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Environmental Technology Verification Program

Advanced Monitoring Systems Center

Test/QA Plan for Verification of
Leak Detection and Repair Technologies

Test/QA Plan
For
Verification of
Leak Detection and Repair Technologies

September 18, 2008

Prepared by

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ACRONYMS AND ABBREVIATIONS

AMS	Advanced Monitoring Systems
COC	Chain-of-custody
DQI	Data quality indicator
EPA	U.S. Environmental Protection Agency
ETV	Environmental Technology Verification
FEM	Fugitive emission monitoring
GC	Gas chromatograph
IR	Infrared
LDAR	Leak detection and repair
LOD	Limit of Detection
LRB	Laboratory record book
MDL	Method detection limit
pdf	Adobe portable document format
PE	Performance evaluation
QA	Quality assurance
QC	Quality control
QCS	Quality control samples
QMP	Quality management plan
r^2	Coefficient of determination
SOP	Standard operating procedures
TSA	Technical systems audit

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SECTION A
PROJECT MANAGEMENT

A1 VERIFICATION TEST ORGANIZATION

The verification test will be conducted under the auspices of the U.S. Environmental Protection Agency (EPA) through its Environmental Technology Verification (ETV) Program. It will be performed by Battelle, which is managing the ETV Advanced Monitoring Systems (AMS) Center through a cooperative agreement with EPA. The scope of the AMS Center covers verification of monitoring technologies for contaminants and natural species in air, water, and soil.

The day to day operations of this verification test will be coordinated and supervised by Battelle, with the participation of the vendors who will be having the performance of their technologies for leak detection and repair (LDAR) verified. Testing will be conducted at a laboratory (BP laboratory in Naperville, IL), a petrochemical plant in the Gulf Coast region of Texas and a chemical plant also in the Gulf Coast region of Texas. Staff from these host facilities will support this test by providing infrastructure, coordination and overseeing the testing at their respective site. Each LDAR vendor will provide two units of their respective technologies, operate the technology through portions of the test (unless they give written consent and training for host facility staff to operate it), and repair or maintain their technology during the test.

The organization chart in Figure 1 identifies the responsibilities of the organizations and individuals associated with the verification test. Roles and responsibilities are defined further below. Quality Assurance (QA) oversight will be provided by the Battelle Quality Manager and also by the EPA AMS Center Quality Manager, at her discretion.

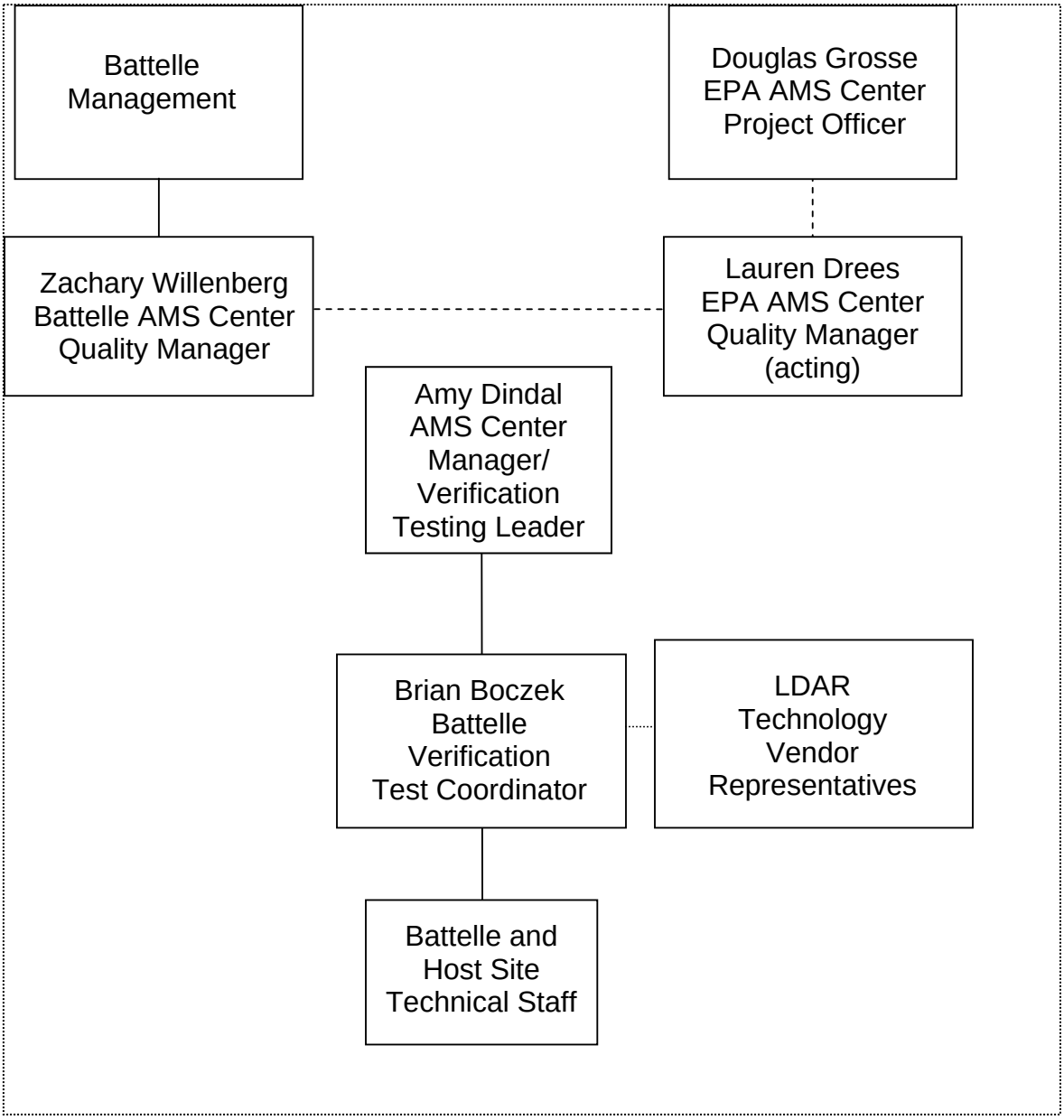

Figure 1. Organization Chart for the Verification Test

A1.1 Battelle

Mr. Brian Boczek is the AMS Center's Verification Test Coordinator for this test. In this role, Mr. Boczek will have overall responsibility for ensuring that the technical, schedule, and cost goals established for the verification test are met. Specifically, Mr. Boczek will:

- Prepare the test/QA plan, verification reports, and verification statements.
- Revise the test/QA plan, verification reports, and verification statements in response to reviewers' comments.
- Establish a budget for the verification test and manage staff to ensure the budget is not exceeded.
- Coordinate and communicate with host sites and subcontractor.
- Assemble a team of qualified technical staff to conduct the verification test.
- Direct the team in performing the verification test in accordance with this test/QA plan.
- 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. Responsibility for each aspect of the verification test will be confirmed.
- Ensure that all quality procedures specified in this test/QA plan and in the AMS Center Quality Management Plan[1] (QMP) are followed.
- Serve as the primary point of contact for vendor representatives.
- Ensure that confidentiality of sensitive vendor information is maintained.
- Work with host sites to ensure protection of site confidential business information.
- Assist vendors as needed during verification testing.
- Become familiar with the operation and maintenance of the technologies through instruction by the vendors, if needed.

- Respond to any issues raised in assessment reports, audits, or from test staff observations, and institute corrective action as necessary.
- Where applicable to the host site, ensure that all contractors are approved with the site prior to entering the site. This may require completion of certain courses and passing a drug test.
- Ensure that all guests to host site (contractors, technical staff, etc.) comply with site health and safety requirements.
- Coordinate distribution of the final test/QA plan, verification reports, and verification statements.

