NEXT GENERATION EMISSIONS MONITORING TOOLS AND TECHNIQUES FOR EMISSIONS LOCALIZATION, QUANTIFICATION, AND REDUCTION

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Abstract: SENSIT Technologies has developed a suite of tools for helping with all facets of leak detection and quantification. These tools include (1) continuous monitoring, (2) open path handheld systems, and (3) aspirated handheld detection instrumentation. Continuous monitoring solutions can detect down to 200 PPB of methane and are capable of being deployed up to 3 miles away from the leak source. When equipped with meteorological instrumentation, these systems can localize the leak to an area of interest and provide estimates of the emissions rate within said area. Once localized to an area of interest that is typically 100ft2, open path handheld systems are effective at pinpointing the detected emission to with 10 ft2. Subsequently, the aspirated detection instruments can pinpoint the leak to a single point.

SENSIT has worked with all areas of the natural gas value chain to demonstrate the efficacy of this three-tiered approach to leak detection and quantification. SENSIT has also validated the equipment and approach with academic institutions like CSU METEC through blind tests for above ground and underground leaks.

We will show data highlighting the efficacy of each of the individual tiers of detection listed above. Furthermore, we will also demonstrate the efficacy in the fusion of continuous monitoring, open path surveys, and near-source surveys towards identifying, locating, and quantifying leaks.

In blind tests, our continuous monitoring systems could identify 72% of controlled releases with a 90% POD of down to 3 kg/hr, while our aspirated handheld detection instrumentation was capable of detection and quantification down to 0.03 kg/hr. The fusion of these three approaches where manned surveys were guided by continuous real time monitors helped oil and gas operators achieve up to 60% reduction in methane emissions.

Finally, we intend to showcase the promise of next generation detection and quantification methodology, using drones and un-manned vehicle surveys. While still early, initial proof of concept deployments with customers shows significant promise towards greatly increasing the efficiency of leak detection and repair.

Keywords: For the keywords use <“WGC_text” style> separated with semicolon.

1. Introduction and Background

To lower methane emissions, we need faster, cheaper leak detection. To effectively detect oil and gas leaks, a tiered approach is necessary. The tiers, listed below, range from covering the largest area but providing aggregate information to covering the smallest area but capable of pinpointing the leak.

- **Site-level monitoring:**
    - Continuous monitoring for real-time leak alerts.

  - Periodic surveys (vehicle/satellite) for cost-effective, multi-site assessments.
- **Asset-level monitoring:**
  - Open-path TDLAS handhelds for remote methane measurement and rapid leak localization.
  - Optical Gas Imaging (OGI) handhelds for thermal gas visualization.
- **Component-level monitoring:**
  - "Sniffer" handhelds (EPA Method 21) for pinpointing leaks at specific components.

An example of each level of detection is shown in Fig. 1. Maximize leak detection efficacy by integrating data from each tier. Using tools outside their intended level is resource-intensive. For example, using a sniffer to survey an entire site each month or quarter is possible, but this requires significant manpower whereas the use of an open path laser or OGI camera will allow for significant manpower savings).

Fig. 1: Examples of each level and type of monitoring.

2. Workflows of Different Tools for Leak Detection and Repair

Effective leak detection requires a defined workflow that integrates tools from each level. SENSIT's proven workflow and product suite deliver cost-effective results in oil and gas. This workflow is shown in Fig 2. It consists of continuous real-time monitoring for site level monitoring (SENSIT FMD), open path remote monitoring handhelds for asset level monitoring (SENSIT LZ30), and a sniffer handheld for component level monitoring (SENSIT Gold G3).

