



## ER Leak Detection

May 2013

Soap is a universal leak detection method

Leak rates

Foamer <0.1 cc/min, very small bubbles looks like foam

Bubbler 0.5-10 cc/min clear bubbles 1 cm in dia

Vigorous bubbler 10-50 cc/min large bubbles

Whistler >50 cc/min can hear the leak



### What Happens If We Do Nothing?

#### Will It Get Worse?

Corrosion of metal valve by a corrosive gas is a process that takes months not minutes for total failure

A full 150 lb cylinder contains 150 lbs of liquefied Chlorine Gas

The gas specific volume of  $\text{Cl}_2$  at 70°F is 5.39 ft<sup>3</sup>/lb

5.39 ft<sup>3</sup>/lb x 150 lbs = 808.5 ft<sup>3</sup> of gas

808.5 ft<sup>3</sup> x 28,315 cc/ft<sup>3</sup> = 22,892,677 cc

At a leak rate of 50 cc/min this will leak for 457,854 minutes (318 days)!

#### Leak rate is measured at cc/sec which is expressed as a power of ten

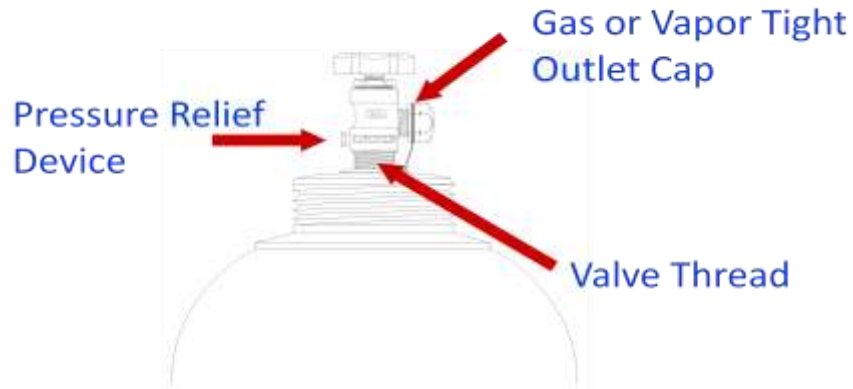
0.1 cc/sec	is	1 X 10 <sup>-1</sup>
0.01 cc/sec	is	1 X 10 <sup>-2</sup>
0.00003 cc/sec	is	3 X 10 <sup>-5</sup>

A common cylinder valve thread leaker is 0.1 cc/min (10<sup>-3</sup> cc/sec)

A valve leaking at 10<sup>-6</sup> cc/sec will leak 10 cc in 3 months and will pressurize a typical diaphragm valve to 110 psig behind the vaportight outlet cap.

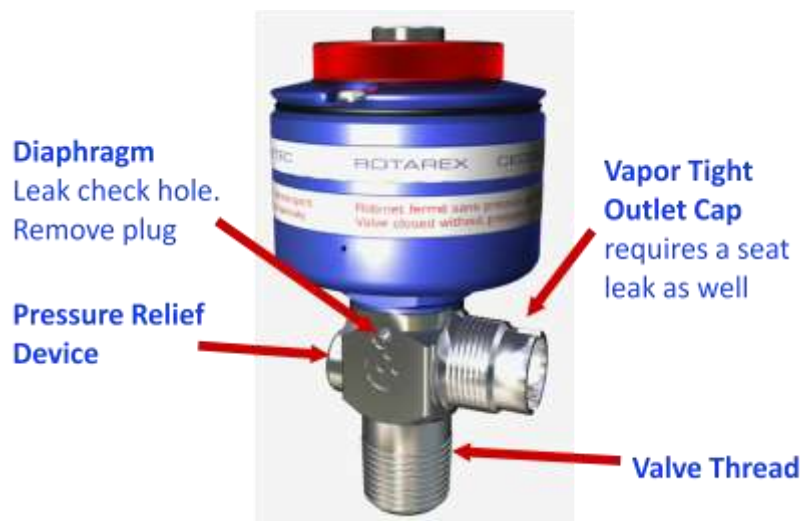


Most likely leak points on a cylinder



**Evidence of leaks include:**

- Flames
- Charred or bubbled paint
- White, Brown or Green fumes
- Green or Brown liquid dripping down the sides of the cylinder
- Green or Brown Corrosion
- Solids Around Connections
- Black or red deposits
- Hissing sound



Over 99% of leaks if they were to occur during normal transportation are small, < 0.1 cc/min

**Most Likely Leak Points During Use**

- Cylinder valve outlet connection
- Pigtail connection to gas panel



## DOT Definition of a leak

“There will be no identifiable (without the use of instruments) release of hazardous materials to the environment.”

