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MSA The Safety Company

Ultrasonic Gas Leak Detection

By Jon Einar Handeland

About Gassonic

About Gassonic

- 1995 – Originated in Denmark
- 2006 – Acquired by General Monitors
- 2010 – Gassonic & GM acquired by MSA

Over 4,000 detectors installed in the field

About GM + MSA

Over 100 years of experience and capability in comprehensive safety solutions have made MSA a modern and forward-looking company for the protection of people, facilities, and the environment.

MSA is one of the few suppliers of fixed gas and flame detection (FGFD) measurement technology that develops and manufactures a complete range of products and integrates them into safety solutions.

With the acquisition of General Monitors in September 2010 and Senscient in 2016, the MSA FGFD product portfolio expanded even further. As these unmatched experts in gas and flame detection joined forces, we are proving that the right mix of durable products and innovative technology increases safety while driving operational efficiency.

Together we have the widest range of sensing technologies for gas and flame detection. We create solutions that not only provide worker safety and protect facilities, but also decrease overall cost of ownership.

Our Mission & Vision

Mission

… to see to it that men and women may work in safety and that they, their families and their communities may live in health throughout the world.

Vision

… to be the world's leading provider of safety solutions that protect workers when life is on the line.

We pursue this vision with an unsurpassed commitment to integrity, customer service, and product innovation that creates exceptional value for all MSA stakeholders.

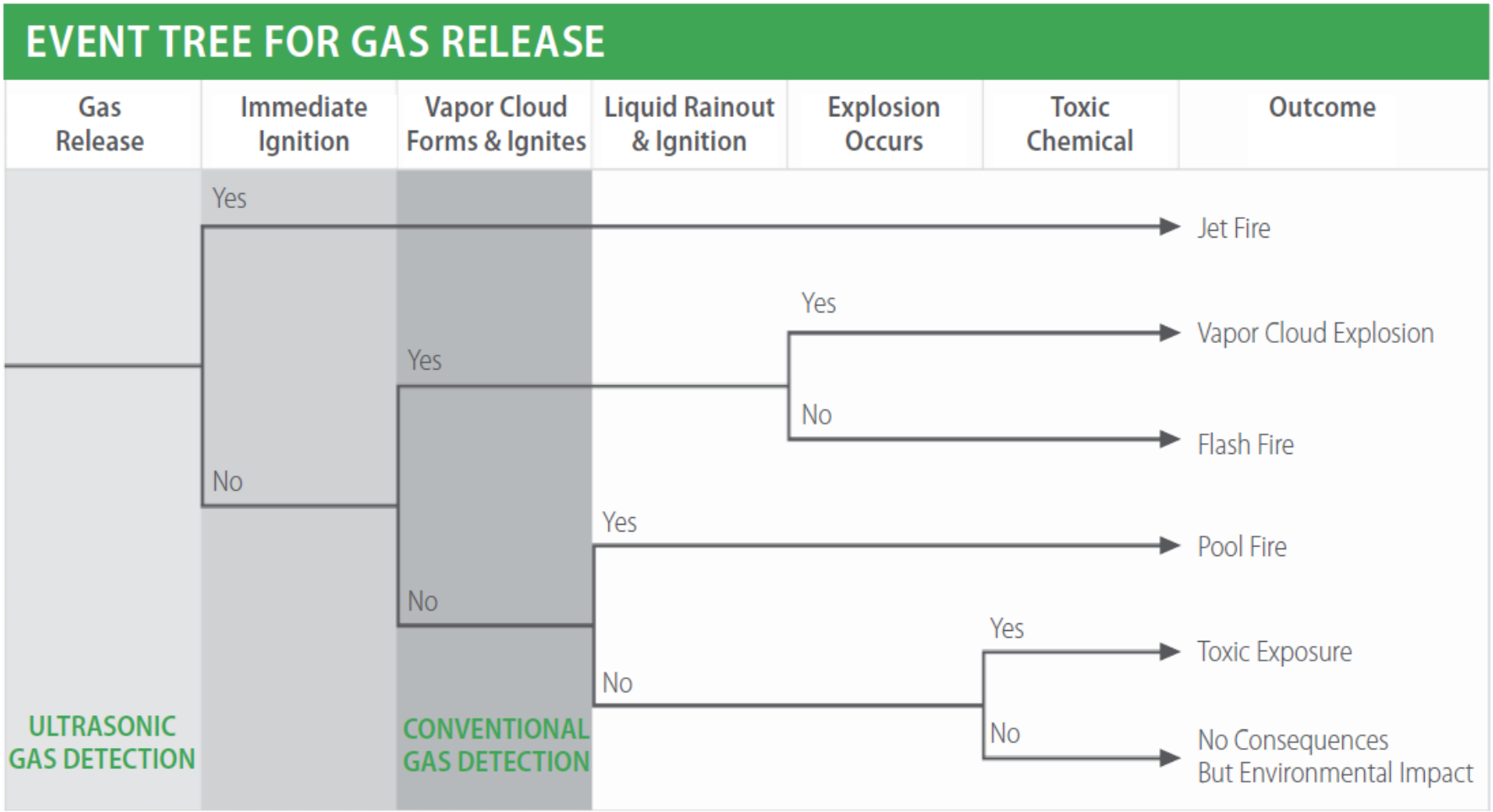
Ultrasonic Gas Leak Detection (UGLD)

UGLD Application Area

- Instant detection of flammable gas leaks
- Pressurized gas installations
- Outdoor or ventilated areas
- Explosion hazardous areas
- Fixed installations

Gas Release Event Tree

Deployment of early response to improve hazard management



Leak Rate vs. LEL

- **Lower Explosive Level (% LEL):**
  - A concentration measurement in a pre-defined point that may create a true picture of the nature of the gas leak.

- **Leak rate (kg/s):**
  - Detection related to the leak rate, makes it possible to introduce a performance standard for the gas leak detection system.

  - Example:
    Gas leaks with a leak rate of 0.1 kg/s (0.22 pounds/sec) or more must be detected.

What is a LEAK?

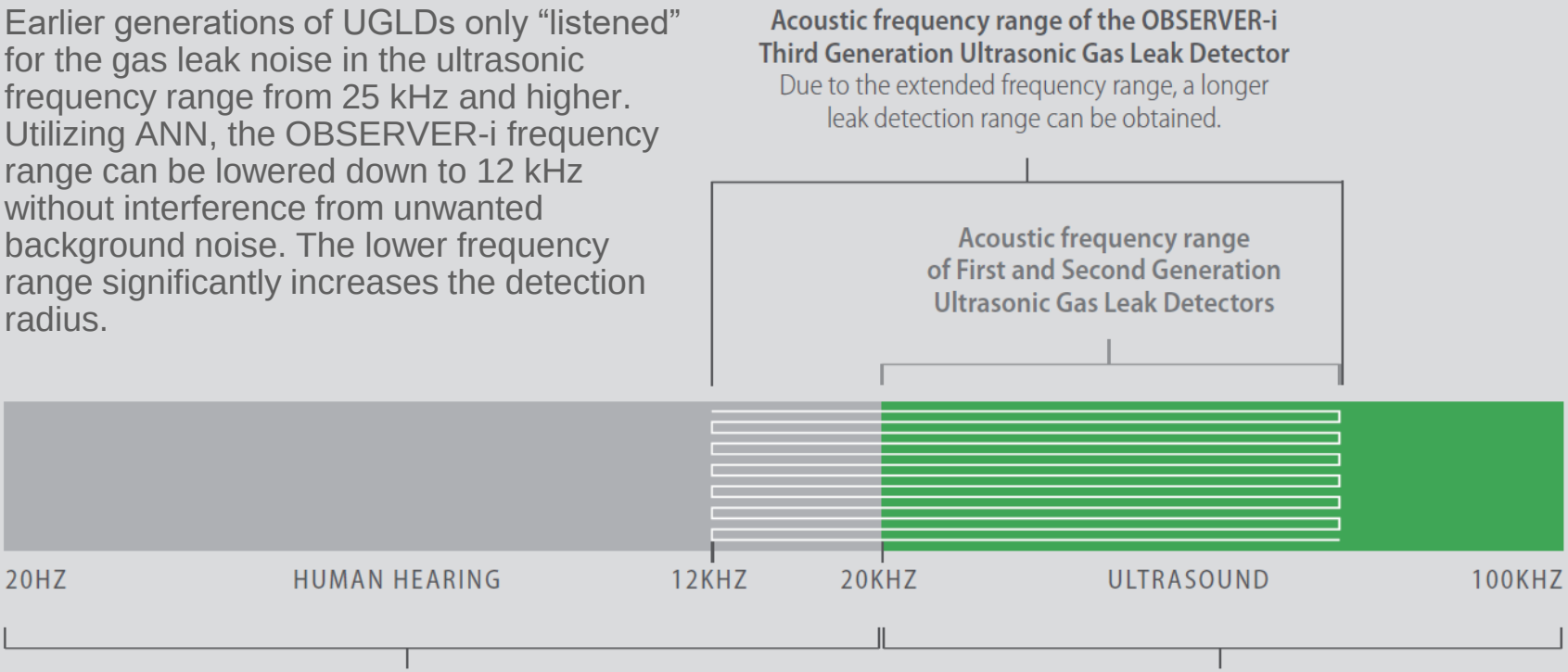
- Performance standard is 0.1 kg/sec (0.22 pounds/sec)

- Leak rate (mass flow rate) categories for methane based gas leaks (Ref: HSE from UK):
  - Minor gas leak: 0 – 0.1 kg/s
  - Significant gas leak: 0.1 – 1 kg/s
  - Major gas leak: 1 kg/s or larger

- A 0.1 kg/sec Methane leak:
  4 mm (0.16 in) hole size at 45 Bar (653 psi) gas pressure

Operation Modes

Earlier generations of UGLDs only “listened” for the gas leak noise in the ultrasonic frequency range from 25 kHz and higher. Utilizing ANN, the OBSERVER-i frequency range can be lowered down to 12 kHz without interference from unwanted background noise. The lower frequency range significantly increases the detection radius.



