Distran Ultra Pro X Emissions

Technology Description

Submitted to

The United States Environmental Protection Agency
Air Emission Measurement Center



Submitted by
Distran USA Corp.
3800 Highway 365, Suite 119,
Port Arthur, Texas 77642

DISTRAN·USA

Table of Contents

Table of Figures....3
1. Introduction....4
1.1. Overview of the Distran Ultra Pro X Emissions....4
1.2. Type of measurement and application....5
2. Scientific theory....6
2.1. Acoustic imaging....6
2.2. Gas leaks Acoustic Emission (AE)....6
3. The Distran Ultra Pro X Emissions....9
3.1. Physical description of the device....9
3.2. Data workflow: from pressure and optical data to composite images....10
3.2.1 Data acquisition....11
3.2.2 Data processing....11
3.2.3 Ultra Pro leak rate quantification module....13
3.2.4 Detection Confidence Limit....13
3.2.5 Health Center....13
3.2.6 GPS....13
4. Data handling, storage and delivery....14
4.1. Data handling and storage....14
4.2. Data delivery....14
5. Performances....15
5.1. Component-level spatial resolution....15
5.2. Leak resolution....16
5.2.1 Detection limit under laboratory conditions....16
5.2.2 Detection limit in industrial environment....17
5.2.3 Probability of detection, tests at METEC....17
5.3. Technology limitations....19
6. Bibliography....20

Table of Figures

Figure 1: Methane leak on a flange detected on a natural gas metering station. Left, with an OGI camera. Right, with Distran Ultra Pro X.....4

Figure 2: Left: schematic of the detection of a sound wave by an array of microphones. Right: Acoustic imaging of a single leak.....6

Figure 3: Simultaneous detection of two gas leaks.....6

Figure 4: Schematic of the emission of acoustic waves by a pressurized gas leak (adapted from Tam 2008).....7

Figure 5: Sound spectra comparison: Gas leak vs. Machinery noise.....8

Figure 6: Detailed view of the Distran Ultra Pro X.....8

Figure 7: Camera interface.....9

Figure 8: High level view of the acoustic camera electronics architecture.....10

Figure 9: Distran Ultra Pro X composite image and leak quantification screen indications.....12

Figure 10: Leak detection and localization at the component-level at a distance > 4 m.....14

Figure 11: Selected results for the detection of CH_4 leaks with the Ultra Pro X in laboratory conditions.....15

Figure 12: Probability of detection versus emission rate, results of the evaluation of the Distran Ultra Pro X at METEC (adapted from METEC 2024).....17

1. Introduction

This document contains the technical description of the Distran Ultra Pro X Emissions, a technology used for the monitoring of fugitive emissions at Oil & Gas facilities. The document contains the information required by and described in 40 CFR 60.5398b(d)(3).

1.1. Overview of the Distran Ultra Pro X Emissions

The Distran Ultra Pro X Emissions is an advanced Acoustic Leak Imaging (ALI) detector often referred to as acoustic camera or ultrasound camera. The Ultra Pro X Emissions detects ultrasound and makes the ultrasound sources visible in real-time, in particular gas leaks. The detector is optimized for industrial environments, such as refineries, petrochemical sites, FPSOs as well as compressor stations, combined cycle power plants, nuclear power plants, and gas stations, allowing for the detection of leaks as small as 0.2 liters per hour[1]. The technology works for any type of gas, including methane, VOCs, and hydrogen, provided they are pressurized (> 50 mbar or 0.7 psi for a good Limit of Detection [2]).

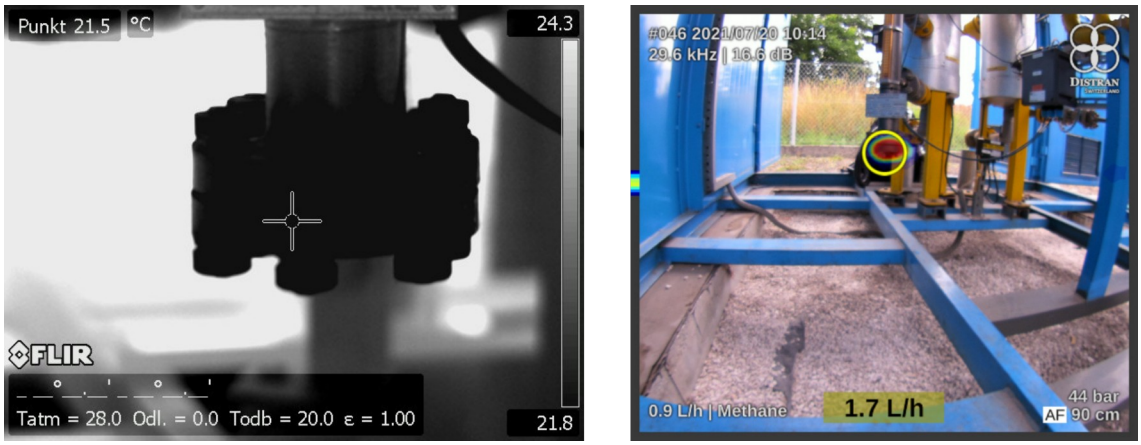


Figure 1: Methane leak on a flange detected on a natural gas metering station. Left, with an OGI camera. Right, with Distran Ultra Pro X.

