing the technology to determine the intensity of the light being absorbed by the correlation cell. The presence and concentration of different gasses in the atmosphere can be determined by this modulation technique, simply by filling the correlation cell with the gas of interest.

A3 VERIFICATION TEST DESCRIPTION AND SCHEDULE

The purpose of this verification test is to generate performance data on airborne leak detection technologies. The data generated from this verification test are intended to provide organizations and users interested in these technologies with information on their potential utility and operational performance.

A3.1 Verification Test Description

The verification test will include one field testing campaign conducted under potentially challenging conditions for the technologies being verified. Testing will focus on the evaluation of the following performance parameters:

- Leak location mapping capabilities;
- Leak rate determination;
- Pipeline inspection rate;
- Speciation of ethane/methane; and
- Data processing time between runs.

For this test, multiple intentional gas leaks will be established along a predetermined virtual pipeline at the RMOTC testing site. The gas leaks will include both aboveground releases as well as buried releases, and will involve a range of pre-determined leak rates. The leaks will be established in variable terrain conditions to challenge the technologies over a variety of test conditions. Testing will involve the performance of multiple flight passes per day over the pipeline sections during a one week testing period. Testing will be conducted during different times of the day to assess performance under different illumination and meteorological conditions. Furthermore, the locations and the leak rates for the intentional leaks will be varied from run to run to provide differing challenge conditions. Ground-based measurements will be made to confirm the rate and location of each leak, as well as airborne natural gas concentrations in the vicinity of the leaks and meteorological conditions.

Subsequent to the verification test, a joint Verification Report including a joint Verification Statement will be drafted for each technology. This report will be reviewed by the vendor and by peer reviewers, after which they will be revised, and submitted to EPA and Environment Canada for final approval. In performing the verification test, Battelle will follow the technical and QA procedures specified in this TQAP and will comply with the data quality requirements in the AMS Center QMP[1] and the Canadian ETV Program GVP.

A3.2 Proposed Testing Schedule

Table 1 shows the planned schedule of testing and data analysis/reporting activities to be conducted for this verification. The field campaign will be conducted over a period of one week. Exact dates for testing will be established based on availability of testing staff and the vendor representatives, and the on-site conditions that meet the criteria of this TQAP.

Table 1. Planned Verification Test Schedule

Time line (In Series)	Activity	Data Analysis and Reporting
1 week	Field testing campaign	Prepare report template Review and summarize field testing staff observations Compile data from leak detection systems Compile reference method results Begin draft report Perform data analysis Conduct Technical Systems Audit Conduct audit of Data Quality
5 weeks	Prepare draft report	Complete draft report
3 weeks	Conduct peer review	Complete peer review of draft report
4 weeks	Finalize report	Revise draft report Submit final report

A3.3 Test Facilities

The RMOTC field site (www.rmotc.doe.gov) is a U.S. Department of Energy field test site located 35 miles north of Casper, Wyoming, within the Naval Petroleum Reserve No. 3 in the Teapot Dome Oilfield. The RMOTC field site provides a test site for energy-related technologies and techniques for the federal government, private sector producers, service companies, equipment manufacturers, and research organizations. The RMOTC field site is a 10,000-acre operating oil and gas field with approximately 1,200 well bores and approximately 600 producing wells. Produced natural gas is currently processed, compressed, and reinjected via the RMOTC gas plant. The produced natural gas will be used as the gas source for many of the leak sites. Gas cylinders placed on the ground but hidden from view will be used for the leaks of single component gases (e.g., ethane or methane).

The climate and terrain at the RMOTC field site can be characterized as a high desert plain with an elevation of approximately 5,200 feet above sea level. Table 2 summarizes the average high and low temperatures, record temperatures, and average precipitation for Casper, Wyoming in the spring, summer, and fall.

Table 2. Average and Record Seasonal Weather Conditions in Casper, Wyoming

Seasonal Data	Spring	Summer	Fall
Average High Temperature	56 °F	87 °F	73 °F
Average Low Temperature	29 °F	53 °F	42 °F
Record High Temperature	84 °F	104 °F	97 °F
Record Low Temperature	-6 °F	30 °F	16 °F
Average Precipitation	1.5 inches	1.3 inches	0.98 inches

A4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The objective of this verification test is to evaluate the performance of the airborne leak detection technologies under potentially challenging operating conditions. This evaluation will involve a single field testing campaign where technologies being tested will be flown over predefined virtual pipelines that include a series of intentional natural gas releases to simulate leaks in the pipelines. The performance of the technologies being tested will be evaluated on their capabilities with respect to the performance parameters listed in Section A3.1. Additionally, the verification test will rely upon operator or Battelle testing staff observations (if Battelle staff are allowed to accompany the operator during test flights) to assess other performance characteristics of the airborne leak detection technologies, including data completeness, ease of use, and maintenance requirements.

To ensure that this verification test provides suitable data for a robust evaluation of the performance of the airborne leak detection technologies being verified, data quality objectives (DQOs) have been established. The DQOs indicate the minimum quality of data required to meet the objectives of the verification test and were established to assess the performance of the airborne leak detection technologies relative to the stated performance parameters. In order to provide a suitable benchmark for comparison, the intentional leaks introduced to the virtual pipelines must be well characterized. The DQOs for this verification test include specific objectives for the accuracy of the leak rates, positioning of the leaks, meteorological measurements, and "ground-truth" concentration measurements. The DQOs are quantitatively defined in Table 3 in terms of specific data quality indicators (DQIs), along with their acceptance criteria.