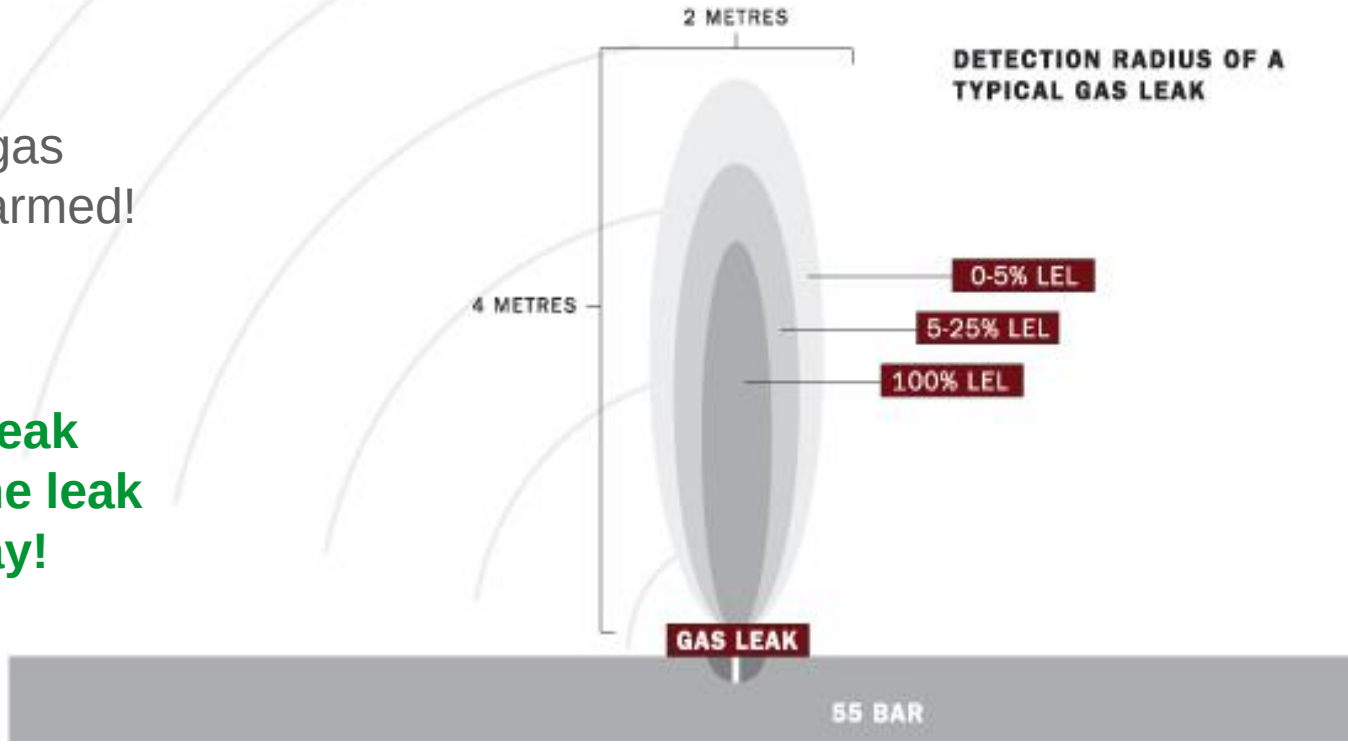
Real Gas Leak Test with Ultrasonic Detectors

Live gas leak test on a North Sea off-shore installation:

Within 4-5 meters the gas concentration around the leak was below 5% LEL!

None of the existing gas detection systems alarmed!

Leak size: 3 mm
Gas pressure: 55 Bar (808 psi)
Leak rate: 0.06 kg/s



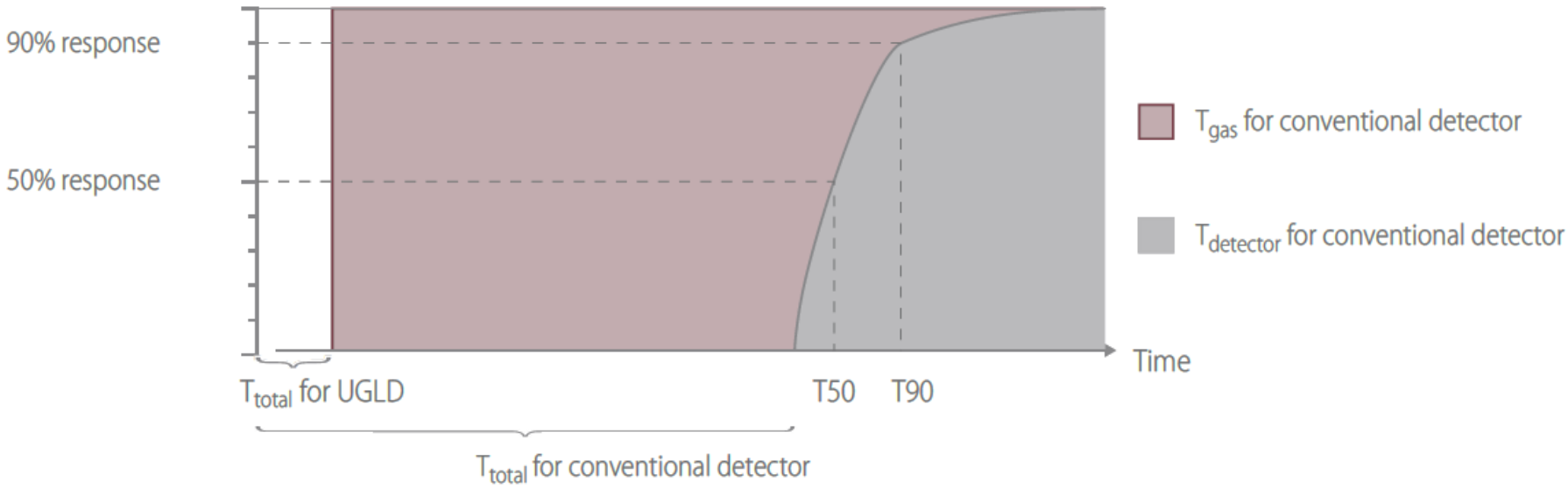
The ultrasonic gas leak detector detected the leak up to 19 meters away!