The Ultra Pro X Emissions is routinely used in maintenance as well as for planned industrial inspections. Compared to other tools available to detect and locate fugitive emissions, Ultra Pro X Emissions is easy-to-use, and results are therefore repeatable with different operators. Its wide field of view makes it able to detect leaks at unexpected location, especially in cramped or congested spaces. Inspections are also conducted at a significantly faster pace due to the extended inspection distance and the clear visualization of leaks on its display (Figure 1). Furthermore, daily calibration is not required. The device enhances safety by enabling operators to detect hazardous gas leaks from a safe distance. It has also received ATEX certification (Zone 2 for gas group IIC) and IECEx certification.

Acoustic cameras like the Ultra Pro X Emissions are widely used across various industries, including Oil & Gas, Chemicals, Power Generation, and Composites. There, they play a crucial role in enhancing safety

[1] Example given for a methane leak, 70 bars, ~ 30 cm from the leak.
[2] See section 3.2.4 for more details on the Ultra Pro X real-time LoD.

(Distran, Oct. 2023), mitigating pollution (Distran, Jan. 2024), speed-up tasks such as turnarounds (Distran, Dec. 2023), and lowering production costs (Distran, Jul. 2024).

1.2. Type of measurement and application

The Distran Ultra Pro X Emissions is a handheld acoustic camera designed to perform mobile in-situ inspections of any above-ground Oil & Gas facilities. The technology is capable of detecting fugitive emissions at long distances (greater than 50 meters) and to pinpoint leaks at the component-level at distances up to 10 m.

2. Scientific theory

2.1. Acoustic imaging

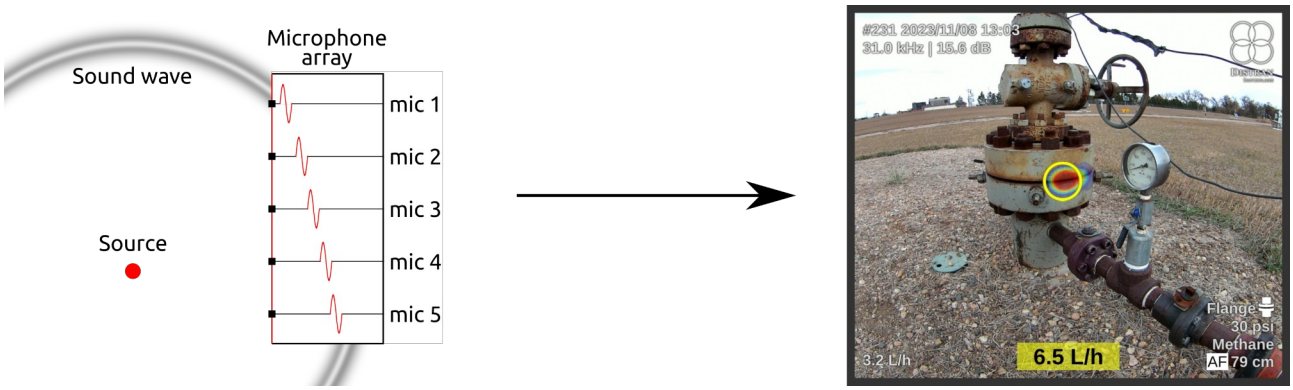


Figure 2: Left: schematic of the detection of a sound wave by an array of microphones. Right: Acoustic imaging of a single leak.

An acoustic camera such as the Distran Ultra Pro X Emissions uses acoustic imaging techniques to make ultrasound sources visible (Dobler 2005, Erić 2011). The camera is equipped with an array of sensors (microphones) that detect and capture sound waves (pressure waves) coming from various sources. The sound waves arrive at each microphone at different times and amplitudes which depends on microphones relative positions and the position of the sound source, as depicted in Figure 2 (left).

The core concept of acoustic imaging involves analyzing these signal differences to determine the location, intensity, and characteristics of the sound sources. For that, advanced signal processing algorithms (Eret 2012) are used to process simultaneously the signals from all microphones and combine them into an acoustic image overlaid onto an optical image (see Figure 2 right for an example). Because each sound source has a unique combination of time of arrival, and amplitudes at each microphone, the camera can separate and identify multiple sources within the same acoustic environment. Error: Reference source not found shows the example of the simultaneous detection of two ultrasound sources, that are natural gas leaks.

2.2. Gas leaks Acoustic Emission (AE)

In the field of acoustic leak imaging, acoustic cameras are employed to detect and localize pressurized gas leaks by capturing the ultrasound waves they emit.

When a pressurized gas escapes through an opening, it flows from the region of higher pressure to the region of lower pressure. The pressure difference between the interior and exterior of the container causes the gas molecules to exit at high velocity, thereby colliding with and perturbing the surrounding air molecules, resulting in the generation of turbulence. Turbulence is characterized by irregular and complex flow patterns, such as turbulent eddies and vortices (Figure 3). These turbulent structures interact with each other and the surrounding air, causing rapid and random fluctuations in pressure. These pressure fluctuations propagate through the air as sound waves (Tam 1995 & 2008, Howe 2003, Powell 1963, Lighthill 1952 & 1954).