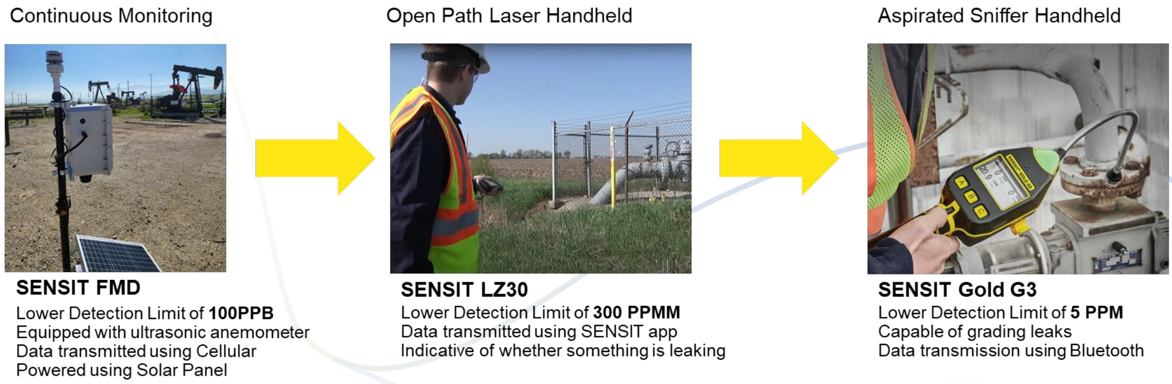


Fig. 2: Workflow recommended by SENSIT. This has been deployed in the field and has seen success in reducing methane emissions. The specification for each device is shown in the image.

Operators used six solar-powered SENSIT FMDs (100 ppb methane detection, cellular data, ultrasonic anemometer) to continuously monitor a 100-acre site for 18+ months without calibration or bump tests. These units provide indications of whether the site was leaking, as well as provided high-probability leak areas as defined by a user-defined leak threshold. To optimize leak detection, they iteratively adjusted the leak threshold over the first four weeks, starting at 10 ppm and ending at 50 ppm. During each week, all leak indications above the threshold were investigated by operator personnel. A false positive was defined as no leak was found during the investigation.

A schematic representation of false positive rates vs. The week and threshold is shown in Fig. 3. Initial false positive rates were high, but by the 4th week and a leak threshold of 50 PPM, false positive rates were below 10%. Over the course of the next 1.5 years, the operator slowly re-adjusted their leak threshold back to 10 PPM while keeping their false positive rate less than 20%..

This site tuning process is necessary because these false positives are caused by different large leaks causing a large number of methane signatures that confuse the localization algorithms. The is best to target the largest leaks first (i.e. starting with a high leak threshold) – once these leaks are fixed, then to move to the smaller leaks. This is also more cost effective since the false positive rate remain low since as the larger leaks are fixed, the site condition becomes less complicated, making it more conducive to find the lower level leaks.

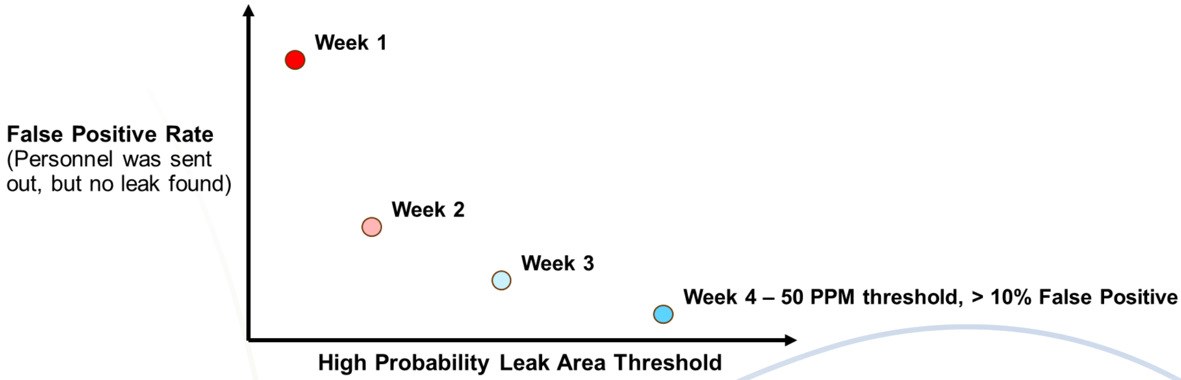


Fig. 3 – Schematic representation of the false positive rate vs. leak threshold. The leak threshold increased week after week until the false positive rate was below 10%, which occurred in week 4.

Operators used SENSIT's laser (LZ30) and sniffer (Gold G3, Method 21) to investigate the positive leak indications from the continuous system. The investigation was focused on the high leak probability area reported with the positive leak indication. The Gold G3 has been used extensively to find leaks in natural gas distribution, and detects leaks as small as 0.03 kg/hr. The operators found leaks over 90% of the time.

