Development and Implementation of a Leak Detection and Repair (LDAR) Program to Mitigate Methane Emissions in the Oil and Gas Sector

Global Methane Initiative
Leading methane action since 2004

DISCLAIMER

This course is not intended to address applicable national, state, Tribal, or local LDAR regulations.

Prior to developing a non-regulatory LDAR program, please ensure you understand any relevant LDAR regulations that may apply in your jurisdiction.

Welcome

This course explains the concept, objectives, systematic approach, challenges and benefits of a non-regulatory leak detection and repair (LDAR) program for managing methane emissions from equipment leaks at oil and natural gas facilities. In addition, it provides specific guidance on designing, implementing, and managing the LDAR program.

This course was developed in support of the Global Methane Initiative (GMI).

What is the GMI?

What Is the Global Methane Initiative?

Global Methane Initiative
Leading methane action since 2004

The Global Methane Initiative (GMI) is an international public-private partnership focused on reducing barriers to the recovery and use of methane as a valuable energy source.

globalmethane.org

GMI Partner Countries represent **nearly 75%** of global methane emissions from human activities.

Course Modules

Module 1

Introduction and Objectives

Module 2

Equipment Leaks

Module 3

Designing and Managing an LDAR Program

UP NEXT

Module 4

LDAR Instruments Selection

Module 5

Implementing an LDAR Program

Module 4
LDAR Instruments Selection

What you will learn

In this module, company managers and others responsible for designing and implementing an LDAR program will learn:

- What leak detection instruments are used for LDAR surveys?
- What leak rate quantification instruments are used for LDAR surveys?

What leak detection instruments are used for LDAR surveys?

- Introduction
- General considerations for leak detection instruments
- Leak detection instruments
  - Spray bottle containing soap solution (bubble test)
  - Portable or handheld gas detectors Ultrasonic leak detectors
  - Laser leak detectors
  - Optical gas imaging (OGI) infrared (IR) cameras
- Supplemental leak detection measures

Introduction

LDAR surveys are typically performed using portable (usually handheld) leak detection instruments.

Common options in the general order of increasing upfront cost include:

1. Spray bottle containing soap solution (bubble test)
2. Portable or handheld gas detectors
3. Ultrasonic leak detectors
4. Laser leak detectors
5. Optical gas imaging (OGI) infrared (IR) cameras

Stationary leak detection systems may be used to supplement the LDAR surveys, such as permanently installed gas detectors, flow indicators, and continuous monitoring.

Performance requirements and leak detection procedures for Options 1 and 2 are given by U.S. EPA Method 21. Similar information for Option 5 is provided in U.S. EPA Alternative Work Practice.

EPA does not offer a specific method for Options 3 and 4, so the manufacturer's operating instructions should be followed for these two instruments.

General considerations for leak detection instruments

To conduct a leak survey, the LDAR survey team should be equipped with appropriate leak detection instruments.

Leak detection instruments should have the following features:

- The instrument should detect methane and be fast-responding.
- Detection threshold capabilities lower than the leak definition established by the LDAR program and discussed in module 3 of this training.
- Portability and ease of use.
- Ruggedness and weather resistance.
- Cost-effectiveness.

Any instruments to be used in process areas must be rated for safe use in hazardous locations.

In the USA, a leak is defined as a screening value of ≥10,000 ppm total hydrocarbons measured in accordance with US Environmental Protection Agency's (EPA's) Method 21 or a visible hydrocarbon emissions measured using an optical gas imaging (OGI) infrared (IR) camera in accordance with "Appendix K" to US EPA 40 CFR Part 60. EPA's New Source Performance Standards series for crude oil and natural gas facilities (40 CFR Part 60 Subpart OOOO) defines a leak as 500 ppmv or greater.

Satellite, aircraft, drone and vehicle-based **monitoring technologies** can be used to efficiently screen large areas for facilities that offer the greatest opportunities to reduce methane emissions. Then, more comprehensive LDAR surveys can be conducted at the identified high-emitting facilities.

Leak detection instruments:
Spray bottle containing soap solution (bubble test)

A soap solution is applied to a potential leak source using a spray bottle. Bubbles will form if there is a leak.

The soap solution can be prepared by using either a commercially available leak detection solution or using common detergent and water.

