WHITE PAPER

KONICA MINOLTA

Contribution of Konica Minolta GMP02 quantification to emissions estimation

Recent technology advances in the Optical Gas Imaging (OGI) arena have demonstrated the ability to quantify or calculate emissions observed during routine leak detection and repair (LDAR) inspections. In particular, Konica Minolta OGI camera GMP02 has been tested by a third party and deemed as meeting the requirements of NSPS OOOOa and was certified as an Approved Instrument Monitoring Method (AIMM) by the Colorado Department of Public Health and Environment (CDPHE). As a technology solutions provider, our objective is to support the oil and gas industry in the US in its own goals of methane and GHG emissions.

Description of the technology

Our quantification is a technology that displays the result as shown in Figure 1, by specifying the gas area to be estimated with 4 points, and inputting the gas type, shooting distance and temperature as shown in Figure 2. Quantifiable distance range is from 4 ft to 328 ft. The estimated result is the average over a 5 second period of recorded material and updates every 5 seconds. Minimum video length for quantification is 7 seconds.

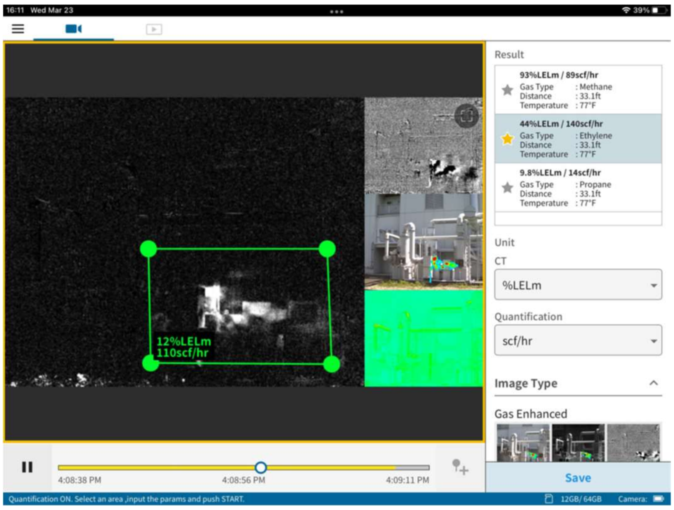


Figure 1. Result display screen

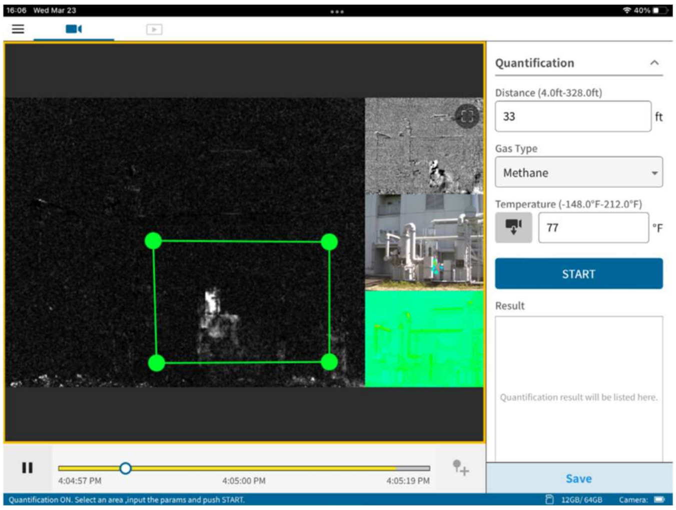


Figure 2. Information input screen

The technology consists of two estimation techniques: a) gas concentration length and b) gas flow velocity. By calculating the amount of gas from a) gas concentration length, and the passage time of gas from b) gas flow velocity, a gas flow rate per unit time is estimated. A schematic diagram is shown in

Figure 3. Wind measurement is unnecessary as the gas flow velocity is estimated by tracking the gas movement from the images. A patent has been applied for this technique.[1]

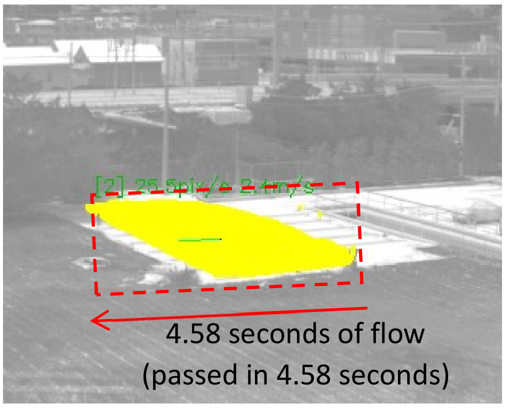


Figure 3. Gas flow rate estimation

Gas concentration length can be theoretically calculated by the gas temperature, the background temperature in the presence of gas and the background temperature without gas. The gas temperature is assumed to be the ambient temperature input by the user. Furthermore, the background temperature in the presence of gas and without gas are estimated from time-series changes in the infrared images taken as shown in Figure 4. Please see the patent for more details.[2]