The quality of the data used for evaluation of the airborne leak detection system will be assured by adherence to these DQI criteria and the QA/quality control (QC) activities, which are discussed in detail in Sections B2-B7 of this TQAP. Calibration equipment and compressed gas standards used during this verification test will meet National Institute of Standards and Technology (NIST) traceability, when available.

The verification test relies in part on observations of the Battelle and ETV Canada field testing staff for assessment of the performance of the systems being tested. The requirements for these observations are described in Section B1.1.7. The discussion of documentation requirements and data review is found in Section B10, and Section D contains a discussion of and data verification requirements for this verification test.

Battelle's Quality Manager or designee will perform a TSA once during this verification test to review these QA/QC requirements. The ETV Quality Managers of the respective programs (U.S. and Canada) also may conduct an independent TSA at their discretion.

A5 SPECIAL TRAINING/CERTIFICATION

Documentation of training related to technology testing, field testing, data analysis, and reporting should be maintained for all technical staff participating in verification testing. The Battelle Quality Manager may verify the presence of appropriate training records prior to the start of testing. Battelle technical staff and QA staff supporting this verification test will have a minimum of a bachelor's degree in science/engineering.

The verification test described in this TQAP will be performed at RMOTC. All participants in this verification test will adhere to the health and safety requirements of the RMOTC facility, and Battelle's standard environmental health and safety practices.

Table 3. DQIs and Criteria for Critical Measurements for Reference Methods

DQI	Performance Parameter(s)	Method of Assessment	Responsible Party	Frequency	Acceptance Criteria	Corrective Action
Gas composition	Leak rate determination; Speciation of ethane/methane	Measurement of collected gas sample by GC analysis per ASTM D1945 - 03(2010)	Commercial analytical laboratory	Once within 1 week prior to testing campaign	NA	NA
Leak rate accuracy	Leak location mapping capabilities; Leak rate determination	Comparison to independent flow transfer standard	Battelle	At least once for each leak location	± 10% of target flow rate	Adjust leak rate; replace needle valve/orifice as needed.
Leak rate consistency	Leak location mapping capabilities; Leak rate determination	Measurement before and after each test run	Battelle	Each leak	± 10% of target flow rate	Investigate discrepancy. Replace leak source for future tests. Flag data.
Leak position accuracy	Leak location mapping capabilities; Pipeline inspection rate	Comparison to independent GPS coordinates	Battelle	When hardware for leak generation is installed	± 2 m agreement	Investigate discrepancy if possible. Repeat measurements. Replace measurement device(s) if necessary.
Flame Ionization Detector (FID) or LEL measurement accuracy	Leak location mapping capabilities; Leak rate determination	Calibration with compressed gas standards	Battelle	At start and end of each test day	± 10% of calculated concentration	Investigate discrepancy if possible. Repeat measurement and recalibrate FID/LEL if necessary.
Wind speed/direction accuracy	Leak location mapping capabilities; Leak rate determination	Comparison to independent sensor(s)	Battelle	At least once during periods 1-3 of each day of testing campaign	± 10%	Investigate discrepancy if possible. Repeat measurement and recalibrate or replace sensor if necessary.

NA – Not Applicable

During the verification test, vendor staff will operate their own technologies. The vendors will be responsible for securing the services of a qualified pilot to conduct the test flights during verification of their technologies.

A6 DOCUMENTATION AND RECORDS

The records and documents generated for this verification test include the TQAP, chain-of-custody forms, laboratory record books (LRB), data collection forms, electronic files (both raw data and spreadsheets), video and photographic records, final verification reports, and verification statements. The documentation and results of the leak rate measurements, leak positions, meteorological data, and "ground-truth" concentration measurements will be compiled and provided to the Battelle VTC. Copies of all of these records will be maintained by the Battelle VTC during the test, shared with EPA and ETV Canada at the end of each testing period, and then transferred to permanent storage within 2 months of the final verification reports being issued. All Battelle LRBs are stored indefinitely by Battelle's Record Management Office. EPA will be notified before disposal of any files. Section B10 further details the data recording practices and responsibilities.

All data generated during the conduct of this project will be recorded directly, promptly, and legibly in ink. All data entries will be dated on the date of entry and signed or initialed by the person entering the data. Any changes in entries will be made so as not to obscure the original entry, will be dated and signed or initialed at the time of the change and shall indicate the reason for the change. Project-specific data forms will be developed prior to testing to ensure that all critical information is documented in real time. The draft forms will be provided to the Battelle QAM for review.

SECTION B

MEASUREMENT AND DATA ACQUISITION

B1 EXPERIMENTAL DESIGN

The verification test described in this joint TQAP will address verification of airborne leak detection technologies. The verification test has been designed to include a single field testing campaign under potentially challenging conditions. Testing will focus on the evaluation of the following performance parameters:

- Leak location mapping capabilities;
- Leak rate determination;
- Pipeline inspection rate;
- Speciation (ethane/methane); and
- Data processing time between runs.

To the extent possible, the testing procedures performed during the field campaign will be comparable. Detailed descriptions of the testing procedures are given below.

