Validation Methods for Methane Emissions Quantification Technologies – White Paper

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Background

Starting in 2015, NYSEARCH and a large group of members worked collaboratively and performed formal technology assessments to understand the range of capabilities and limitations of various technologies in quantifying methane emissions for non-hazardous Type 3 leaks. Once measured, if accurate, these emissions measurements would be used to help prioritize the repair of non-hazardous Type 3 leaks. In order to address the LDC application, the technologies needed to be tested to quantify methane emissions flow rates as low as 0.1 SCFH up to greater than 50 SCFH.

In the early stage of this multi-phased program, the funders were interested in emissions measurements in terms of leak rate bins. Thus, the members defined a binning/classification for emission rates as shown in Table 1.

Category	Leak Rate Bins (SCFH)
Very low	0.2 to 0.5
Low	0.6 to 2.0
Medium	2.1 to 10.0
High	> 10.0

Table 1

In a white paper published in the Pipeline and Gas Journal in February 2018[i], the NYSEARCH technology evaluation program was described. One of the conclusions of this work was that the technologies that were evaluated had a wide range of accuracy and precision. More specifically, data analysis showed that accuracy of predicted vs actual flow rate indicated a 77% accuracy shown to within one order of magnitude. See Figure 1.

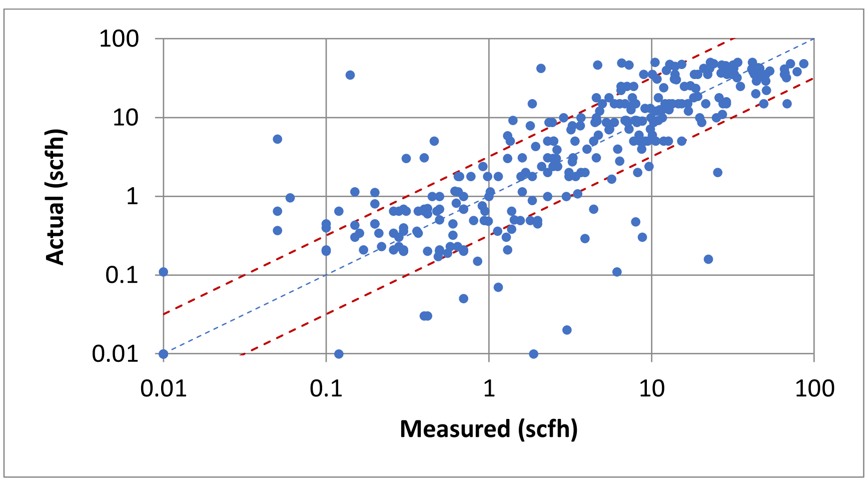

Figure 1. Actual Emission Rate vs Measured Emission Rate, All Tests

Methodology

Following analysis and reporting on the live field-testing results combined with the prior data set collected through controlled testing, there was a need to develop a methane emissions measurement validation process. The goal of this additional project, cofunded with DOT/PHMSA, was to define a process for independent validation of mobile methane emissions measurement technologies. The gas company participants and our independent consultant from P-PIC agreed that a flexible validation guideline that is tested and determined to reflect a standardized approach allows gas companies to conduct 'boots-on-the-ground' investigations and verify the system-specific methane emission. The guideline that was developed in cooperation among the NYSEARCH funders and an independent consultant who used API1163 as a model, was used to govern additional tests conducted with technology service providers in the field in late 2017 and 2018.

In the measurement trials in this project and the prior effort, the funders focused the assessment to primarily mobile measurement technologies. However, in this work, we also included stationary methods for verifying the emissions measurements that are taken from mobile platforms. There were two additional methods, Surface Expression Measurement and a known 'additive marker gas' were used. Also, at the start of the measurement process metered gas releases were provided to calibrate the technology providers' equipment. [Accurate metered gas releases were made through NYSEARCH's mass flow controller kit. See Figure 2.]