Spray bottle containing soap solution (bubble test)

Advantages	Disadvantages
• Most sensitive leak detection technique. • Useful for pinpointing the exact point(s) on a component where leakage is occurring. • Least expensive leak detection option and requires no capital investment. • Can be used to provide semi-quantitative leak-rate results based on the size and rate of bubble formation (see Method 21). • Minimal training is required to apply the technique. • Windshield antifreeze washer fluid can be added to the soap solution if the screening is conducted in cold weather.	• Requires close contact with the leaking equipment component. • Does not work on hot surfaces or open-ended lines. • Not practical for detecting large leaks. • Does not work on rotating equipment.

Leak detection instruments: Portable or handheld gas detectors

Portable or handheld gas detectors can be used to identify leaks. These instruments can detect gases by measuring hydrocarbon concentrations at the potential leakage points on equipment components in natural gas service. This is typically done in accordance with EPA Method 21.

The measurement result is called a leak screening value. It is compared to the applicable leak definition to determine if the component is classified as a leaker.

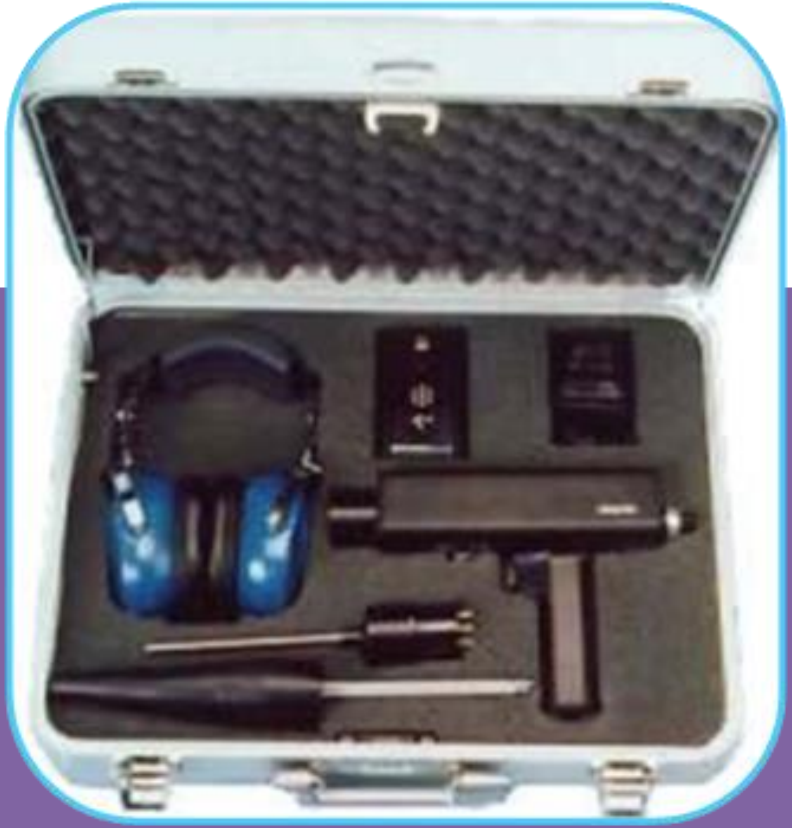
The selected instrument should comply with the performance requirements of EPA Method 21 (e.g., response time, minimum detection limit, and detectable gases). The instrument should detect methane, be fast-responding (e.g., <30 seconds to reach 90% of final methane or hydrocarbon reading), and have a minimum detection limit of ±2.5 percent of the specified leak definition concentration.

Portable or handheld gas detectors

Advantages	Disadvantages
• Good leak detection sensitivities. • Useful for pinpointing the exact source and point(s) of the leakage. • Low to moderate capital costs. • Moderate leak detection efficiency (e.g., an LDAR technician can typically screen about 350 equipment components per day). • Minimal training required to use the instrument.	• Periodic calibration of instruments required. • Close contact with the leaking equipment component required. • Susceptible to instrument fouling and damage (cannot tolerate any liquids being drawn into the instrument). • Not suited to use in rainy or freezing weather.

Leak detection instruments: Ultrasonic leak detector

These portable instruments can detect leaks based on the ultrasonic sound that is produced by escaping pressurized gas or vapor.



Photos of an ultrasonic leak detector and its accessories.