Ms. Amy Dindal will serve as Verification Testing Leader and is also Battelle's Manager for the AMS Center. Ms. Dindal will:

- Support Mr. Boczek in preparing the test/QA plan and organizing the testing.
- Review the final test/QA plan.
- Attend the verification test kick-off meeting.
- Review the draft and final verification reports and verification statements.
- Ensure that necessary Battelle resources, including staff and facilities, are committed to the verification test.
- Ensure that confidentiality of sensitive vendor information is maintained.
- Support Mr. Boczek in responding to any issues raised in assessment reports and audits.
- Maintain communication with EPA's technical and quality managers.
- Issue a stop work order if Battelle or EPA QA staff discover adverse findings that will compromise test results.

Battelle Technical Staff will support Mr. Boczek in planning and conducting the verification test. The responsibilities of the technical staff will be to:

- Assist in planning for the test and making arrangements for the receipt of the technologies.
- Perform statistical calculations specified in this test/QA plan on the technology data as needed.
- Provide results of statistical calculations and associated discussion for the verification reports as needed.
- Support Mr. Boczek in responding to any issues raised in assessment reports and audits related to statistics and data reduction as needed.

Mr. Zachary Willenberg is Battelle's Quality Manager for the AMS Center. Mr. Willenberg will:

- Review the draft and final test/QA plan.
- Attend the verification test kick-off meeting.
- Conduct a technical systems audit at least once during the verification test, or designate other QA staff to conduct the audit.
- Audit at least 10% of the verification data or designate other QA staff to conduct the data audit.
- Prepare and distribute an assessment report for each audit.
- Verify implementation of any necessary corrective action.
- Request that Battelle's AMS Center Manager issue a stop work order if audits indicate that data quality is being compromised.
- Provide a summary of the QA/QC activities and results for the verification reports.
- Review the draft and final verification reports and verification statements.

A1.2 Technology Vendors

The responsibilities of the technology vendors are as follows:

- Review and provide comments on the draft test/QA plan.
- Accept (by signature of a company representative) the final test/QA plan prior to test initiation.
- Provide two units of their technology for evaluation during the verification test.
- Provide all other equipment/supplies/reagents/consumables needed to operate their technology for the duration of the verification test.
- Provide an operator for the duration of the test, or supply training on the use of the technology and written consent and instructions for test staff to carry out verification testing, including written instructions for routine operation of their technology.
- Provide maintenance and repair support for their technology, on-site if necessary, throughout the duration of the verification test.
- Review and provide comments on the draft verification report and statement for their respective technology.

A1.3 EPA

EPA's responsibilities in the AMS Center are based on the requirements stated in the "Environmental Technology Verification Program Quality Management Plan" (EPA QMP).[2] The roles of specific EPA staff are as follows:

Ms. Lauren Drees is EPA's acting AMS Center Quality Manager. For the verification test, Ms. Drees or her designee will:

- Review the draft test/QA plan.
- Perform at her option one external technical systems audit during the verification test.
- Notify the EPA AMS Center Project Officer of the need for a stop work order if the external audit indicates that data quality is being compromised.
- Prepare and distribute an assessment report summarizing results of the external audit.
- Review draft verification reports and verification statements.

Mr. Douglas Grosse is EPA's Project Officer for the AMS Center. Mr. Grosse will:

- Review the draft test/QA plan.
- Approve the final test/QA plan.
- Review the draft verification reports and verification statements.
- Oversee the EPA review process for the test/QA plan, verification reports, and verification statements.
- Coordinate the submission of verification reports and verification statements for final EPA approval.

A1.4 BP Naperville, IL Test Facility

This test will be conducted in collaboration with the BP Naperville, IL Test Facility, who will provide in-kind support for this test. The responsibilities of personnel from the BP Naperville, IL Test Facility include the following:

- Coordinate use of the test site for the purposes of ETV testing, assuring access to the test site for Battelle, EPA, and vendor representatives.
- Support the test by providing facilities and needed utilities (e.g., laboratory space, test apparatus, electricity, and compressed gases) for the technologies and reference methods during testing.
- Following BP safety requirements, conduct a Process Safety Management Review.
- Assist Battelle and vendor staff in the operation and testing of the technologies at the test site.
- Perform testing activities and data acquisition, as needed, as specified in this test/QA plan.
- Review the draft verification reports and verification statements.

A1.5 Petrochemical Plant and Chemical Plant

This test will be conducted in collaboration with the petrochemical plant and chemical plant, both located in the Gulf Coast region of Texas, who will provide in kind support for this test. The responsibilities of personnel from these two sites include the following:

- Coordinate use of the test site for the purposes of ETV testing, assuring access to the test site for Battelle, EPA, subcontractor, and vendor representatives.
- Support the test by providing facilities and needed utilities (e.g., work space, electricity) for the technologies and reference methods during testing.
- Identify components or portions of the plant appropriate for use as field testing venues for the LDAR technologies.
- Assist Battelle and vendor staff in the operation and testing of the technologies at the test site.
- Perform testing activities and data acquisition, as needed, as specified in this test/QA plan.
- Collect and report basic meteorological data (e.g., wind speed, wind direction, temperature, and relative humidity) at the test site during the field period.
- Review the draft verification reports and verification statements.
- Provide contractors with necessary health and safety training prior to field testing, as specifically required by the sites.

A1.6 Sage Environmental Consulting Richardson, TX

Quantification of the leakage rates of leaks found during testing will be established by enclosing (or bagging) the leaking components and analyzing the captured samples. The reference method sample collection and analysis will be subcontracted to Sage Environmental

Consulting from Richardson, Texas. This firm has experience in performing these analyses for similar testing conducted in the past. They will follow the EPA reference methods with the variations stated in Section B4. The responsibilities of personnel performing the reference analysis include the following:

- Coordinate with Battelle, host site, and vendor personnel in carrying out the field testing procedures.
- Perform the on-site reference bagging procedure and analytical determination of leaks.
- Provide all supplies necessary to carry out the reference method collection and analytical determination.
- Conduct all QC efforts as specified in this test/QA plan.
- Calculate the reference results in terms of leak rate and provide a data package to Battelle that includes all sampling data sheets, analysis records, calibration data, and QA/QC information, and that presents the reference sample analysis results.

A2 BACKGROUND

The ETV Program conducts third-party performance testing of commercially available technologies that detect or monitor natural species or contaminants in air, water, and soil. The purpose of ETV 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 guided the development of this test on LDAR technologies.

The purpose of this test/QA plan is to specify procedures for a verification test applicable to commercial LDAR technologies. The purpose of the verification test is to evaluate the performance of participating technologies in both field and laboratory environments. In performing the verification test, Battelle will follow the technical and QA/QC procedures

specified in this test/QA plan and will comply with the data quality requirements in the AMS Center QMP.[1]

A3 VERIFICATION TEST DESCRIPTION AND SCHEDULE

A3.1 Summary of Technology Category

Currently in the United States and in other industrialized countries, fugitive emission monitoring (FEM) programs are based on U. S. EPA Method 21[3] which involves the use of a portable hydrocarbon analyzer to monitor for leaks at industrial component interfaces such as flanges, couplings, and valves. Current fugitive emission monitoring methods such as organic vapor analyzers, bubblers, and ultrasonic leak detection equipment, have traditionally been used in accordance with Method 21. Method 21 requires sampling of each of the numerous components of a plant that may leak. While thorough, this procedure is costly because it requires a large amount of operator effort. In addition, since most of the fugitive emissions come from a few large leaks, the practice of individually checking each potential source is not very efficient. The actual number of components to be tested in a refinery or chemical plant can be quite large, making Method 21 monitoring both time intensive and expensive.