B1.1 Field Testing Procedures

During the field testing campaign, a series of intentional leaks of compressed natural gas will be generated by RMOTC staff to simulate leaks along a "virtual" pipeline. The virtual pipeline will be laid out by RMOTC staff to simulate an actual natural gas pipeline and the vendors participating in the verification test will be provided with global positioning system (GPS) coordinates for the pipeline, but not of the intentional leaks. Infrastructure will be installed to allow for a number of potential leak sources along the pipeline, and the potential leaks will include both aboveground and buried leaks. Flow restrictions (e.g., critical orifice or pressure gauge) will be used to allow the leak sources to be set to a predetermined flow rate. The potential leaks along the pipeline will vary in leak rate intensity over a range of flow rates from 50 to 2,000 standard cubic feet per hour (scfh). During each testing day, a selected number of the potential leak sources will be used, and the flow rates from the individual potential sources may be varied from day to day. The leaks will be initiated by RMOTC at the direction of

Battelle technical staff and on each day, the position and leak rate of one leak during each test run will be disclosed to the vendors and serve as a calibration point for the systems being verified each day. Other than the calibration leak, the positions and leak rates of the other intentional leaks will not be disclosed to vendor representatives.

During each day of testing, the flow rates at each of the intentional leaks will be measured by Battelle staff before and after the testing period using one or more dry gas meters or rotameters with an accuracy of 10% of target flow rate to ensure consistent leak rates. If the flow rates for more than one of the leaks vary by more than 10%, an additional test flight will be performed if possible, otherwise the drift in flow rate will be noted, and the lower of the two flow rates will be used for the technology evaluation. Additionally, after sufficiently low gas concentrations are confirmed by RMOTC safety personnel, concentration measurements will be made by Battelle staff using a flame ionization detector (FID) hydrocarbon monitor or lower explosive limit (LEL) sensor. These measurements will only be made when airborne concentrations are below 10% of the LEL. Because of the flammable nature of the gases used in this verification test, appropriate safety procedures will be implemented to avoid potentially hazardous situations. All testing staff, vendor representatives, and test observers will adhere to Battelle environmental health and safety, as well as all RMOTC site specific safety procedures. A LEL sensor will be used to ensure that testing staff are performing activities within a safe environment. The concentration measurements will be made at a minimum of four equally spaced positions around the leak on concentric circles at two distances of approximately 1 and 5 meters from the leak (see Figure 2), with at least one position nominally downwind of the perceived predominant wind direction. The actual measurement distances will be determined based on readings from an LEL sensor. The concentration measurements will be made at three heights corresponding to approximately knee, waist, and chest height and are intended to be indications of the plume position and relative concentration for illustrative purposes representing an "instantaneous" indication of the plume position rather than a long-term monitoring of plume position during testing.

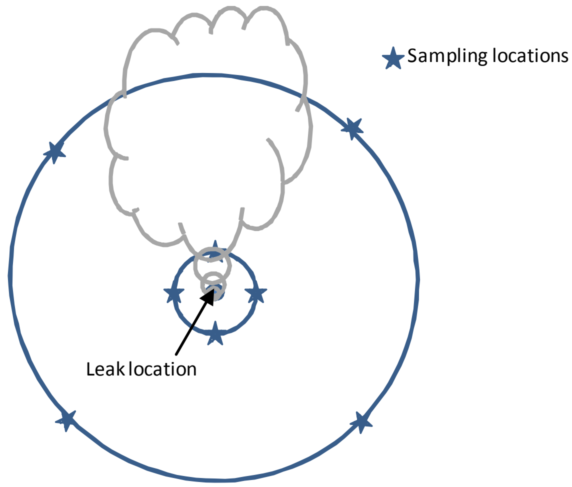

Figure 2. Diagram of Sampling Near Intentional Leak

A minimum of one portable meteorological station will be installed by Battelle staff and operated in the vicinity of the virtual pipeline during each day of testing to record ambient temperature, barometric pressure, relative humidity, and wind speed/direction. If available, additional portable meteorological stations will be deployed along the virtual pipeline. Meteorological measurements will also be recorded using sensors installed at the RMOTC central meteorological station. Spot checks of ambient temperature, barometric pressure, relative humidity, and wind speed will also be recorded daily using calibrated handheld sensors.

Testing will be performed over three days during the field campaign. On each day, a total of three to six test flights will be performed to characterize leaks in the virtual pipeline. Between four and eight leaks will be established for each test flight. The number and position of the leaks will not be revealed to the vendors until after completion of the test flights and receipt of the data report from the vendors. Between flights, the technology operator will be allowed to review collected data and make adjustments to the technology or data collection parameters as deemed necessary. Any adjustments will be observed and documented by Battelle technical staff. During each day of testing at least one flight will be performed within each of the following time periods to evaluate performance under differing daylight conditions:

Period 1: 8:00 – 10:00 a.m.,

Period 2: 11:00 – 1:00 p.m.,

Period 3: 3:00 – 5:00 p.m.

Additional flights may be performed within these periods or between periods. Between flights, the intentional leaks may be changed by RMOTC, Battelle, or ETV Canada staff to vary the conditions of testing.

As soon as possible after the completion of each test day, the operators will provide the Battelle and ETV Canada technical staff with preliminary results in the form of a completed table indicating the position and estimated leak rate (if available) for each of the detected leaks (see example table in Appendix A). Preliminary results should be provided within 24-hours after each testing day, with a complete, detailed report provided within two weeks of the completion of the testing campaign.