Ultrasonic leak detector

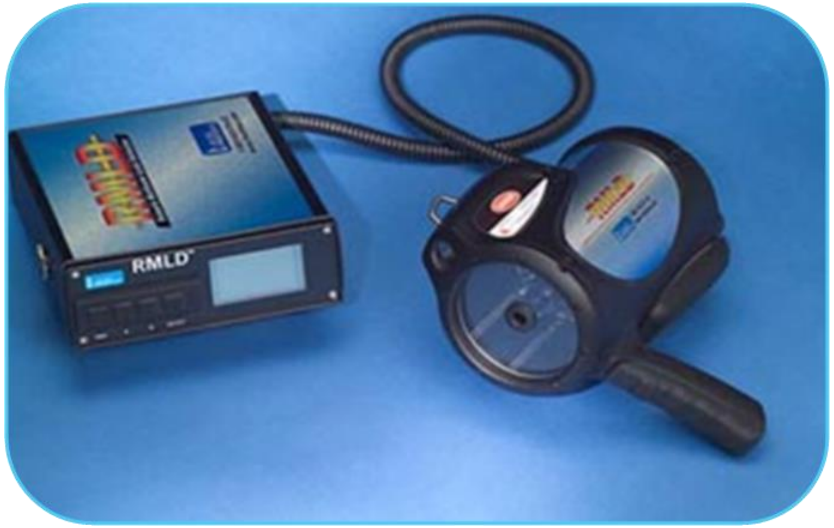
Advantages	Disadvantages
• Moderate leak detection sensitivity. • Good screening efficiency (scans large number of components quickly). • Close contact with the leaking equipment component not required. • Able to survey elevated, inaccessible or unsafe-to-access components. • Able to pinpoint individual leaks. • Low to medium capital cost. • Minimal training required to use the instrument.	• Does not distinguish between methane, steam, air, nitrogen or other types of gas or vapor leaks. • Can only detect leaks above certain velocities; may not be able to detect low pressure leaks • Does not work well for components that are wet (e.g., during or immediately following rain or immediately following a soap bubble survey). • Potential interference from background noise from pneumatic actuated valves. • Leak detection decreases with distance from the leak. • High concentration of leaks may confuse the operator.

Leak detection instruments: Laser leak detectors

Laser leak detectors can locate equipment component leaks, leaks from buried pipelines (especially gas distribution lines) and are eye-safe.

An audible alarm sounds when a high concentration or quickly changing gas cloud is detected.

Photos of a laser leak detector.



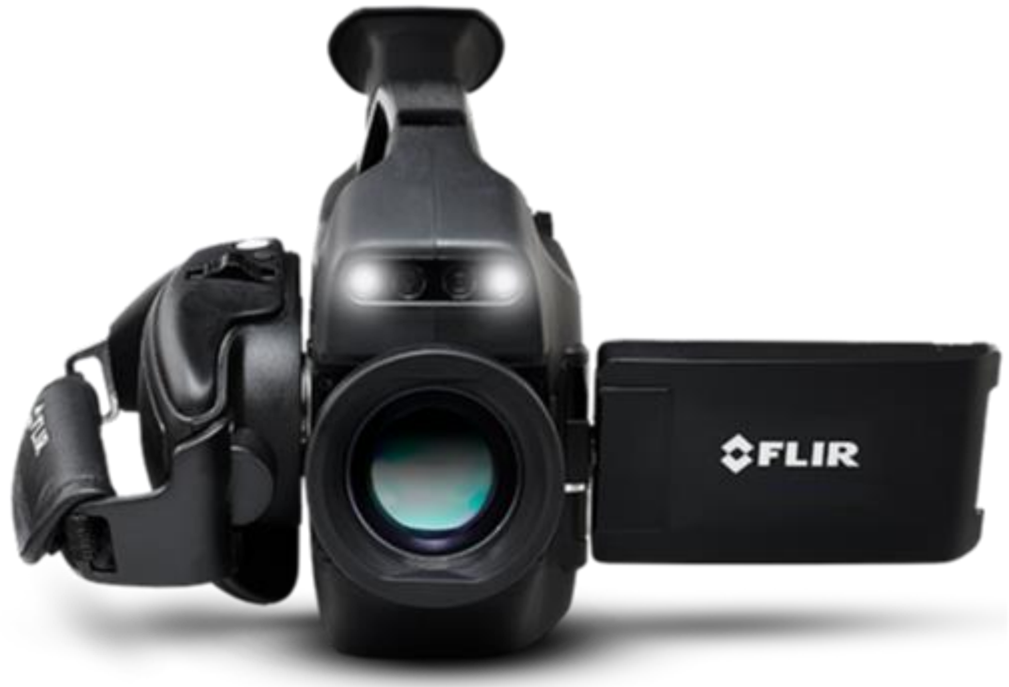
Laser leak detectors

Advantages	Disadvantages
• Moderate leak detection sensitivity. • Close contact with the leaking equipment component not required. • Able to survey elevated, inaccessible or unsafe-to-access components. • Moderate capital cost. • Quickly identifies large leaks. • Minimal training required to use the instrument.	• Does not work in congested process areas. • Susceptible to interference caused by emissions from other nearby leaks or emission sources. • Somewhat heavier and less compact than other detectors.

