Leak Detection Technologies and Best Practices

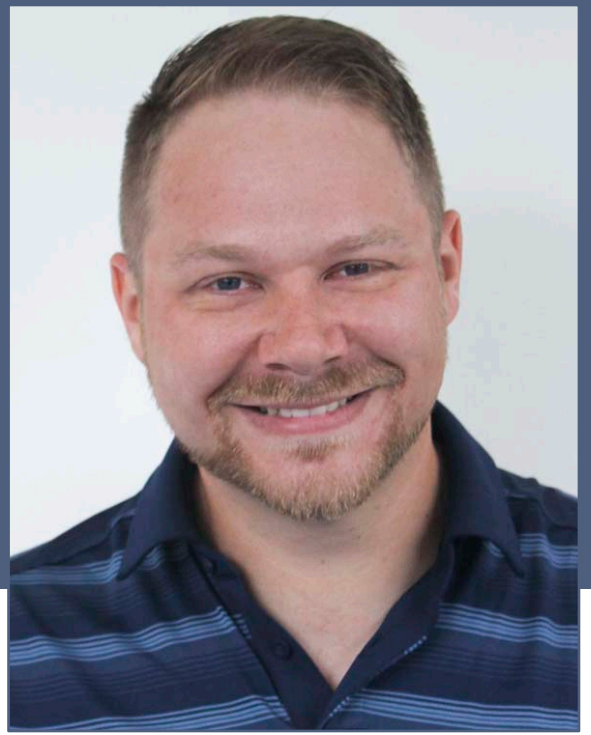
National HVACR Educators & Trainers Conference

March 2019

Bob Belvick

Product Manager, Service Tools

Leak Detection



INFICON

Overview

Why we leak check

Refrigerant characteristics and types

Leak detection methods

Electronic leak detection sensor technologies

Tips and best practices

Predicting the future

Why we Leak Check

Why repair leaks?

Save the planet

- Reduce global warming potential (GWP)
- Reduce ozone depletion potential (ODP)

Regulations

- Phase-out of CFCs and HFCs
- EU regulations say you cannot add refrigerant to a leaky system

Leaks are expensive

- Especially new refrigerants
- Phase-out refrigerants rising in cost

Refrigerant Characteristics and Types

Important Refrigerant Characteristics

Ozone Depletion Potential (ODP)

- Relative degradation of the ozone layer
- Compared to R11 (ODP of 1, very bad)
- Lower number is better

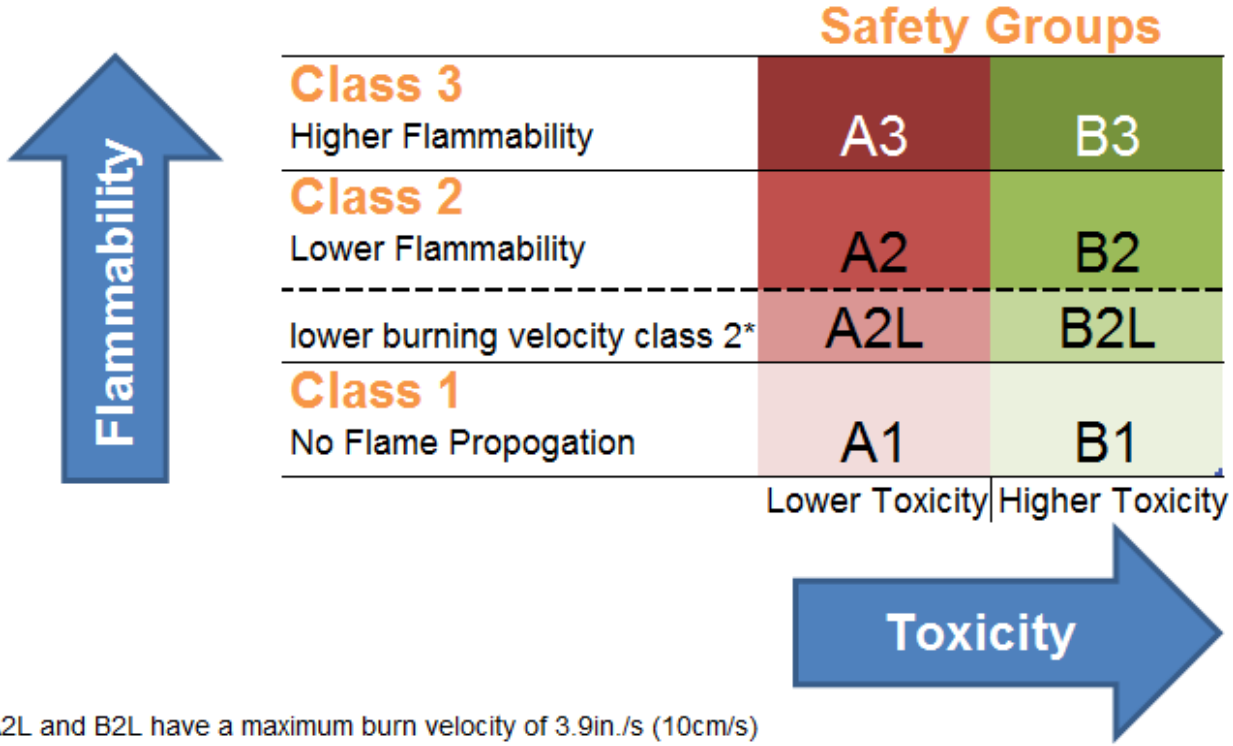
Global Warming Potential (GWP)