3. Controlled Release Testing of the SENSIT FMD and MOSPOD at CSU METEC

SENSIT participated in CSU's ADED program, a methane detection technology assessment. In 2023, they deployed 6 FMDs (laser based systems), and in 2024, 4 FMDs and 10 MOSPODs (cheaper metal-oxide based systems). The lower detection limit of a SENSIT FMD is 100 PPB whereas that for the SNESIT MOSPOD is around 1 PPM, while being 3-4 times lower in price. The total system cost in 2023 and 2024 was the same. METEC conducted blind methane release tests, with SENSIT (Vendor P) reporting emissions found by their system. A sample of the 2023 data (Fig. 4) showed FMDs successfully detecting leaks. In 2024 (sample data shown in Fig. 5), SENSIT FMD data was used to correct the drift seen on the MOSPODs. Collocated units showed a R2 of 0.8 between the FMD and MOSPOD. The MOSPODs allowed SENSIT to greatly increase coverage around the site without increasing the cost while the data correction algorithm minimized the decrease in data quality. However, it must be noted that even with the corrections, MOSPOD data are indicative, and should not be used for quanitification. Only FMD data was used for quantification.

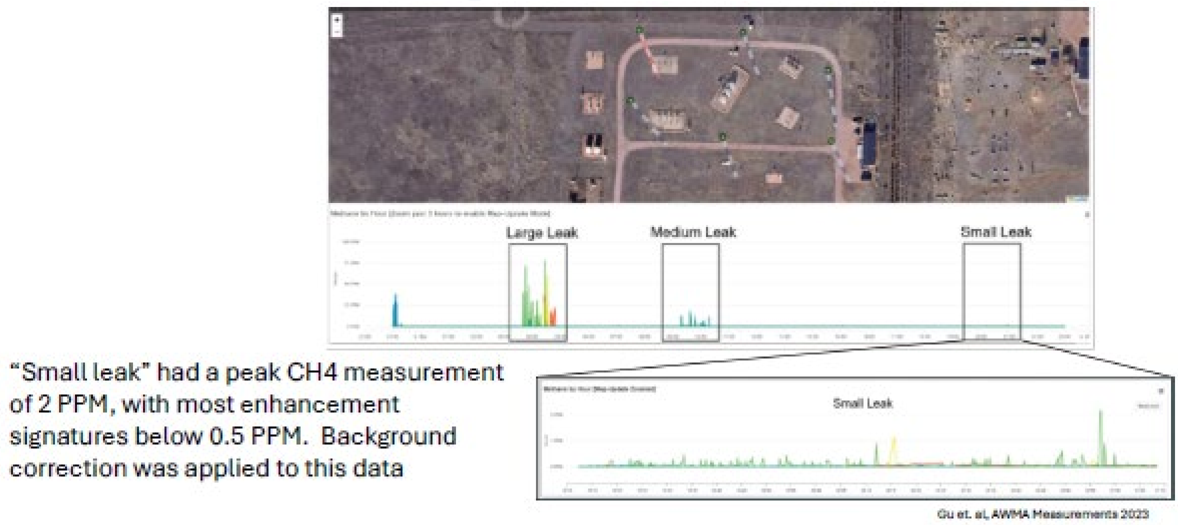
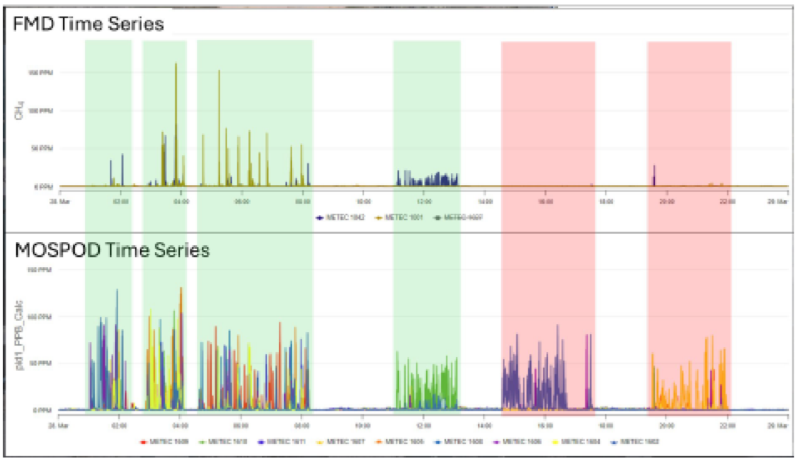


Fig. 4 – Sample data from SENSIT's 2023 ADED deployment. Leaks from the site are easily visible. The "Small Leak" showed peaks of 0.5 to 2 PPM.



In all cases, because of the significantly better coverage, the MOSPOD deployment was able to better identify when the site was leaking.

In the two red highlighted leaks, the MOSPOD was able to identify the leaks while the FMD missed the leak due to its sparse coverage.