Figure 2. Calibration of Technology through Accurate Metered Release/NYSEARCH kit

Surface Expression Measurement

Stationary Surface Expression measurements were used as a 'referee' to aid validation during data collection with third party technologies. The Surface Expression Measurement process utilizes a flux chamber (tarp) laid over the suspected area or pattern of emerging gas. Then, a vacuum draws the tarped air/gas mixture in at a known total flowrate. A methane detector is placed in the flow to measure methane concentration in parts per million (ppm). Based on the methane concentration and total flowrate, a calculation approximates the methane emission flow rate.

During the course of the project, this particular method was deemed to be critical in verifying the providers' data. Thus, the process for taking Surface Expression measurements was followed carefully and the locations of surface expression readings were documented and studied. The accuracy of the surface expression measurements collected during the three series of tests performed in the project and using an 80% confidence interval for all flow rate ranges was 27.1%. An illustration of the Surface Expression measurement tasks is shown in Figure 3.

Figure 3. Setup and measurement using Surface Expression Method

Results of Testing according to the NYSEARCH Validation Guideline

Based on findings in the earlier Technology Evaluation program and discussions among funders early in this project, it was concluded that the success of the tests to confirm the use of the Validation Guideline would be based on accuracy and precision of the measurements provided by the technology provider. During all the testing, a test plan that conformed to the NYSEARCH Validation guideline was followed. The close adherence to the test plan ensured consistency during the three series of field tests and throughout each test. It also provided a repeatable process for data collection and subsequent independent statistical evaluation. Figures 4a and 4b below provide illustrations in 1:1 Unity and log-log

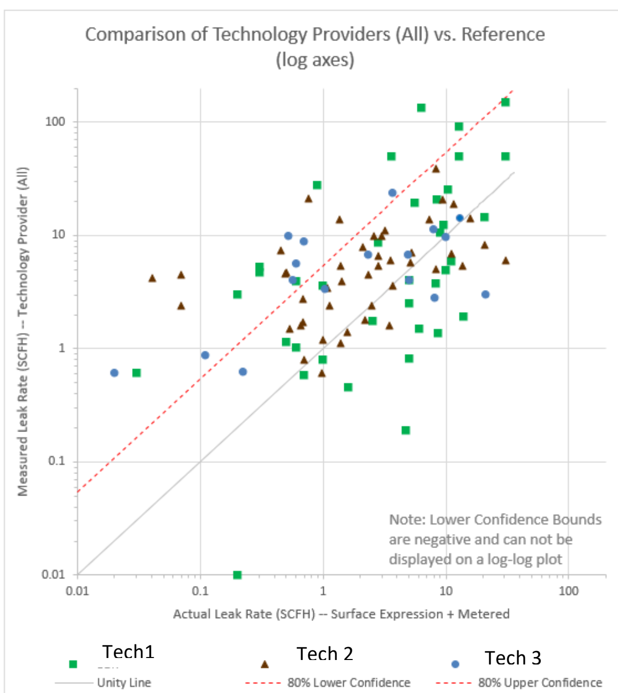

Figure 4a. ***Actual methane quantification (scfh) vs Measured quantification (scfh)***

scales of the combining of all the technology providers' data from the validation tests using an 80% confidence interval. Subsequently, the validation guideline was issued to funders and PHMSA as a performance-based guideline for use by local gas distribution companies. We believe that through use of this validation guideline, it can: 1) help users select a methane emissions quantification system that is suitable for the conditions encountered (e.g. area type, wind, temperature, atmospheric stability, etc), 2) ensure that reports of emissions indications use common nomenclature, and 3) ensure that data and results are provided consistently.