Total Speed of Response

Ultrasonic leak noise vs. gas accumulation

TOTAL SPEED OF RESPONSE (CONVENTIONAL): $T_{total} = T_{detector} + T_{gas}$

TOTAL SPEED OF RESPONSE (UGLD): $T_{total} = T_{detector} + T_{ultrasound}$

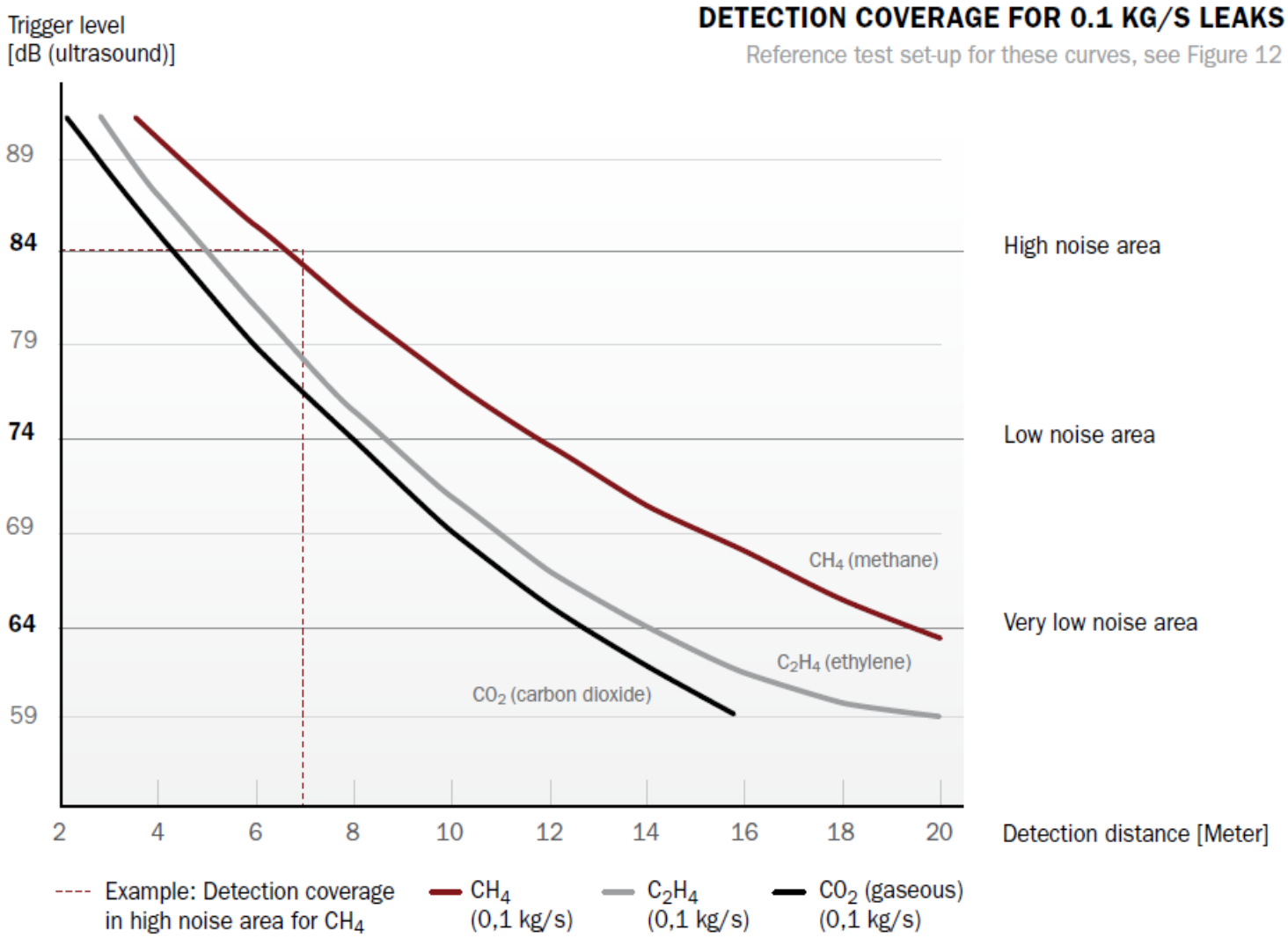


Gas Detection Limitations

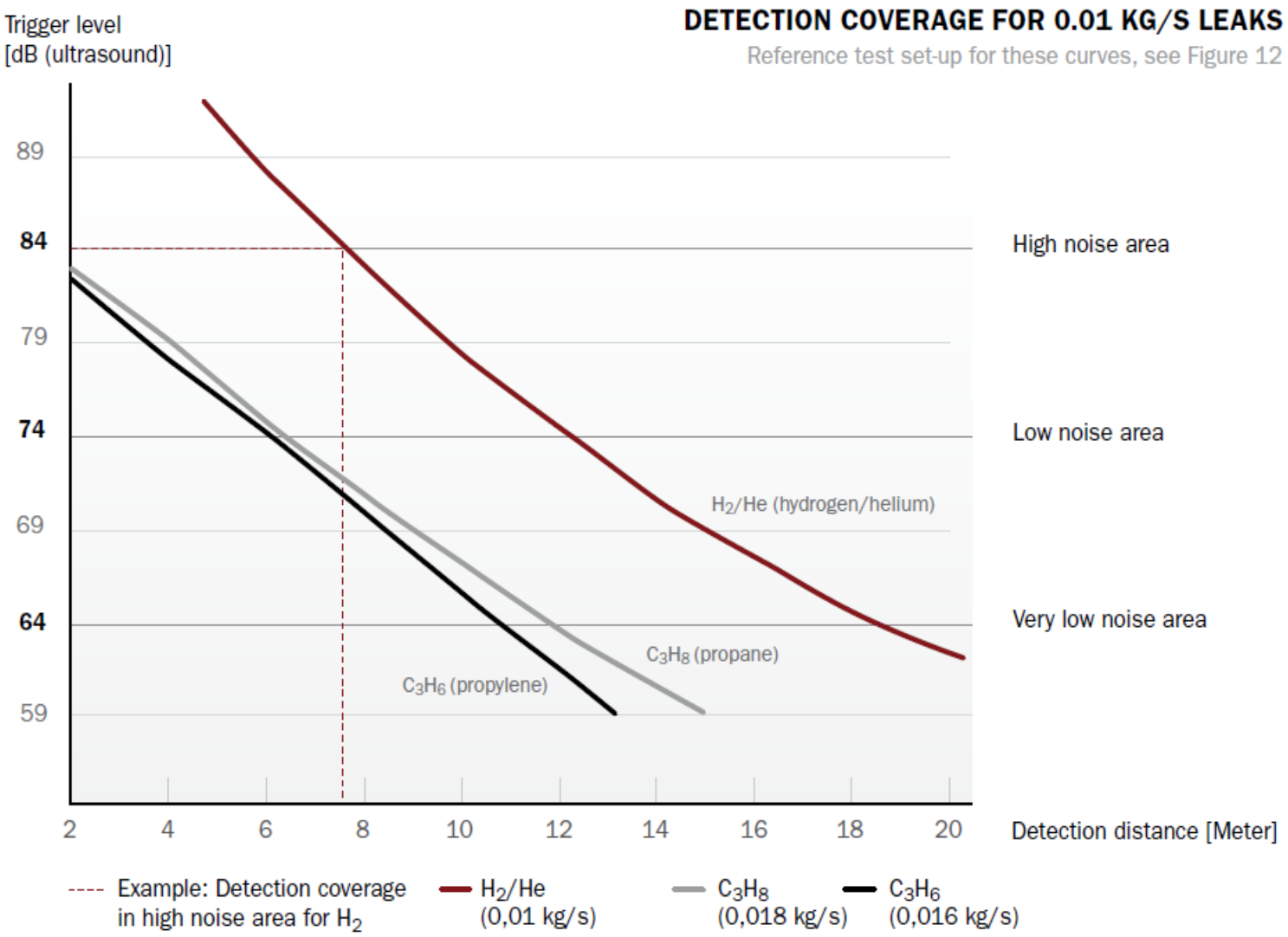
- Why traditional technologies can be problematic?
  - Changing wind directions
  - Gas dilution
  - Direction of the leak

- Acoustic technology limitations
  - Low pressure (2 Bar/29 psi min, 10 Bar/150 psi normal)
  - Not suited for liquids

Leak Detection Coverage



Leak Detection Coverage



The 3 Generations of UGLD

1st Generation

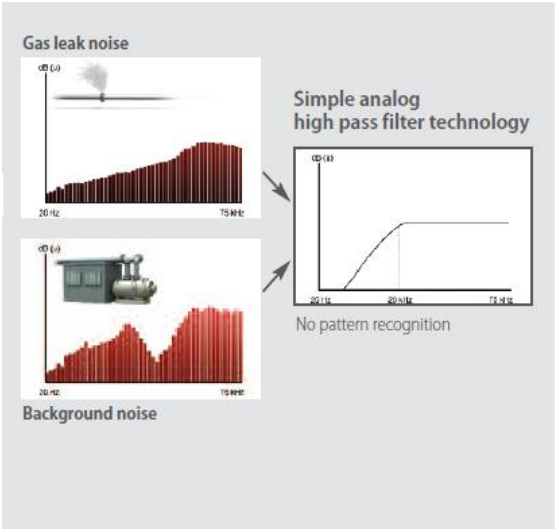
- Simple analog high pass filters
- Suppress low frequency acoustic noise
- Trigger Levels depending on background noise
- In very noisy areas the detection range is reduced

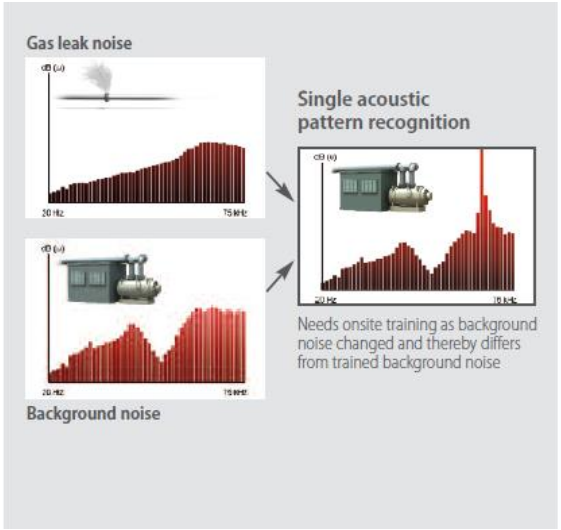
2nd Generation

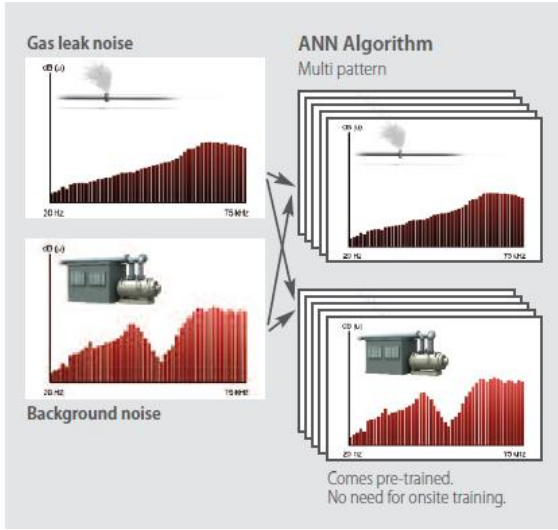
- Single pattern recognition
- Each detector is trained after installation
- Suppress only the specific acoustic background noise
- Trigger Levels still needed
- If the background noise signature changes false alarms can occur
- New training is required

3rd Generation

- Utilize Advanced Neural Network (ANN) technology
- ANN algorithms are pre-trained with real gas leak noise and background noise signatures
- No Trigger Levels needed
- Maximum coverage in all areas
- Plug and play and no need for re-training

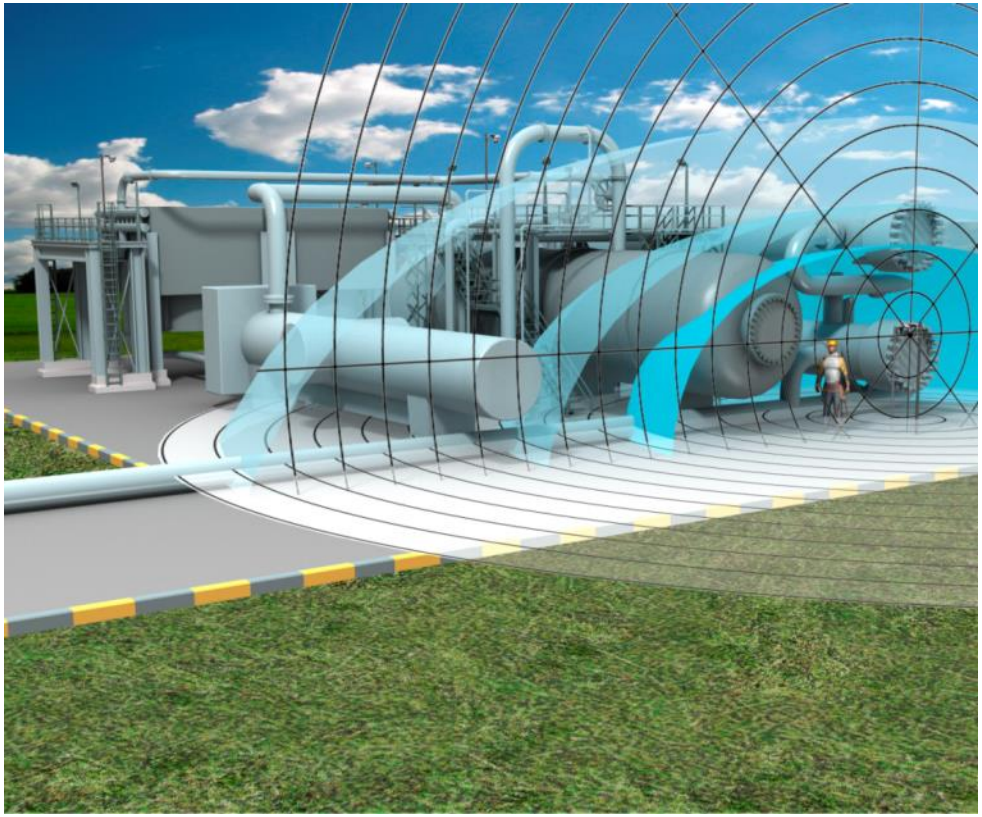






Detection Coverage for UGLD

1st & 2nd Generation UGLD



High-noise areas:
Background noise <78dB
5 – 8 m (16 – 26 ft) coverage (84dB)
Ex: Turbo compressor area or complete open offshore weather deck

Low-noise areas:
Background noise <68dB
9 – 12 m (30 – 39 ft) coverage (74dB)
Ex: Areas with no machinery or low-frequency machine made noise

Very low-noise areas:
Background noise <58dB
13 – 20 m (43 – 66 ft) coverage (64dB)
Ex: Salt dome gas storage or onshore wellhead area in calm environment

The coverage of a 0.1kg/sec leak is based on the trigger level setting and can be as small as 8 meter.

Detection Coverage for UGLD

3rd Generation UGLD

OBSERVER-*i*

Detection is based on ANN algorithms and not trigger levels in Enhanced Mode.

Maximum coverage of 28 meters can be achieved in all background noise levels.