Fig 5 – Sample data from SENSIT's 2024 ADED deployment. The leak periods shown in green indicate leaks that were found by both FMD and MOSPOD, whereas the red indicates leaks where the MOSPOD saw the leak, but the FMD didn't. This is attributed to the greater coverage of the MOSPOD around the site.

Fig. 6 shows SENSIT's 2024 ADED localization dashboard. It displays time-series data and a wind rose showing methane levels and wind direction. Red sectors in the wind rose indicate elevated methane when wind blew from that direction. The map highlights high leak probability areas (red) calculated from device data and wind direction. The algorithm pinpointed the leak to tanks in the center, later confirmed by METEC when the controlled release keys were published.

Fig. 7 shows METEC results. In 2024, SENSIT improved: 72.3% true positive detection, 8% false positives, 90% leak localization accuracy, and a 3.2 kg/hr detection threshold. This threshold is significantly below the EPA's 100 kg/hr "super emitter" standard, indicating the ability to detect small leaks using this continuous monitoring approach.

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Fig. 6 – Sample image of SENSIT's leak localization algorithm. Within the map, the areas of greatest red indicate the area with the highest probability of a leak. In this case, the tank asset at the center of the site was indicated as leaking – this was subequently confirmed after the results were released.

Year	# of leaks	True Positive (TP)	False Positive (FP)	Localize Asset (of TP)	90% POD Leak Rate
2023	565	66.4%	12.6%	84.3%	4.6 kg/hr
2024	783	72.3%	8.0%	90.5%	3.2 kg/hr

Fig. 7 – Results from ADED 2023 and 2024. True Positive indicates times when SENSIT indicated leak, and the site was leaking. False positive indicates times when SENSIT indicated leak, and the site was not leaking. Localize Asset indicates times when SENSIT indicated leak and was correct in locating the specific asset leaking.

4. Pairing of Asset-level and Component-level tools with Site-level Tools

SENSIT's workflow (Fig. 2) was used on a 100-acre well pad with six optimally placed monitors determined using SENSIT's Deploy algorithm and feedback from the operators. Initially, investigating all 10+ PPM leak alerts yielded 80% false positives. After a 4-week tuning period (Fig. 3), a 50 PPM threshold achieved 90%+ leak investigaton efficacy. After the tuning period, the operator only checked the dashboard once each morning to identify the high probability leak areas, and subsequently dispatched leak investigation personnel. Over 9 months, the average daily methane readings dropped from 4 to 2.5 PPM, and the maximum daily methane reading dropped from 150 to 50 PPM.

Over the course of the next 9 months, the leak threshold was dropped in a step-wise manner every few months back down to 10 PPM. This was done while still keeping the leak investigation efficacy above 80%. As the leak thresholds decreased, so did the leak size and accordingly, the difficulty to find the leak increased. After 18 months, average and maximum daily detected methane fell to 2.2 and 7 PPM, respectively.

One particularly difficult to find leak was a sporadic leak from the stuffing box of one of the oil derricks. Fig. 8 shows the continuous monitoring dashboard that triggered multiple investigations on different days. Those investigations yielded no results. It was observed that this leak is more prevalent at night – operators waited until the continuous monitoring system saw a high methane reading before going out to perform the investigation. There was 10+ oil derricks in the area; upon arriving at the area, the investigators used the LZ30 to quickly scan through the different assets and was able to identify the leaking assets within 5 minutes on site. On the right of Fig. 8 is a picture the leaking oil derrick with the operator holding the LZ30 showing 1348 PPMM.