A class of technology, generally referred to as optical imagers or leak detection and repair (LDAR) devices, offers operators the ability to monitor components from a distance and instantaneously identify leaking components within the line of sight of the optical imager. The remote sensing and instantaneous detection capabilities of optical imaging technologies allow an operator to scan areas containing many potential leaks, thus eliminating the need to visit and individually measure all potential leak sites. Significant leaks are identified immediately, allowing quicker repair, and ensuring efficient use of resources.

Typically, remote monitoring using these technologies can be broken down into two approaches: active and passive. Active imagers use a powered radiation source to illuminate the region of interest, while passive imagers rely on differential absorption and scene differences.

The majority of the passive imagers used in the petrochemical industry rely on detecting infrared (IR) radiation changes due to the molecular IR transitions of many hydrocarbon species. Different molecules have IR spectral features at different wavelengths, and imaging different wavelengths requires different imaging devices or detectors. This evaluation will be testing passive infrared imaging technologies.

A potential difficulty with using this type of technology in the field is the differing environments in which it might be used. Since the passive imagers rely on the physical characteristics of the environment and the molecules being imaged to create an image viewed by the operator, the environmental characteristics may confound the measurement. For example, if there is not sufficient thermal emission or absorption by the leaking gas, the imager may not be able to detect a leak against the ambient thermal background.

The passive technologies that will be evaluated in this verification test will be chosen on specific criteria as potential alternatives to Method 21. These criteria are:

- The technology must be commercially available.
- The technology must be portable, i.e., hand-held or able to be carried through the plant by one person on foot.
- The technology must rapidly relay a real-time response. This can be an image on a screen showing the leak plume or an electronic reading of the relative intensity or concentration of the leak.
- The technology must have wavelength response that allows detection of a variety of chemicals of importance in the petroleum and petrochemical industries.
- The technology must have readily-accessible data collection capability.
- The technology must be intrinsically safe in a potentially explosive atmosphere (i.e., a hydrocarbon plant).

A3.2 Verification Test Schedule

Table 1 shows the planned schedule of testing and data analysis/reporting activities to be conducted in this verification test. As shown in Table 1, preparation to test the technologies will begin summer and fall of 2008. The preparation includes training on operation of the technologies, fulfilling any health and safety documentation for the laboratory and field testing sites, and fulfilling any training requirements for approval to work at the test sites (i.e., safety training and drug testing). The field and laboratory testing activities are planned to be conducted from summer/fall 2008 through winter/spring 2009. The period of testing is estimated to cover six months because of coordination with the laboratory site and with multiple field sites, many safety requirements, the host site facilities' schedules, and desire to test in both winter and summer. The laboratory testing will be conducted first and is expected to last approximately one week. The field testing will follow the laboratory testing and will be scheduled at one site during the winter and the other site during the summer. Battelle, the subcontractor, and the vendors will be performing the testing. Following testing, a separate ETV verification report will be drafted for each LDAR technology. The reports will be reviewed by the technology vendor and subsequently by peer reviewers selected from the stakeholders, the funding organizations, and the EPA. The final reports will be submitted to EPA for final signature, and these documents will be made publicly available on both the EPA/ETV and the Battelle AMS Center websites.

A3.3 Test Sites

Laboratory testing will be conducted at the BP Naperville, IL Research Complex. Field testing will be conducted at two industrial plants to include one petrochemical plant and one chemical plant, both located in the Gulf Coast region of Texas. Sample bagging at the field sites for the reference sample collection will be conducted by a subcontracted laboratory who typically perform this function at the site. Reference analysis of the bagged samples will be performed by a sub-contracted analytical laboratory. In performing this verification test at the

various sites, Battelle will follow the procedures specified in the test/QA plan and will comply with quality requirements in the AMS Center QMP.[1]

Table 1. Planned Verification Test Schedule

Completed by Month/Year	Testing Activities	Data Analysis and Reporting
August/Sept. 2008	• Technology training by vendor or coordination with vendor representative • Coordinate for technologies and testing supplies to be delivered to testing sites • Conduct Process Safety Management Review • Coordinate for all testing personnel to be approved with the site. This may require completion of certain courses and passing a drug test.	• Begin preparation of ETV report template
Oct. 2008 to Feb. 2009	• Perform testing at laboratory site (approximately 1 week) • Perform testing at field sites (approximately 1 week per site) • Calibration of technologies regularly and as needed	• Compile data from all technologies at all sites • Compile testing environment conditions • Collect and analyze data from reference samples
May 2009		• Analyze and finalize all data • Complete common sections of reports • Prepare draft reports
June 2009		• Internal review of draft reports • Vendor review of draft reports
July 2009		• Revision of draft reports • Peer review of draft reports
September 2009		• Revision of draft reports • Submission of final reports for EPA approval

A3.4 Health and Safety

Battelle will conduct all verification testing and reference measurements following the safety and health protocols in place for the host facilities. This includes maintaining a safe work environment and a current awareness of handling potentially toxic chemicals. Exposure to potentially toxic chemicals will be minimized, personal protective equipment will be worn as needed, and safe laboratory practices will be followed.

A4 QUALITY OBJECTIVES

In performing the verification test, Battelle will follow the technical and QA procedures specified in this test/QA plan and will comply with the data quality requirements in the AMS Center QMP.[1] This verification test is designed to evaluate the performance of the LDAR technologies for detecting gaseous leaks from processing plant piping systems and from laboratory manifested scenarios. Calibrations of LDAR technologies will follow manufacturer specified procedures and acceptance criteria. The verification of technology performance will include a comparison of the technology results to known leak rates produced using calibrated flow meters and gas cylinders in the laboratory, and to EPA reference method results in the field. In addition, environmental factors and testing conditions will be documented. The validity of the execution of the reference method analytical procedures will be checked by a Performance Evaluation (PE) audit. The Battelle AMS Center Quality Manager or designee will carry out QA/QC oversight and auditing. This will include a Technical Systems Audit (TSA) and a data quality audit. The planned audit procedures are described in Section C1. The EPA (acting) AMS Center Quality Manager also may conduct an independent TSA, at her discretion.

Data quality objectives indicate the minimum data quality required to meet the LDAR technology verification objectives. Data quality objectives for this verification test include those related to the reference method performance, those related to the LDAR technology performance, and those related to documenting verification testing staff observations. Data quality objectives for the reference method (see Section B4) are presented in terms of data quality indicator (DQI) criteria for the critical measurements associated with the reference method and are listed in Table 5 (Section B5). In the field, the reference method data quality relies, in part, on proper sample collection and preparation, proper application of the reference method, and proper maintenance of reference method instrumentation. In the laboratory, the data quality relies on the known leak rate as calculated by the flow from certified gas cylinders and calibrated flow controllers.

Battelle will rely on the vendor's data quality objectives for each LDAR technology in order to insure that the technology is performing properly during testing. The technology data quality relies on proper operation and maintenance of the LDAR technologies. The results from these technologies are expected to be qualitative and will be reported as either detect or non-detect for the test conditions in both the laboratory and the field. A result is reported as detected when the operator and two confirming individuals all agree that they observe the leak.

A5 SPECIAL TRAINING/CERTIFICATION

Operation of each LDAR technology may be carried out in one of two possible ways. First, a previously trained vendor representative may operate the technology during testing. In this scenario, the vendor will verify that the operator is sufficiently trained to successfully utilize the technology. The second option is that a vendor representative will train a Battelle technical staff member to operate the technology. This training will be documented and verified by both the trainer and the trainee, and the vendor will be required to attest that the operator is adequately trained to carry out the testing. Documentation of training related to technology testing, data analysis, and reporting is maintained with all testing documentation for the specified period of time in the AMS Center QMP.[1] The Battelle AMS Center Quality Manager may verify the presence of the appropriate training records prior to the start of testing.