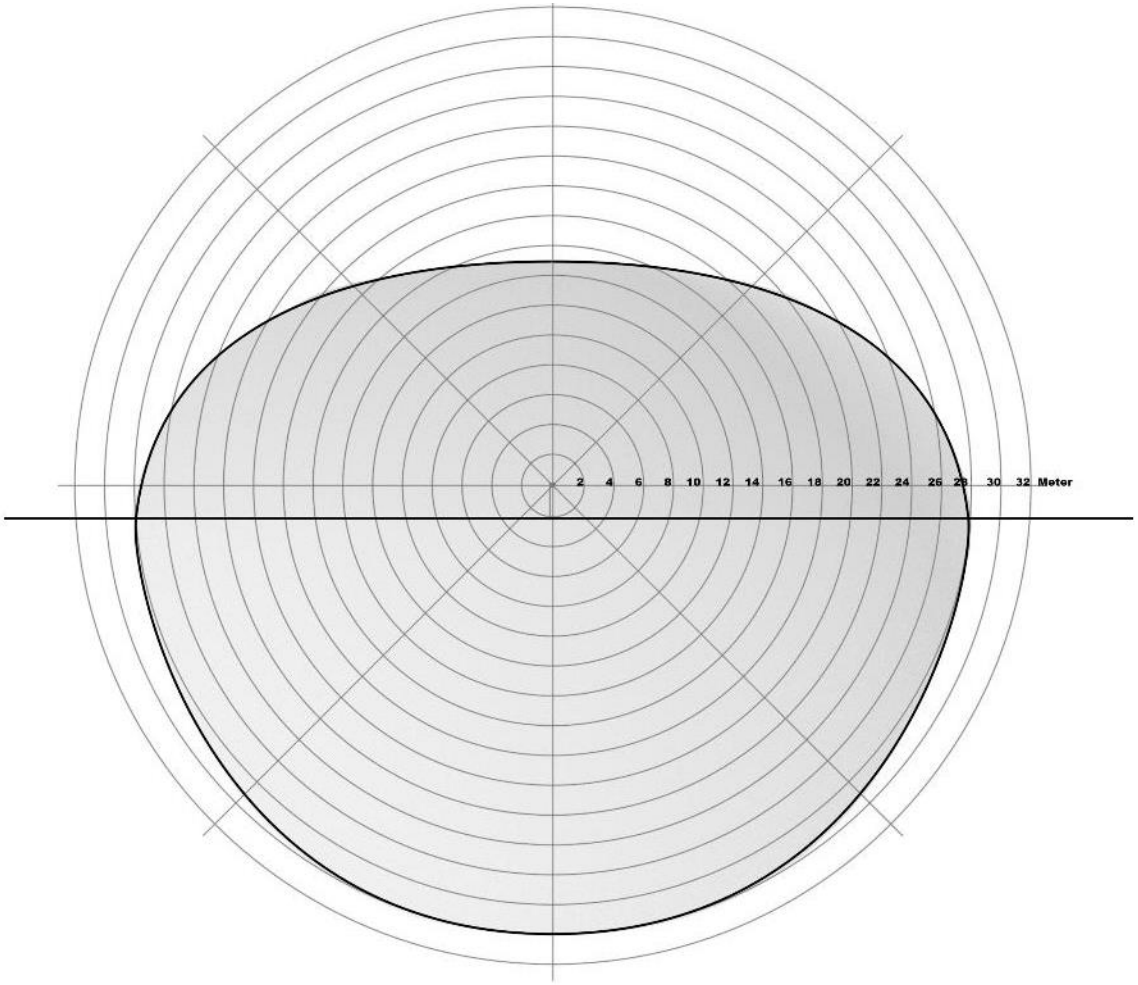
OBSERVER-i Coverage

- Enhanced Mode detection coverage, based on 0.1 kg/sec methane leak
  - FQHI setting: 17 meters (56 ft.) – *Default*
    Ultra-High to Low Background Noise
  - FQLO setting: 28 meters (92 ft.)
    Medium to Low Background Noise

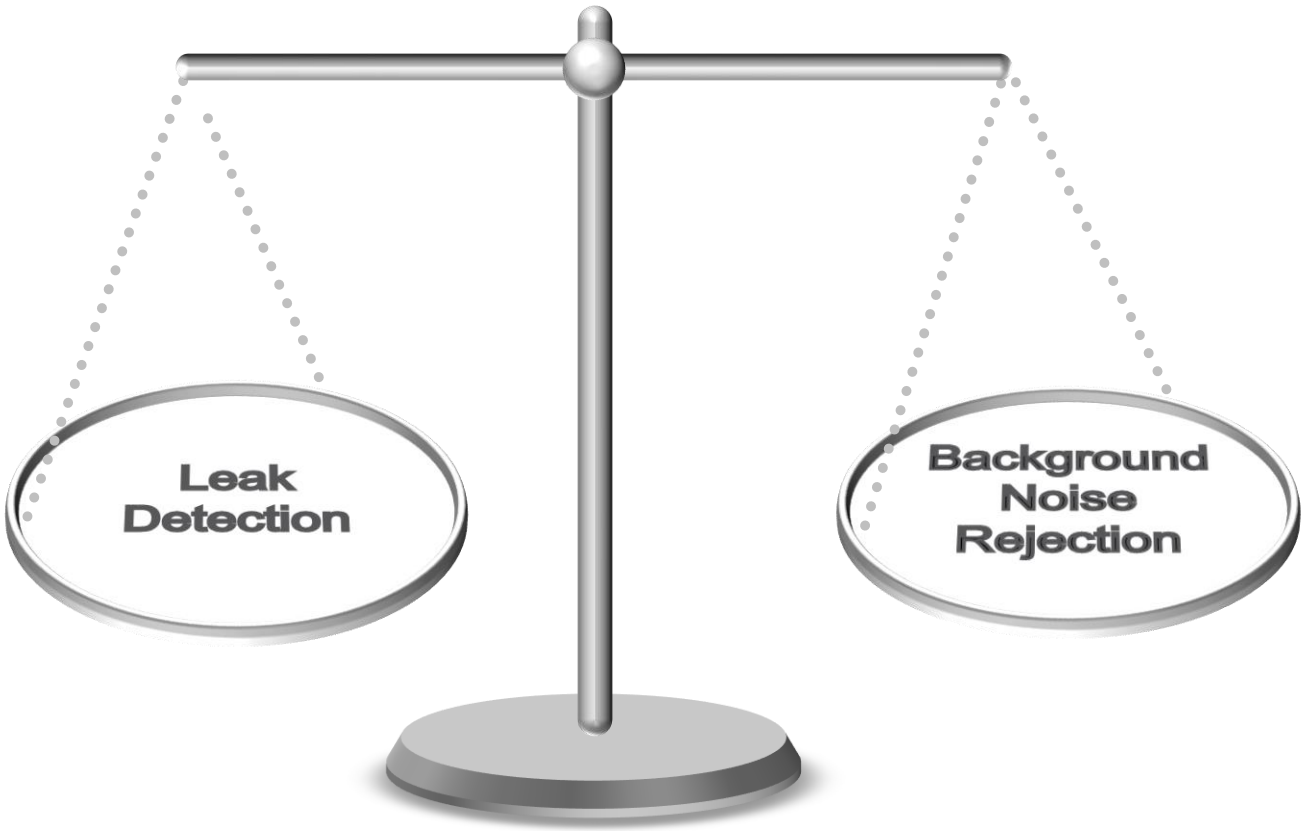
- Classic Mode detection coverage, based on 0.1 kg/sec methane leak
  - Ultra-High: 7 meters (23 ft.)
  - High: 12 meters (39 ft.)
  - Medium: 18 meters (59 ft.)
  - Low: 24 meters (79 ft.)

Detection Coverage for UGLD

OBSERVER-*i* coverage in Enhanced Mode, based on 0.1kg/sec methane leak



Detecting the leaks should take priority!



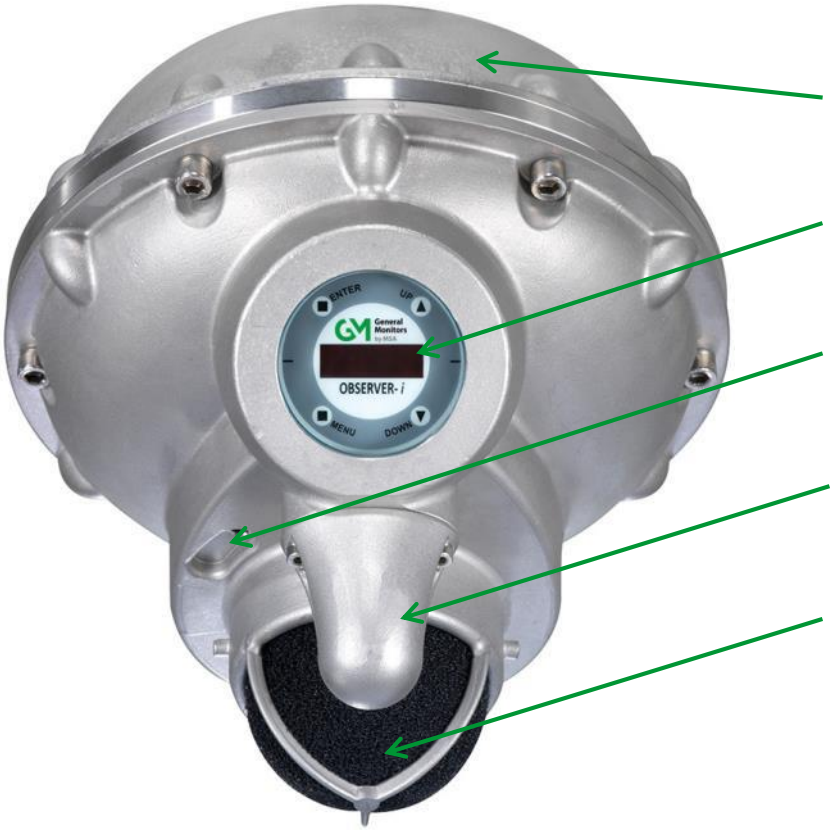
- **Always remember**, there is a fine balance between Background Noise Rejection and the ability to detect dangerous Leaks.
- **Rather move the detector away from the noise source and maintain detection coverage!**

Detector Type Comparison

	Surveyor ---------- UltraSonic IS-5	Observer H ---------- UltraSonic EX-5	OBSERVER-i
Area Classification	Intrinsically Safe	Explosion proof	Explosion proof
Dynamic range	44 to 104 dB	58 to 104 dB	40 to 120 dB
Operation Mode	Classic (dB trigger levels)	Classic (dB trigger levels)	Classic / Enhanced
Coverage (0.1kg/s)	5 to 20 meters	5 to 20 meters	28 meters
Self Test	No	Yes	Yes
Sensor	S.S. Microphone	S.S. Microphone	S.S. Microphone
Safety Integrity Level	SIL 2	SIL 2	SIL 3
Test and Calibration	1701 / SB100	1701 / SB100	1701 / SB100