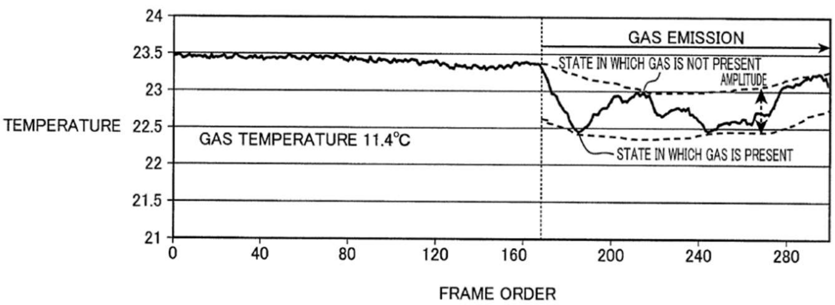


Figure 4. Estimation method of gas concentration length

[1] "US20220034742 - GAS FLOW RATE ESTIMATION DEVICE, GAS FLOW RATE ESTIMATION METHOD, AND GAS FLOW RATE ESTIMATION PROGRAM"
https://patentscope.wipo.int/search/en/detail.jsf?docId=US349429229&_fid=WO2020110411
[2] "US20180364185 - GAS CONCENTRATION-THICKNESS PRODUCT MEASUREMENT DEVICE, GAS CONCENTRATION-THICKNESS PRODUCT MEASUREMENT METHOD, AND COMPUTER-READABLE RECORDING MEDIUM HAVING GAS CONCENTRATION-THICKNESS PRODUCT MEASUREMENT PROGRAM RECORDED THEREON"
https://patentscope.wipo.int/search/ja/detail.jsf?docId=US235210241&_fid=WO2017104607

Gas concentration length can be displayed in 5 types of volumetric flow rates (sl/min, scc/min, scc/sec, scf/min and scf/hr) and 4 types of mass flow rates (g/min, g/hr, mg/sec, lb/hr). The volume flow rate is prefixed with “s” (standard). This indicates that the standard conditions (70°F, 1atm) defined by CGA

(Compressed Gas Association) are used as the standard conditions required for conversion of volumetric flow rates and mass flow rates.

Applicable conditions

1) **Sensitivity (temperature difference between gas and background)**
The larger temperature difference between the gas and the background, the larger temperature change on the infrared image by the gas. And it increases the image sensitivity and accuracy of quantification. Conversely, when the temperature difference between the gas and the background is small, the quantification accuracy is degraded. Therefore, the system does not perform quantification when it determines that the temperature difference is less than 3°C (5.4 °F). In such a case, it is desirable to increase the temperature difference, such as by setting the background in a place exposed to sunlight or in the background of equipment in operation.

2) **Gas type**
At present, the technology supports 100% pure methane, propane or ethylene. Even in the case of gases other than the above three types or mixed gases, it is possible to grasp the relative magnitude of gas amount by measuring with the measurable gas types as long as the gas composition is the same.

3) **Gas flow**
Since this technology estimates the flow rate from the transit time of the gas, good accuracy can be obtained when the gas flows in one direction, as shown in Figure. 5-a. When the gas scatters as shown in Figure. 5-b, it is desirable to take a longer video and utilize the results of the timing of gas flow in one direction.

