



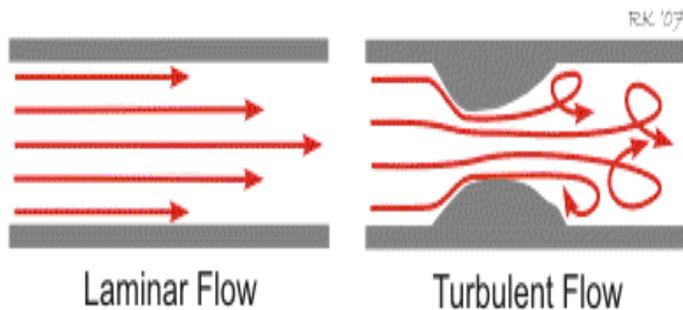
# Ultrasound Leak Detection Introduction & Sensor Training

Benjamin Fried  
CTRL Systems, Inc.





- First launched in July 2001 for International Space Station
  - To evaluate the integrity of the Orbiter to Airlock low and high-pressure interconnect lines
  - In the evaluation of the Hatch seal integrity prior to the schedule pressurized leak check
- More than 30 Orbiter missions beginning in 2002 as standard troubleshooting tool



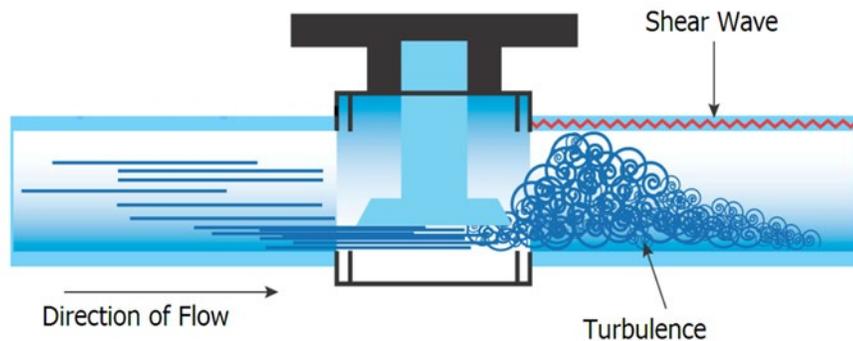
**Turbulent Flow** – Particles tumble due to pressure, volume, size & shape of the hole, etc. and creates ultrasound.