A6 DOCUMENTATION AND RECORDS

The records for this verification test will be contained in the test/QA plan, chain-of-custody (COC) forms, laboratory record books (LRBs), data collection forms, electronic files (both raw data and spreadsheets), and the final verification report and assessment reports. All of these records will be maintained in the Verification Test Coordinator's office or at the field site during the test and will be transferred to permanent storage at Battelle's Records Management Office at the conclusion of the verification test, except for assessment reports, which are permanently stored with the Battelle AMS Center Quality Manager. All Battelle LRBs are stored indefinitely, either by the Verification Test Coordinator or Battelle's Records Management Office. EPA will be notified before disposal of any files. Table 2 has further details regarding the data recording practices and responsibilities. Finally, duplicates will be made of all records and data collected at the field sites and will be left on premises in the possession of the testing site.

All written records must be in ink. Any corrections to notebook entries, or changes in recorded data, must be made with a single line through the original entry. The correction is then to be entered, initialed, and dated by the person making the correction. In all cases, strict confidentiality of data from each vendor's technology will be maintained. Separate files

(including manual records, printouts, and/or electronic data files) will be kept for each vendor's technology.

In some cases, recorded images might have less resolution than the originally viewed image of the technology. All images will be evaluated on the direct image from the technology and not evaluated on a recorded image.

Table 2. 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, technology maintenance, down time, etc.	ETV LRBs or data recording forms	Start/end of test procedure, and at each change of a test parameter or change of technology status	Battelle or technology operator; host facility	Used to organize and check test results; manually incorporated in data spreadsheets as necessary
Technology calibration information	ETV LRBs, data recording forms, or electronically	At technology calibration or recalibration	Battelle or technology operator	Incorporated in verification report as necessary
Technology readings	Recorded electronically by the technology and downloaded to an independent computer, or hard copy data printed by the technology and taped into the ETV LRB, or hand entered into ETV LRBs or data recording forms	Recorded continuously for electronic data, printed after each measurement for hard copy print-outs, or recorded manually with each reading	Battelle or technology operator	Converted to or manually entered into spreadsheet for statistical analysis and comparisons Shared with the testing site to facilitate necessary repairs
Sample collection for reference method analysis procedures, calibrations, QA, etc.	LRBs, chain-of-custody, or other data recording forms	Throughout sampling and analysis processes	Subcontractors, Battelle, and others assisting in reference sample collection and sample analysis	Retained as documentation of sample collection or reference method performance
Reference method results	Electronically or manually into ETV LRBs or data recording forms	Every sample or QC analysis	Subcontractors, Battelle, or other reference sample analysis technician	Transferred to spreadsheets for calculation of results, and statistical analysis and comparisons

SECTION B
MEASUREMENT AND DATA ACQUISITION

B1 EXPERIMENTAL DESIGN

LDAR technologies will be tested in a laboratory under controlled conditions and in the field at petroleum and/or chemical plants. The laboratory tests will allow comparison of the technology results to known scenarios under a specified set of conditions that eliminate other confounding variables (humidity, ambient light, exposure to the elements, etc). Field tests will allow for performance evaluation under "real world" conditions. Overall, the performance of the LDAR technologies will be verified based on the following factors:

- Detection of different chemical gas species relative to a portable monitoring device (acceptable under Method 21)
- Method detection limits for each detectable species
- Inter-unit comparability
- Influence of confounding factors (wind, background, etc.)
- Operational factors (ease of use, sampling time, sampling costs)

The responses to these parameters will be collected as either detect or non-detect from the technologies; however, a quantitative method will confirm leak flow rates. Test compounds that a technology proves capable of detecting in the laboratory portion will be tested in the field. The laboratory test will have known leaks from gas cylinders with calibrated flow meters to calculate the leak emission rate. The flow rates of the field leaks will be determined by a reference method, called the bagging method or *EPA Protocol for Equipment Leak Emissions Estimates*.[4] This method involves completely enclosing the leak with non-permeable material, collecting the leak with a flow of clean air or nitrogen entering the bag, and mass measurement of the bagged leak from an analytical method. More details on the bagging method are provided in Section B4.

The evaluations will be performed according to the vendor's recommended procedures as described in the user's instructions or manual, or during training provided to the operator. Care will be taken to use and record the use of the most appropriate lens and zoom features for the technology. Similarly, calibration and maintenance of the technologies will be performed as specified by the vendor. The technologies will be evaluated on chemicals observable according to the vendor stated abilities. Results from the technologies being verified will be recorded

manually by the operator on appropriate data sheets or captured in an electronic data system and then transferred manually or electronically for further data workup. The results from each technology will be reported individually and evaluated from the direct reading and not from the recorded image. There could be a resolution difference between the original viewing and the recorded image that will not be tested in this evaluation. No direct comparison will be made between technologies, but each technology will undergo the same testing so it is convenient for end users to evaluate the ETV testing results.

B1.1 Test Procedures

The following sections describe the test procedures that will be used to evaluate LDAR technologies in the laboratory and the field scenarios.

B1.1.1 Laboratory Test Procedures

The laboratory LDAR technology evaluation will be conducted at the Naperville BP plant near Chicago, Illinois. The testing group will consist of lab host site staff setting up the experiments, the technology operator, and two confirming individuals to verify the result.

The laboratory testing will be conducted with the specific testing conditions that are presented in Table 3. The experimental factors to be altered for each chemical tested are the background materials, wind speed, and stand-off distance. These experimental factors were chosen, because the passive imagers rely on physical characteristics of the monitoring environment. The background will demonstrate the ability of the technology to visualize the leak with a background similar to the leaking component (curved metal gas cylinder) and with a background that is different than the leaking component, but more uniform in nature (cement board). The wind speed variations and the stand-off distances will elucidate these effects on the method detection limit, and in turn on real-world applicability.

A list of chemicals to be used in laboratory testing is shown in Table 4. From one to all of these chemicals will be used in the laboratory testing of each LDAR technology; however, this list might be limited by the vendor-stated capabilities of detecting the chemicals and the testing constraints of time, labor, funding, etc. This list of chemicals encompasses different groups of chemicals that absorb at different wavelengths. It is an abbreviated but representative list of chemicals of interest that were identified by the stakeholder committee, which is made up of experts in this field from governmental agencies and private companies. Many of the chemicals

have a general absorbance in the 3 – 5 µm range and a fingerprint absorbance specific to the compound in the 7 - 14 µm range. Thus, these chemicals would be applicable for a mid or long range imaging technology. The list also includes some chemicals that would be found at the field sites so as to challenge the technologies in controlled and real world environments with some similar chemicals.