Leak detection instruments: Optical gas imaging (OGI) infrared (IR) cameras

Hydrocarbon gases absorb infrared light at specific wavelengths (i.e., 3.2-3.4 microns [µm]). The OGI IR camera uses this characteristic to detect natural gas emissions from equipment.

The IR camera scans the leak area in real time at a 60 hertz scan frequency. The scanned area is then converted into a moving image in real time such that the gas plumes are visible due to their absorption of the IR light.



OGI cameras

Advantages	Disadvantages
• Moderate leak detection sensitivity. • Close contact with the leaking equipment component not required. • Able to survey elevated, inaccessible or unsafe-to-access components. • Able to detect excess emissions from non-traditional LDAR components, such as flares and storage tanks • Allows more rapid screening than other techniques. • Able to quantify leaks (i.e., using a post-processing software available as an accessory on newer OGI cameras).	• Most expensive purchase price compared to other technologies (e.g., $70,000 to $120,000+ USD). • Requires suitable background contrast for leaks to be detected (may require viewing potential emission sources from different angles). • Requires special training to use. • Not effective during rain, snow, sleet, drizzle, or fog. • Cost-effectiveness decreases as the size of the facilities decreases and the portion of the time spent traveling between sites increases. • Not suited to extended use in very cold or high temperature environments.

Summary of leak detection instruments

Instruments	Cost	Screening Efficiency	Detection Sensitivity	Quantification of Leak Concentration	Direct Access Required
Spray bottle containing soap solution (bubble test)	Low	Low to Moderate	High	No	Yes
Portable or handheld gas detectors	Low to Moderate	Low to Moderate	Moderate to High	Yes	Yes
Ultrasonic leak detectors	Moderate	Moderate	Moderate to High	No	No
Laser leak detectors	Moderate	Moderate	Moderate	No	No
OGI cameras	High	Moderate to High	Moderate	No	No

Supplemental leak detection measures

Measures that may be implemented to supplement LDAR surveys include:

- Achieving early detection of large leaks by permanently installing gas detectors for continuous coarse monitoring of process areas or entire facilities, such as:
  - Permanently mounted OGI cameras with remotely controlled zoom, swiveling, and pivoting capabilities
  - Strategically placed gas detectors that feed into source detection and locating software
- Enabling safe and easy leak screening by installing hydrocarbon monitoring ports or flow indicators on blowdown and emergency vent systems.
- Continuous or frequent monitoring of reoccurring leaks using dedicated leak detection equipment (e.g., components in thermal cycling service, thief hatches on vapor-controlled tanks, etc.).

What leak rate quantification instruments are used to supplement LDAR surveys?

- Introduction
- General considerations for leak quantification instruments
- Leak rate quantification instruments
  - Calibrated vent bags
  - Velocity probes
  - Portable flow meters
  - Hi-Flow samplers TM
  - Quantitative OGI system (FLIR QL320 and Opgal)

Introduction

When designing an LDAR program, it is not essential to quantify individual leak rates; however, this quantification data is very useful for determining the benefits achieved.

Leak rate quantification is desirable for:

- Prioritizing leak repairs
- Tracking performance of the LDAR program
- Quantifying the benefits achieved including:
    - Economic benefits of avoided natural gas losses.
    - Improved workplace health and safety.
    - Improved local air quality, resulting in human health and environmental benefits.

General considerations for leak quantification instruments

To conduct a leak survey, the LDAR survey team should be equipped with appropriate leak quantification instruments.

Leak quantification instruments should be characterized by:

- Adequate range to quantify the anticipated leak flow rates.
- Portability and ease of use
- Ruggedness and weather resistance
- Cost-effectiveness

Key measurement parameters for direct quantification of a leak rate include:

- Temperature
- Pressure
- Concentration of methane and total hydrocarbons
- Volumetric flowrate

Any equipment to be used in process areas must be rated for use in hazardous locations.