- Energy absorbed by the atmosphere from emissions of 1 ton of gas
- Compared to CO_2 (GWP of 1, very good)
- Usually compared over 100 years
- Lower number is better

Important Refrigerant Characteristics

ASHRAE 34 Safety Group Classification

- Letter indicates toxicity (A is better)
- Number indicates flammability (low number is better)



*A2L and B2L have a maximum burn velocity of 3.9in./s (10cm/s)

Important Refrigerant Characteristics

More on Flammability

- A3 refrigerants include high flammable gas like propane
  - Use an intrinsically safe leak detector and other equipment
  - Do not vent into enclosed area (can explode or start fire)
  - System charges are usually small (currently up to 150g (5 oz.))

- A2L includes R32 and new refrigerants like HFO
  - Semi flammable with low burn velocity
    - Flames will usually self extinguish without a constant ignition source
  - Do not need an intrinsically safe leak detector
  - Cannot vent due to regulation, but will not cause fire or explosion in most cases

Refrigerant Types

CFC (Chlorofluorocarbon)

- Contain chlorine
- R12, R11, R13, R113, R114
- High ODP and GWP
- Must be recovered

HCFC (Hydrochlorofluorocarbon)

- Contain chlorine
- R22, R123, R124, R141b, R502, R503
- Lower ODP and GWP than CFCs
- Must be recovered

Refrigerant Types

HFC (Hydrofluorocarbon)

- No chlorine
- R134a, R125, R23, R410a, R404a, R32*
- No ODP and lower GWP
- Must be recovered

HFO (Hydrofluoro-olefin)

- No chlorine
- R1234ze, R1234yf, R454a/b
- No ODP and almost no GWP
  - 1234yf has 335 times lower GWP than 134a
- Semi flammable – A2L refrigerant
- Must be recovered

*Semi flammable, but lower GWP than other HFCs

Refrigerant Types

Natural

HC (Hydrocarbon)

- Highly flammable – A3 refrigerant
- Small charges
- R441a (mix) 100yr GWP – 3.6
- R290 (propane) 100yr GWP – 3.3
- R600a (isobutane) 100yr GWP – 3
- No ODP
- Can be vented (not in an enclosed area)

Refrigerant Types

Natural

Ammonia (R717)

- No ODP, GWP = 0
- B2L classification
  - Semi flammable
  - Toxic
- Can be vented (not in an enclosed area)

CO_2 (Carbon dioxide, R744)

- No ODP, 100yr GWP = 1 (CO_2 is the standard for GWP)
- High pressure
- Can be vented (not in an enclosed area)