Table 3. Laboratory Testing Matrix for Each Chemical of Interest

Test Condition	Experimental Factors			
	Component	Background	Wind Speed	Stand-off Distance
1	Valve	Curved metal gas cylinder	0 m/sec	10 ft
2	Valve	Curved metal gas cylinder	0 m/sec	30 ft
3	Valve	Curved metal gas cylinder	2.5 m/sec	10 ft
4	Valve	Curved metal gas cylinder	2.5 m/sec	30 ft
5	Valve	Curved metal gas cylinder	5 m/sec	10 ft
6	Valve	Curved metal gas cylinder	5 m/sec	30 ft
7	Valve	Cement board	0 m/sec	10 ft
8	Valve	Cement board	0 m/sec	30 ft
9	Valve	Cement board	2.5 m/sec	10 ft
10	Valve	Cement board	2.5 m/sec	30 ft
11	Valve	Cement board	5 m/sec	10 ft
12	Valve	Cement board	5 m/sec	30 ft

Table 4. Chemicals of Interest in Testing

Chemical Group	Chemical	Lab Testing	Field Testing
Acetate	Acetic acid	X	
Acid	Acrylic acid	X	
Alcohol	Methanol	X	X
Alkane	Pentane	X	X
Aromatic	Styrene	X	X
Aromatic	Benzene	X	X
Chlorinated	Methylene chloride	X	X
Chlorinated	Propylene dichloride	X	X
Inorganic	Hydrochloric acid	X	X
Olefin	1,3-Butadiene	X	X
Olefin	Ethylene	X	X

The general testing procedure for the laboratory experiments will begin with a specific testing condition set up. Then, the operator will view this condition at a leak rate high enough to be identified by the operator and two confirming individuals. The method detection limit will be determined and recorded for the leak condition. Detection limits will be determined for each of the twelve testing conditions with each chemical tested. See section B1.1.2 for the procedure for

assessing the detection limit. At each detection limit, a portable monitoring device (acceptable under Method 21) will "sniff" the leak to determine if it would detect a leak at that rate and under the tested conditions. In addition, two units of the technology will be operated by the same staff following the same procedure to assess inter-unit reproducibility. All results will be recorded along with the corresponding environmental conditions. Specifically, the temperature of the chemical plume and the ambient temperature will be recorded and reported for each testing condition. Any operational factors will be noted by the operator related to the use of the technology.

B1.1.2 Field Test Procedures

The evaluation of LDAR technologies will be performed at two field sites: a petrochemical and a chemical plant. The chemicals tested in the laboratory will be possible leaking chemicals at the field sites. The testing group will consist of the technology operator, two confirming individuals to verify the result, and the bagging team to collect the reference samples. Additionally, representatives from the host testing sites will be permitted to operate their own LDAR equipment simultaneously during the field testing. This group will move through the plant screening for possible leaking components using a portable monitoring device (acceptable under Method 21) as specified in the bagging reference method. Once a leak is detected, leak characteristics and environmental factors will be recorded (i.e. type of component, background, date and time, temperature, etc). Where space permits, the operator will then take readings from two units of the same LDAR technology at three stand-off distances (10, 30, and greater than 30 feet, if possible) adjusting and noting the lens and zoom features, as needed. Meteorological parameters and operational factors related to the use of the technology will be noted by the operator to further characterize the testing environment. Meteorological data will be retrieved from the nearest meteorological data station. Every reading will be verified by two confirming individuals and recorded by the operator as detect or non-detect. The operator and the two confirming individuals must agree on each result. If they do not agree, the result will be considered a non-detect. Once all the technologies being evaluated have scanned the leak, the bagging team will commence collecting the reference samples using the procedure described in Section B4. This procedure will conclude with a final screening from an accepted portable monitoring device to verify that the leak has not changed from the beginning to the end of testing the component. If a leak changes more than 20% between the pre- and post- screening with the portable monitoring device, the leak will not be considered consistent enough to report in the

results. All field conditions will be reported with the technology results. This entire process will be repeated between 20 and 40 times or as scheduling permits at each field site. Collecting a large sample size at each field site, randomizing the testing order of the technologies, and collecting a broad range of sample types (different leak rates, components, time of day, etc) at the field sites will mask the variability of the field conditions. To reduce the possible variability from day to day conditions of the field environment, this sampling process for each leak will be completed on the same day it begins. Finally, on a daily basis, the testing group will report to the testing site the leaking components detected by the technology to assist the site in making necessary repairs.

B1.1.3 Testing Parameters for Laboratory and Field Testing

The following sections describe in more detail the evaluation of the testing parameters at the laboratory and/or field sites.

B1.1.3.1 Detection of Chemical Gas Species Relative to a Portable Monitoring Device

The detection of a single chemical gas leak in either the lab or field environments will be determined by the operator as well as two confirming individuals and reported qualitatively as either detected or non-detected. All three individuals must agree on the results. If they do not agree, the result will be reported as a non-detect. The leak rate will be known from certified gas cylinders and calibrated flow meters in the laboratory, or determined through the bagging method in the field environment. Whether a leak is detected or not will be reported along with the conditions of the leak and the environment. A portable monitoring device (acceptable under Method 21) will "sniff" the leaks as part of the field reference method. In the lab, these qualitative data will be reported with the technology results. This will reflect whether or not a technology would have detected a leak relative to a device acceptable under Method 21. This will be reported as percent agreement by chemical that would have been detected by Method 21.

B1.1.3.2 Method Detection Limit

Method detection limits will only be determined in the laboratory portion of this test. Once it has been determined that a LDAR technology can detect a specific chemical, the method detection limit will be determined. To do this, the leak rate will be set at a nominally detectable level that is either specified by the vendor's LOD or is based on previous literature concerning the technology's capabilities. The criteria for finding the leak are as follows:

- The operator and two confirming individuals all must identify the leak.
- They will view the leak through the intended view (eye piece or monitor) for the technology as specified by the vendor.
- They will have five seconds to identify the origin of the leak or be able to track the cloud back to the leaking component.

For the laboratory portion of the test, if all three individuals identify the leak, then the leak rate will be reduced at the discretion of the testing staff. Once a leak rate that is not identifiable by all three people has been reached, the rate will be increased to the level where all three can again identify the leak using the LDAR technology. This rate is the method detection limit for the technology under the tested conditions. The detection limit and testing conditions will be reported. This process will be completed for every testing trial listed in Table 3 for each chemical gas species tested.

B1.1.3.3 Inter-unit Reproducibility

Each technology will be tested with duplicate units to evaluate the inter-unit reproducibility. The same operator will use both units and all results will be verified by the confirming individuals. In the lab, Inter-unit reproducibility will be determined by calculating a linear regression comparing the MDLs of the two units for each chemical of interest. The field results will determine inter-unit reproducibility by calculating percent agreement between the detect and non-detect results from both units for measurements at each field site.

B1.1.3.4 Confounding Factor Effects

Confounding factors will be assessed in the lab and field environments. In the lab, the conditions will be controlled and will follow the test conditions presented in Table 3 for each chemical. These include two different backgrounds, three wind speeds and two stand-off distances. In the field, in addition to background, wind speed, and distance, other factors that will be noted include: component type, relative wind direction with respect to the LDAR technology, humidity, temperature, location, and meteorological conditions (among other components or stand-alone).

B1.1.3.5 Operational Factors

Operational factors such as maintenance needs, calibration frequency, data output, consumables used, ease of use, repair requirements, and sample throughput will be evaluated based on operator observations. A laboratory record book (LRB) or data sheets will be used to

document observations. Examples of information to be recorded include the daily status of diagnostic indicators for the technology, use or replacement of any consumables, the effort or cost associated with maintenance or repair, vendor effort (e.g., time on site) for repair or maintenance, the duration and causes of any technology down time or data acquisition failure, operator observations about technology startup, ease of use, clarity of the vendor's instruction manual, user-friendliness of any needed software, overall convenience of the technologies and accessories/consumables, or the number of samples that could be processed per hour or per day. These observations will be summarized to aid in describing the technology performance in the verification report on each technology.

B1.2 Statistical Analysis

The statistical methods and calculations used for evaluating quantitative performance parameters are described in the following sections.

B1.2.1 Method Detection Limit

The method detection limit will be assessed in the lab through the procedure stated in section B1.1.3.2 and reported as such. The detection limits will be reported in tabular form relative to the conditions specified in Table 3. An overall detection limit variation will be calculated as the standard deviation of the detection limits determined under all the conditions for each chemical of interest. The equation for standard deviation is as follows:

$$S_x = \left[\frac{1}{n-1} \sum_{k=1}^{n} (C_k - \overline{C})^2 \right]^{1/2} \quad (1)$$

where S_x is the standard deviation of all detection limits determined for chemical x, n is the number of replicate samples, C_k is the leak rate measured for the kth sample, and $\overline{C}$ is the average leak rate of the replicate samples.

