H.E.A.T.

Hager Environmental & Atmospheric Technologies

Established 2009

Gas and Oil Application

Hager Environmental & Atmospheric Technologies, LLC
7308 Nubbin Ridge Drive
Knoxville, TN 37919
http://www.heatremotesensing.com

Yolla Hager, President
(865) 389-6533
Yolla@Heatrsd.com

Hager Environmental & Atmospheric Technologies, LLC (Hager Environmental) was founded in 2009 to develop an advanced and unique technology aimed at revolutionizing the Vehicle Emission Testing Industry. This technology, EDAR (Emissions Detecting And Reporting), is an eye safe laser-based technology capable of remotely detecting and measuring the infrared absorption of environmentally critical gases. EDAR contains a multi-patented system of hardware and software, which allows for a hyper spectral 3-dimensional image of the plume Additionally, EDAR provides an increased sensitivity, in some cases of over 2,000%, and resolutions of a million times greater versus existing technologies in use today.

J. Stewart Hager, inventor and PhD Molecular Physicist, founded Hager Environmental. Dr. Hager has over 25 years experience working with remote sensing technology and his previous work includes consulting with NASA Langley on the ASCENDS satellite. He works with a team of experienced engineers and technicians, cumulatively, which represents over 80 years of professional experience.

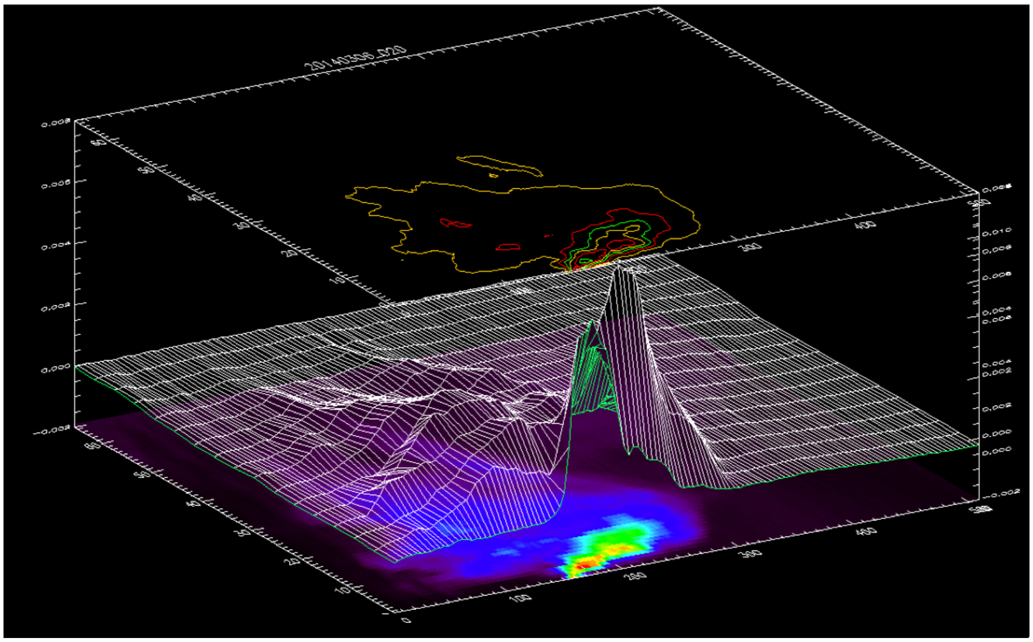
The EDAR technology eliminates the need for calibration and is designed to collect data on various gases such as CO, CO2, NOx, Hydrocarbons including the speciation of hydrocarbons (methane, ethane and ethylene to name a few), Particulate Matter (PM2.5) and any molecule in a gaseous state shown in the HITRAN chart (*Appendix A*), as part of an unmanned system.

The integrity of our data has been validated by various studies comparing EDAR to a traditional Portable Emissions Measurement System (PEMS), other in-situ measurement devices.

Hager Environmental currently owns four patents, as well as significant trade secrets directly related to the EDAR technology and its use.

EDAR contains a robust, fully tested hardware assembly and a software engine containing a sequence of well-proven algorithms. These algorithms, when combined with EDAR's unique equipment location geometry, allows the entire gas plume to be examined. As seen in Exhibit 1, the EDAR system provides a 3D hyper spectral image of the entire plume

Exhibit 1: One of the 3D Multi- spectral Images of Exhaust Plume (as captured by EDAR); 512 pixels per scan



The benefits of using EDAR are:

- **Reduction of Costs**: EDAR is an un-manned, stand-alone system that minimizes costs for oil and gas industry leaders by detecting and quantifying leaks at refineries and pipelines remotely.