**Laminar Flow** – Particles run parallel and create no ultrasound.

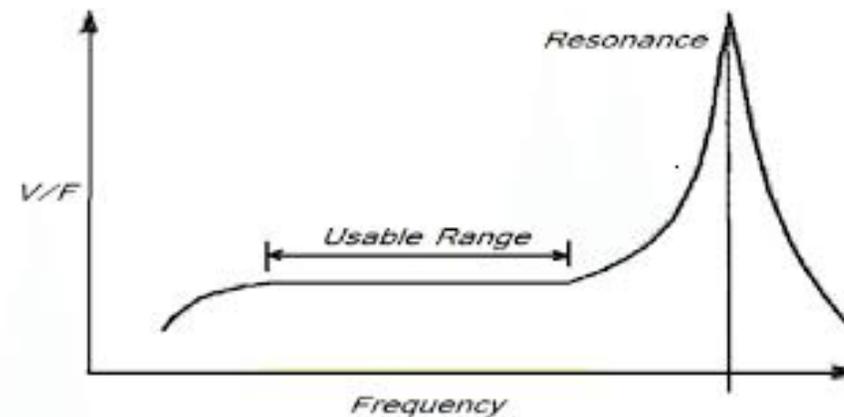
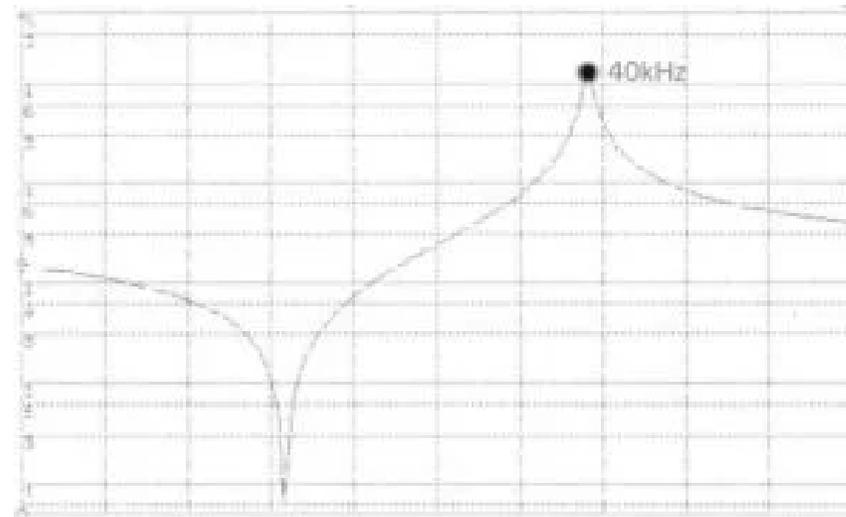
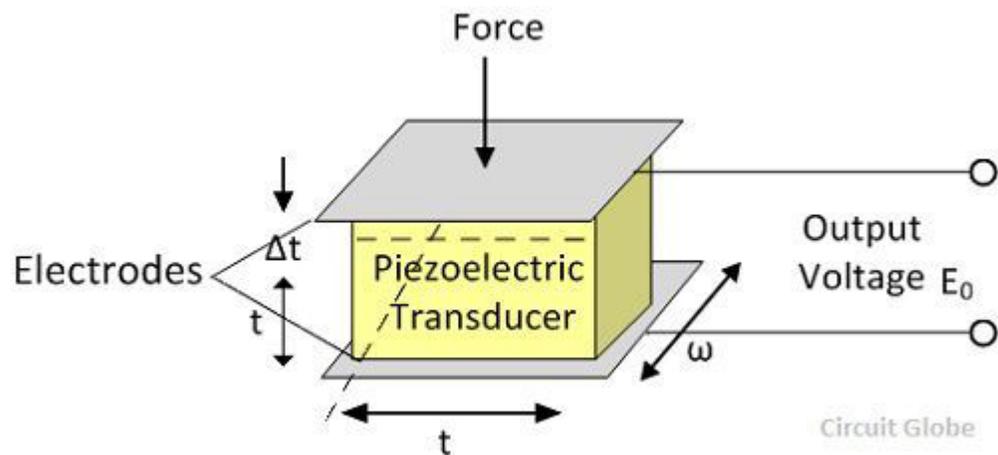
$Re = (\rho \cdot v \cdot l) / \eta$  where:

Re	Reynolds number dimensionless	
$\rho$	Density of the liquid or gas	[kg m <sup>-3</sup> ]
v	Mean velocity of the flow	[m s <sup>-1</sup> ]
l	Characteristic length	[m]
$\eta$	Dynamic viscosity	[Pa s]