B1.2.2 Linear Regression

Inter-unit reproducibility for the laboratory results will be assessed by linear regression with the MDLs for unit # 1 along the x-axis and the corresponding MDLs for unit # 2 along the y-axis. Linearity will be expressed in terms of the slope, intercept, and the coefficient of determination (r^2).

B1.2.3 Percent Agreement

The field results will assess inter-unit reproducibility by calculating the percent agreement between the two units. Percent agreement will be calculated using the following:

$$\%Agreement = \frac{A}{T} \times 100 \quad (2)$$

where A is the number of tests that both units agree and T is the total number of tests.

Percent agreement will also be used to assess the agreement between the technology and the portable monitoring device (acceptable under Method 21) in the laboratory for each chemical of interest. The inverse of the percent agreement will be the percentage of the results that the technology would detect a leak when Method 21 would not.

B1.3 Reporting

The data obtained in the verification test will be compiled separately for each vendor's technology, and the data evaluations will be applied to each technology's data set without reference to any other. At no time will data from different vendor's technology be inter-compared or ranked. Following completion of the data evaluations, a draft verification report and verification statement will be prepared for each vendor's technology, stating the verification test procedures and documenting the performance observed. 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 draft report. Each report will briefly describe the ETV Program, the AMS Center, and the procedures used in verification testing. The results of the verification test will be stated quantitatively, without comparison to any other technology tested, or comment on the acceptability of the technology's performance. Each draft verification report will be submitted for review by the respective technology vendor and by EPA and other peer reviewers. Comments on the draft report will be addressed in revisions of the report. The peer review comments and responses will be tabulated to document the peer review process. The reporting and review process will be conducted according to the requirements of the AMS Center QMP.[1]

B2 SAMPLING REQUIREMENTS

B2.1 Sample Collection, Storage and Shipment

Samples in the forms of leaks in both lab and field environments will be detected by the LDAR technologies in real time. The reference method samples for each leak will be collected and handled in either bags or canisters as specified in the reference method. The reference samples will be collected and analyzed in duplicate to obtain an average mass emission from the leak. They will be analyzed on-site or sent to an analytical laboratory. Reference sample shipments will be via a traceable overnight delivery service to the Battelle sample custodian or an appropriate analytical lab. The samples will be stored at room temperature. The holding time will be determined by the analytical chemist developing the GC method following EPA Method 18[5]. It will depend on the collection container (Teflon bag or canister) and the chemical collected.

B3 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Reference sample custody will be documented throughout collection, transport, shipping (if necessary), and analysis using standard chain-of-custody (COC) forms provided by Battelle or supplied by others providing samples for testing, as appropriate. Samples transferred within Battelle may be documented in bound sample login LRBs. Each COC form will summarize the samples collected. The COC forms will track sample release from the sampling location to Battelle. Each COC form will be signed by the person relinquishing the samples once that person has verified that the COC form is accurate. The original sample COC forms will accompany the samples; the shipper will keep a copy. Upon receipt, COC forms will be signed by the person receiving the samples once that person has verified that all samples identified on the COC forms are present. Any discrepancies will be noted on the form and the sample receiver will immediately contact the Verification Test Coordinator to report missing, broken, or otherwise compromised samples. Copies of all COC forms will be delivered to the Verification Test Coordinator, and maintained with the test records. Samples being transferred within Battelle may be documented in a sample login LRB which will be used to note the current location of all samples housed at Battelle.

B4 REFERENCE METHOD

The laboratory will not use a specified reference method for determining the leak rate of the test conditions. Certified gas cylinders will be used with a calibrated flow meter. Once gas flow is equilibrated through the system, this will constitute a known leak.

The reference method for all field samples will be the combination of a reference collection method and an analytical method for the determination of the reference samples. The U.S. EPA *Protocol for Equipment Leak Emission Estimates*[4] Section 4 describes the bagging method used to collect the reference samples. It incorporates an initial screening of the leaking component with a portable monitoring device. Then the leaking component is completely enclosed with a non-permeable material and a known clean air or nitrogen flow is supplied to the enclosure to equilibrate the mass flow. The material may be Mylar™, Tedlar™, Teflon™, aluminum foil, or aluminum Mylar™ with a thickness ranging from 1.5 mm to 15 mm. The contents of the enclosure or "bag" are then sampled in duplicate into a Teflon™ bag or a canister for analysis by a gas chromatographic (GC) method. Finally, the component is re-screened with the portable monitoring device. There are two basic variations to this approach that have been widely utilized to measure the mass emissions from equipment leaks: the vacuum method and the blow-through method. The main difference procedurally, is that the vacuum method uses a vacuum pump to pull the air through the enclosure and the blow-through method uses a carrier gas such as nitrogen (or another inert gas) blown into the enclosure. Either method may be used depending on the expected sample concentrations and resources available for the test. The vacuum method is preferred when monitoring larger leaks and the blow through method is preferred when monitoring smaller leaks. The bagging protocol will have two variations from the stated EPA procedure.

- No background samples will be taken when using the vacuum method. They would have a negligible effect on the results from higher leaking components.
- No analytical tests will be performed on any liquid leak materials collected. Vapor leak detection is the objective of the performance evaluation; therefore, only the vapor will be analyzed through the reference method procedure.

The analytical method will determine the concentration of the collected sample and will follow EPA Method 18 *Measurement of Gaseous Organic Compound Emissions by Gas Chromatography.*[5] This is a general analytical method that is specific to leak-emission type samples. It is a GC method that may be equipped with a flame ionization detector or an electron

capture detector. Because of the varying numbers and kinds of possible compounds to be detected at differing concentrations, this method allows the technical analyst to research the correct analytical column and temperature program to obtain the necessary detection limit and separation of the compounds of interest. The QA/QC requirements for the documentation and performance of the analytical method are described as data quality indicators (DQI) in Section B5.

B5 QUALITY CONTROL CRITERIA FOR REFERENCE METHOD MEASUREMENT DATA

Table 5 presents the DQIs and criteria for the reference collection and analytical method critical measurements. The reference method measurement quality will be assured by adherence to these DQI criteria.

Prior to start of the reference sampling, the portable monitoring device will be calibrated according to the manufacturer's specified procedure. Initial calibration will consist of an un-spiked gas standard and then four or more additional concentrations of gas standard. A calibration check sample will also be sampled at a minimum of 5 % of the samples to verify the calibration of the portable monitoring device over time. On each day of testing the device will be calibrated and verified that the overall sensitivity has changed < 10 %.

The bagging procedure will be verified by bagging an artificial leak at a known rate in the middle of the analytical calibration curve called a Leak Rate Check. This is to be performed at the beginning and end of the testing period and two times per week of testing. This procedure will be followed as specified in the EPA *Protocol for Equipment Leak Emissions Estimates*[4] with any flow meters or measurement equipment being calibrated following the manufacturer's specified procedure. 80% to 120% recovery will be the acceptable range. If this criterion is not met, the procedure and supplies will be investigated and corrected before sampling continues.