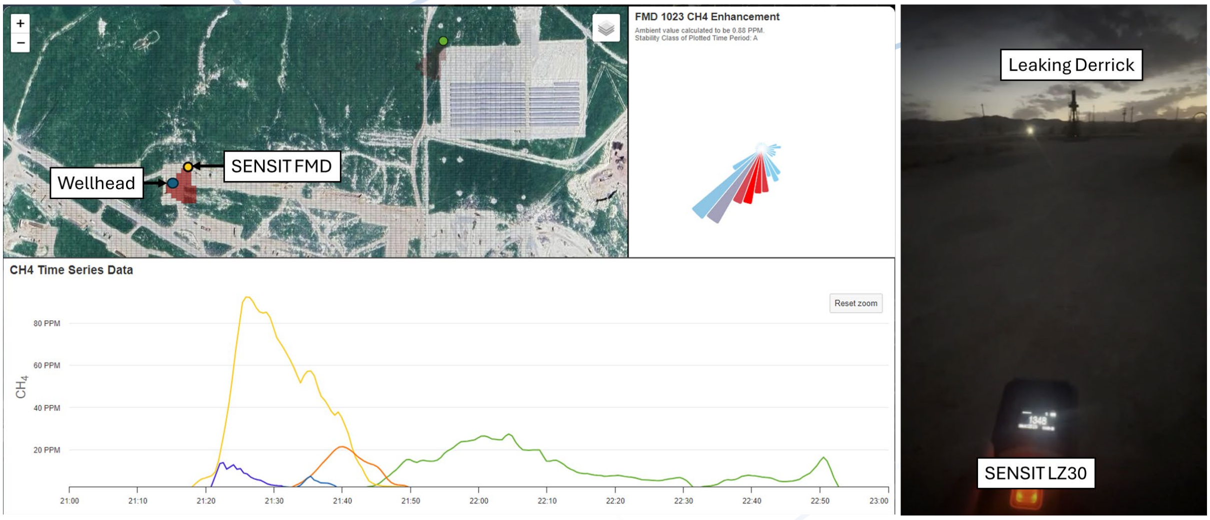

Fig. 8 – Dashboard image that triggered the investigation, and the subsequent open path laser handheld scan that indicated the leaky derrick.

These hard-to-find leaks only became apparent after the larger leaks were found and fixed. This is best explained by the following analogy:

Imagine you're trying to hear a tiny whisper in a noisy room.

- Big leaks are like loud shouts: They're easy to find.
- Small leaks are like quiet whispers: They're hard to hear.
- When the loud shouts (big leaks) are happening, they drown out the whispers (small leaks).
- Once the shouts stop (big leaks are fixed), you can finally hear the whispers (small leaks).

In short: Big leaks make it impossible to find small leaks because they overwhelm and convolute the signals from the sensors. Only after the big leaks are gone can the small, tricky ones be detected.

The efficacy of this approach is very site specific – it is very dependent on-site geometry, meterological conditions, as well as how much normal process emissions (i.e. venting) there is on site. The tuning procedure described above with an example provided in this section is needed because it standardizes these parameters from an operational perspective. It allows the user to select the false positive rate they are operationally comfortable with, thereby allowing them to focus on the largest leaks on site. As the site becomes cleaner, it becomes easier to locate the smaller leaks.

5. Conclusions and Next Steps

In conclusion, this paper demonstrates the effectiveness of a tiered methane leak detection and repair approach, integrating site-level, asset-level, and component-level monitoring technologies. Through real-world deployment and controlled release testing, SENSIT's workflow, utilizing continuous monitoring (FMD, MOSPOD), open-path laser technology (LZ30), and component-level sniffers (Gold G3), has proven successful in reducing methane emissions in oil and gas operations. The importance of site-specific tuning, exemplified by the iterative adjustment of leak thresholds, was shown to be crucial for optimizing detection accuracy and minimizing false positives. Furthermore, the integration of lower-cost MOSPOD sensors, corrected using FMD data, significantly enhanced site coverage without compromising overall system effectiveness. The case study on a 100-acre well pad highlighted the practical application of this multi-tiered approach, demonstrating a substantial reduction in both average and maximum methane readings over an 18-month period. Notably, the ability to detect and locate even sporadic, hard-to-find leaks after addressing larger emission sources underscores the value of a comprehensive and adaptable monitoring strategy. Ultimately, this research provides valuable insights into the implementation of efficient and cost-effective methane mitigation practices, contributing to improved environmental stewardship within the oil and gas industry.

References < Select style “WGC_references_title”>

References in the text should consist of the Author’s surname followed by a year of publication in parentheses, e.g. (Bullen, 1985). If more than two authors, please give the first author’s name followed by “et al.” and year, e.g. (Smith et al., 2005). All references cited in the text must be included in the reference list at the end of the paper. Use the word “References” as the title of the reference list. The references are to be in 9-points font. This is done automatically when you enter the reference using the <“WGC_references” style>. References should appear in alphabetical order at the end of the paper. Please refer to examples below:
Bullen KE, Bolt BA (1985) An Introduction to the Theory of Seismology, Cambridge, 400 pp. (in the case of a book)
Mrokowska MM, Rowiński PM, Kalinowska MB (2015) A methodological approach of estimating resistance to flow under unsteady flow conditions, Hydrology and Earth System Sciences, 19, 4041-4053 (in the case of a journal article)