OBSERVER-*i*

OBSERVER-i



Top chamber with terminals

User interface and display

Optical link window

Test sound source

Windscreen and stainless steel microphone

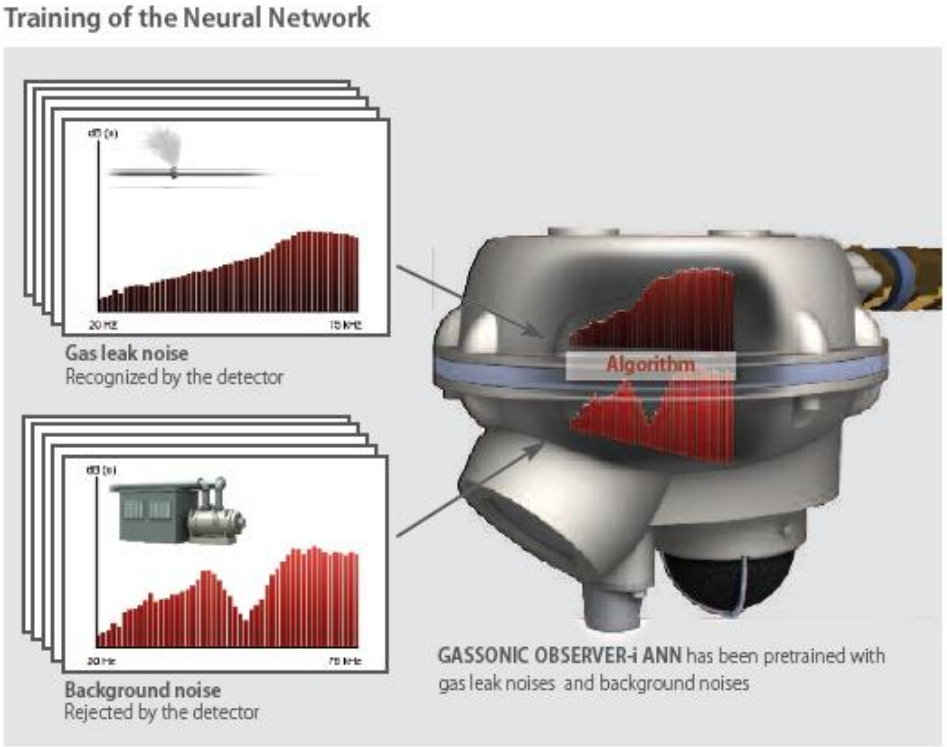
OBSERVER-i

Main Features:

- Artificial Neural Network (ANN)
- 15 year field proven Electret Microphone technology
- SENSSONIC™ integrated acoustic self-test
- Backwards compatible with older models
- Standard 4-20 mA analog
- HART
- Dual Modbus serial digital interface
- Alarm Relay and Error Relay outputs
- Explosion proof housing (Eexd)
- 316L stainless steel
- Minimal calibration and low maintenance
- FM, CSA, ATEX, IECEx certification
- SIL 3 suitable (FM certified to IEC 61508)

Artificial Neural Network (ANN)

- True ANN, not “single fingerprint” learning
- ANN is similar to face recognition, but with noise sources
- Programmed to ignore background noise and only respond to leaks
- No complicated setup and special software
- No need for background noise mapping before installation
- No need for re-training when plant conditions change



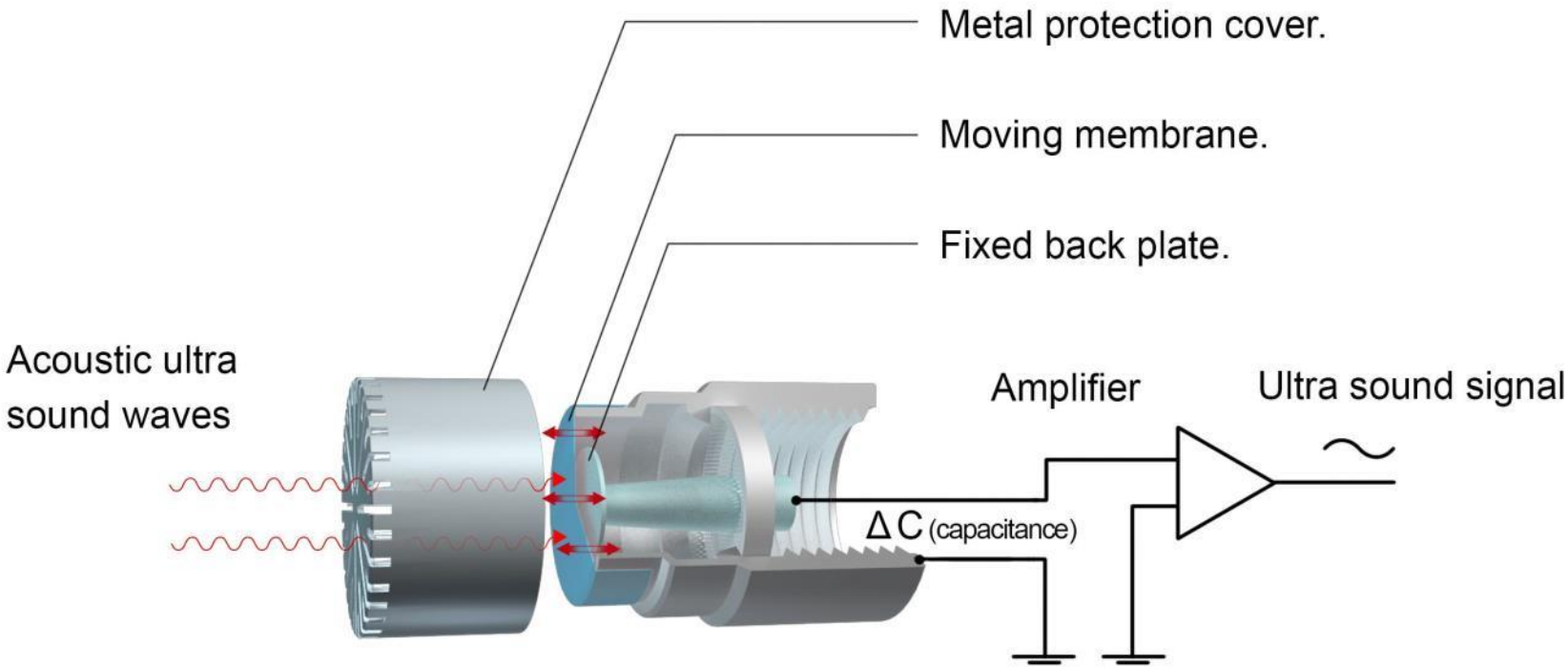
Microphone Technologies

- Two technologies used for converting sound waves into electrical signal used by modern ultrasonic gas leak detectors:
  - Piezo based microphone technology
  - Electret based microphone technology

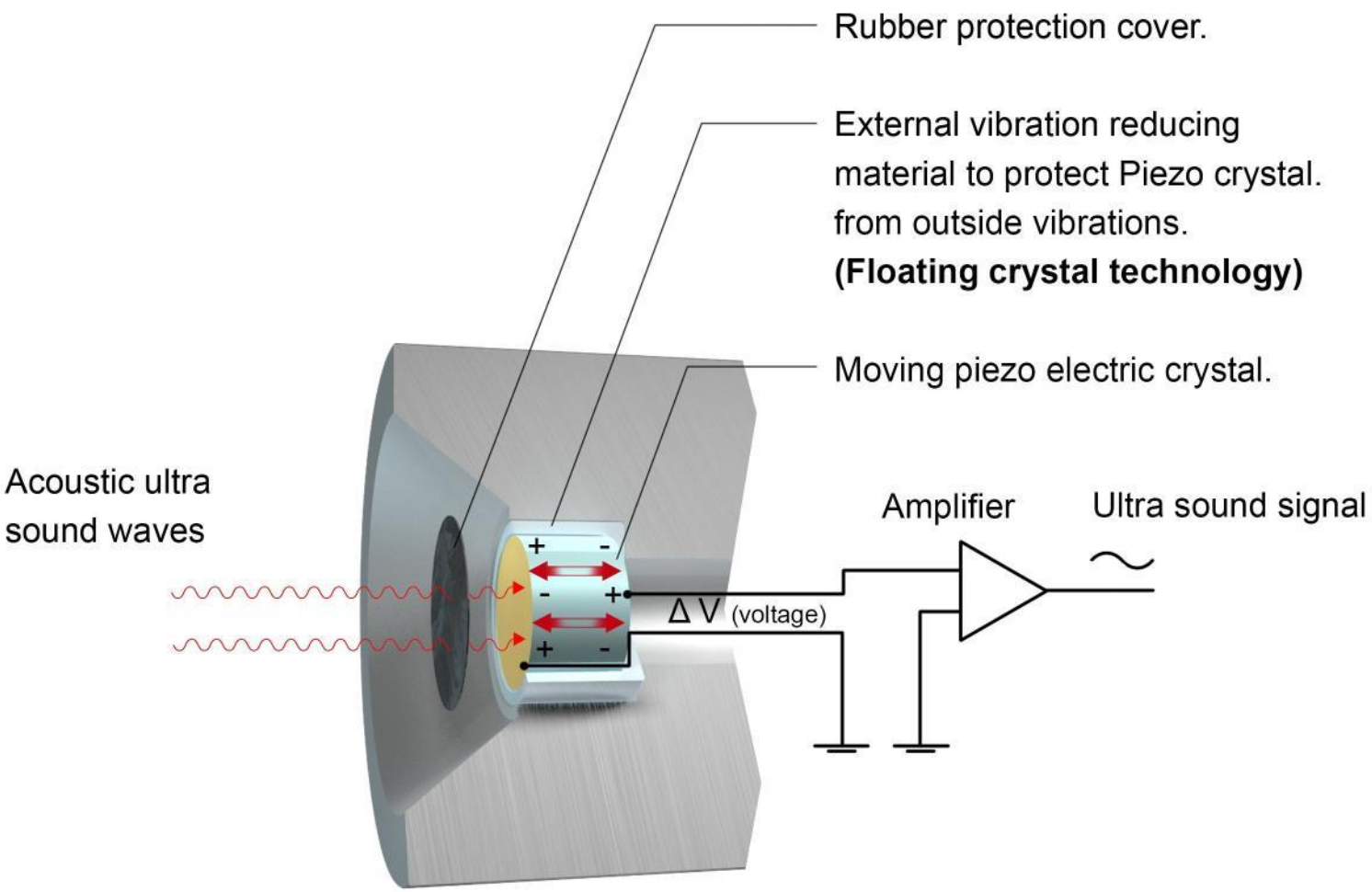
BOTH TYPES OF MICROPHONE TECHNOLOGY INCOORPERATE MICRO MOVEMENTS!