The reference method GC analytical measurement quality will be monitored by comparing the analytical instrument response with calibration standards traceable to certified gas cylinder standards. The calibration curve will consist of an un-spiked standard and four or more additional concentrations of gas standards. The gas standards should be within 2% of the certification. If not, the source of standard contamination or changes in the instrument parameters will be investigated and the standards re-analyzed. Steps will be taken to maintain the quality of data collected during this verification test. This will include analyzing specific

quality control samples (QCS) at a regular frequency. QCSs will include negative controls and positive controls. Negative control samples are blank samples that will be used to help ensure that no sources of contamination are introduced in the analysis procedures. The positive control samples will indicate to the operator whether or not the GC is functioning properly and be at a mid-level calibration concentration. QCSs producing results that do not meet the anticipated criteria will be reanalyzed and corrective action taken if needed to ensure that test sample results are not affected. Positive controls will be accepted if there is ≤ 10% change. Corrective actions for positive controls may include reanalyzing samples to verify that the GC is operating properly, conducting maintenance, or recalibrating. For negative controls, the source of contamination should be investigated, corrected, and the samples re-analyzed. Positive and negative controls will be analyzed at a frequency of approximately 10 % based on the total number of test samples for the LDAR technologies.

Table 5. DQIs and Criteria of Critical Measurements for Reference Method

DQI	Method of Assessment	Frequency	Minimum Acceptance Criteria	Corrective Action
Confirmation of Detected Leaks	Portable monitoring device measurement before and after bagging of component	All field test samples	Pre and post screening results within 20%	Data considered suspect and reanalyzed or reported with qualifiers if reanalysis is not possible
Bias and Accuracy of Sample Screening Measurements- using Portable Monitoring Device	Initial Calibration- various levels of calibration gas. Starting with un-spiked gas standard then 4 or more additional concentrations of gas standard.	Perform initial calibration at the start and end of every verification testing day or if overall device sensitivity changes > 10%.	Each calibration gas standard concentration within 10%	Investigate sources of standard contamination or changes in monitoring device, reanalyze standards.
	Calibration check Sample- one concentration of calibration gas standard	Minimum 5% of all samples tested.	Check standard is within ≤ 10% change in response from initial calibration after adjustment of overall monitoring device sensitivity	Adjust overall monitoring device sensitivity; check new calibration check samples; repeat initial calibration Reanalyze affected sampled components since last successful check if calibration check change is > 10%
Bias and Accuracy of enclosure equilibration gas- zero for bagging component	Collect equilibration gas in bag and analyze for contamination	Before using cylinder as equilibration gas	Concentration of organic compounds should be < 0.1 ppm of chemical of interest	A fresh cylinder or a different equilibration gas should be used

Table 5. (Continued)

Bias and Accuracy of Bagging Procedure-Leak Rate Check for Bag Sampling	Create an artificial leak of a known gas to clarify the magnitude of any bias in the combination of sampling/test method and define the variance in emissions estimate due to the sampling	At the beginning and end of the testing period and 2 times per week during testing	80% to 120% is the accepted recovery range	Investigate and correct before sampling continues
Completeness	Amount of valid data obtained	Overall number of data points collected for test	90% of overall data points collected should be valid	If feasible, analyze additional samples to meet the acceptance criteria
Representativeness	Performance Test and Environmental Samples	Overall for test	Samples which span the responses obtained in the initial calibration curve	Dilute sample and reanalyze
Bias and Accuracy of GC Analytical Method	Initial Calibration-various levels of certified calibration gas. Starting with un-spiked gas standard then 4 or more additional concentrations of gas standard	Perform initial calibration at the start and end of every analytical sequence or if overall instrument sensitivity changes > 10%	Standards are within 2% of certification	Investigate sources of standard contamination or changes in instrument parameters, reanalyze standards
	Positive Control Sample/Calibration check Sample- one concentration of calibration gas standard	Minimum 10% of all samples tested	Check standard is within ≤ 10% change in response from initial calibration after adjustment of Overall Instrument Sensitivity Reanalyze affected samples since last successful check if calibration check change is > 10%	Adjust Overall Instrument Sensitivity; check new calibration check samples; repeat initial calibration
	Negative Control Sample	Minimum of 10% of all samples tested	Must remain lower than the lowest calibration standard	Investigate source of contamination or changes in instrument parameters, reanalyze sample.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

The test condition and reference equipment used in this test (i.e., instrumentation used for reference measurements, temperature, flow rates, etc.) will be tested, inspected, and maintained as per the manufacturer's recommendations so as to meet the performance requirements established in this document. When technical staff operate and maintain technologies undergoing testing, those activities will follow directions provided by the technology vendor.

B7 INSTRUMENT CALIBRATION AND FREQUENCY

Prior to start of the reference sampling, the portable monitoring device will be calibrated according to the manufacturer's specified procedure. Initial calibration will consist of an un-spiked gas standard and then four or more additional concentrations of gas standard. A calibration check sample will also be sampled at a minimum of 5 % of the samples to verify the calibration of the portable monitoring device over time. On each day of testing the device will be calibrated and verified that the overall sensitivity has changed < 10 %.

The reference method GC analytical measurement quality will be monitored by comparing the analytical instrument response with calibration standards traceable to certified gas cylinder standards. The calibration curve will consist of an un-spiked standard and four or more additional concentrations of gas standards. The gas standards should be within 2% of the certification. The positive control samples will indicate to the operator whether or not the GC is functioning properly and be at a mid-level calibration concentration. Positive controls will be accepted if there is ≤ 10% change. Positive controls will be analyzed at a frequency of approximately 10 % based on the total number of test samples for the LDAR technologies.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

All materials, supplies, and consumables will be ordered by the Verification Test Coordinator or designee. Where possible, Battelle will rely on sources of materials and consumables that have been used previously as part of ETV verification testing without problems. Battelle will also rely on previous experience or recommendations from EPA advisors, host facilities, or the LDAR vendor.

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 during the verification test. Table 2 summarizes the types of data to be recorded. All maintenance activities, repairs, calibrations, and operator observations relevant to the technology operation will be documented by technical staff in LRBs or on data sheets. Results from the reference methods, including raw data, analyses, and final results, will be compiled by Battelle, and duplicates of the data will be left on premises of the testing sites.

Records received by or generated by any technical staff during the verification test will be reviewed by a Battelle staff member within two weeks of generation or receipt, before the records are used to calculate, evaluate, or report verification results. 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 who originally 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, any calculations performed by technical staff will be spot-checked by Battelle QA and/or technical staff to ensure that calculations are performed correctly. Calculations to be checked include any statistical calculations described in this test/QA plan. The data obtained from this verification test will be compiled and reported independently for each technology. Results for technologies from different vendors will not be compared with each other. Finally, representatives from the testing sites will have the opportunity to review all images and data prior to public distribution or publication.

Among the QA activities conducted by Battelle QA staff will be an audit of data quality. This audit will consist of a review by the Battelle AMS Center Quality Manager (or his designee) of at least 10% of the test data. During the course of any such audit, the Battelle AMS Center Quality Manager will inform the technical staff of any findings and any need for immediate corrective action. If serious data quality problems exist, the Battelle AMS Center Quality Manager will request that Battelle's AMS Center Manager issue a stop work order. Once the assessment report has been prepared, the Verification Test Coordinator will ensure that a response is provided for each adverse finding or potential problem, and will implement any

necessary follow-up corrective action. The Battelle AMS Center Quality Manager will ensure that follow-up corrective action has been taken.

Data obtained during the verification test will be maintained confidentially at Battelle, and used only for purposes of the LDAR evaluation. Data reporting in the final report will consist of tabular results of the calculations in Section B. Any images from the LDAR devices that are presented will only be included after permission from the host site has been granted, and it has been determined that no proprietary information is contained in the image. All data and images, to the extent possible, will be host site anonymous.