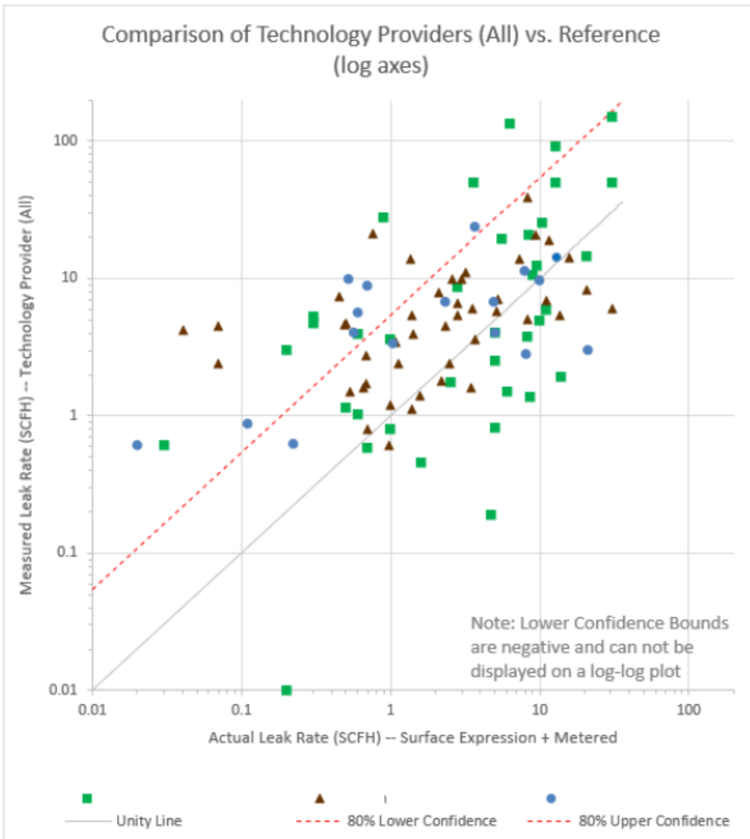

Figure 4b. ***Actual methane quantification (scfh) vs Measured quantification (scfh) (log-log scale)***

Significance of Data Collected during Validation project & prior Technology Evaluation Project

When combining the data from the original NYSEARCH Technology Evaluation project and the subsequent Validation project, there were over (300) data points collected. This data was significant because of the shear amount of information including actual leak rates. Also, the data was considered sound because of the formal test procedures that were used to collect the data and the fact that each technology provider was allowed time after the tests to process the data before submission.

Adam Brandt et al[ii] have shown that more frequent surveys of gas systems even with less sensitive detection devices can substantially support methane emissions measurements. NYSEARCH data allows actual implementation of such an approach by defining quantitative uncertainties of mobile leak quantification systems in realistic conditions.

Advancement of Promising Method known as Surface Expression Measurement

Following completion of the Methane Emissions Quantification Validation project, NYSEARCH members saw an opportunity to optimize the stationary method and process used to verify other mobile technologies with the Surface Expression Measurement collection of equipment. During the course of the 'validation' project, the surface expression data showed uncertainty to +/-27.1% which meant that it had the best accuracy of the methods used; albeit the process is from a stationary platform. With the members' preference then to use the Surface Expression method as a 'referee' for other techniques, there was a need to conduct additional work to learn the sources of error in this technique and to further optimize its performance for quantification of emissions as a stationary alternative.

The work on the Surface Expression Measurement started with a Design of Experiment to systematically isolate sources of error. Then improvements to software, hardware and the field procedures were made. The project in ongoing and is targeting a range of field tests to measure the impact of those improvements.

Acknowledgements

Numerous Local Distribution Companies (LDCs) actively participated in the funding, project design, test plan review, development of validation guidelines and provided facilities and/or guidance throughout the project. We would like to acknowledge those sponsors: Central Hudson Gas & Electric, Consolidated Edison of New York, National Grid (for companies formerly known as Keyspan and Niagara Mohawk Power Corporation), National Fuel Gas, New York State Electric & Gas, Orange and Rockland Utilities, Rochester Gas & Electric, Pacific Gas & Electric, PECO Energy, Public Service Electric & Gas, Southern California Gas, SouthWest Gas, Xcel Energy, and Union Gas. Also, in this phase of work, we gratefully acknowledge the cofunding and participation of DOT/PHMSA and their program manager, Robert Smith.

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[i] Daphne D'Zurko, Joseph Mallia "Measurement Technologies Look to Improve Methane Emissions", Pipeline & Gas Journal, February 2018, 55 – 58.

[ii] Chandler E. Kemp, Arvind P. Ravikumar, and Adam R. Brandt "Comparing Natural Gas Leakage Detection Technologies Using an Open-Source "Virtual Gas Field" Simulator" Environ. Sci. Technol. 2016, 50, 4546−4553