➢ Be careful, some vendor claim “no moving parts”, it is a false claim!

Electret Microphones (Moving Membrane)



Piezo Microphones (Moving Crystal)



Optimal Microphone Technology

Why Electret microphones instead of Piezo microphones?

- ✓ Best linear frequency responds
- ✓ Best temperature stability
- ✓ Very wide directional characteristic, wide detection range
- ✓ 15 years field proven technology

Number of Microphones

Why one microphone versus multiple microphones?

- ✓ Due to piezo microphones “narrow directional characteristic“, four microphones i necessary to cover 360 deg.
- ✓ Electrec Microphones has very whide directional characteristic so only one microphone is needed

Microphones

Why Electret microphones instead of Piezo microphones?

- ✓ Best linear frequency responds
- ✓ Best temperature stability
- ✓ 15 years field proven technology

Test & Calibration with GM 1701 Tester

Provides **Traceable** Test and IF necessary **Traceable** Calibration

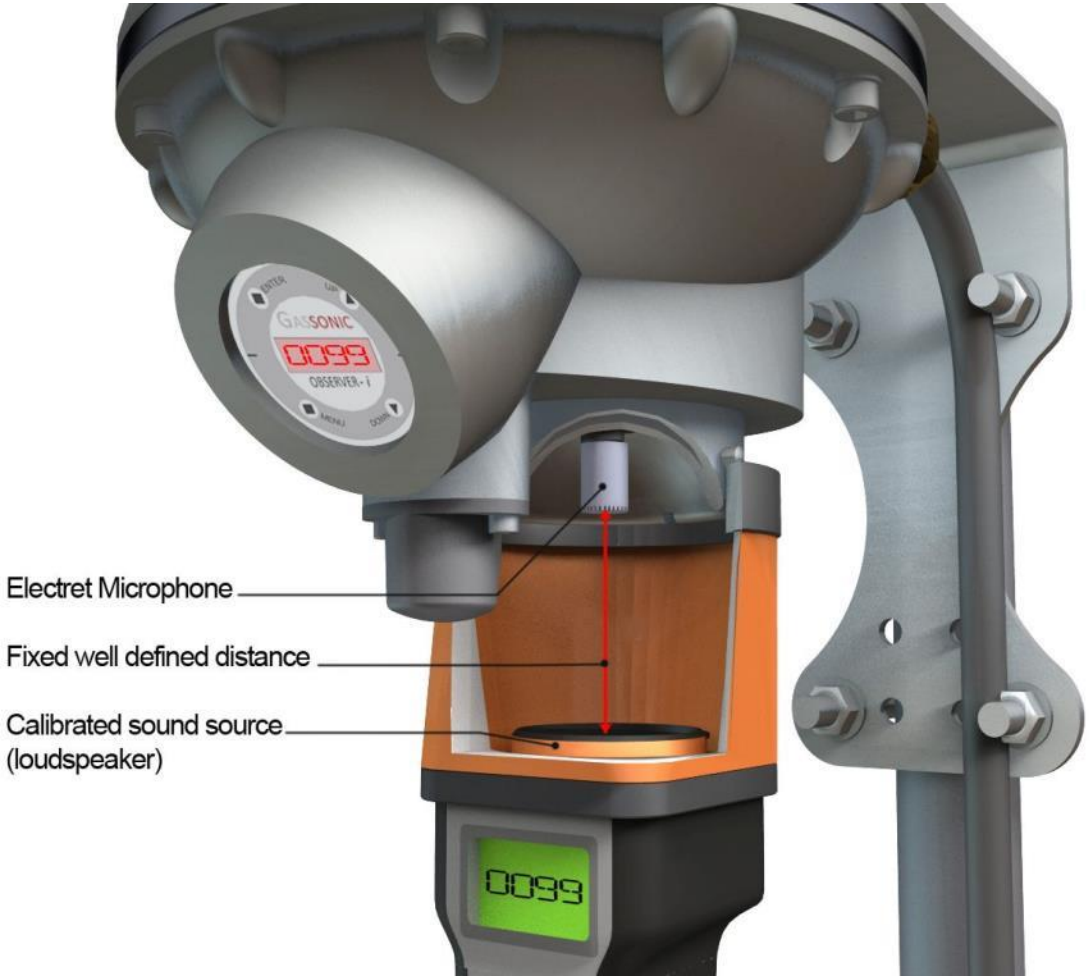
Test & Calibration with GM 1701 Tester

The OBSERVER-i can be tested, linked to ISO9001 traceable international calibration standards:

- Ensures ALL OBSERVER-i always have same detection coverage
- Ensures same detection coverage in life time of detectors
- Ensures that test and calibration of each detector can be documented to traceable standards

Controlled Test & Calibration

- Fixed distance between sound source and microphone
- No interfearing background noise due to closed test chamber



BE CAREFULL, Myth to be killed!

Following statement is false:

“Calibrated for life……..”

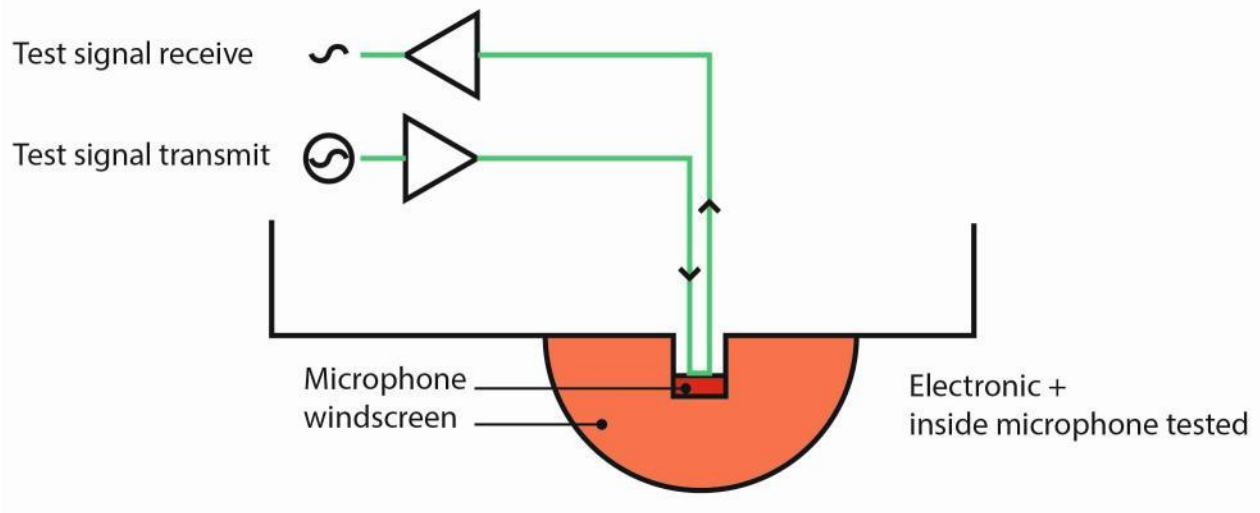
Nothing is calibrated for life, all instrumentation needs a traceable reference to repeatedly prove stability!
Therefore the use of the GM 1701 tester.

Selftest Principles

There are 3 types of self test principles:

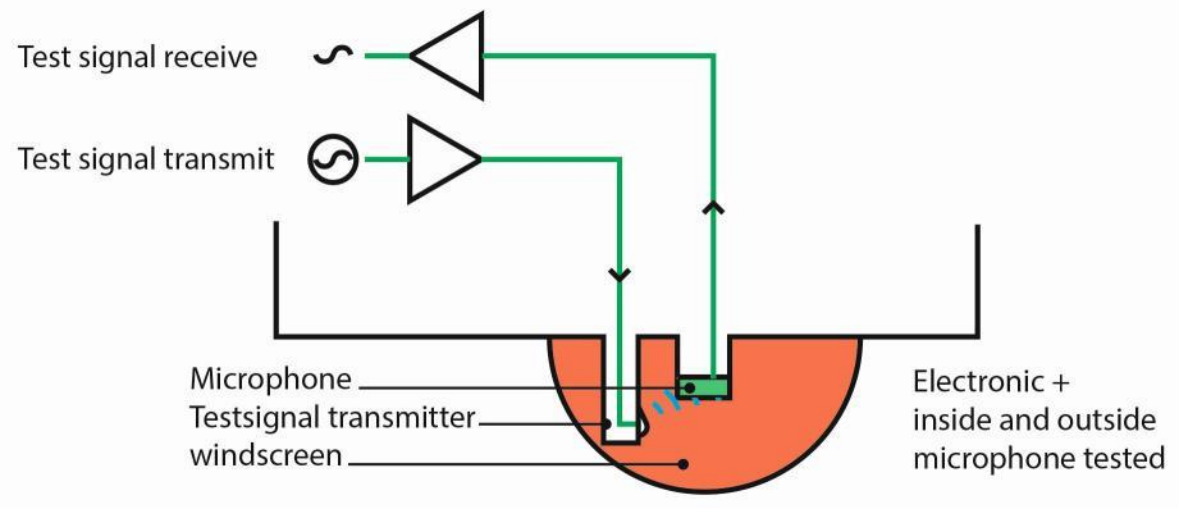
- Electronic selftest
- Semi acoustic selftest
- Full Senssonic Acoustic selftest

Electronic Selftest



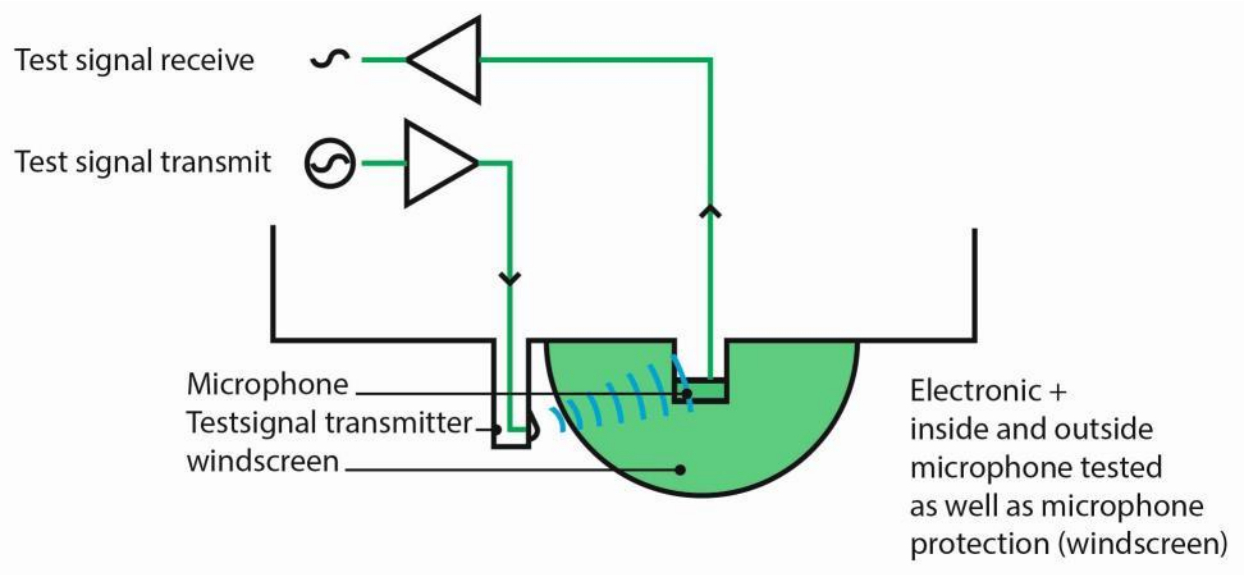
- Electronic selftest only test internal electronic circuits behind electret/piezo microphone sensor.
- Blocked electret/piezo microphone sensor or blocked windscreen not tested.