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 test/QA plan is to establish mechanisms necessary to ensure this. The procedures described in this test/QA plan, which is peer reviewed by a panel of outside experts, implemented by the technical staff and monitored by the Verification Test Coordinator, will give information on data quality on a day-to-day basis. The responsibility for interpreting the results of these checks and resolving any potential problems resides with the Verification Test Coordinator. Technical staff have 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 Verification Test Coordinator, who will work with the Battelle AMS Center Quality Manager to resolve any issues. Action will be taken to control the problem, identify a solution to the problem, and minimize losses and correct data, where possible. Independent of any EPA QA activities, Battelle will be responsible for ensuring that the following audits are conducted as part of this verification test.

C1.1 Performance Evaluation Audits

A Performance Evaluation (PE) audit will be conducted to establish the traceability of the GC analytical reference method measurements made in this verification test. The reference method PE audit will be performed using an independent, certified cylinder calibration gas mixture. This PE audit sample will be analyzed in the same manner as all other samples and the analytical results for the PE audit samples will be compared to the nominal concentration. The target criterion for this PE audit is agreement of the analytical result within 25% of the nominal concentration. If the PE audit result does not meet the target criterion, the PE audit will be repeated. If the outlying results persist, the source of error will be investigated and corrective action taken as necessary until successful PE audit results are obtained. This audit will be performed once prior to the start of the test at each field site, and will be the responsibility of the Verification Test Coordinator or designee.

C1.2 Technical Systems Audits

The Battelle AMS Center Quality Manager will perform a technical systems audit (TSA) at least once 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] this test/QA plan, using the EPA designated reference method, and any Standard Operating Procedures (SOPs) used by Battelle. In the TSA, the Battelle AMS Center Quality Manager or a designee may review the reference method used, compare actual test procedures to those specified or referenced in this plan, and review data acquisition and handling procedures. The Battelle Quality Manager will tour the test sites, observe and review the test procedures, and review record books. He will also check calibration certifications for test measurement devices. A TSA report will be prepared, including a statement of findings and the actions taken to address any adverse findings. The EPA AMS Center Quality Manager will receive a copy of Battelle's TSA report. 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 AMS Center Quality Manager will audit at least 10% of the verification data acquired in the verification test. The Battelle AMS Center Quality Manager will trace the data from initial acquisition, through reduction and statistical comparisons, to final reporting. All calculations performed on the data undergoing the audit will be checked.

C1.4 QA/QC Reporting

Each assessment and audit will be documented in accordance with Sections 3.3.4 and 3.3.5 of the AMS Center QMP.[1] The results of the technical systems audit will be submitted to EPA. Assessment reports will include the following:

- Identification of any adverse findings or potential problems
- Response to adverse findings or potential problems
- Recommendations for resolving problems

- Confirmation that gases have been implemented and are effective
- Citation of any noteworthy practices that may be of use to others.

C2 REPORTS TO MANAGEMENT

The Battelle AMS Center Quality Manager, 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 Battelle AMS Center Quality Manager is authorized to request that Battelle's AMS Center Manager issue a stop work order. Once the assessment report has been prepared, the Verification Test Coordinator will ensure that a response is provided for each adverse finding or potential problem and will implement any necessary follow-up corrective action. The Battelle AMS Center Quality Manager will ensure that follow-up corrective action has been taken. The test/QA plan and final report are reviewed by EPA (acting) AMS Center Quality Manager and EPA AMS Center Project Officer. Upon final review and approval, both documents will then be posted on the ETV website (www.epa.gov/etv).

SECTION D
DATA VALIDATION AND USABILITY

D1 DATA REVIEW, VALIDATION, AND VERIFICATION REQUIREMENTS

The key data review requirements for the verification test are stated in Section B10 of this test/QA plan. In general, the data review requirements specify that the data generated during this test will be reviewed by a Battelle technical staff member within two weeks of data generation. The reviewer will be familiar with the technical aspects of the verification test, but will not be the person who generated the data. This process will serve both as the data review and the data verification, and will ensure that data have been recorded, transmitted, and processed properly. Furthermore, this process will ensure that the LDAR technology data and the reference method data are collected under appropriate testing conditions and that the reference method data meet the reference method specifications.

The data validation requirements for this test involve a data quality assessment relative to the DQIs and audit acceptance criteria specified for this test. The DQIs listed in Section B5 will be used to validate the data quality. The QA audits described within Section C of this document, including the performance evaluation audit and data quality audit, are designed to validate the data quality.

D2 VALIDATION AND VERIFICATION METHODS

As part of the normal data and report review process the TCEQ and the US EPA will have the opportunity to review the draft final report and provide comments. Data verification is conducted as part of the data review, as described in Section B10 for this test/QA plan. 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 technologies and other instruments used during the test will be inspected to ensure proper transfer from the data logging system. Data manually incorporated into spreadsheets for use in calculations will be checked against handwritten data to ensure that transcription errors have not occurred. 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 inspecting the equations used in calculations and verifying 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 validation procedures will be performed. Section C of this test/QA plan provides a description of the validation safeguards employed for this verification test. Data validation and verification efforts include the completion of QC activities and the performance of TSA and PE audits as described in Section C. The data from this test will be evaluated relative to the measurement DQIs described in Section A4 and B5, and the PE audit acceptance criteria given in Section C1.1 of this test/QA plan. Data failing to meet these criteria will be flagged in the data set and not used for evaluation of the technologies, unless these deviations are accompanied by descriptions of their potential impacts on the data quality.

A data quality audit will be conducted by the Battelle AMS Center Quality Manager to ensure that data review, verification, and validation procedures were completed, and to assure the overall data quality.

D3 RECONCILIATION WITH USER REQUIREMENTS

The purpose of a verification test performed following this test/QA plan is to evaluate the performance of commercial technologies which detect gaseous leaks from industrial components. This test evaluates the LDAR technology capability only and is not a verification of whether or not the measurement quantitatively measures fugitive emissions. This evaluation will include comparisons of the results from the technologies to results from standard reference techniques. To meet the requirements of the user community, the data obtained in such a verification test will include thorough documentation of the technology's performance during the verification test. The data review, verification, and validation procedures described above will assure that verification test data meet these requirements, are accurately presented in the verification reports generated from the test, and that data not meeting these requirements are appropriately flagged and discussed in the verification reports. Additionally, all data generated using the reference method, which are used to evaluate technology results during the verification

test, should meet the QA requirements of any applicable standard operating procedures or instrumentation instruction manuals.

This test/QA plan and any resulting ETV verification report(s) generated following procedures described in this test/QA plan will be subjected to review by participating technology vendors, ETV AMS Center staff, test collaborators, EPA, and external expert peer reviewers. These reviews will assure that this test/QA plan, verification test(s) of LDAR technologies, and the resulting report(s) meet the needs of potential users and regulators. The final report(s) will be submitted to EPA in 508 compliant Adobe Portable Document Format (pdf) and subsequently posted on the ETV website.

SECTION E

REFERENCES

E1 REFERENCES

1. Quality Management Plan for the ETV Advanced Monitoring Systems Center, Version 6.0, U.S. EPA Environmental Technology Verification Program, Battelle, Columbus, Ohio, November 2005.

2. Environmental Technology Verification Program Quality Management Plan, EPA/600/R-03/021, U.S. Environmental Protection Agency, Cincinnati, Ohio, December 2002.

3. EPA Method 21- Detection of Volatile Organic Compound Leaks, EPA-600/2-18-110; U.S. EPA, September 1981.

4. EPA Protocol for Equipment Leak Emissions Estimates, EPA-453/R-95-017; U.S. EPA: Research Triangle Park, NC, November 1995.

5. EPA Method 18 – Measurement of Gaseous Organic Compound Emissions by Gas Chromatography, 40 CFR, Part 60, Appendix A; U.S. EPA, 1994.