Leak Detection Methods

Leak Detection Methods

Halide Torch

An open flame changes color if chlorine-based refrigerant is present

Advantages

- Simple
- Inexpensive

Disadvantages

- Poor sensitivity (~0.5 oz. [14 g] /year)
- Reaction based on chlorine
  - Won’t pick up HFCs
- Fire Hazard
- Health Hazard

Leak Detection Methods

Soap Bubbles

Advantages

- Inexpensive
- Simple

Disadvantages

- Can mask leaks from other detection methods
- Slow and not very sensitive
  - 0.25 oz. (7 g) /year leak takes 10 – 15 min. to make 1 bubble
  - Electronic leak detector takes less than 1 second

Leak Detection Methods

Fluorescent Dye

Advantages

- Can find multiple leaks at once
- Good for quick leak checks
  - If you keep dye in the system

Disadvantages

- Must be able to see the leak
- Takes time for dye to cycle through system
- Not feasible with very large systems
- Hard to clean
- Difficult to use with large leaks
- Not approved for use by all manufacturers

Leak Detection Methods

Forming Gas

95% nitrogen / 5% hydrogen, AKA Tracer Gas

- A mixture of nitrogen and hydrogen is added to a leaky system
- A combustible gas leak detector is used to detect the hydrogen in the gas
- Not considered flammable

Leak Detection Methods

Forming Gas

95% Nitrogen / 5% Hydrogen

Advantages

- Safe, non-flammable
- Inexpensive alternative to helium or refrigerant
- Environmentally safe

Disadvantages

- Must have HC leak detector
- Time consuming
  - Recover refrigerant, charge forming gas, leak check, recover forming gas, repair leak, charge forming gas . . .
- Learning curve

Leak Detection Methods

Electronic Leak Detectors

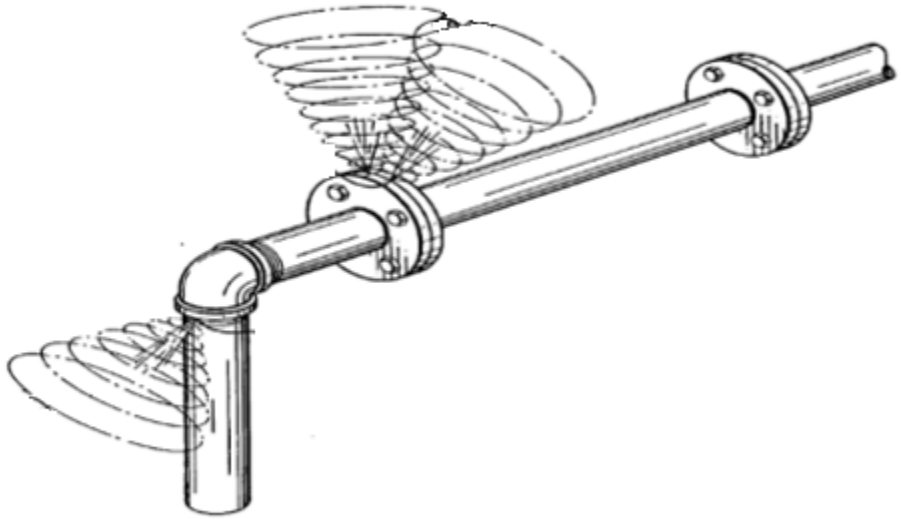
- Ultrasonic
- Corona Suppression
- Surface Reaction
- Heated Diode
- Infrared

Electronics Leak Detector Sensor Technologies

Sensor Technologies

Ultrasonic Leak Detection

- A specially tuned microphone that “listens” for the sound of a leak
- Leaks emit a sound at a frequency higher than we can hear (ultrasonic)



Sensor Technologies

Ultrasonic Leak Detection

Advantages

- Can be used on any gas (as long as there is pressure or vacuum)
- Effective on pressure or vacuum leaks
- No consumables (filters, sensors)
- Many other applications
  - Car tires
  - Pneumatic lines
  - Bearings