Re < 2,300 the flow will be laminar

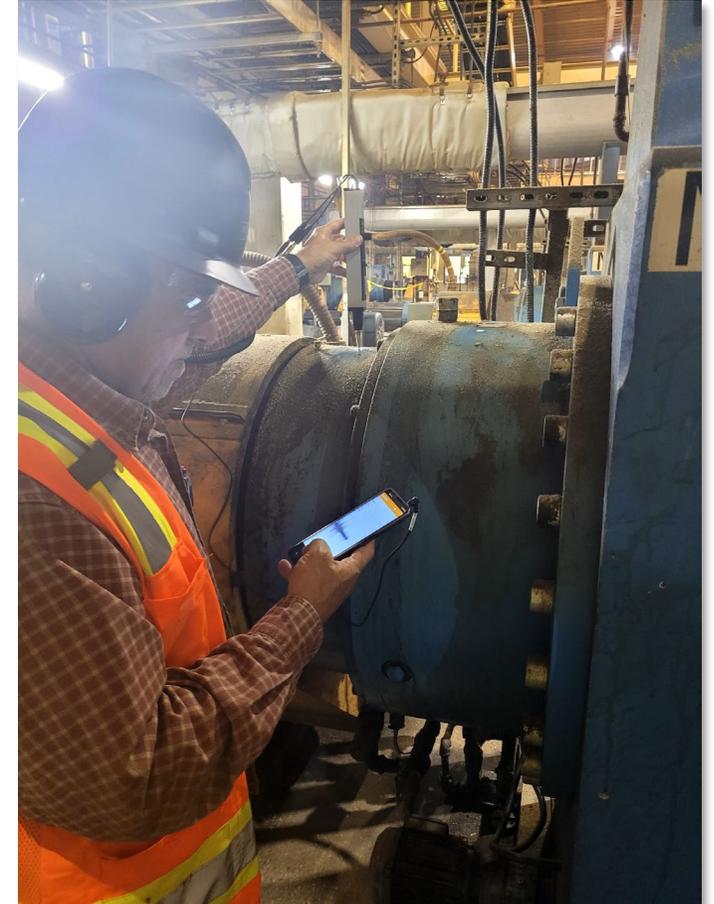


## What Are Piezoelectric Transducers?



## Why Use Piezoelectric Transducers?

- High sensitivity to ultrasonic frequencies.
- Compact and lightweight, ideal for handheld and remote devices.
- Wide frequency range for diverse applications.\*
- Robust and reliable under various environmental conditions.
- Low power consumption, enabling long-term monitoring.