B1.1.1 Leak location mapping capabilities

During the field campaign, a summary table will be prepared by Battelle technical staff showing the GPS coordinates of each leak along with the measured leak rates in scfh and ground-truth concentration measurements. (i.e., measurements from FID or LEL sensors). The GPS coordinates of the actual leaks and the leaks detected by the airborne leak detection technologies will be tabulated and reported to assess leak location mapping capabilities. False positive and false negative indications (i.e., detect/non-detect) by the airborne leak detection technologies will also be indentified and reported.

B1.1.2 Leak rate determination

Quantitative estimates of leak rates determined from the airborne leak detection technologies will be compared to the actual measured leak rates and will be reported, along with the relative percent difference between the measured and actual rates. Since the technologies being tested may measure only one component of natural gas, the composition of the natural gas released from the intentional leaks will be measured and provided to the technology vendors to allow for the calculation of the gas mixture leak rate based on the measurement of only one component (e.g., natural gas leak rate based on measurement of ethane only).

B1.1.3 Pipeline inspection rate and capabilities

The pipeline inspection capabilities will be determined from both the fraction of pipeline that the systems are able to fly over and the time required to inspect the virtual pipeline used for the verification test. The fraction of pipeline scanned per flight pass will be calculated and reported as:

$$Fraction = \frac{Miles\ of\ pipeline\ inspected}{Total\ miles\ of\ pipeline\ in\ test.}$$

The pipeline inspection rate will be calculated and reported in terms of miles of pipeline inspected per hour of flight as:

$$Rate = \frac{Miles\ of\ pipeline\ inspected}{Duration\ of\ inspection.}$$

For each technology, the minimum leak rate that was detected will also be reported to indicate the level of sensitivity that was achieved at the reported inspection rate to allow potential users of these technologies to assess appropriateness for their needs.

B1.1.4 Speciation (ethane/methane discrimination)

The majority of the intentional leaks will involve natural gas, however, the ability of the technologies to speciate pure methane and ethane will be assessed by including intentional leaks of pure ethane or methane at different locations along the pipeline section being inspected. Based on the measurement capabilities of the technologies being verified, at least one of the leaks for each test run will be either methane or ethane. Species that cannot be measured by the technology being tested will not be included as a pure gas.

B1.1.5 Data processing time between runs

Data processing time for the individual technologies being tested may vary dramatically depending on the amount of post-test processing that is necessary. For this verification test, the vendors will submit preliminary data within 24 hours of completion of each day of testing, with a final comprehensive report submitted within two weeks of completion of the testing campaign. Data processing time will be reported in terms of the number of days for which preliminary data are submitted within 24 hours of testing completion. Preliminary results may simply include the identification of approximate GPS coordinates for individual leak sites. The time from completion of the testing campaign that is required to submit the final reports will also be presented.

B1.1.6 Data Completeness

Data completeness will be calculated as the percentage of valid data collected during each test run from the initiation to completion of the flight path over the virtual pipeline. The data completeness for each test run will be reported along with the fraction of test runs from which at least 75% valid data are collected.

B1.1.7 Operational Factors

Operational factors such as maintenance needs, data output, consumables used, ease of use, repair requirements, etc., will be evaluated based on observations recorded by Battelle or ETV Canada staff, and explained by the vendors as needed. Battelle or ETV Canada technical staff will be present during testing, including during each test run, and will record all activities performed on the monitoring systems. A LRB will be maintained by Battelle and will be used to enter daily observations on these factors. Examples of information to be recorded in the record books include observations about meteorological conditions; use or replacement of any consumables for the airborne leak detection systems; the effort or cost associated with maintenance or repair; vendor effort for repair or maintenance; the duration and causes of any down-time or data acquisition failure; and observations about ease of use of the airborne leak detection systems. These observations will be summarized to aid in describing operational performance in the joint verification report.

B1.2 Reporting

Reporting on each of the variables described above will be based on the results of the verification testing, and information on the operational performance will be compiled and reported. A joint Verification Report will be prepared that presents a summary of the test procedures and test data, as well as the results of the evaluation of those data.

Operational aspects of the leak detection systems will be recorded by Battelle testing staff at the time of observation during the field tests, and summarized in the joint Verification Report. For example, descriptions of the data acquisition procedures, use of vendor-supplied proprietary software, consumables used, repairs and maintenance needed, and the nature of any problems will be presented in the report. The verification report will briefly describe the U.S. and Canadian ETV programs, and the procedures used in verification testing. The results of the verification test regarding performance of the leak detection systems will be stated quantitatively. The draft joint verification report will be subjected to review by the vendor, EPA, Environment Canada, and peer reviewers. The resulting review comments will be addressed in a subsequent revision of the report, and the peer review comments and responses will be tabulated to document the peer review process and submitted to EPA and Environment Canada. The reporting and review process will be conducted according to the requirements of the ETV/AMS Center QMP and the Canadian ETV Program GVP.

B2 SAMPLING METHOD REQUIREMENTS

No samples will be collected during this verification test.

B3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

No samples will be collected during this verification test.