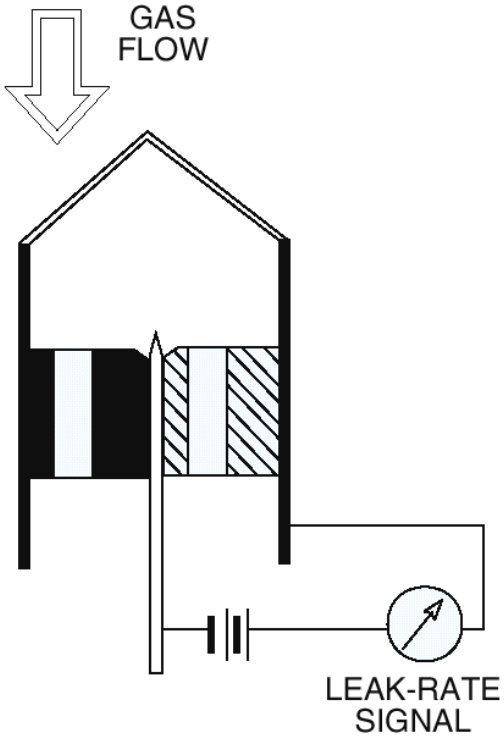
Disadvantages

- Difficult to pinpoint in noisy environments
- Less sensitive than other electronic leak detectors (may not find very small leaks)
- Learning curve
- Doesn’t work on every leak

Sensor Technologies

Corona Suppression

- A static charge between two electrodes creates a current
- An insulating gas (like refrigerant) reduces the current in the sensor, causing an alarm



Corona Suppression Technology

Sensor Technologies

Corona Suppression

Advantages

- Sensitive to multiple gases
- Inexpensive to manufacture

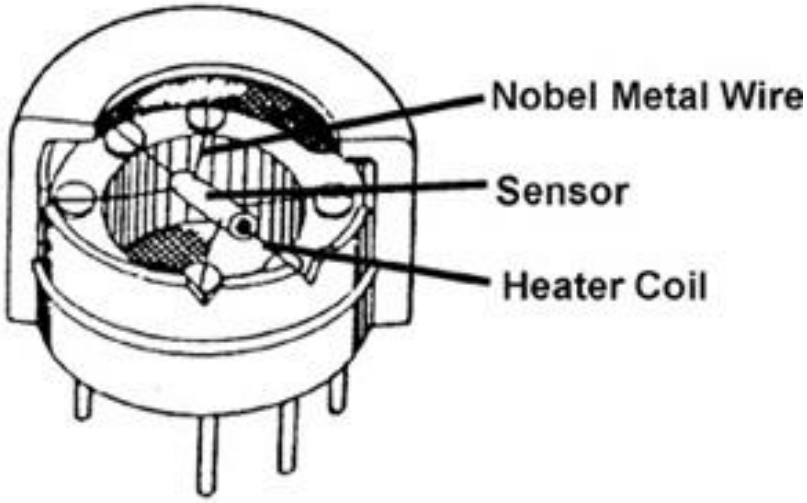
Disadvantages

- Cross sensitivity
- Humidity will give false alarms
- Dirt, oil, grease will shorten sensor life

Sensor Technologies

Surface Reaction

- An electrical circuit is masked to a metal oxide substrate.
- Metal oxide attracts oxygen in clean air
- When the sensor is exposed to reducing gases (like refrigerant), the oxygen reacts with it and burns off
- This reaction increases the current, causing an alarm



Sensor Technologies

Surface Reaction

Advantages

- Rugged Construction
- Low power consumption
- Inexpensive to manufacture
- Can detect refrigerant and combustible gases