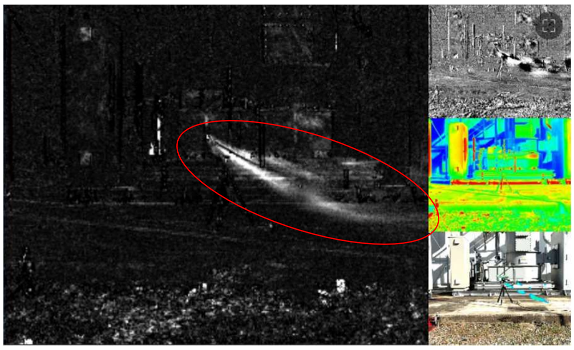


Figure 5-a. Good gas flow

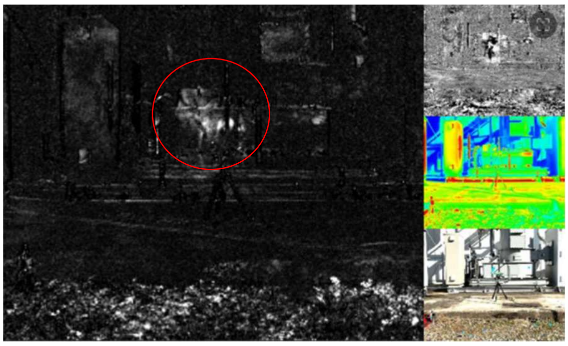


Figure 5-b. Difficult gas flow

4) **Temperature**
Since the inputted temperature is regarded as the gas temperature, it is desirable to input the ambient temperature as accurately as possible. When using the camera, avoid placing it on the

ground as this could pick up geothermal heat, or being exposed to continuous direct sunlight. The reason for this is the location of the camera thermometer being underneath the camera body.

5) Area designation

As shown in Figure 6-a, the area is set so as to enclose the width direction along the direction of gas movement. It doesn't matter if the leak source is included or not. Better accuracy can be obtained by enclosing the area as large as possible without noise. If the width direction is not completely enclosed as shown in Figure 6-b, the result may be miscalculated.

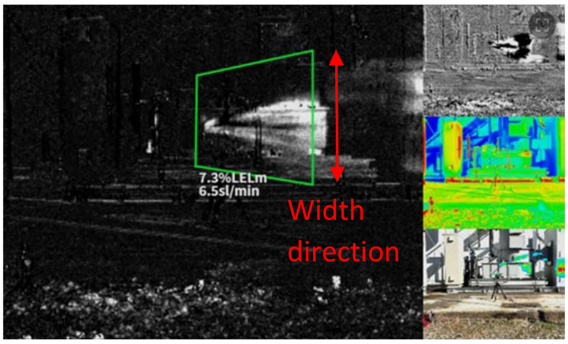


Figure 6-a. Good area designation

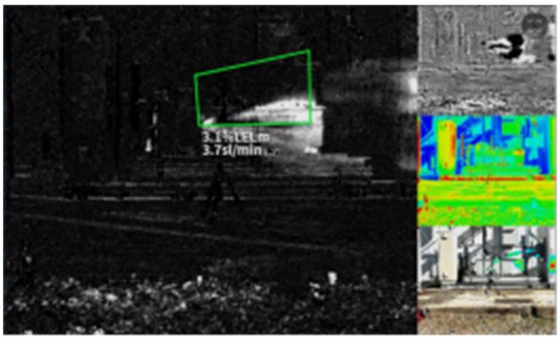


Figure 6-b. Bad area designation

In addition, as shown in Figure. 7-a and 7-b, pixels appearing white in gas-enhanced (black and white) images other than gas itself are noise. It is desirable to specify an area that contains as little noise as possible by adjusting the shooting position. If the system determines that it is noisy, no quantification is performed.

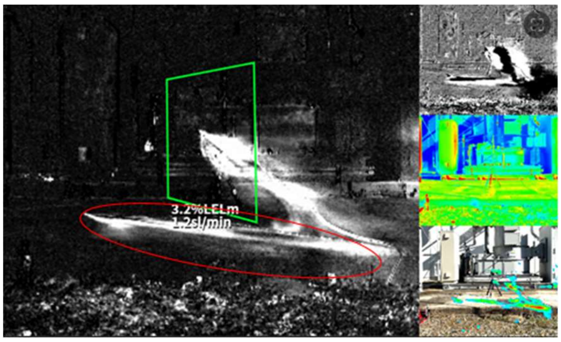


Figure 7-a. Noise example - gas shadow

Figure 7-b. Noise example - moving object

6) Distance

Accurate input is desirable because the error in the distance affects the square of the error (as an area) when calculating the gas amount from gas concentration length.

7) Shooting condition

To avoid vibration noise, make sure the camera is in a stable environment. A tripod is preferred. The magnitude of vibration noise can be confirmed on the gas-enhanced image. As shown in Figure 8-b, when the gas cannot be seen due to white noise caused by vibration, accurate estimation is difficult. In that case, stabilize the camera so that it appears as shown in Figure 8-a.