General considerations for leak quantification instruments (continued)

Additional factors to consider when selecting and using the quantification instruments include the following:

- Fouling of the measurement equipment (e.g., due to condensing vapor or lube oil mists in the captured emissions)
- Backpressure limitations of the sources being measured.
- Size and accessibility of leaks
- Gas composition dependencies of the leak quantification instrument.
- Emission capture challenges when dealing with sources other than vents (for example, valves, connectors, pressure relief valves, and tank hatches).

Leak rate quantification instruments

Specific options presented in the general order of increasing cost include:

1. Calibrated vent bags.
2. Velocity probes.
3. Portable flow meters.
4. Hi-Flow samplers.™
5. Quantitative OGI system (FLIR QL320 and Opgal).

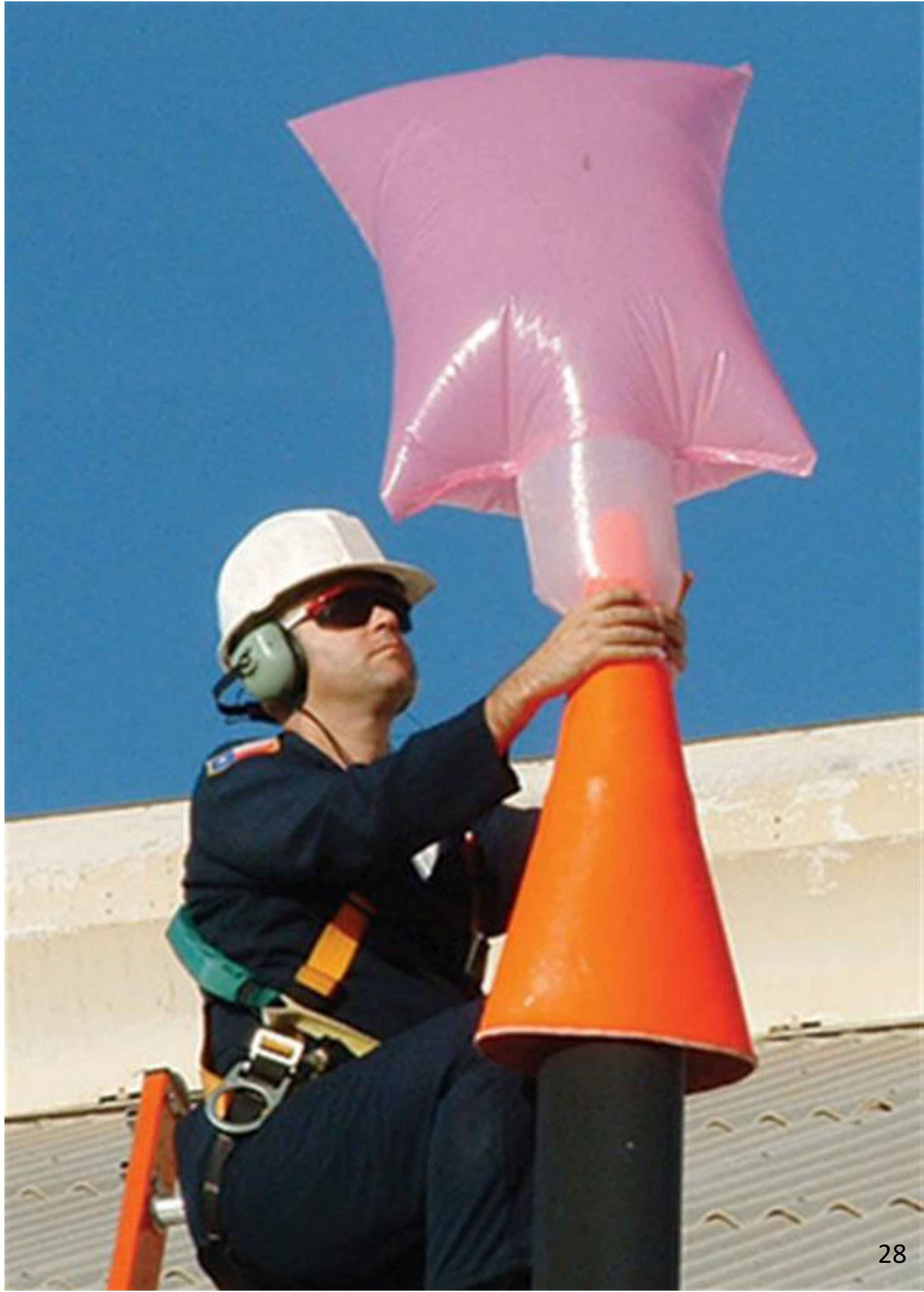
All measurement techniques need to be able to report the results in either volumetric units referenced at standard conditions (e.g., 101.325 kPa and 15°C), or mass units.