## Applications in Airborne Ultrasound



Condition  
Based /  
Predictive  
Maintenance



Energy  
Savings / Leak  
Detection

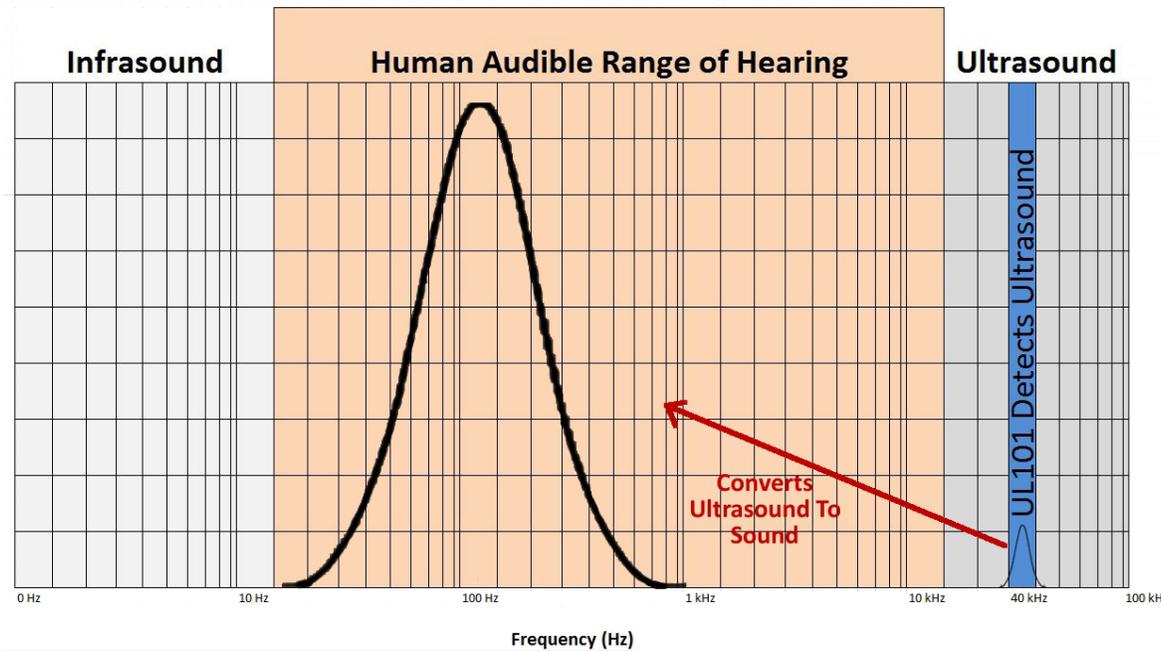


Electrical  
Inspection /  
Partial  
Discharge



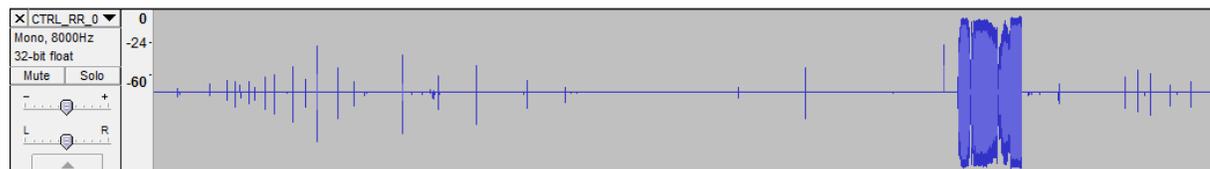
Valve / Steam  
Trap  
Inspections

## Using Piezoelectric Transducers Effectively

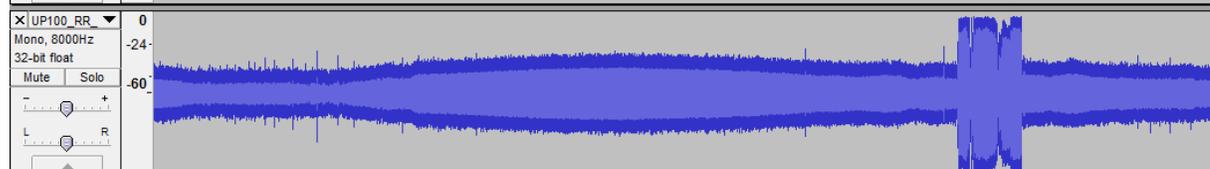


## Using Piezoelectric Transducers Effectively

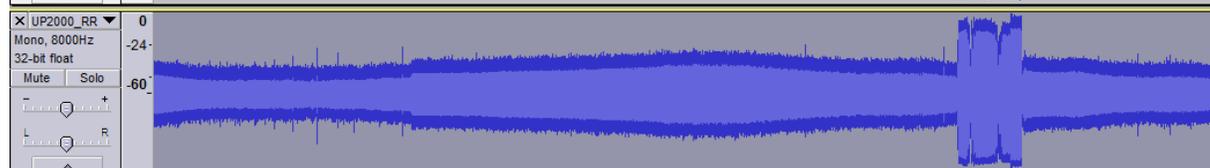
UL101 Ultrasound Detector



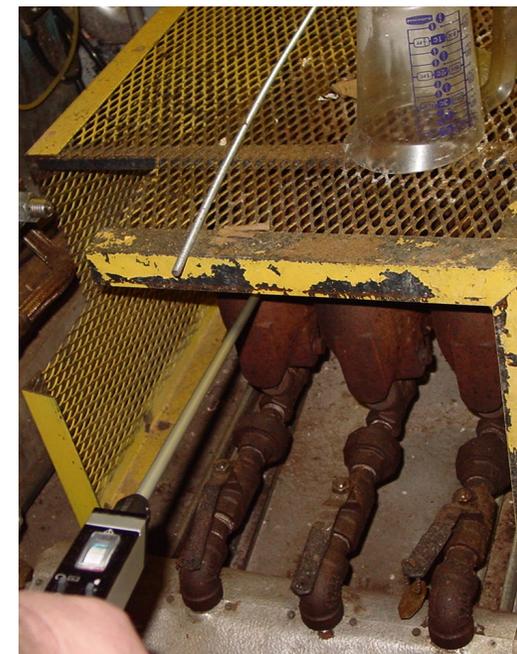
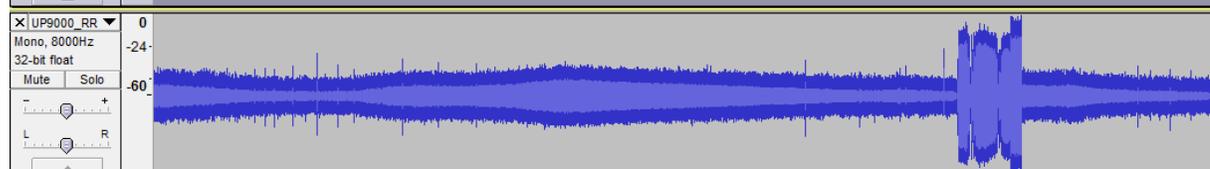
Ultrasound Detector #1



Ultrasound Detector #2



Ultrasound Detector #3



Listening to a Steam Trap



Astronaut C. Michael Foale, Expedition 8 commander and NASA ISS science officer, performs in-flight maintenance (IFM) on the nadir window using the UL101 ULD in the Destiny laboratory of the International Space Station (ISS).