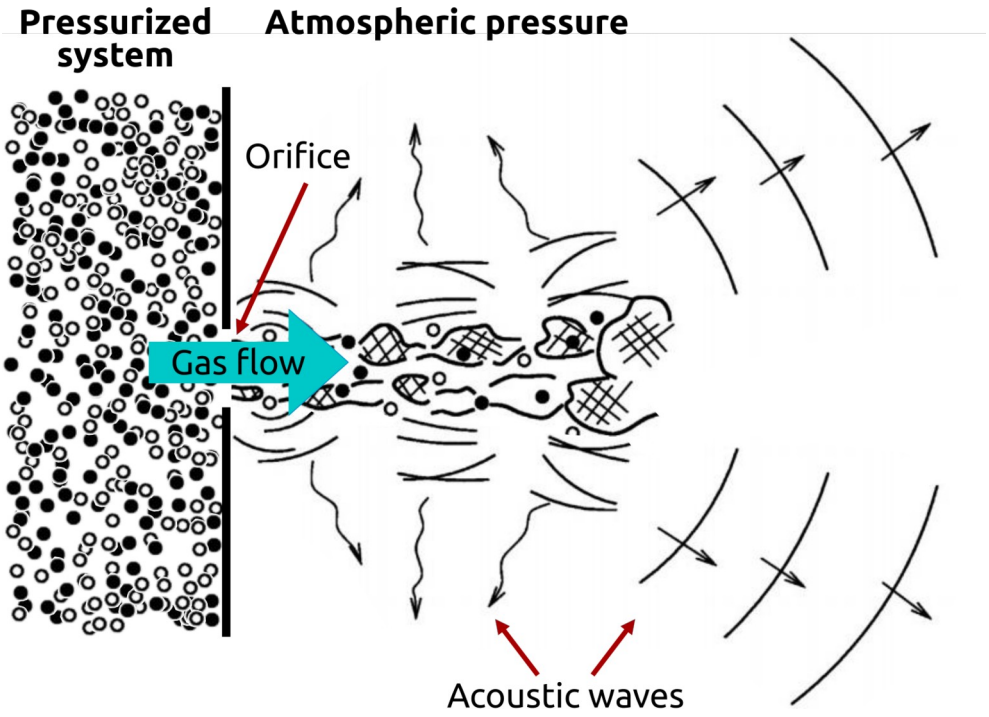


Figure 3: Schematic of the emission of acoustic waves by a pressurized gas leak (adapted from Tam 2008).

The characteristics of these waves—such as their frequency and amplitude—depend on various factors, including the geometry of the leak, the physical properties of the gas, and the pressure differential. As a result of the complex and multi-scale nature of the turbulent structures, the emitted noise has a broadband frequency content (Figure 4). It contains both audible sounds, such as the hissing noise heard when a tire deflates, and ultrasounds which are beyond the range of human hearing. In noisy industrial environments, machinery predominantly generates sounds within the audible spectrum (Figure 4), often masking the sounds of gas leaks to the human ear. However, machinery emits relatively few ultrasounds, facilitating the detection of ultrasounds produced by gas leaks.

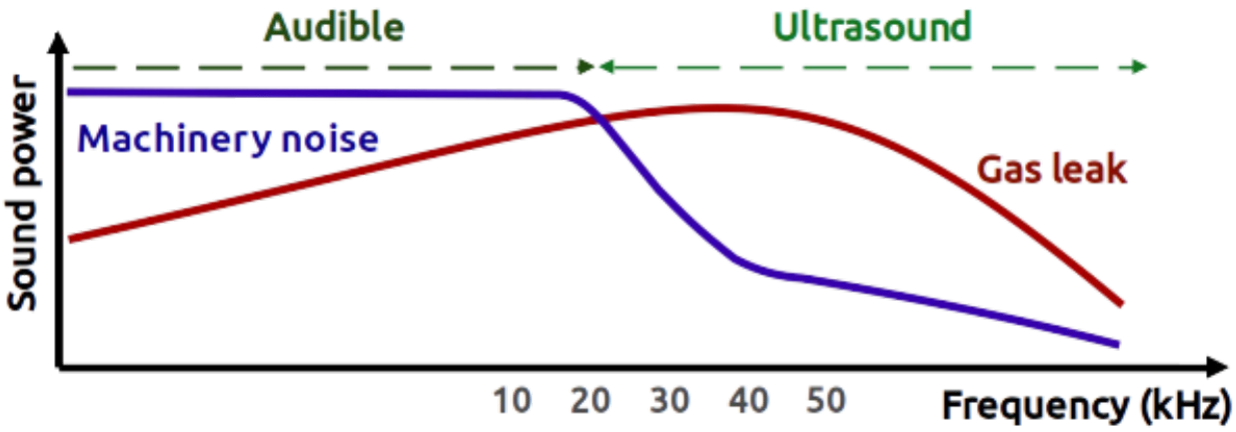


Figure 4: Sound spectra comparison: Gas leak vs. Machinery noise

3. The Distran Ultra Pro X Emissions

3.1. Physical description of the device

The Distran Ultra Pro X is the flagship detector of Distran Ltd. (https://distran.us), pioneer in Acoustic Leak Imaging. It has been developed with and for experts performing extensive inspections in the harshest environments. Weighing 1.5 kg including the battery, the camera is designed to be operated with a single hand, so that the operator can safely inspect at all times. The Ultra Pro X was the first acoustic camera to be certified ATEX for use in zone 2 and IIC gas class in January 2021. Since June 2024, Ultra Pro X is also IECEx certified.



Figure 5: Detailed view of the Distran Ultra Pro X

The front panel of the camera (red diamond in Figure 5 left), facing the scene to be inspected, houses the detectors. The 124 high-sensitivity microphones (1) constituting the microphone array are spread across the panel according to a pattern optimizing the acoustic imaging characteristics of the camera. The high-resolution fish-eye video camera (2) is located at the center and is surrounded by eight integrated LEDs (3) which facilitate inspection in low light areas or at night without the need for an external light source.