- **Real Time Detection and Data:** EDAR has the ability to instantaneously provide a reading to engineers alerting them of any issues before leaks get out of control.

- **Maximizes Air Quality Benefits**: Highest accuracy measurement of CO, CO2, CH_4, NO, NOx and Hydrocarbons.

Measurement of absolute amounts of methane leaks from natural gas wells.

EPA's Air Rules for the Oil & Natural Gas Industry have new requirements for processes and equipment at natural gas well sites. Equipment and processes at the well site may be covered by requirements under the New Source Performance Standards (NSPS) for volatile organic compounds (VOCs), and the National Emissions Standard for Hazardous Air Pollutants (NESHAP) for oil and natural gas production.

The path from the wellhead to the transmission line has many gas-driven controllers and actuators. Natural gas must be treated before it is inserted in the transmission pipeline, such as dehydration. This takes many valves, fittings and connections.

EDAR can **detect** and **quantify** methane leaks from wellheads. EDAR can be equipped with a large aperture scan head. Instead of scanning back and forth, it can create any pattern. Exhibit 2 shows a cone shaped pattern around a wellhead. Methane gas exiting the cone can be detected and quantified using the same techniques in car exhaust remote sensing. Wind speed can be calculated using a local weather station or wind Lidar. Once the wind velocity is established flow rate can be calculated and leaks can be quantified in units of amounts per time, e.g. ft^3/hour.