# Using The Ultrasound Leak Detector



40 KHZ ULTRASONIC MICROPHONE

ANALOG METER

OUTPUT SWITCH (METER/BATTERY)

GAIN SWITCH (SENSITIVITY)

POTENTIOMETER (SENSITIVITY ON/OFF)

RUGGEDIZED ALUMINUM HOUSING  
SOLID STATE ELECTRONIC BOARD

9 VOLT BATTERY(45-50 HOURS)

HEADSET JACK



# Using The Ultrasound Leak Detector



2x, 5°



1.5x, <5°

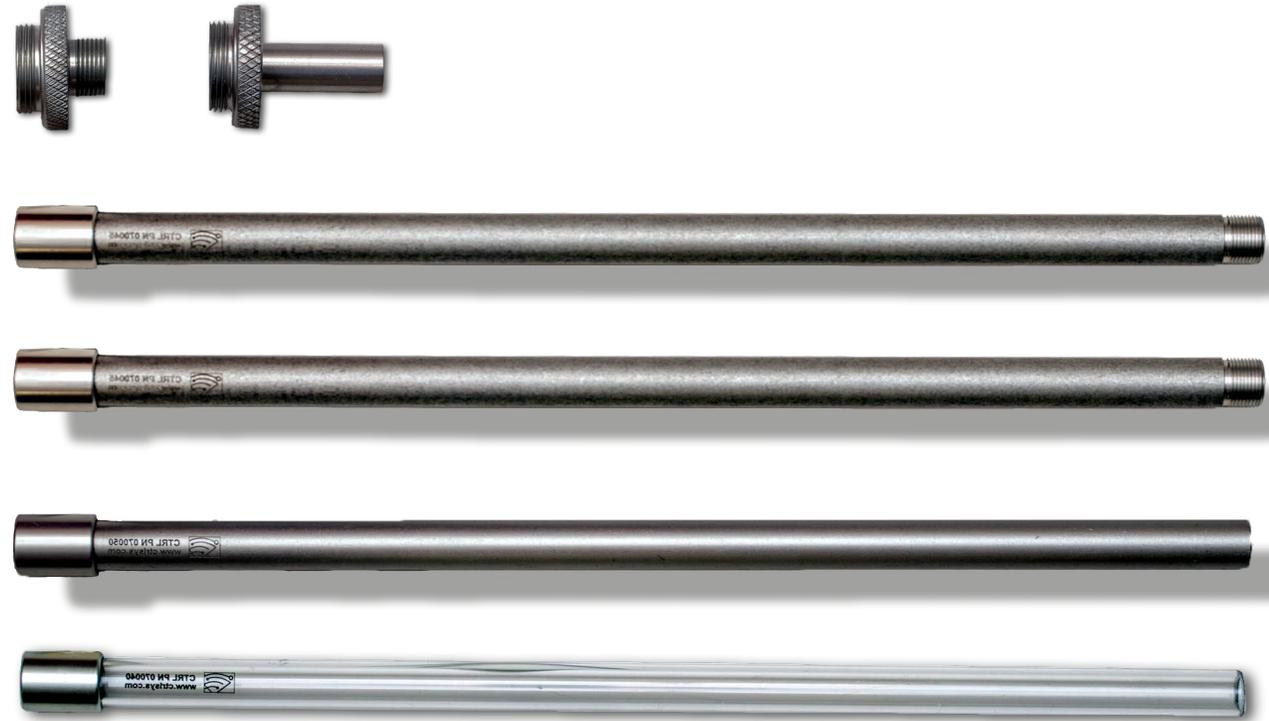


Pinpoint



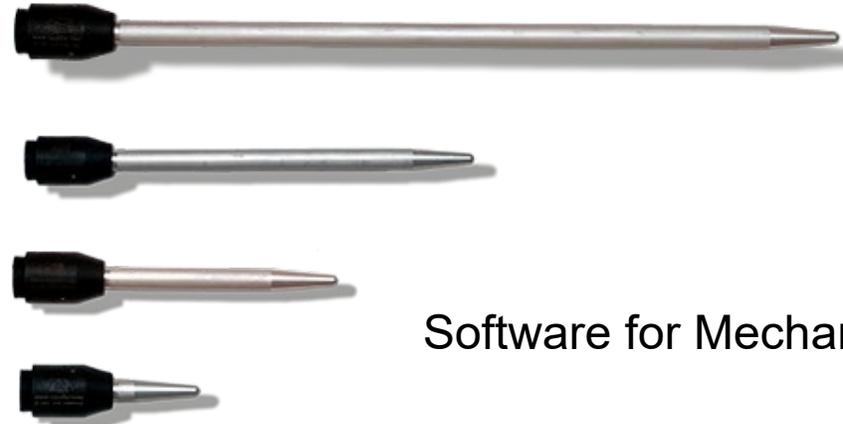
Concentrator Probes

# Using The Ultrasound Leak Detector



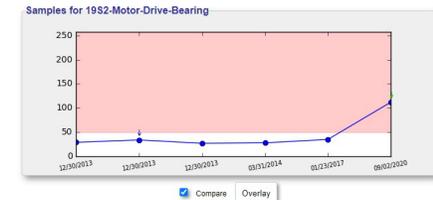
Acoustic Extension Probes

# Using The Ultrasound Leak Detector

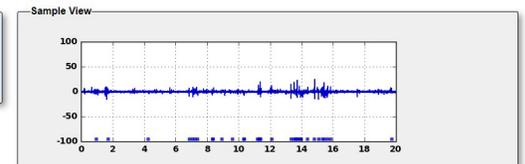


Solid Probes

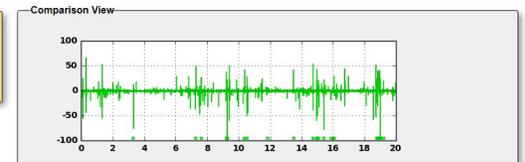