The rear panel of the camera (Figure 5 right), facing the operator, hosts the user interface. The main element is a built-in capacitive touch screen (5). During normal operations, it displays the acoustic images calculated in real-time by the Ultra Pro X Emissions, overlaid onto the optical images. Additionally, it displays settings and camera interface ().

The back side of the camera also has two buttons: the power button (4) and the action button (6). The latter allows the operator to record images, videos, and voice messages. The same functions are also accessible

through the touch screen. Audio and voice messages can be recorded thanks to the presence of two additional microphones located above the touch screen.

The frame is equipped with a one-hand handle for ease of use and mounts to attach the neck and wrist straps for added safety. The instrument is powered by a rechargeable lithium-ion battery, located at the bottom of the handle. In the same compartment is located a memory card (SD card) storing the images and videos that are recorded by the user.

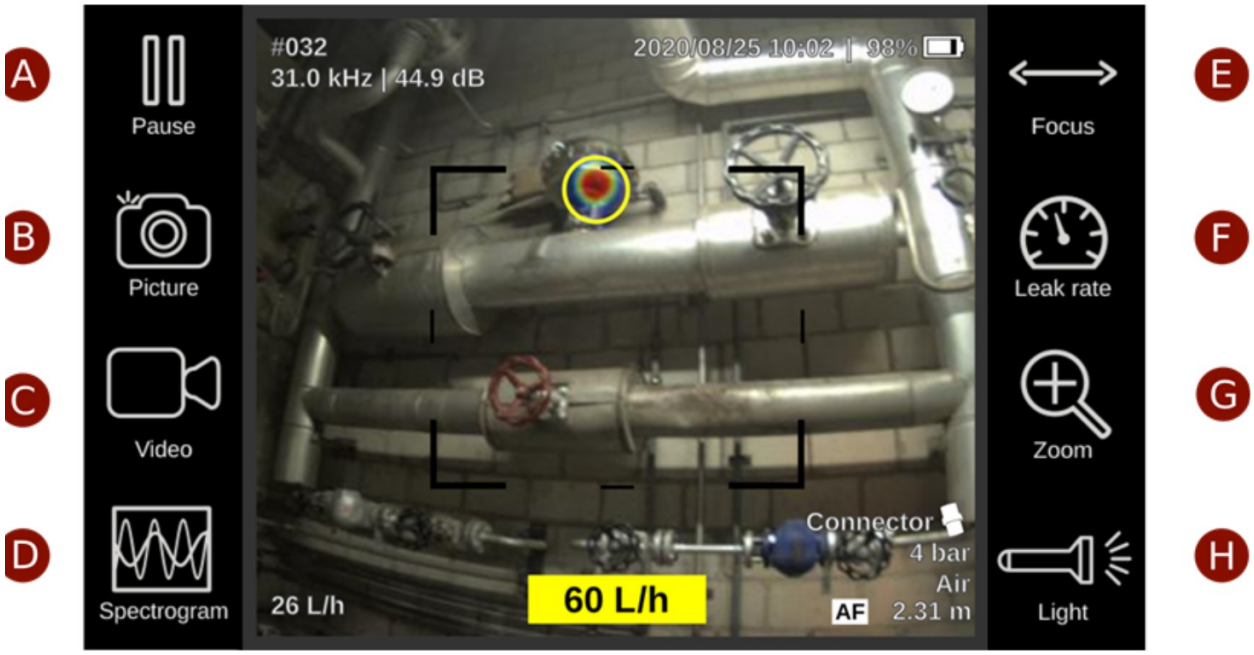


Figure 6: Camera interface.

The Ultra Pro X Emissions interface provides streamlined access to key functions, enhancing operational efficiency. Button **A** pauses acoustic imaging, temporarily halting the process. Button **B** captures inspection images, while **C** records videos with ultrasound (shifted to audible frequencies) or voice notes. **D** opens the detection frequency selection menu, and **E** allows adjustment of the focus distance. Button **F** accesses the leak quantification menu, enabling toggling between sound measurements (dB) and estimated leak rates (L/h or ft³/h), with options to input gas type, pressure, and leak source details for precise calculations. **G** activates a 2x zoom for detailed inspection, and **H** switches on the LED front light for enhanced visibility in low-light conditions.

3.2. Data workflow: from pressure and optical data to composite images

Error: Reference source not found presents a simplified overview of the Distran Ultra Pro X Emissions data workflow from data acquisition to deliverables. The different stages are introduced in the sections hereafter.

3.2.1 Data acquisition

Distran Ultra Pro X Emissions collects acoustic and optical data via its integrated sensors. Each of the microphones in the acoustic array outputs a signal that is proportional to the sound pressure it measures, i.e. the difference between the long-term averaged local atmospheric pressure and the instantaneous local pressure. The optical camera provides context to the measurement with a constant stream of raw video.

3.2.2 Data processing

The data pipeline can be described as follows:

- The microphones are synchronously acquired by an acquisition unit; the acquisition unit outputs a joint stream of temporal sound pressure data.
- Each of the soundtrack is transformed using the equivalent of a Short-Term Fourier transform (SFST; see Allen 1977)
- Depending on the user-settable frequency band (default around 30kHz), the given joint frequency band acoustic data are converted into an acoustic image (e.g Leclere 2009)
- The optical image and the acoustic image are overlaid to create an easy-to-understand composite image to the camera operator.