Exhibit 2: EDAR System Footprint

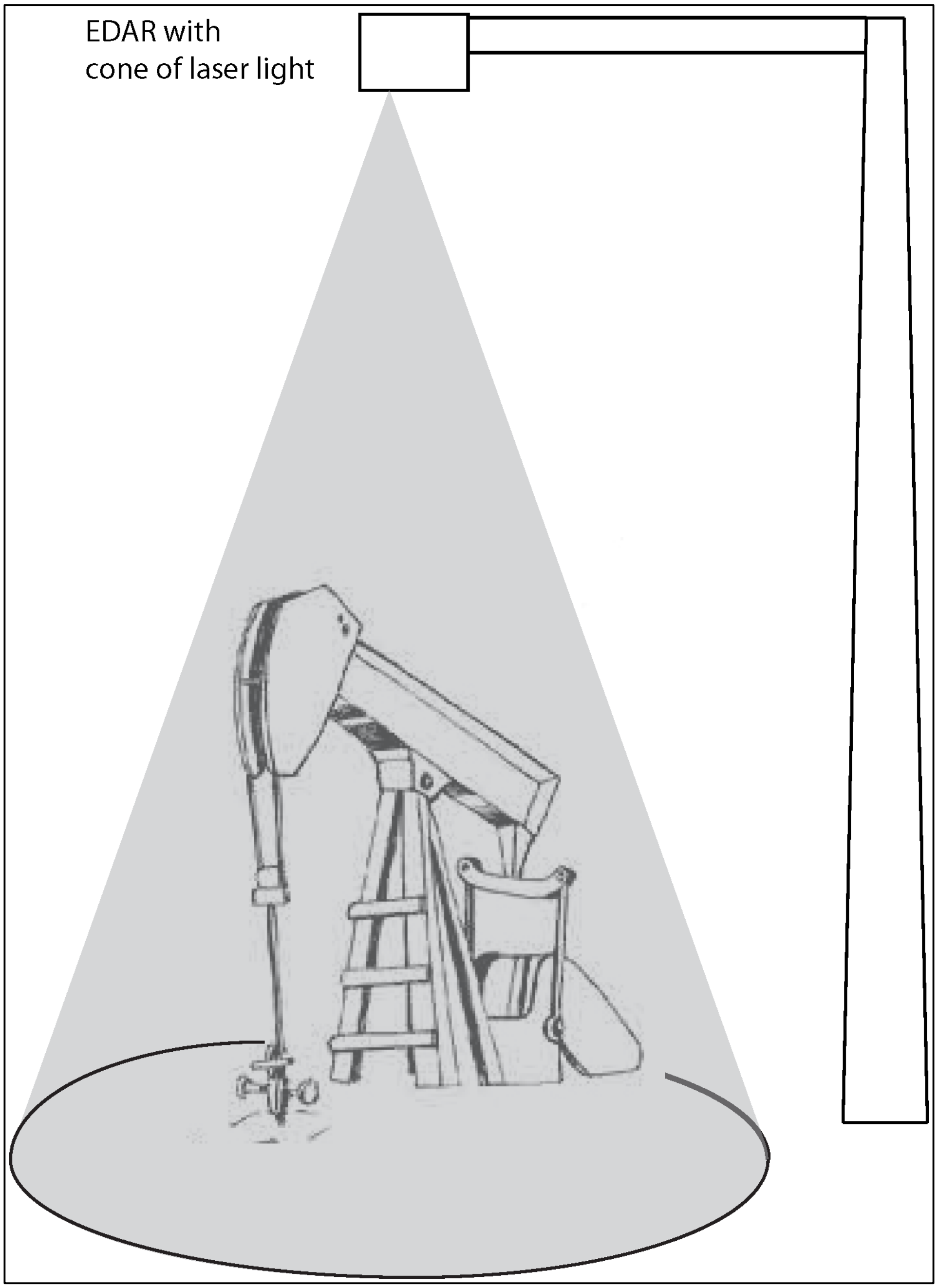


Exhibit 2: A pattern of a cone can be established by using a scan head on the EDAR device. Methane leaks can be detected and quantified by the amount in the scan and the wind velocity. EDAR can be mounted on a pole similar to a streetlight above the well site.

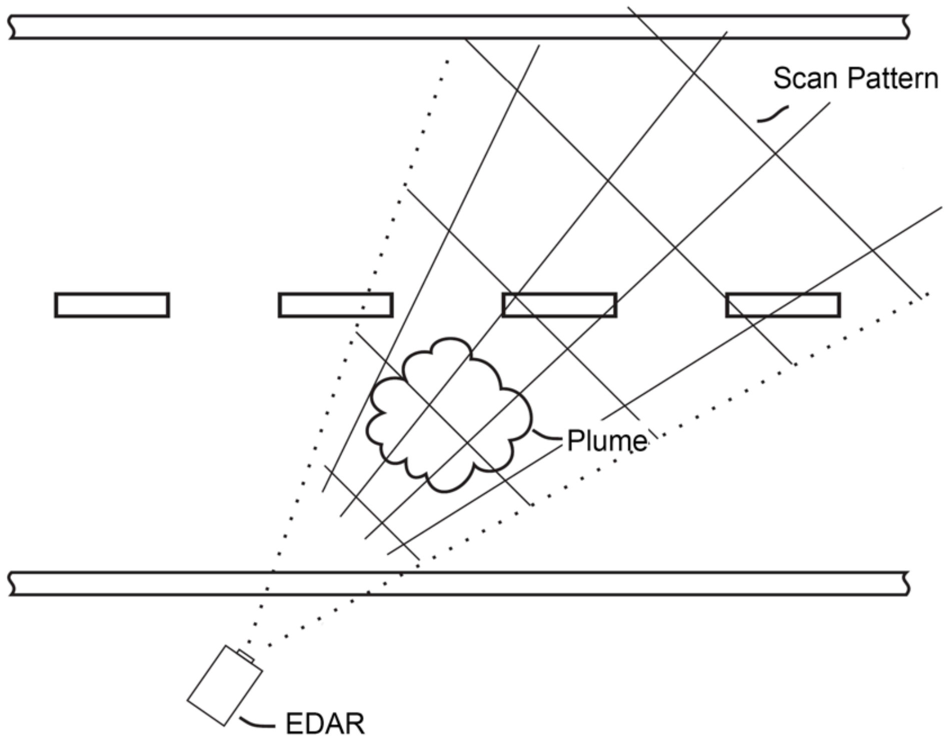
Since EDAR can measure the amount of methane at any one time, it can also measure the rate at which the methane is crossing the barrier of the laser scan by just measuring the wind velocity.

The all-in-one EDAR system is fully weatherproofed to protect it from environmental elements (heat, rain, snow, wind, etc.). Prior to active deployment, each unit will also be tested under various environmental extremes in a specially designed environmental test chamber.

The nature of EDAR's technology eliminates the need for any calibration. EDAR's patented technology uses similar principals as active satellite remote sensing platforms. It can remotely measure quantities and relative amounts of targeted molecules in a plume. Due to the absolute nature of the measurement, calibration is not necessary. This gives our data more accuracy, precision, consistency and allows for minimal human operational intervention

Customizable Scan Head

EDAR can scan in 2 dimensions creating any pattern as shown above using an XY scan head. EDAR uses a variation of DIAL to measure and quantify atmospheric gases independent of temperature and pressure.