Semi Acoustic Selftest



- Semi Acoustic selftest only test internal electronic electret/piezo microphone sensor.
- Blocked windscreen not tested!

Senssonic Acoustic Self Test



- Full Senssonic selftest tests internal **electronic, microphone sensor, and windscreen protection.**

- Full Senssonic selftest ensures that microphone failure, or blocked windscreen are constantly checked every 15 min to ensure no loss in detection performance.

GM Acoustic Selftest (SENSSONIC™)

SENSSONIC™ selftest includes full acoustic selftest of the OBSERVER-i

- Real acoustic self test includes the following tests:
  - All relevant electronic circuits are tested
  - Microphone membrane are tested
  - Windscreen are tested
- Ensure full failsafe operation of detector
- Providing the only **true & safe** test of detector

GM Acoustic Selftest (SENSSONIC™)

- SENSSONIC™ built-in acoustic integrity test
  - External loop configuration
  - Controlled functionality and integrity test every 15 min
  - No unrevealed failures between inspections
  - Fault indicated on 4-20 mA, Error Relay, Display, Modbus, and HART

Test transducer

Field Replaceable Parts

OBSERVER-i can be serviced in the field,
does NOT need to go back to factory for service:

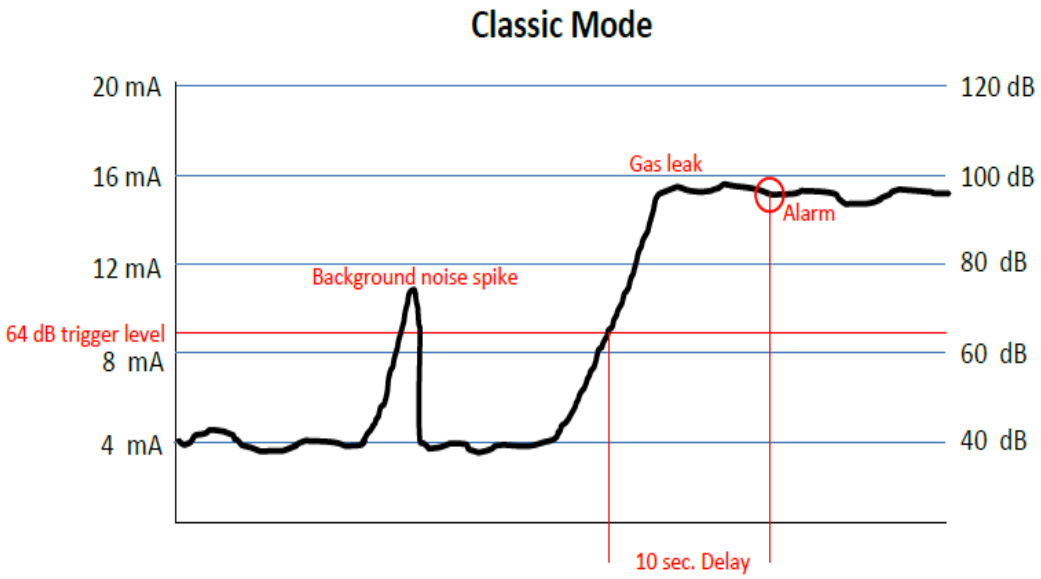
- ✓ Microphone sensor can be replaced in the field
- ✓ SENSSONIC™ self test sensor can be replaced in the field

Operation Modes

- The OBSERVER-i has two output modes:
  - Enhanced Mode (ANN)
  - Classic Mode
    (backwards compatible with the Observer H/UltraSonic EX-5)

Classic Mode

- Need Trigger Level and Delay Time
- Trigger Level determines the coverage (Sensitivity)
- 40 to 120 dB = 4 to 20 mA
  (Better than Observer H/UltraSonic EX-5)



Enhanced Mode

- **NO trigger level needed,** only delay time

- **Three output modes:**
  Discrete SPL (EAO1), Discrete (EAO2), SPL Only (EAO3)

  - **EAO1** and **EAO2** has discrete AO similar to MSIR Flame Detector (16 mA Warning, 20 mA Alarm)
  - **EAO1** 40 to 120 dB = 4 to 12 mA, 16 mA = Warning, 20 mA = Alarm
  - **EAO2** 40 to 120 dB = 4 mA Normal, 16 mA Warning, 20 mA Alarm

Operation Modes

OBSERVER-i Classic Mode and Observer H/UltraSonic EX-5 analog output comparison

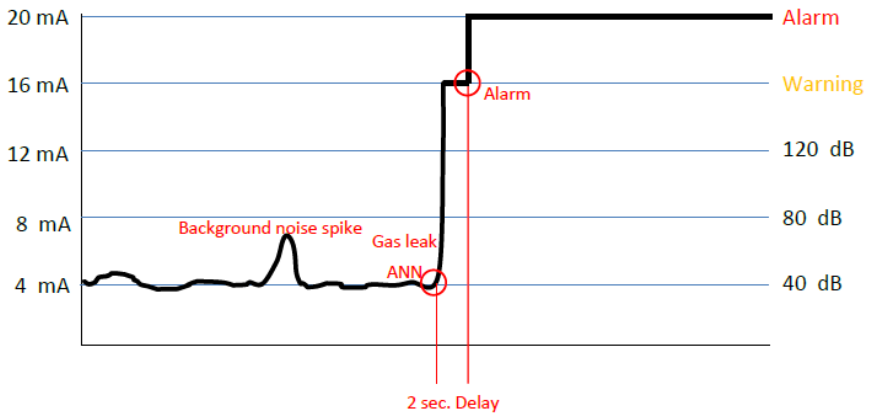
	OBSERVER-i	UltraSonic EX-5 Observer H
SPL	mA	mA
40	4.0	
44	4.8	
49	5.8	
54	6.8	
58	7.6	4.0
59	7.8	4.3
64	8.8	6.1
69	9.8	7.8
74	10.8	9.6
79	11.8	11.3
84	12.8	13.0
89	13.8	14.8
94	14.8	16.5
99	15.8	18.3
104	16.8	20.0
109	17.8	
114	18.8	
120	20.0	

Operation Modes

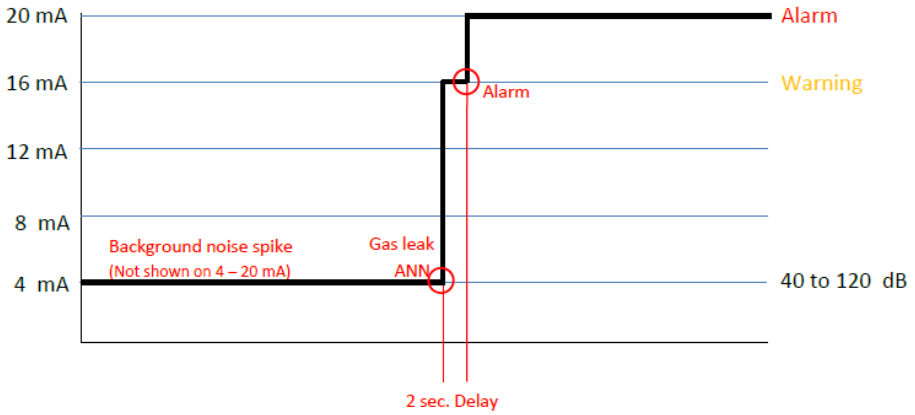
- Alarm function in enhanced mode
  - It is an “AND” function
  - Sound level has to pass ANN Sensitivity Level “AND” a real gas leak identified
  - ANN Sensitivity Level default at 59 dB can be set as low as 44 dB (recommended)

Enhanced Modes

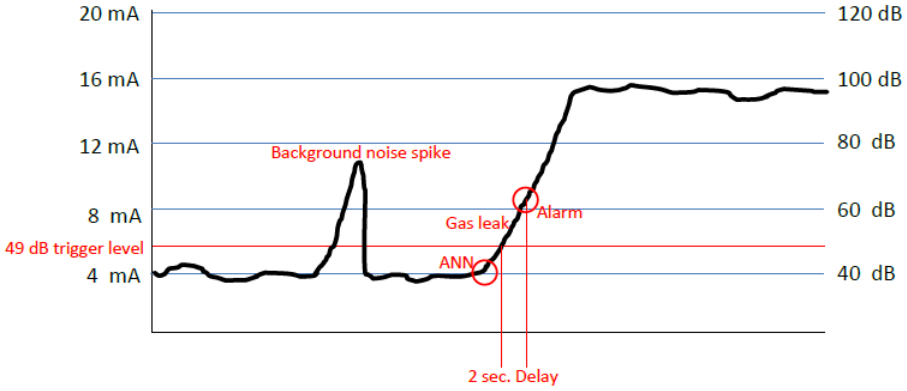
Enhanced Mode (EAO1)



Enhanced Mode (EAO2)



Enhanced Mode (EAO3)