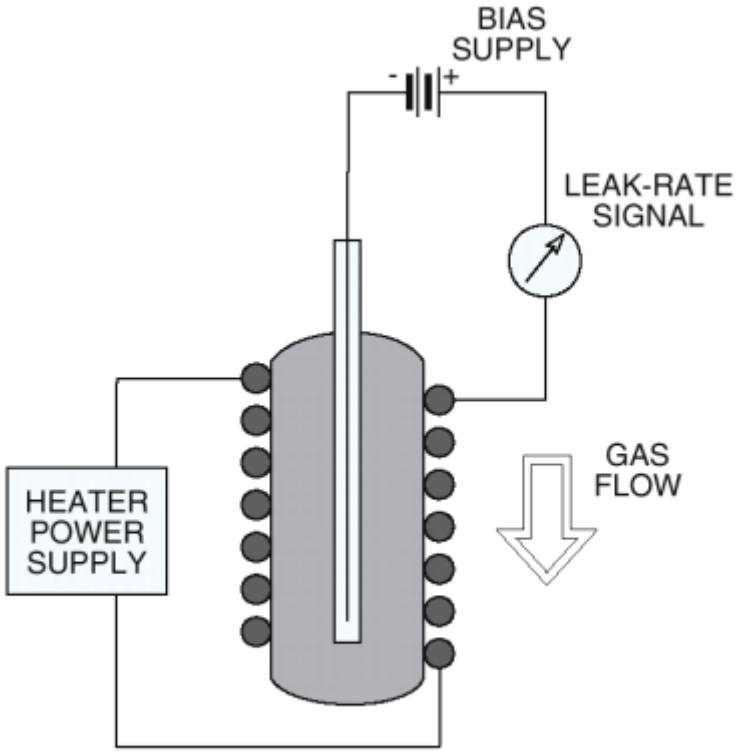
Disadvantages

- Cross sensitivity
- Low sensitivity to HFCs
- Longer reaction/recovery times

Sensor Technologies

Heated Diode

- A coiled wire coated with ceramic material is heated to 1400° F
- The heated sensor breaks apart refrigerant molecules, leaving chlorine and fluorine ions
- Chlorine and fluorine ions create a current that causes an alarm



Heated Anode Technology

Sensor Technologies

Heated Diode

Advantages

- Halogen selective
  - Resulting in fewer false alarms
- High sensitivity to chlorine-based refrigerants
- Quick reaction and recovery

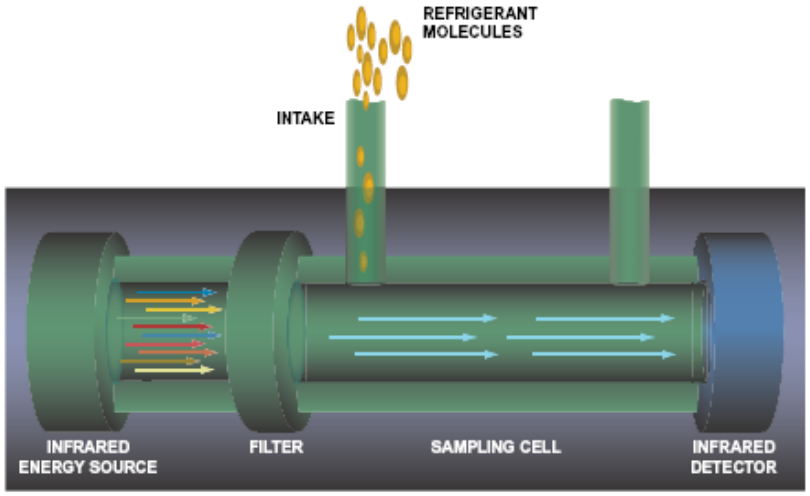
Disadvantages

- Expensive to manufacture
- Sensitivity to HFCs is not as good as HCFC or CFC refrigerants
- Short sensor life (~100 hours)

Sensor Technologies

Infrared Absorption

- Infrared light is shone down a tube to a detector
- A filter only allows wavelengths of light absorbed by refrigerants into the tube
- When refrigerant is present, it absorbs the light and reduces the amount of light received by the detector, causing an alarm



Sensor Technologies

Infrared Absorption

Advantages

- Typically the most sensitive
- Selective to refrigerant compounds
  - Fewer cross-sensitivities
- Allows for quantitative measurements
- Quick reaction and recovery time
- Longer sensor life, 1,000+ hours
- Sensitivity does not degrade over time

Disadvantages

- Expensive to manufacture
- High power consumption
- Large sensor
- Not always field serviceable

Cloud Hunting

What is it?

