VERIFICATION OF QUANTITATIVE OPTICAL GAS IMAGING SYSTEM

Executive Summary Report

The Saskatchewan Research Council (SRC), in collaboration with CMC Research Institutes, has developed and executed a technology verification testing plan to verify the performance of the QL320 quantitative optical gas imaging system developed by Providence Photonics. SRC conducted this technology verification project as part of its broader Center for Demonstration of Emissions Reductions (CeDER) initiative. This project received financial support from the Alberta Upstream Petroleum Research Fund (AUPRF), managed by Petroleum Technology Alliance Canada (PTAC).

This technology is designed to work with FLIR GF300/GF320 handheld gas detection cameras and provides a remote quantitative measurement of mass leak rates or volumetric leak rates for most hydrocarbons. The QL320 was first tested in a controlled environment before being tested at a field site in collaboration with an industry partner.

All initial controlled tests were performed outdoors at SRC's test facility in Saskatoon, SK. A section of piping and valve were used to simulate a leaking piece of equipment that could be found at an oil and gas facility. A Teflon line was run from the methane cylinder through the mass flow controller and secured in place behind the piping, and a steel water tank, painted matte black, was used to achieve the desired background temperature with either hot or cold water.

The test criteria and factors were decided beforehand under the guidance of all stakeholders. As expected, some changes had to be made to the test plan when confronted with real-world test conditions. Wind speed and ambient temperature were difficult to predict. Mild temperatures just above or below the freezing mark were experienced during the initial controlled tests, which resulted in changes to the planned temperature range from ±10˚C to ±5˚C.

During testing it was observed that windspeed had a large impact on plume dynamics, which were seen to affect the results. With low wind speeds, the plume would accumulate and swirl back and forth around the QL320's measurement ring, seen on the screen during testing, and biased the results high. In a high wind speed scenario, it was observed that the plume dispersed too quickly for the QL320 to measure, which biased the results low.

Analysis of Variance (ANOVA) design of experiments was used to screen the variables for significance. Using an ANOVA design allowed SRC to evaluate the significance of several environmental factors on the accuracy of the technology. Factors considered included wind speed, ambient temperature, temperature differential (ΔT) (the difference between ambient and background temperature) and distance. All of the main factors had a significant effect on the accuracy of the FLIR/PP system with the exception of distance. However, many of the second and third level interactions between distance and the other factors were significant; therefore, strictly speaking, all the main factors should be considered when developing future test plans.

From the ANOVA experiment, ambient temperature and the interaction of ambient temperature with distance had less significant impacts on the results. As such, it was determined that it would be more beneficial to focus on the most significant factors in the on-site test campaign. To mitigate the effect on the other factors, distance would be kept constant and ambient temperature recorded during the time of testing. Therefore, the important factors in the second test campaign would be wind speed, ΔT, flowrate and gas type, which had not yet been tested.

The verification testing was done at an operational oil battery, about 85 km southeast of Regina, SK, between the dates of May 29th and June 27th, 2018. SRC's CeDER trailer was used on site to house the cylinders of gas and other equipment required for the testing. A line was run from the cylinders and mass flow controller in the CeDER trailer to the leak location where the testing would take place. A valve was chosen near a tank as the location to simulate the gas leak.

The test criteria and factors were decided beforehand under the guidance of the Project Advisory Group. Two gas types were chosen for the testing to be representative of what would be found on site. Flow rates were chosen at 1, 5 and 10 litres per minute (lpm).

The limitations of the technology that were experienced during this testing are listed in the table below.

Limitations	Explanation
Insulation or reflective material	Insulation on the pipes caused disturbance in the measurements due to the reflectivity of the material. As a result, data collected during week one was not used in the analysis. Version 2.0.0.0 of the QL320 includes an exclusion box to help resolve this issue.
Equipment set up and ΔT	Depending on the location of the leak, it may be difficult to set up the tripod required for the FLIR camera while ensuring a sufficient background/ΔT.
Operability	While the operation of the QL320 is user-friendly, it is important that the operator is well trained, understands how different wind speeds affects the plume dynamics, and is experienced in adjusting all settings available.
Taking a single reading	Results show that there is more confidence in the average result of a large number of readings.
Low flow rates	The readings at 1 lpm during this testing were statistically different from the actual release rate. Low ΔT and reflectivity in the pipes played a factor in the results. In QL320 Version 2.0.0.0 the exclusion box and threshold setting adjustments can help get more accurate results at low flow rates.

Analysis on all data from weeks two and three of testing showed that flowrates between 5 and 10 lpm of methane or Gas C mixtures on non-insulated pipes was accurate and verifiable. This means that if an operator were to take a large number of readings in the field of a system meeting those criteria, they could be 95% confident that the average of those readings would be the same as the actual flowrate. However, because of the large standard deviation of these readings, if an operator was to take a single reading of a leak/vent, the actual flowrate could be anywhere from zero to double that reading.

Data showed that gas type does have an effect on the results at flowrates between 5 and 10 lpm. Further analysis showed that if the ambient conditions are such that $\Delta T>10C$, there is no reflective insulation, and the unknown release has a flowrate between 5 and 10 lpm of a gas similar in composition to gases A or C, the measurement is expected to be +/- 30% of the actual flowrate.