B4 ANALYTICAL METHOD REQUIREMENTS

B4.1 FID Hydrocarbon Measurements

FID measurements will be performed in the vicinity of each of the leaks prior to and at the end of each testing period. Field measurements will be made by Battelle staff using a Foxboro TVA 1000 FID analyzer, or equivalent. Field testing staff will make measurements at eight locations surrounding each leak, with four measurements approximately 90 degrees apart on a circle with a radius of one meter centered on the leak, and four similar measurements five meters from the leak. The concentration measurements will be made at three heights corresponding to approximately knee, waist, and chest height and are intended to be indications of the plume position and relative concentration for illustrative purposes rather than definitive mapping of the plume. The actual distances from the leak will be determined using an LEL sensor to ensure safety for the measurement personnel. FID measurements will only be made when airborne concentrations are below 10% of the LEL.

B5 QUALITY CONTROL REQUIREMENTS

Table 4 summarizes the QC requirements for the verification test, including frequency of the QC activities, the acceptance criteria, and corrective actions.

Table 4. Quality Control Activities

QC Activity	Frequency	Minimum Acceptance Criterion	Corrective Action
Leak rate measurement	Each leak	± 10% of nominal	Adjust flow rate. Replace metering device if necessary.
FID calibration	At the beginning and end of the testing day	± 10% of actual concentration for span value; ± 1% of range setting for zero air	Recalibrate FID. Remeasure. Replace or repair FID if necessary.
FID calibration check	At the beginning of the testing day	± 10% of actual concentration	Recalibrate FID. Remeasure. Replace or repair FID if necessary.
Duplicate measurement of GPS coordinates	Each leak	± 2 m	Remeasurement of coordinates. Replacement of GPS units if necessary.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Prior to testing the gas leak system components, including casings, compressed gas cylinders, regulators, and leak metering devices, will be visually inspected by RMOTC staff to ensure proper structural integrity and installation. Damaged or improperly operating components will be removed from the gas system and replaced. Once inspected, care will be observed to properly maintain the gas system and avoid damage to any components during the field testing campaign.

Instrumentation and equipment used for measurement of gas flow rates and airborne gas concentrations will be tested to ensure proper operation as summarized in Table 4. This testing will include instrument calibrations and calibration checks to be performed prior to and at the completion of testing. Based on the relatively short duration of the field testing campaign, no preventive maintenance activities outside of routine operating procedures and calibration procedures are anticipated.

B7 INSTRUMENT CALIBRATION AND FREQUENCY

B7.1 FID Analyzer

The FID analyzers will be calibrated daily during the field campaign. The analyzers will undergo a minimum of a two-point calibration using a compressed methane gas standard at a concentration at the upper end of the range of concentrations expected to be measured in the field (e.g., < 10% LEL), and using zero air. The calibration will be verified by measuring the calibration standard gases after completion of the calibration, and comparing the measured concentrations to the expected concentrations. The measured concentration at the upper calibration point should agree with the actual concentration to within ± 10%. The measured value at zero should be equal to zero within 1% of the range setting. A separate NIST traceable standard, whose concentration is approximately midrange of the anticipated testing range, will be analyzed following the calibration each day as an independent check standard. Agreement between the measured and actual concentrations should be within ± 10%. Testing will not begin before this daily calibration standard meets acceptable QC criteria.

B7.2 Meteorological Sensors

The meteorological sensors used for this verification will include those installed on the central weather station at the RMOTC as well as a portable meteorological station provided by Battelle. The sensors on the portable meteorological station will be calibrated by the manufacturer within 12 months prior to the beginning of the field campaign. These calibrated sensors will be collocated with the RMOTC sensors prior to the beginning of the field campaign to verify the accuracy of the RMOTC sensors. Handheld meteorological sensor units (Kestrel Model 4000) will be used to conduct spot check measurements of ambient temperature, barometric pressure, relative humidity, and wind speed. These sensors will be calibrated within 12 months prior to the beginning of the field campaign. Table 5 shows the nominal sensor resolution and acceptance criteria for the calibration of the meteorological sensors.

Table 5. Resolution and Calibration Acceptance Criteria for Meteorological Sensors

Parameter	Sensor Resolution	Acceptance Criterion
Wind speed	0.1 m/s	0.2 m/s + 5%
Wind direction	1^{o}	$< 5^{o}$
Temperature	0.1 °C	0.5 °C
Barometric pressure	0.05 mmHg	< 1 mmHg
Relative humidity	2% RH	< 5%

B7.3 Flow Meters

Approximate flow rates will be established based on preliminary readings from factory pre-calibrated rotameters (e.g., Dwyer or similar). Actual flow rates of the intentional leaks will be measured by Battelle staff using one or more calibrated dry gas meters or rotameters. If needed, multiple flow meters will be used in order to span the range of anticipated flow rates. The flow meters used to measure the intentional leak rates will undergo NIST-traceable calibration within two months prior to the beginning of the field campaign, and will have a calibrated accuracy of < 1.5%. The calibration of these meters will be verified within 2 weeks of completion of the field campaign to assess the degree of drift that may have been introduced to the meters. If the measured drift exceeds 1.5%, the leak rates measured during the field campaign will be flagged and may be corrected based on extrapolation between the pre- and post-campaign calibration results.

B7.4 Aircraft Sensors

On-board instrumentation for measurement of elevation and air speed will be calibrated per the standard procedures of the aviation company contracted to perform the flights and will comply with appropriate Federal Aviation Administration regulations. The accuracy of these sensors will not be verified in this verification test.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Upon receipt of any supplies or consumables used for the testing Battelle or RMOTC facility staff will visually inspect and ensure that the materials received are those that were ordered and that there are no visual signs of damage that could compromise the suitability of the materials. If damaged or inappropriate goods are received, they will be returned or disposed of and arrangements will be made to receive replacement materials. Certificates of analysis or other documentation of analytical purity will be checked for all reagents, gases, and standards used to ensure suitability for this verification test. Unsuitable materials will be returned or disposed of and arrangements for the receipt of replacement materials will be made.