The resulting image, computed in real-time, is shown in Figure 7.

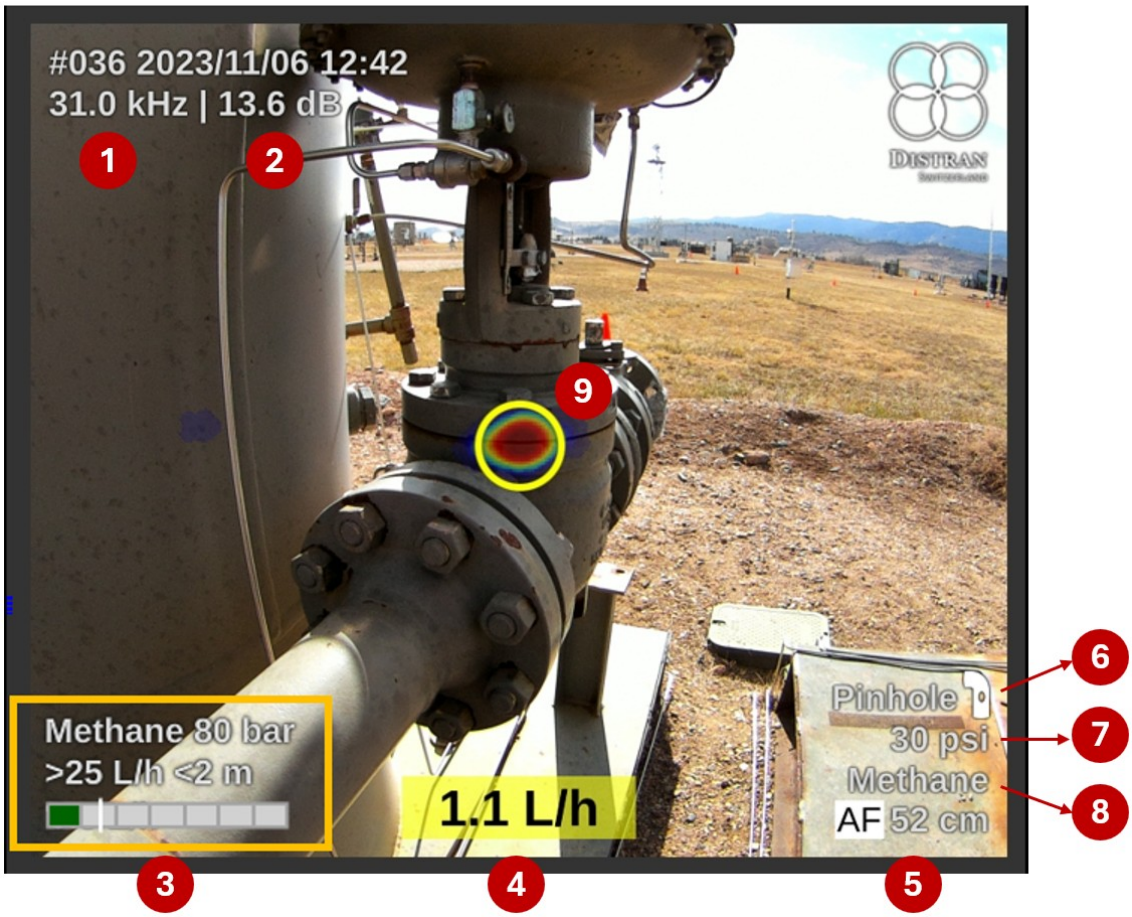


Figure 7: Distran Ultra Pro X Emissions composite image and leak quantification screen indications.

3.2.3 Ultra Pro leak rate quantification module

Distran has developed the Ultra Pro leak rate quantification module to help the Ultra Pro X Emissions users to better assess risks, take faster decisions and prioritize interventions. The module is optional and can be deactivated without compromising the Ultra Pro X Emission's detection capabilities or overall performance, ensuring the camera continues to operate at full functionality regardless of its activation. When deactivated, the camera displays the sound intensity of the source in decibels (dB). When activated, it provides a real-time leak rate estimation, accompanied by the parameters used for its calculation, as illustrated in Figure 9.

The Ultra Pro leak rate quantification module employs advanced numerical models derived from an extensive database of acoustic measurements obtained from industrial facilities and laboratories. It estimates the leak rate in real-time by analyzing the sound intensity received by the camera (2), the focal distance calculated by the auto-focus (5), and user inputs. The most adequate numerical model is automatically selected based on user-defined parameters such as gas type (8), pressure difference (7), leak type (6), and sampling frequency (1).
When the leak quantification module is activated, real-time leak estimation will be displayed in the yellow box at the bottom center of the screen (4) upon detection of a leak within the quantification frame (10). A yellow ring (9) will highlight the position of the leak being quantified.

3.2.4 Detection Confidence Limit

The Detection Confidence Limit (DCL) is a feature that may be toggled in the quantification sub-menu to provide a visual confidence cue that a leak threshold can be detected for a given set of factors. By providing a leak rate threshold input into the device, the DCL will show the confidence level of finding the set leak rate in different sound environments in real time, ensuring that leaks of interest are not missed even in challenging conditions.