Options for EDAR Applications in Gas and Oil:

- **Fence line Monitoring** – around the clock remote detection and quantification of emissions in real-time.
- **Mobile Mounted Monitoring –** vehicle mounted with an EDAR system on a pole to locate, detect, and quantify leaks.
- **Monitoring of Wellhead –** detect and quantify leaks at the source as well as around connections, fittings, and valves.

Gas & Oil Industry: A Comparison:

Major Players Using Infrared Cameras and FTIRs:

- Rebellion Photonics
- Telops
- Providence Photonics
- Williamson Corporations

Currently, major players in the gas and oil industry use infrared (IR) cameras to detect leaks, specifically Passive FTIR and SOS FTIR systems. **Infrared cameras** have certain **limitations**, which are **not found in EDAR**.

A few examples of **FTIR limitations** include:

- IR cameras cannot see or measure gas if it is the same temperature as the surroundings.
- Passive FTIR systems need the plume to be at relatively high temperatures and they cannot image the plume.
- SOS FTIR systems depend on the Sun's position to measure column amounts, but they cannot use the most sensitive methane absorption features because ambient amounts remove the Sun's light at those wavelengths.

Key Differentiators:

	NPL DIAL System	EDAR
Return Signal	Backscattering from ambient aerosols	Backscattering from solid surface
Size	Tractor Trailer	Breadbox
Sources	Nd-YAG pumped dye lasers with crystal different frequency mixing	DFB Narrowband wavelength lasers
Range	2 Kilometers	500 meters
Cost	High	Low

In comparison, **EDAR's unique approaches** include:

- EDAR can scan up and down and side to side in order to do fence line monitoring.
- EDAR can be equipped with a Lower Explosive Limit (LEL) meter in the boxes and can go into immediate shutdown if necessary.
- EDAR can be attached to existing infrastructures inside a refinery. For instance, it can sweep out a "tent" of laser light. Any fugitive emissions from underneath the "tent" could then be quantified.

Conclusion:

Hager Environmental's EDAR remote sensing technology is an important enhancement to existing leak detection devices that we believe will noticeably improve real time data for the oil and gas industry. EDAR has been validated in various environments in both real world and in laboratory settings, which translated in conclusive accuracy and validity results. EDAR is an unmanned system that is able to remotely detect and quantify virtually any molecule in a gaseous state with the highest accuracy allowing for a reduction of time and effort in identifying the location and composition of the leak without calibration. The system itself is customizable and easily deployable in either a permanent or temporary setting, therefore, preventing the hassle of an obtrusive device; allowing for continuous remote detection of leaks. The engineering approach implicit in the EDAR technology is a quantum jump in leak detection.

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Appendix A:

HITRAN Chart: High-resolution Transmission Molecular Absorption Database

name	formula
Water vapour	H_2O
Carbon dioxide	CO_2
Ozone	O_3
Nitrous oxide	N_2O
Carbon monoxide	CO
Methane	CH_4
Dioxygen	O_2
Nitrogen oxide	NO
Sulfur dioxide	SO_2
Nitrogen dioxide	NO_2
Ammonia	NH_3
Nitric acid	HNO_3
Hydroxyl radical	OH
Hydrogen fluoride	HF
Hydrogen chloride	HCl
Hydrogen bromide	HBr
Hydrogen iodide	HI
Chlorine monoxide	ClO
Carbonyl sulfide	OCS
Formaldehyde	H_2CO
Hypochlorous acid	HOCl
Nitrogen	N_2
Hydrogen cyanide	HCN
Chloromethane	CH_3Cl
Hydrogen peroxide	H_2O_2
Acetylene	C_2H_2
Ethane	C_2H_6
Phosphine	PH_3
Carbonyl fluoride	COF_2
Sulfur hexafluoride	SF_6
Hydrogen sulfide	H_2S
Formic acid	HCOOH
Hydroperoxyl radical	HO_2
Oxygen	O
Chlorine nitrate	$ClONO_2$
Nitrosonium ion	NO^+
Hypobromous acid	HOBr
Ethylene	C_2H_4
Methanol	CH_3OH
Bromomethane	CH_3Br
Acetonitrile	CH_3CN
Carbon tetrafluoride	CF_4
Diacetylene	C_4H_2
Cyanoacetylene	HC_3N
Molecular hydrogen	H_2
Carbon monosulfide	CS
Sulfur trioxide	SO_3