B9 NON-DIRECT MEASUREMENTS

No non-direct measurements will be used during this verification test.

B10 DATA MANAGEMENT

Various types of data will be acquired and recorded electronically or manually by Battelle, ETV Canada, RMOTC, and vendor staff during this verification test. Table 6 summarizes the types of data to be recorded. All maintenance activities, repairs, calibrations, and operator observations relevant to the operation of the monitoring systems being tested will be documented by Battelle, ETV Canada, or vendor staff in the LRB or data forms developed for the test. Measurements taken during the collection of the reference method samples will be compiled by subcontractor staff in electronic format, and submitted to Battelle in the form of an analytical report at the conclusion of reference sampling periods. A dedicated shared folder within the ETV AMS Center SharePoint site will be established for all project records.

Battelle will provide technology test data and associated reference data (including records, data sheets, and notebook records) from the first day of testing within one day of receipt to EPA and ETV Canada for simultaneous review. The goal of this data delivery schedule is prompt identification and resolution of any data collection or recording issues. The final data report generated by each technology vendor for the test campaign will be provided by Battelle to EPA and ETV Canada within one week of completion of field testing. This will be provided to EPA and ETV Canada for informational purposes as the Battelle audit of data quality will not have been completed.

Records received by or generated by any of the verification staff during the verification test will be reviewed by a Battelle staff member within two weeks of receipt or generation, respectively, before the records are used to calculate, evaluate, or report verification results. The review will be documented as the dated initials of the reviewer. Some of the checks that will be performed include the following.

- Check that QC samples and calibration standards were analyzed according to the TQAP, and the acceptance criteria were met. Ensure corrective action for exceedances was taken.
- Ensure that 100% hand-entered and/or manually calculated data were checked for accuracy.
- Check that the calculations performed by software were verified at a frequency sufficient to ensure that the formulas are correct, appropriate, and consistent.
- Ensure that for each cut and paste function, the first and last data values were correct.
- Ensure data are reported in the units specified in the TQAP.
- Check that the results of QC samples are reported.

If a Battelle staff member generated the record, this review will be performed by a Battelle technical staff member involved in the verification test, but not the staff member that originally received or generated the record. The review will be documented by the person performing the review by adding his/her initials and date to the hard copy of the record being reviewed. In addition, data calculations performed by verification staff will be spot-checked by Battelle technical staff to ensure that calculations are performed correctly. Calculations to be checked include any statistical calculations described in this TQAP.

Table 6. Summary of Data Recording Process

Data to Be Recorded	Where Recorded	How Often Recorded	By Whom	Disposition of Data
Dates, times, and details of test events, leak rates, leak locations, pipeline coordinates, meteorological data	ETV LRBs, field sampling records	Start/end of test event	Testing staff	Used to organize/check test results; manually incorporated in data spreadsheets as necessary
Flight times, flight paths, and flight durations for each test run	ETV LRBs, or electronically	When performed	Vendor and/or testing staff	Incorporated in verification report as necessary
Leak detection system readings	Recorded electronically by each system and then downloaded to computer daily	Recorded continuously by each monitoring system	Vendor for transfer to testing staff	Converted to spreadsheet for statistical analysis and comparisons
FID method procedures, results, calibrations, QC, etc.	ETV LRBs, or data recording forms	Throughout sampling and analysis processes	Testing staff	Retained as documentation of reference method performance

SECTION C

ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

Every effort will be made in this verification test to anticipate and resolve potential problems before the quality of performance is compromised. One of the major objectives of this TQAP is to establish mechanisms necessary to ensure this. Internal QC measures described in this TQAP, which is peer reviewed by a panel of outside experts, implemented by the technical staff and monitored by the Battelle and ETV Canada VTCs, will give information on data quality. The responsibility for interpreting the results of these checks and resolving any potential problems resides with the Battelle VTC, who will contact the Battelle AMS Center Manager, Battelle AMS Center Quality Manager, EPA AMS Center Project Officer, and EPA AMS Center Quality Manager if any deviations from the TQAP are observed. The Battelle VTC will describe the deviation in a teleconference or by e-mail, and once a path forward is determined and agreed upon with EPA, the deviation form will be completed.

Technical staff has the responsibility to identify problems that could affect data quality or the ability to use the data. Any problems that are identified will be reported to the Battelle and ETV Canada VTCs, who will work with the Battelle and ETV Canada Quality Managers to resolve any issues. Action will be taken to identify and appropriately address the issue, and minimize losses and correct data, where possible. Independent of any EPA QA activities, Battelle and ETV Canada will be responsible for ensuring that the following audits are conducted as part of this verification test.

C1.1 Performance Evaluation Audit

A PEA will be conducted immediately prior to or within the first day of testing during the field campaign to assess the quality of the critical measurements associated with the leak rate determination and the coordinates of the individual leaks. Table 7 shows the critical measurements to be audited, with the audit procedures and acceptance criteria for the audit comparisons. If the PEA results do not meet the acceptance criteria shown, they will be repeated. If the outlying results persist, a change in instrumentation and a repeat of the PEA may be considered, and data will be flagged until the PEA results are acceptable. These audits will be performed once during the field campaign of the verification test, and will be the responsibility of the Battelle VTC. Results from the PEAs will be provided to EPA within 10 days of receipt of the results.