3.2.5 Health Center

The Health Center is a feature that ensures the camera sensors are mission-ready before inspections. Upon accessing the Health Center option in the User Interface, a System Health self-check can be triggered which will evaluate the status of the video processor, acoustic processor, microphone array, and hardware temperature thresholds to ensure that the device is in working order. A documented verification that the camera is operating within specifications is then saved onto the device's internal memory and exportable for record-keeping.

3.2.6 GPS

Recorded leak pictures and videos can now be coupled with a geolocation tag using Distran's GPS option. By toggling on the GPS option in the camera, media recorded in GPS-available locations will now contain a geolocation tag when uploaded into the Audalytics tool, providing geolocation for recorded media and a map location when accessed via Audalytics. This helps track inspections and aids in record-keeping when using Distran's Audalytics reporting tool.

4. Data handling, storage and delivery

4.1. Data handling and storage

The Distran Ultra Pro X Emissions can record images and videos with voice notes or heterodyne sound (i.e. ultrasounds made audible by frequency shifting). They are saved on the SD card of the device and can also be optionally transferred to Audalytics, a proprietary cloud based reporting platform when the camera is connected to a WiFi network. More details on the data handling and storage, and Audalytics can be found in the description of the method and the User Manual.

4.2. Data delivery

Images and videos recorded by the camera user are directly available on the SD card. The users can also decide to create annotated reports with selected recordings using the Audalytics platform.

5. Performances

5.1. Component-level spatial resolution

The Distran Ultra Pro X Emissions is a dual sensor detection device. The acoustic sensor (i.e. the microphone array) is capable of distinguishing two sources 5 cm apart when inspecting at 1 m and 28 cm apart when inspecting at 6 m. The optical sensor offers a high spatial resolution of just a few millimeters at typical inspection distances. The combination of both imaging sensors leaves no room for interpretation and helps the operator to pinpoint the exact location of the leak at the component-level as illustrated in Figure 8.



Figure 8: Leak detection and localization at the component-level at a distance > 4 m.

5.2. Leak resolution

5.2.1 Detection limit under laboratory conditions

Since the first prototype, the detection capabilities of the Distran Ultra Pro X Emissions have been rigorously tested under laboratory conditions at Distran facilities and renowned institutions such as the French National Institute for Industrial Environment and Risks (INERIS) in France. These tests evaluated the performance of the acoustic camera on customized leak scenarios, encompassing diverse orifice geometries, variable flow rate conditions, and a range of pressure levels. The results from these tests demonstrated that the Distran Ultra Pro X Emissions can detect methane leaks with leak rates as low as 1 g/h with a pressure difference of 0.2 bar.

The Figure 9 below presents selected data for pinhole-type methane leaks, with each dot representing a successfully detected leak at the specified pressure and leak rate.

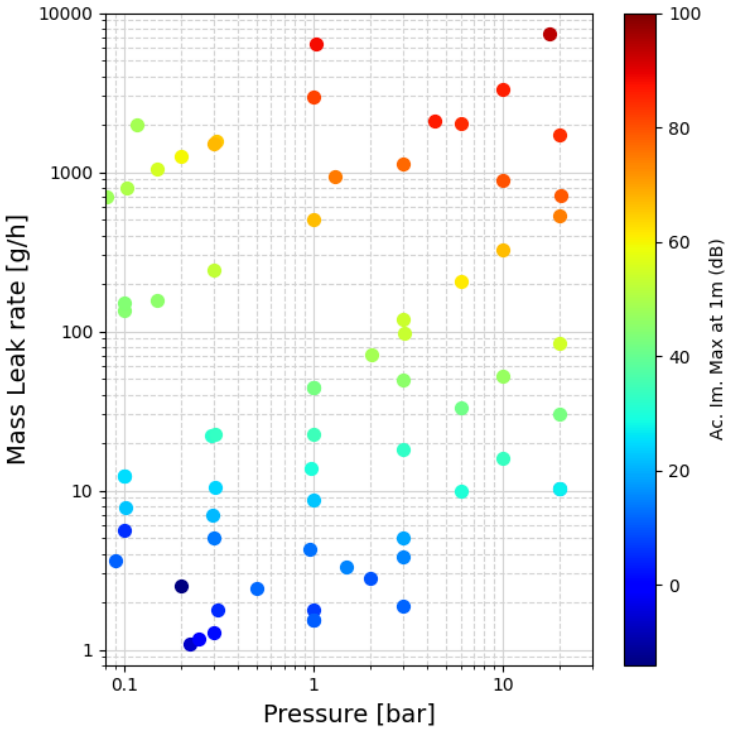


Figure 9: Selected results for the detection of CH_4 leaks with the Ultra Pro X Emissions in laboratory conditions.

5.2.2 Detection limit in industrial environment

Conducting tests in controlled laboratory conditions allows for evaluating the camera's improvements, collecting additional data for further upgrades, and understanding the camera's limitations to some extent. However, these conditions cannot fully replicate the types of leaks and operating environments found in typical Oil & Gas facilities. Factors such as external noise sources and elevated operating pressures can significantly impact the camera's sensitivity. Specifically, external noise can elevate the Limit of Detection (LoD) of the camera, while higher operating pressures can facilitate the detection of smaller leaks. To address these challenges and validate the camera's performance in real-world settings, Distran has organized and participated in several field campaigns. Notably, one such campaign, detailed in the white paper by Lambert (Distran January 2024), involved comparing the Distran Ultra Pro X with an Optical Gas Imaging (OGI) camera and a Flame Ionization Detector (FID) during the inspection of an interconnection station operated by one of Europe's largest gas transporters. The Ultra Pro X demonstrated its effectiveness by detecting an equivalent volume of emissions as the OGI + FID but in just one-fifth of the time.
In similar field campaigns, operators of the Distran Ultra Pro X have reported detecting leaks as small as 0.1 g/h of natural gas pressurized to 70 bar, with these measurements corroborated by third-party operators using Hi-Flow Samplers or Bagging techniques[3]. These findings underscore Ultra Pro X's high sensitivity and effectiveness in diverse operational environments.