## Software for Mechanical Diagnostics



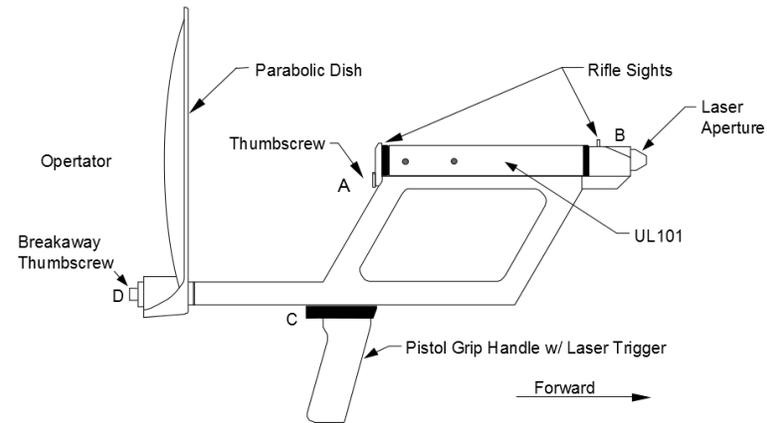
**Primary Sample**  
 Date Recorded: 12/30/2013 01:09PM  
 Comment 1:  
 Comment 2:  
 RMS Value: 34  
 Health: Normal  
 Status Change: No Change  
[Detail View](#)



**Comparison Sample**  
 Date Recorded: 09/02/2020 08:57AM  
 Comment 1: lg 6.1 inch probe  
 Comment 2:  
 RMS Value: 112  
 Health: Suspect  
 Status Change: No Change  
[Detail View](#)



# Using The Ultrasound Leak Detector



300' (95m), 1°



PowerBeam 300 Parabolic Dish Attachment

# Using The Ultrasound Leak Detector



Overall Sound Pressure Level (OSPL) for the frequency range 10 Hz – 70 kHz at 60 cm was measured by NASA to be 99 dB