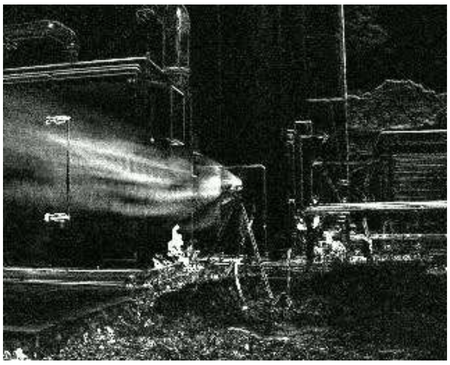


Figure 8-a. Good example

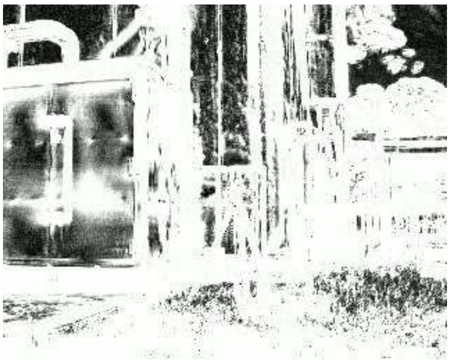


Figure 8-b. Bad example

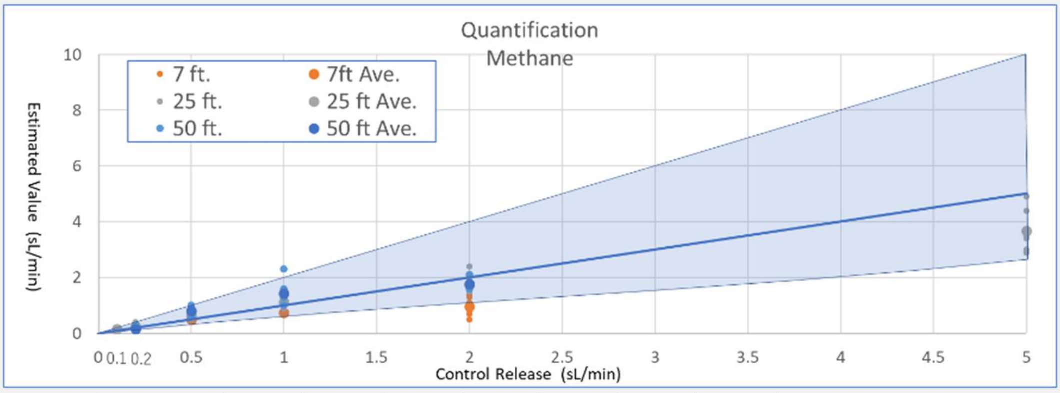
8) Calibration

This technology does not require calibration.

Validation testing

We created an in-house experimental environment to conduct the evaluation as shown in Figure 9. Multiple quantifications were performed while changing the amount of methane released and the distance to the source. The amount of release was controlled with a mass flow meter. As shown in Figure 10, the average values of each experiment, after eliminating abnormal values due to wind and noise, were within the variation of 0 to 60% of the actual flow rate.

Figure 9. Built experimental environment



Actual flow rate		0.1	0.2	0.5	1.0	2.0	5.0
Quantification	7 ft Ave.	No data	0.25	0.50	0.73	0.98	No data
	Gap		25%	0%	-27%	-51%	
	25 ft Ave.	0.15	0.26	0.65	1.13	1.76	3.69
	Gap	50%	29%	30%	13%	-12%	-26%
	50 ft Ave.	No data	0.15	0.80	1.44	1.76	No data
	Gap		-25%	60%	44%	-12%	

*A temperature controlled background plate was used (Approx. Δt was 70 °F).

Figure 10. In-house experimental result

Furthermore, we quantified leaks detected at an actual producing facility with the GMP02 and compared the result with a high-flow sampler being used by the host operator's. The results are shown in Figure 11. We have plans on conducting more field validations with additional O&G operators.

			(uni:scf/h)
	High-Flow Sampler	Konica Minolta Quantification*	Gap
Leak #1	0.05	0.031	61%
Leak #2	0.03	0.016	53%
Leak #3	0.07	0.069	99%

*Konica Minolta Quantification is average value after removing outliers from multiple output results

Figure 11. In-house experimental result

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Applicable area

As long as the previously mentioned applicable limitations are kept in mind, this technology is widely suitable for a number of scenarios. The video captured by the OGI camera is easily quantifiable, after wirelessly connecting the camera to any tablet or mobile phone. Since the method of quantification is image-based and embedded within the camera, it is possible to estimate emission amounts in high places, inaccessible hazardous areas, and even indoor emissions.

Conclusion

The aforementioned is the description, application conditions, test results, and applicability of the quantification technique we developed. We've also confirmed through several site evaluations that the quantified emissions differ for the same components such as valves and flanges. We believe that this indicates the need to take more effective actions by determining priorities according to the actual situation and thermal conditions.

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