5.2.3 Probability of detection, tests at METEC

During field campaigns in real facilities, leaks are uncontrolled, and the actual number of leaks is unknown, making it impossible to define a detection rate or a Probability of Detection (POD). To determine the 90 % POD required by the EPA, the Ultra Pro X was evaluated under single-blind controlled release testing at the Methane Emissions Technology Evaluation Center (METEC), see Bell & Zimmerle (2022) for the test protocol. METEC is a test facility designed to emulate the emissions behavior and wind transport characteristics of upstream and midstream operational oil and gas (O&G) facilities. It is important to note that METEC was developed when concentration-based detectors were the standard tools for detecting methane leaks. Consequently, the system was not designed to reproduce the high-pressure levels found in the field, with most leaks occurring at pressures below 2 bars. This presents an additional challenge for acoustic-based detectors such as the Ultra Pro X, which rely on the pressure difference at the leak orifice to generate acoustic waves.
The test campaign took place in November 2023. The results are displayed in Figure 10. The analysis provided by the METEC team (METEC 2024) showed a 90% probability of detection level of 0.9 kg/h when calculated using a power curve fit, or 1.0 kg/h when calculated using a logistic regression fit (see Bell 2023 for explanation on the method). Both values meet the EPA requirement for a leak resolution of 1 kg/h. It is noteworthy that these probabilities of detection for the Distran Ultra Pro X, operated by an operator with low experience (< 30 sites) are similar to those found in Zimmerle et al. (2020) for low-experience LDAR inspectors operating OGI cameras. Additionally, we anticipate that the leak rate for a 90% probability of detection to be lower in actual O&G facilities, where higher operating pressures result in increased acoustic

[3] The lower detection threshold observed in field settings compared to laboratory conditions is attributed to the higher-pressure differential, which results in noisier leaks.

emissions at the leaks. This expectation aligns with the test campaign results discussed in the previous section.