Ultrasound Transmitter

## Ultrasound Acoustic Cameras

- MEMS Microphone array
- Beamforming
- Time of flight calculation
- Visualization

## Applications

- Typically Handheld
  - Leak Detection
  - Partial Discharge Detection



## Mounted Ultrasound Sensors

### HHA for Leak Detection in Petro-Chemical

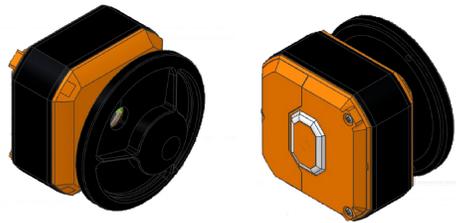


Figure 1

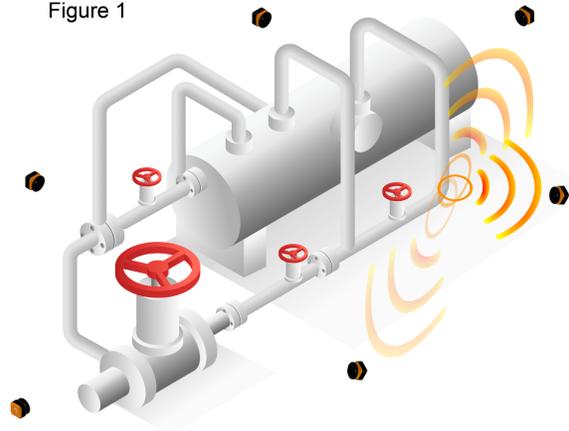


Figure 1

- A leak is detected in this pipeline by 3 different sensors.
- Each sensor indicates the loudness detected.
  - The alarm and loudness level (dB or RMS) is sent to a control panel.
  - The control panel's software uses algorithms developed (and developing) by AI to determine this is a leak and not a false positive.
  - The software also determines the approximate location of the leak by triangulation from the 3 sensors

Figure 2

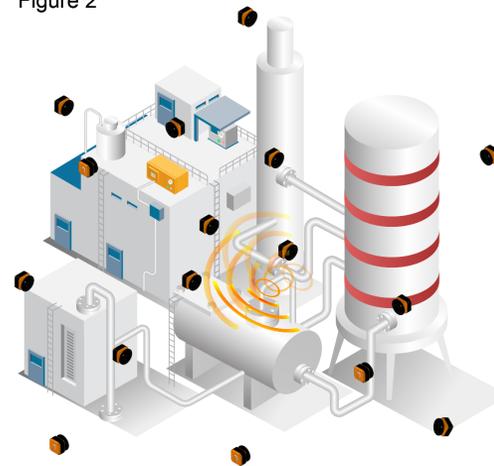


Figure 2

#### HHA Sensor Features

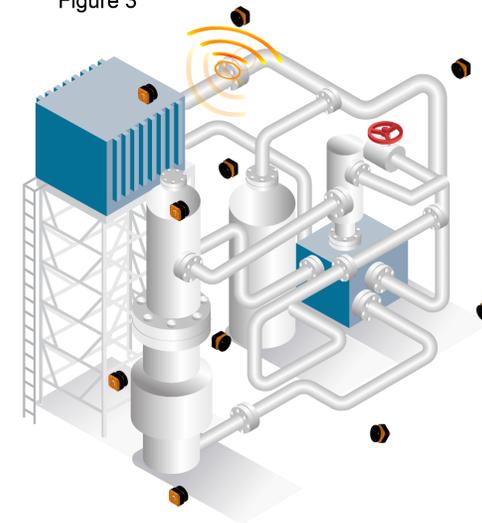
- 24/7
- Bluetooth / Wireless
- Battery operated (min. 2 years)
- Calibrated every 2 years (battery, sensitivity, operation, etc.)
- Detects ultrasound at 40 kHz +/- 1.5 kHz
- Can be communicated to with iPad to control sensor and record data
- Sensitivity set at installation to maximize area being inspected (0 dB - 60 dB gain)
- Adjustable mount for directionality (magnetic with pivot or non-ferrous surface option)
- Intrinsically Safe (ANSI and ATEX)
- Stainless Steel Housing
- Ingress Rating: IP65 or 66 / NEMA 4X enclosure
- Operating Temp.: -40°C to +60°C