This may require the use of some secondary instruments such as temperature and barometric pressure sensors. It may also require typical gas analyses reports from the survey facility to determine the methane content.

Leak rate quantification instruments: calibrated vent bags

Vent-bagging uses bags of known volume (e.g., 1 m^3, 2 m^3), made from antistatic plastic with a neck designed for easy sealing around the vent.

The measurement is made by placing the bag over the vent outlet and timing the bag expansion to full capacity (without any pressurization) using a stopwatch.



Calibrated vent bags

Advantages	Disadvantages
• Simple, low-cost solution for measuring the flowrate from vents, open-ended lines, and potentially other types of point sources. • Suitable for measuring low to moderate leak rates. • Does not exert significant back pressure on the vented component. This eliminates any potential interference with the vent operation. • Minimal training required to use the instrument.	• Only suited to small to medium sized vents, open-ended lines, and potentially other types of point sources. • Requires end-of-vent access. • Suffers from poor accuracy, especially at low and high flows.

Leak rate quantification instruments: velocity probes

Velocity probes are used to measure flowrates in pipes or ducts where ports are available and at the outlet of vents and open-ended lines. Velocity probe technologies include micro-tip vane anemometers, pitot tubes, vortex anemometers, thermal anemometers, etc. To measure flowrates with velocity probes:

- Small to medium diameter velocity probes are inserted into a gas stream to measure flow velocities over the cross-sectional area of a duct or vent.

Velocity probes (continued)

- The velocities are then integrated over the flow area (e.g., using U.S. EPA Method 1A, International Standard Organization [ISO] 16956) and corrected to standard conditions and for the methane concentration in the vent stream.

Velocity probes

Advantages	Disadvantages
• Generally provides good accuracy. • Low to moderate capital cost. • Operating range of 1- 80 m/s.	• Need to choose intrinsically safe designs. • Susceptible to fouling and damage to the probe. • Suitable monitoring ports or safe and easy end-of-pipe access may not be available. • Some types of probes (e.g., thermal anemometers) need to be corrected for the gas composition. • Measurements and post-measurement data processing can be time-consuming. • Typically requires two people to perform a measurement (i.e., one person to position the probe and the other to record the readings).

Leak rate quantification instruments: portable flow meters

A portable flow meter can be temporarily installed at the outlet of small to medium diameter vents and ducts to measure total emission flow rates.

Potential options include:

- Rotameters
- Dry gas test meters (diaphragm meters)
- Ultrasonic transit-time flow meters
- Turbine meters
- Vortex meters
- Orifice meters

Flow meters can be installed inline if suitable connections are available.