## ER Gas Leak Detection Simple Methods

- Soap Solution Applied to Potential Leak Points
  - Alcohol Based Used for Freezing Temperatures
  - Small Leaks of Water Soluble Gases May Not Be Detected
  - Can Interfere with Other Methods
- Aqueous Solutions Held By Leak Points
  - Ammonia For Acid Gases
  - Hydrochloric Acid For Ammonia or Amines
- Wet Litmus Paper for Acid or Base Gases
- Lead Acetate Paper for Hydride
- Potassium Iodide Paper for Fluorine Gases

## Leak Detection Method Sensitivity

- Leak detection fluids (soap solution)
  - $1 \times 10^{-3}$  to  $1 \times 10^{-5}$ \* cc/sec atm He
- Test Papers (litmus, KI etc.)
  - $1 \times 10^{-3}$  to  $1 \times 10^{-5}$ \* cc/sec atm He
- Chemical sprays
  - $1 \times 10^{-3}$  cc/sec atm He
- Instrumentation
  - $1 \times 10^{-5}$  to  $1 \times 10^{-9}$  cc/sec atm He

## Gas Leak Hazards

- Flammable
- Toxic
- Asphyxiant

## ER Electronic Gas Leak Detectors Key Requirements

- Must be sensitive to level of interest ppm for Acid and ppb for Hydrides
- Must be specific for gas of interest with minimum of interferences
- Must be capable of working when needed, Battery operated
- Must be fast and be able to pinpoint leak point
- Accuracy/Precision Not as critical as other parameters
- Continuous
- Extraction rather than diffusion
- Ergonomically designed for ER use in PPE
- Problem is most gas detectors will become saturated if the leak is more than a foamer



General gas meter, oxygen and flammable with 2 additional cells (H<sub>2</sub>S, Cl<sub>2</sub>, CO, etc)

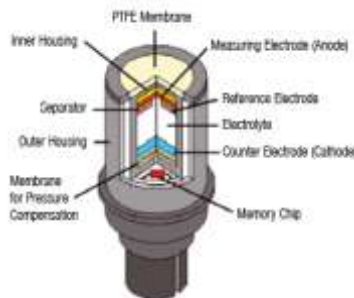
Flammable gas detection is typically catalytic bead



Principle : Hot wire catalytic platinum filament oxidizes flammable gases or vapors at lower levels than they would normally oxidize in air. causing an increase in temperature and resistance

Thermal conductivity detectors measure the change in thermal conductivity of the air drawn across a resistance cell. The larger the difference in thermal conductivity of the gas and air, the greater the sensitivity. To zero, air is drawn across the detector and the sensor is adjusted for no alarm

The most common chemical detection technology used in industry is electrochemical. Electrochemical sensors are typically diffusion type, which have a liquid or gel electrolyte that reacts with the gas.



For ER the electrochemical gel sensors are the most practical

The gas specific sensor can be inserted depending on the type of gas leaking.

Key is having a small trickle charging case which keeps the sensors in equilibrium and immediately ready for use





Personal Monitors, electrochemical gel type



Electrochemical Detectors will detect the same chemical family. Metal Hydride family

	IIIA	IVA	VA	VIA	
	5 B	6 C	7 N	8 O	
$B_2H_6$	13 Al	14 Si	15 P	16 S	$H_2S$
$SiH_4$	31 Ga	32 Ge	33 As	34 Se	$PH_3$
$GeH_4$	49 In	50 Sn	51 Sb	52 Te	$H_2Se$
	81 Tl	82 Pb	83 Bi	84 Po	$AsH_3$

### Papertape

Historically the more stable and sensitive chemical detection technology uses chemically impregnated paper tape which will react with the gas. This technology can only be used in an extractive mode with the air pulled through the paper tape. The gas reaction causes a discoloration on the tape and the concentration is measured colorimetrically by the reflection from a light source on this spot

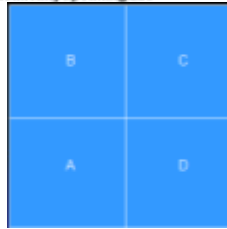
At a typical gas cabinet ventilation flow of 381 cfm (10.8 m<sup>3</sup>/min) a pure silane leak of 63 cc/min will cause a 5 ppm alarm

Gas Detector Tubes, single use

Area sampling. Must consider response time.

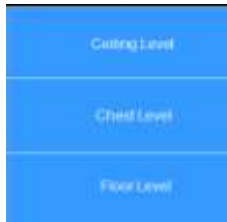
Systematic approach to air monitoring

Break room/building into quadrants



Sample each quadrant at 3 heights

- Ceiling
- Chest
- Floor



A confined space should also be sampled at the 3 heights

When monitoring confined spaces, it is equally important to sample at a distance from the opening because an intrusion near the entrance may result in a false oxygen level reading