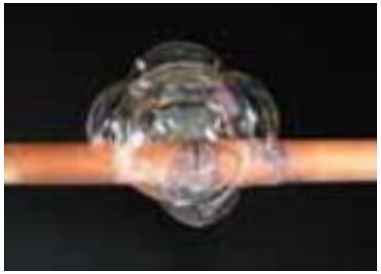
- Use a leak detector with a numeric readout showing background concentration
- Follow the number to the most concentrated area (the cloud)
  - Like a game of hot and cold
- Once you find this area, you can pinpoint the leak
- Less confusing than when a regular leak detector just alarms

Tips and Best Practices

Tips/Best Practices

Use a combination of techniques/equipment

- Helps verify your first technique is working
- Some techniques are better for a certain job



Understand the problem

- How much refrigerant has leaked out?
- How long has it been leaking?
- Is there refrigerant still in the system?
- What type of gas is in the system?

Tips/Best Practices

Refrigerant “drips” out of the leak

- Gross leak check by starting at the low point of the system
- To pinpoint, go from high spots to low spots

Check most common leak sites first

- Valves
- Fittings
- Condenser
- Evaporator

Tips for Electronic Detectors

Know the environment

Outdoors

- Wind will affect readings since it “blows away” the refrigerant.
  - Leak detectors are sampling for the refrigerant
- Block wind whenever possible

Indoors

- Background refrigerant accumulates over time
  - Refrigerant accumulates faster in smaller spaces
- Traditional electronic detectors work best when the background refrigerant is low so you can hunt the leak spot.

Tips for Electronic Detectors

Cross contaminants can cause false alarms

- Cleaners
- Soap bubbles
  - Can also temporarily clog leaks
- Pipe sealers
- Alcohol
- Some materials can outgas
  - Some insulations have chemical properties similar to refrigerants

Tips for Electronic Detectors

Auto zero vs. manual zero

Auto zero

Unit will automatically zero to background every 7-10 seconds

- Once zeroed to background, will only alarm with higher concentration
- Put the probe in clean air to reset zero

Manual zero

User zeros to background by pushing a button

Understand sensitivity settings

High sensitivity isn’t always better

- Large leaks are easier to pinpoint on low

Tips for Electronic Detectors

Know your sensor type

- Corona suppression
- Heated sensor/surface reaction/tin-oxide
- Heated diode
- Infrared

What are the advantages and shortcomings of yours?

For example:

- Surface reaction
  - Many cross sensitivities
- Heated diode
  - Great for R22 but not great for R410a

Tips for Electronic Detectors

Perform proper maintenance

Sensor

- Check with leak standard, sample leak, or returned tank
- For heated diode, best to start fresh each season

Batteries

- When in doubt, replace the battery (alkaline)
- Rechargeable batteries can go bad too

Filters

- Dirty filters reduce airflow to the sensor, decreasing sensitivity
- Change when discolored or visibly dirty

95% of problems are fixed by changing the battery, sensor, or filter

Large Leaks: How to attack it?

1. Visual inspection
   - Look for oil, frozen pipes, obvious signs
2. Gross leak check from low to high to determine area
   - HFC / HCFC refrigerants are heavier than air
3. Remove background refrigerant (clear the air)
4. If quiet environment, start with Ultrasonic detector
5. If there's already dye in the system, check with light
6. Electronic detector

Small Leaks: How to attack it?

1. Visual inspection
2. Remove background refrigerant
3. Use Electronic detector
   - Pinpoint leak checking from high to low
   - Move slowly 1 to 2 inch per second (2 to 4 cm) to find small leaks
   - If unit alarms, pull away from leak and then double check to verify

Predicting the Future

Future Expectations

More natural refrigerants

CO2

- All new refrigeration installations in Europe
- Increased usage in automotive

Flammables

- Refrigerators
- Automotive
- Increased limits mean larger coolers
- Recovery machines?

A2Ls

- 1234yf in automotive
- R32 in China

Future Expectations

Where are leak detectors going?

One detector for all gases

- Many customers are asking for one detector for everything
- HFCs, HFOs, natural refrigerants

Cloud hunting and pinpointing in one

- PPM display
- Pinpoint mode

Example: INFICON D-TEK Stratus®

- Interchangeable sensors for refrigerant and CO2
- PPM display and pinpoint modes

Questions?