Testing

Testing

1701 Portable Test & Calibration Unit

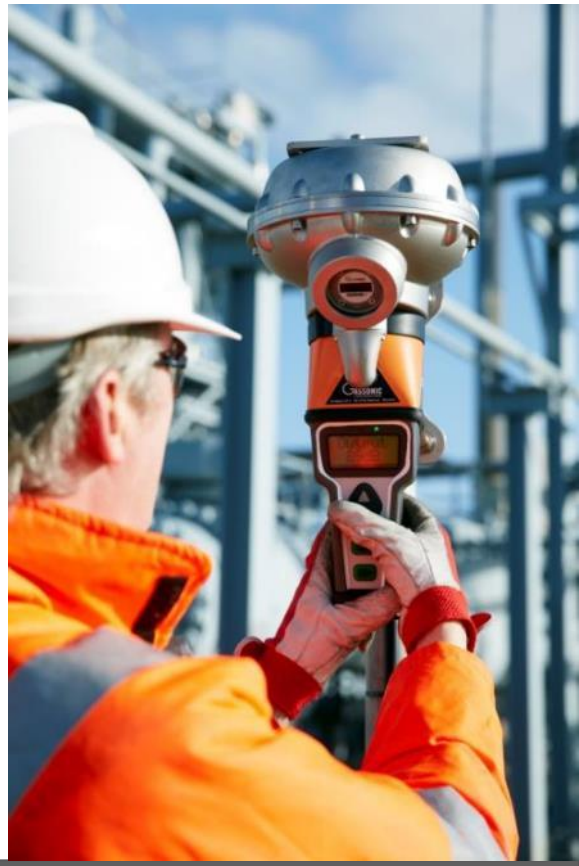
- Intrinsically Safe (ATEX, C-UL)
- Verify the operation and if necessary, calibrate the GASSONIC UGLD
- Requires no electrical connection to the UGLD
- Traceable and calibrated to international standards
- Tests full dynamic range as well as delay function
- No need to open up detector or remove parts in the field

SB100 Bump Tester

- Intrinsically Safe (CSA, FM, ATEX, IECEx)
- For bump test of GM UGLDs
- Not a calibrated device
- Remote testing up to 18m (59ft) away
- Does not replace gas leak simulation
- OBSERVER-i recognizes the SB100 sound signature

Testing 1701 Portable Test & Calibration Unit

- Prior to testing
  - Clean windscreen and optical link window
- Testing/Calibration
  - Traceable to international standards
  - Gain Test (functionality/tolerance)
  - Delay Test (Loop to F&G System)
  - Calibration if required by plant procedures
- Maintenance
  - Factory calibration needed every 2 years



Testing SB100 Bump Tester

- Remote Bump Testing
  - Cannot be used for calibration
  - Testing up to 18 m (59 ft)
  - The table below does not correspond to real gas leaks (Gas leak simulation is recommended)

Test Range Distance	Average Sound Level Reading* +/–5 dB
4 m (13 ft)	88
6 m (20 ft)	82
8 m (26 ft)	78
10 m (33 ft)	74
12 m (39 ft)	70
14 m (46 ft)	68
16 m (52 ft)	64
18 m (59 ft)	60

** As tested on the OBSERVER-i, OBSERVER, Surveyor, MSA EX-5, and MSA IS-5.*

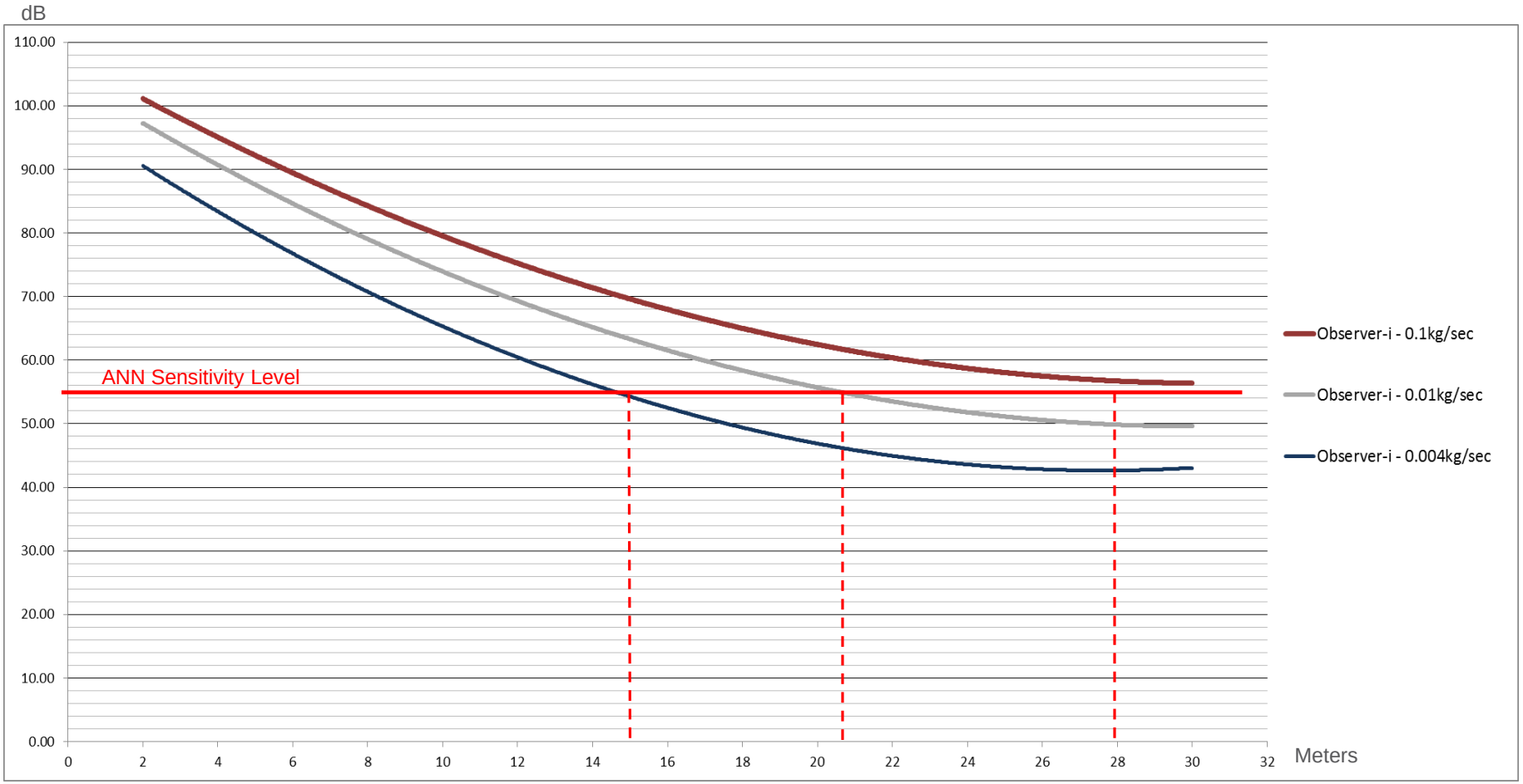
Testing Gas Leak Simulation

- Recommended gas leak equipment
  - 4 m long high pressure hose with regulator, valve and nozzle
  - 2 or 4 mm nozzle

- Testing procedure
  - Maximum 0.1 kg/sec (0.22 pound/sec) leak rate from a standard 50 l nitrogen cylinder
  - Leak testing performed at coverage perimeters

Testing

OBSERVER-i coverage with N_2 leak simulation (FQLO setting)



Installations

Installations Worldwide

Most of the major end-users within the oil and gas industry are implementing UGLD technology for projects worldwide

Europe, Africa, Middle East, Far East/Central Asia, Australasia

- North Sea: England, Norway (Sleipner, Gullfaks)
- Caspian Sea Region: Azerbaijan (Shah Deniz), Russia (Sakhalin II), Kazakhstan (Kashagan)
- Middle East: Oman (Saih Rawl, Saih Nihyada, Al-Kawther, Harweel)
- Far East/Central Asia: China (Bohai Bay), Malaysia (Shell Bintulu), Pakistan (Rehmat), Indonesia (Tangguh)
- Africa: Equatorial Guinea (Marathon ALBA), Algeria (Hassi Berkine)

Installations Worldwide

More than 4000 GASSONIC UGLDs installed worldwide

The Americas

- USA – Dow Chemical, Chevron Global Gas, Caledonia Energy, Shell Offshore, Chevron Pipeline, EnCana, Seneca Resources
- Canada – Dow Chemical, Nexen, EnCana, SBM
- Trinidad & Tobago – BP, BG, NGC
- Chile – Chile LNG
- Argentina – Total
- Mexico – Pemex

Existing Installations – Onshore Wellheads

Ultrasonic detectors installed on wellheads in Europe and Africa

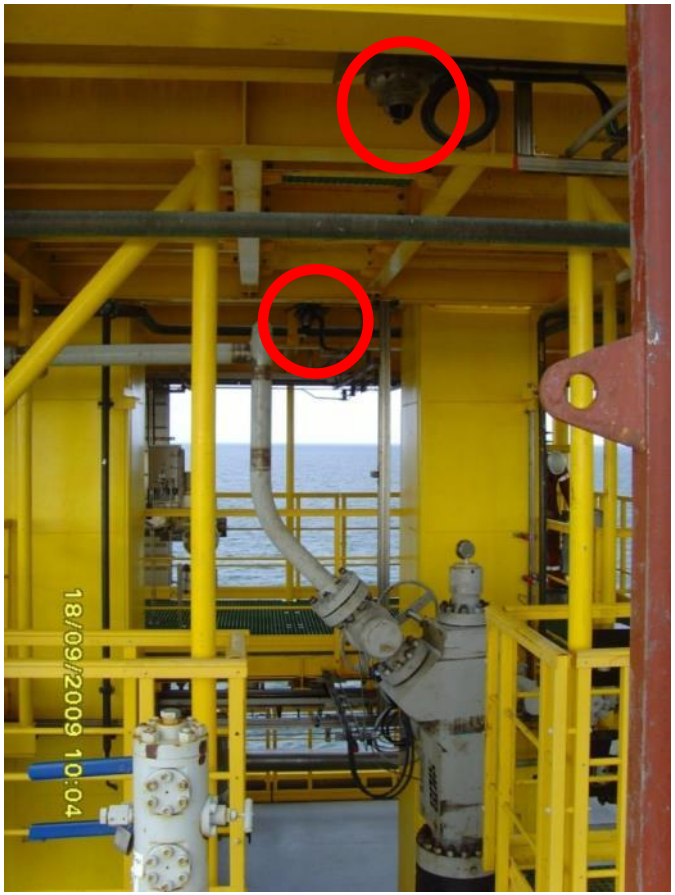
Major gas supplier in Europe using only ultrasonic detectors at its outdoor gas plants

Existing Installations – Offshore Platform

7 out of 9 Ultrasonic detectors installed on a Hess weather deck in the North Sea.

Existing Installations – Offshore Platform

Observers offshore



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THANK YOU

Any questions?