Portable flow meters

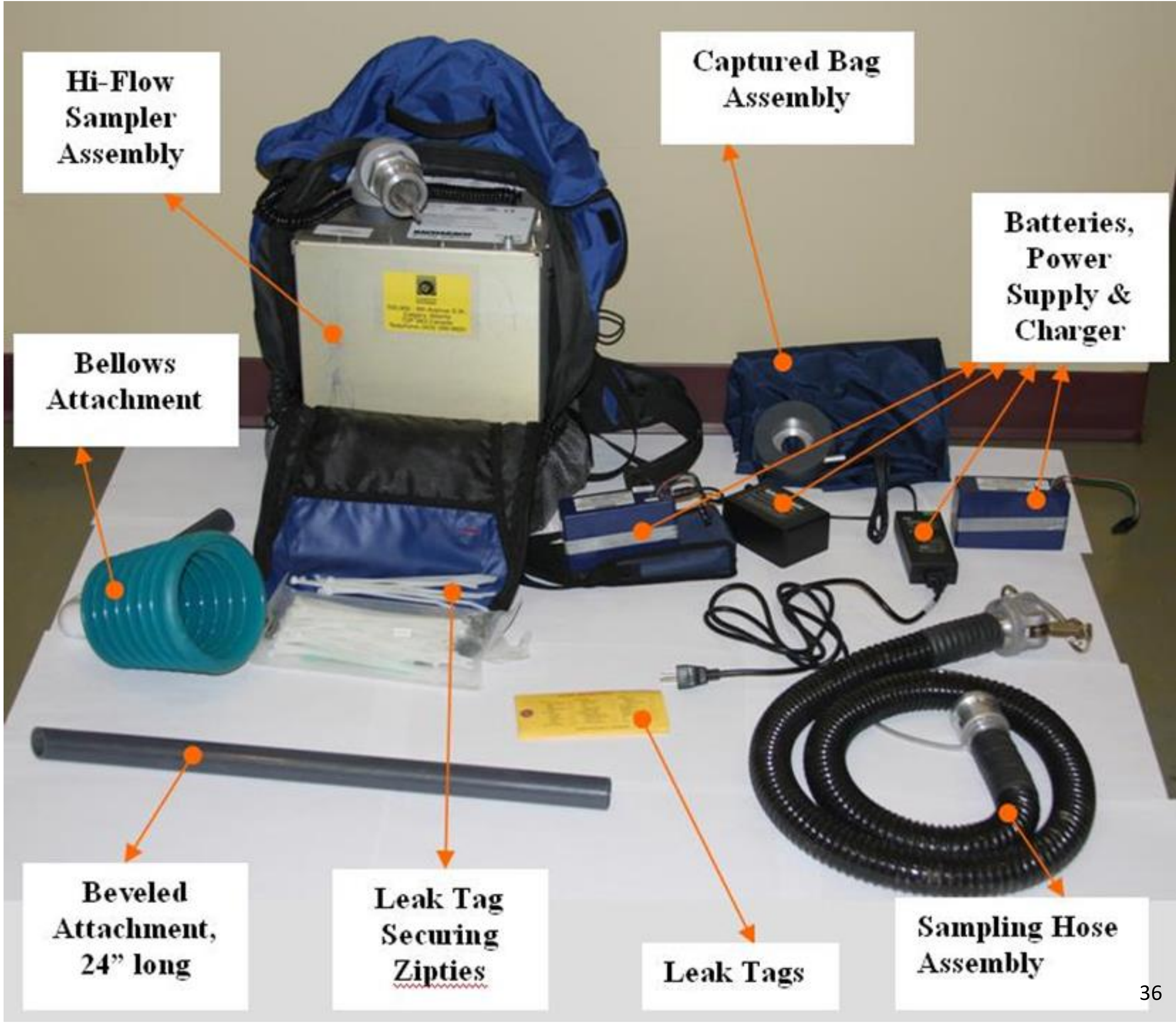
Advantages	Disadvantages
• Generally, they provide good accuracy. • Can be installed and used by a single person. • Often automatically correct the measurement results to standard conditions. • Typically, less susceptible to fouling than most of the other options. • Moderate capital cost. • Operating range varies with the type of flowmeter and size of pipe. The rangeability typically varies from 5:1 for orifice meters to 2000:1 for ultrasonic flowmeters.	• Users need to choose intrinsically safe designs. • The flow meters can be bulky and less portable than other flow measurement instruments. • Special fittings may be required to connect the flow meter to the end of the vent or open-ended line. • Sometimes the vent may be fitted with a rain cap and thereby make an end-of-pipe flow measurement difficult. • Some types of flow meters may impose excessive back pressure on the vent systems or open-ended line.

Leak rate quantification instruments: Hi-Flow Samplers™

Hi-Flow Samplers™ use an induced draft collection system to draw gas from a leaking equipment component into a sampling hose connected to the main body of the instrument. The instrument measures the total air/vapor flowrate through the sampling duct, methane concentration in the captured gas, and background methane concentration immediately upwind of the leaking component. It then calculates the methane flowrate net of background concentrations based on these data.

Components of a Hi-Flow sampler™

This image shows a Hi-Flow sampler™ and its accessories.