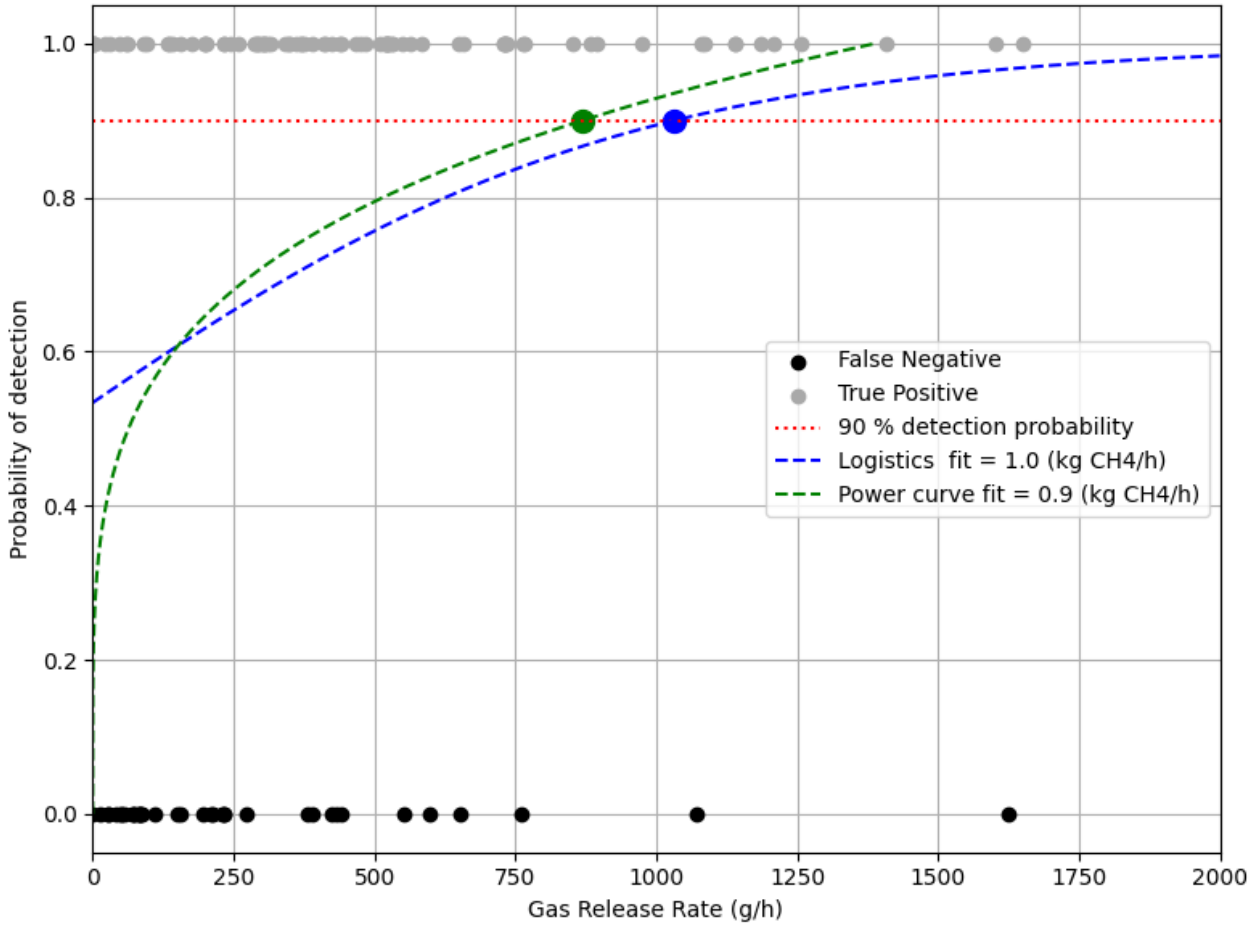


Figure 10: Probability of detection versus emission rate, results of the evaluation of the Distran Ultra Pro X at METEC (adapted from METEC 2024).

5.3. Technology limitations

The Distran Ultra Pro X Emissions is limited by the requirement for leaks to emit ultrasounds to be detectable. Leaks where the gas flow isn’t turbulent and does not generate acoustic waves, are undetectable by the Ultra Pro X Emissions. This limitation is particularly relevant for small leaks through large orifices, such as vents or thief hatches, where the flow remains laminar. Additionally, the effectiveness of the Distran Ultra Pro X Emissions acoustic camera is affected by adverse meteorological conditions, such as strong wind and rain, which can generate ultrasounds from raindrop impacts and structural vibrations, potentially masking the weak gas leak emissions and raising the device Limit of Detection. Interference from strong ultrasound sources, such as flow noise in pipes and rotating fans, can also hide smaller leaks. Furthermore, it is essential to maintain a clear path for ultrasound waves to travel from the leak to the camera's microphones; thus, leaks inside sealed cabinets or behind insulation can be challenging to detect. The Ultra Pro X Emissions is also not recommended for detecting underground leaks.

6. Bibliography

Allen, J. (1977). Short term spectral analysis, synthesis, and modification by discrete Fourier transform. *IEEE transactions on acoustics, speech, and signal processing*, *25*(3), 235-238.

Bell, C., & Zimmerle, D. (2022). METEC controlled test protocol: Survey emission detection and quantification.

Bell, C., Ilonze, C., Duggan, A., & Zimmerle, D. (2023). Performance of continuous emission monitoring solutions under a single-blind controlled testing protocol. *Environmental Science & Technology*, *57*(14), 5794-5805.

Distran. (2023). Ultra Pro X User manual v2.1.29

Distran. (Oct. 2023). *Distran helps ENGIE streamline outage management at Al Ezzel power plant in Bahrain*. https://distran.us/en/engie-power-plant-outage-management/.

Distran. (Dec. 2023). *Ensuring availability of the Dampierre-en-burly nuclear power plant*. https://distran.us/en/ensuring-availability-nuclear-power-plant-dampierre/.

Distran. (Jan. 2024). *White Paper: upcoming EU regulation on methane emissions*. https://distran.us/en/eu-regulation-on-methane-emissions/.

Distran. (Jul. 2024). *How Bostik's production team find leaks in unexpected areas quickly and efficiently.* https://distran.us/en/bostik-vacuum-leak-detection-in-chemical-industry/.

Dobler, D., & Heilmann, G. (2005). Perspective of the acoustic camera. In *INTER-NOISE and NOISE-CON Congress and Conference Proceedings* (Vol. 2005, No. 6, pp. 2491-2498). Institute of Noise Control Engineering.

Eret, P., & Meskell, C. (2012). Microphone arrays for compressed air leakage detection. In *4th Berlin beamforming conference* (pp. 1-14).

Erić, M. M. (2011). Some research challenges of acoustic camera. In *2011 19thTelecommunications Forum (TELFOR) Proceedings of Papers* (pp. 1036-1039). IEEE.

Gade, S., Hald, J., & Ginn, B. (2013). Noise source identification with increased spatial resolution. *Sound & Vibration*, *47*(4), 9-13.

Howe, M. S. (2003). *Theory of vortex sound* (No. 33). Cambridge university press.

Leclere, Q. (2009). Acoustic imaging using under-determined inverse approaches: Frequency limitations and optimal regularization. *Journal of Sound and Vibration*, *321*(3-5), 605-619.

Lighthill, M. J. (1952). On sound generated aerodynamically I. General theory. *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences*, *211*(1107), 564-587.

Lighthill, M. J. (1954). On sound generated aerodynamically II. Turbulence as a source of sound. *Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences*, *222*(1148), 1-32.

METEC. (2024). Survey Emission Detection and Quantification Final Report for Distran Ultra Pro X.

Powell, A. (1953). On the mechanism of choked jet noise. *Proceedings of the Physical Society. Section B*, *66*(12), 1039.

Tam, C. K., Viswanathan, K., Ahuja, K. K., & Panda, J. (2008). The sources of jet noise: experimental evidence. *Journal of Fluid Mechanics*, *615*, 253-292.

Tam, C. K. (1995). Supersonic jet noise. *Annual review of fluid mechanics*, *27*(1), 17-43.

Zimmerle, D., Vaughn, T., Bell, C., Bennett, K., Deshmukh, P., & Thoma, E. (2020). Detection limits of optical gas imaging for natural gas leak detection in realistic controlled conditions. *Environmental Science & Technology*, *54*(18), 11506–11514.