Table 7. Methods and Acceptance Criteria for PEA Measurements

Critical Measurement	PEA Method	Acceptance Criteria
Leak flow rate	Compare to independent flow transfer standard	± 10% actual flow rate
GPS coordinates	Compare to independent handheld GPS unit	± 2 meters
FID measurements	Measurement of independent calibration gas	± 10% actual concentration

The PEA of the leak flow rate will be conducted by Battelle staff using an independent NIST-traceable flow transfer standard. The target criterion for this audit is agreement between the measured and nominal flow rate within ± 10%. If this criterion is not met, the cause of the problem will be investigated and corrected if possible. Components of the leak generation system will be replaced as necessary until the flow rate criterion is met.

The PEA of the GPS device will be conducted by Battelle staff to document the coordinates of the individual leaks will involve comparison to an independent GPS unit. The target agreement between the coordinate readings is ± 2 m. If this criterion is not met, the readings will be performed again. If necessary, alternate GPS units will be obtained and used for the coordinate measurements.

The PEA of the FID measurements will be performed by supplying the FID with a standard compressed natural gas from an independent NIST-traceable gas cylinder at three concentrations in the range from 0 to 1.0%. These audit sample(s) will be analyzed and compared to the known sample concentrations. The acceptance criterion for this audit is for agreement between the measured and actual concentrations within ± 10%. If this criterion is not met, the cause of the problem will be investigated and corrected. The FID will be recalibrated or replaced to meet the criterion.

C1.2 Technical Systems Audits

The Battelle and ETV Canada Quality Managers will each perform a TSA during this verification test. The purpose of this audit is to ensure that the verification test is being performed in accordance with the AMS Center QMP,[1] the ETV Canada GVP,[3] this TQAP, and any Standard Operating Procedures used by the test facility. The Battelle Quality Manager will prepare a project-specific checklist based on the TQAP requirements to guide the TSA, which will compare actual test procedures to those specified or referenced in this plan, and review data acquisition and handling procedures. In the TSA, the Battelle and ETV Canada Quality Managers will tour the test site; observe testing procedures; and review/inspect documentation including data forms and laboratory record books. They may also check gas standard certifications and data acquisition procedures, and may confer with the vendors and testing facility staff. Separate TSA reports will be prepared by the two Quality Managers, including separate statements of findings and the actions taken to address any adverse findings. The Battelle Quality Manager will prepare an initial TSA report and will submit the report to the EPA Quality Manager (with no corrective actions documented) and VTC within 10 business days after completion of the audit. A copy of each final TSA report (with corrective actions documented) will be provided to the EPA AMS Center Project Officer and Quality Manager within 20 business days after completion of the audit. At EPA's discretion, EPA QA staff may also conduct an independent on-site TSA during the verification test. The TSA findings will be communicated to technical staff at the time of the audit and documented in a TSA report.

C1.3 Data Quality Audits

The Battelle and ETV Canada Quality Managers, or their designees, will audit 100% of the calibration and QC data and at least 10% of the verification data shown in Table 7. They will trace the data from initial acquisition (as received from the vendors and testing staff), through reduction and statistical comparisons, to final reporting. All calculations performed on the data undergoing the audit will be checked. The Battelle Quality Manager will review the data being generated in the field during the TSA. Data must undergo a 100% verification by technical staff (i.e., VTC, or designee) before it will be assessed as part of the data quality audit. Since the testing is occurring over three days in the field, a single ADQ that assesses overall data quality, including accuracy and completeness of the technical report, will be prepared as a narrative and distributed to the VTC and EPA within 10 business days of completion of the audit.

C1.4 QA/QC Reporting

Each assessment and audit will be documented in accordance with the respective verification organization's QMP.[1,2] The results of audits will be submitted as a draft that may not contain finding resolution to the EPA Project Officer within 10 business days of conduct of the audit. Assessment reports will include the following:

- Identification of project technology, location of audit, primary contact, and dates of audit;
- Identification of applicable reference documents, standards and calculations used, as appropriate;
- Identification of any adverse findings or potential problems;
- Recommendations for resolving problems;
- Citation of any noteworthy practices that may be of use to others;
- Copy of the audit checklist used, if appropriate;
- List of persons interviewed during the audit;
- Response to adverse findings or potential problems; and
- Confirmation that solutions have been implemented and are effective.

C2 REPORTS TO MANAGEMENT

The Quality Managers of the verification organizations, during the course of any assessment or audit, will identify to the technical staff performing experimental activities any immediate corrective action that should be taken. If serious quality problems exist, the Quality Manager of either verification organization will notify the respective verification organization Program Manager to request that a stop-work order be issued. The Battelle Quality Manager will be responsible for preparation of TSA and ADQ audit reports for Battelle. The QA representatives for ETV Canada and EPA, respectively, will be responsible for preparing reports for audits they perform. The Battelle Quality Manager will route reports through the VTC and

AMS Center Manager. A draft copy of the TSA and ADQ reports will be provided to the EPA QAM within 10 business days of completion of the audits for review, although corrective actions may not have been addressed prior to submission. Once the assessment report has been prepared, the VTC will ensure that a response is provided for each adverse finding or potential problem and will implement any necessary follow-up corrective action. The Quality Managers of the verification organizations will verify that follow-up corrective action has been taken. VTC responses to the audit comments are due to the QA representatives within 10 business days of receipt and the final TSA and ADQ reports with responses will be provided to the EPA Project Officer, QAM, and the ETV Canada Quality Manager within 10 business days.