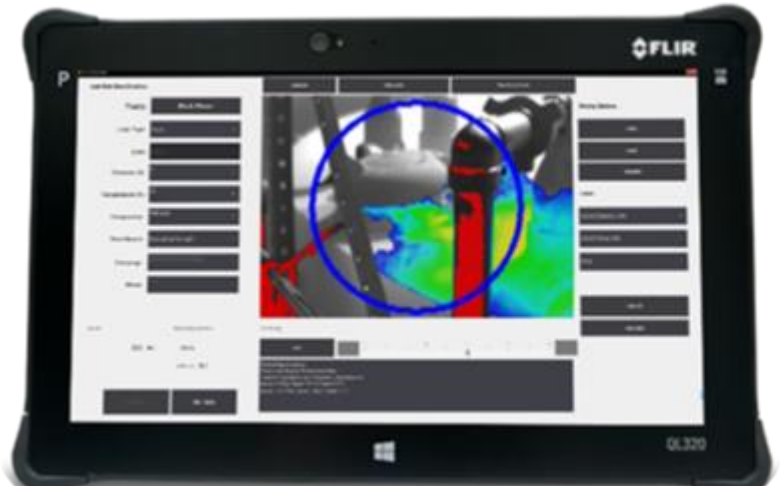


Hi-Flow samplers™

Advantages	Disadvantages
• Well suited to measuring leak rates from a wide variety of leaking equipment components (especially valves and connectors). • Moderate operating range. • Good accuracy (±10 to 15% as reported by the manufacturer). • Moderate to high cost. • Good portability and ergonomics (i.e., the main body of the unit is carried in a backpack which leaves the user’s hands free to operate the controls and hose). • Hose attachments provided to help promote good leak capture and avoid interference from other nearby sources.	• Only suited to measuring small to medium size leaks. • Susceptible to fouling. • Relatively bulky for transport (i.e., typically comprises two cases: one for the instrument and another one for the hose and attachments).

Leak rate quantification instruments: Quantitative OGI system

This technology uses proprietary software that processes infrared (IR) video data captured by the OGI camera to estimate leak rates. Depending on the OGI camera manufacturer, the quantification is either done when the leak is detected, or after the fact by post-processing of recorded data sets.



The camera determines volumetric flowrate based on the movement of the emissions plume across the camera’s view and determines methane concentration based on the intensity of the plume.

Various corrections are made to account for the distance from the leak source and the environmental conditions. The software then calculates the emission rate based on the flowrate and concentration.

Quantitative OGI system

Advantages	Disadvantages (in addition to the disadvantages of using the OGI camera)
• Enables remote quantification of emissions. • Moderate accuracy (average value of ±40 percent under ideal conditions as reported by the manufacturer). • Suitable for rank ordering of leak repairs.	• Moderate to high incremental cost for the quantitation software combined with laptop or table (e.g., $25,000 USD). • Requires a clear view of the emissions plume and good background contrast to quantify leaks (i.e., better than needed to simply see the leak). • Susceptible to interference from other nearby sources.

Recommended technology options by emissions source

Emissions Source	Calibrated Vent Bags	Velocity Probes	Portable flow meters	Hi-Flow Sampler ™	Quantitative OGI system
Connectors				●	●
Valves				●	●
Pressure Release Valves (PRV)	●		●	●	●
Open-ended Lines (OEL)	●	●	●	●	●
Blowdown Systems	●	●	●		●
Compressor Seals	●	●	●	●	●
Tanks		●	●		●

What are some of the common measurement challenges and solutions?

- Elevated measurement points.
- Other source-related hazards.

Elevated or inaccessible measurement points

Measurement approaches for dealing with elevated or inaccessible measurement points include:

- Using an OGI camera to remotely quantify the leak.
- Installing a manual monitoring port at ground level where applicable (e.g., on blowdown systems).
- Permanently installing a monitoring port and continuous acoustical or other leak monitoring system (e.g., on blowdown valves and pressure relief devices).
- Utilizing a ladder, scaffolding, man-lift, or other means of accessing the target equipment component.
- Conducting aerial measurements using drones or aircraft

Other source related hazards

Measurement approaches for dealing with other source-related hazards such as hot or cold surfaces, emergency or unexpected relief events, toxic gases include:

- Using an OGI camera to remotely quantify the leak.
- Developing safe work procedures suited to overcome the different hazardous circumstances that may be encountered.

Module 4
Summary

What You Have Learned

In this module, you learned about different leak detection and quantification instruments, and their advantages and disadvantages.

Additionally, you learned about some of the common source-specific measurement challenges and solutions.

> There isn’t a single technology that works well for all sources under all circumstances. Consequently, it is appropriate to equip an LDAR team with a strategic selection of options.

Thank You!

You have completed:

Module 4: LDAR Equipment Selection