The TQAP and final reports are reviewed by QA staff and Program Management staff of the respective verification organizations, EPA, vendors, and peer reviewers and are approved by Battelle, EPA, and ETV Canada. Upon final review and approval, both documents may be posted on the verification organization's and verification program's Web site, if applicable.

SECTION D

DATA VERIFICATION AND USABILITY

D1 DATA REVIEW AND VERIFICATION REQUIREMENTS

The key data review and data verification specifications for this test are stated in Section B of this TQAP. In general, the data review requirements specify that the first day's data generated during this test will be made available to the VTC, EPA AMS Center QAM, and EPA's Project Officer for the AMS Center within one day for a preliminary review. Also, the full data set from the field test campaign will be made available to the VTC, EPA AMS Center QAM, and EPA's Project Officer for the AMS Center within one week of completion. This process will ensure that the airborne leak detection systems data and supporting leak location, flow rate, and "ground-truth" concentration data were collected under appropriate testing conditions and that the data meet the specifications of this TQAP.

The data verification requirements for this test involve an assessment of the quality of the data relative to the DQIs, stated QC requirements, and audit acceptance criteria specified for this test in Tables 2, 4, and 6, respectively. The results of the QC activities and the PEA results will be compared with the appropriate acceptance criteria in Tables 4 and 6, respectively, to ensure that the measurements were properly performed. Furthermore, the results of the leak rate and GPS coordinate measurements will be compared with the appropriate DQIs listed in Table 2 to verify the quality of the data. Any deficiencies in these data will be flagged and may be excluded from any statistical comparisons to the leak detection systems being tested, unless these deviations are accompanied by descriptions of their potential impacts on the data quality.

D2 VERIFICATION METHODS

Data verification is conducted by the VTC, or his designee, as part of the data review as described in Section B10 of this TQAP. A visual inspection of handwritten data will be conducted to ensure that all entries were properly recorded or transcribed, and that any erroneous entries were properly noted (i.e., single line through the entry, with an error code and the initials of the recorder and date of entry). Electronic data from the leak detection systems and meteorological equipment used during the test will be inspected to ensure proper transfer from the data logging system. All calculations used to transform the data will be reviewed to ensure the accuracy and the appropriateness of the calculations. Calculations performed manually will be reviewed and repeated using a handheld calculator or commercial software (e.g., Excel). Calculations performed using standard commercial office software (e.g., Excel) will be reviewed by inspection of the equations used for the calculations and verification of selected calculations by handheld calculator. Calculations performed using specialized commercial software (i.e., for analytical instrumentation) will be reviewed by inspection and, when feasible, verified by handheld calculator, or standard commercial office software.

To ensure that the data generated from this test meet the goals of the test, a number of data verification procedures will be performed. Sections B and C of this TQAP provide a description of the safeguards employed for this verification test. Data verification efforts include the completion of QC activities, and the performance of TSAs and PEAs as described in Section C. The data from this test will be evaluated relative to the measurement DQIs described in Section A7, and the PEA acceptance criteria given in Section C1.1 of this TQAP. Data failing to meet these criteria will be flagged in the dataset and not used for evaluation of the monitoring systems, unless these deviations are accompanied by descriptions of their potential impacts on the data quality.

An ADQ will be conducted by the Quality Managers of the two verification organizations to ensure that data review and verification procedures were completed, and to ensure the overall quality of the data.

D3 RECONCILIATION WITH USER REQUIREMENTS

This purpose of this verification test is to evaluate the performance of airborne leak detection systems. In part, this evaluation will include comparisons of results from the leak detection systems to the known positions and leak rates of intentional leaks generated in a "virtual pipeline". To meet the requirements of the user community, the data collected during this verification test will include thorough documentation of the performance of the leak detection systems and the intentional leaks generated during the verification test. The data review and verification procedures described above will assure that data meeting these requirements are accurately presented in the verification reports generated from this test, and will assure that data not meeting these requirements will be appropriately flagged and discussed in the verification reports.

This joint TQAP and the resulting verification reports will be subjected to review by the vendor, verification organization staff, test collaborators, the verification programs, and expert peer reviewers. The reviews of this TQAP will help to improve the design of the verification test and the resulting report(s) such that they better meet the needs of potential users of these airborne leak detection systems.

SECTION E

REFERENCES

1. Battelle, Quality Management Plan for the ETV Advanced Monitoring Systems Center, Version 7.0, U.S. EPA Environmental Technology Verification Program, prepared by Battelle, Columbus, Ohio, November 2008.

2. ETV CANADA General Verification Protocol (GVP). February 2007.

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APPENDIX A

Example Data Sheet

Example Field Data Sheet
for Verification Testing of Airborne Leak Detection Systems

Vendor: **Technology:**

Test Date: **Flight start time:**

Test Run: **Flight end time:**

Leak #	GPS Coordinates	Leak Detection Time	Pass number	Estimated Leak Rate	Comments

Signed: **Date:**

Received by: **Date/Time:**