Figure 3

#### HHA Sensor Functionality

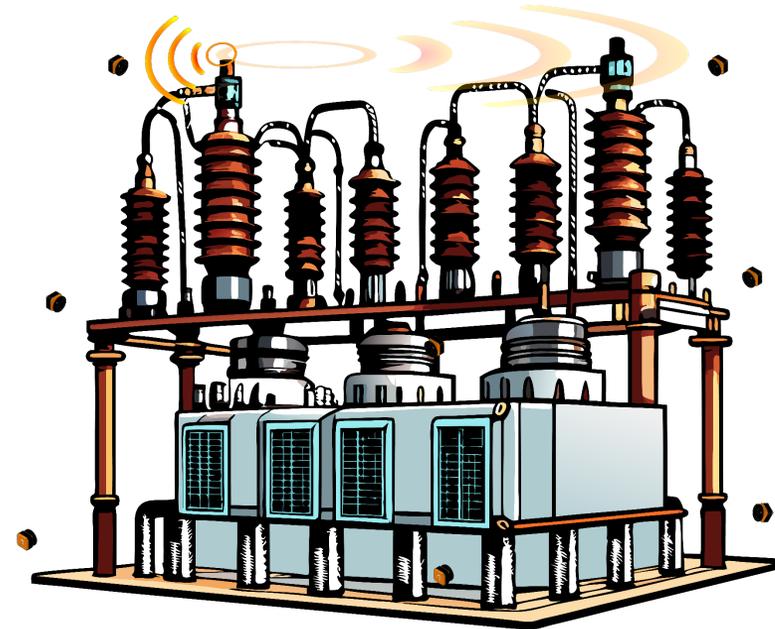
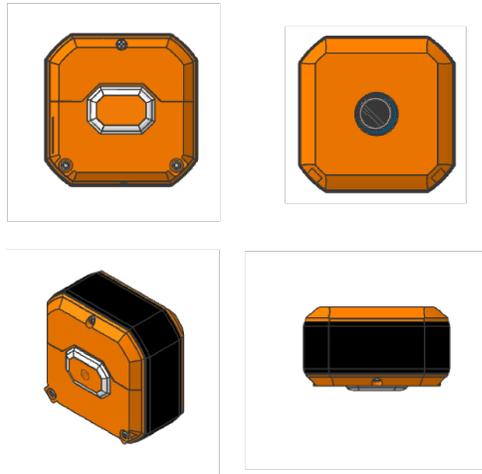
- 24/7 Monitoring (how many times per hour if 2 year battery?)
- Transmits data via Bluetooth to iPad
- Transmits alarm to Control Panel or Cloud via Gateways installed around plant
- Converts 40 kHz to audible range
- Detects gas leaks less than 1 BAR (14 psi) - "non-laminar flow"

Figure 3



## Mounted Ultrasound Sensors

### HHA for Partial Discharge Monitoring



#### Operations

- The mounted HHA sensors wakes up and listens for ultrasound
- A sound is detected inside the cabinet, substation, or transformer by the mounted HHA sensor
- The sensor converts the ultrasound to the audible range and exports the data to a gateway
- The gateway uses AI to determine if the sound is partial discharge or not
- If the sound is partial discharge, the AI determines what type of partial discharge (corona, tracking, or arcing)
- The results and ultrasound data are exported to the specified reporting location (e.g. customer control panel or cloud software)

#### HHA Sensor Features

- 24/7
- Bluetooth / Wireless
- Battery operated (min. 2 years)
- Calibrated every 2 years (battery, sensitivity, operation, etc.)
- Detects ultrasound at 40 kHz +/- 1.5 kHz
- Can be communicated to with iPad to control sensor and record data
- Sensitivity set at installation to maximize area being inspected (0 dB - 60 dB gain)
- Adjustable mount for directionality (magnetic with pivot or non-ferrous surface option)
- Intrinsically Safe (ANSI and ATEX)
- Stainless Steel Housing
- Ingress Rating: IP65 or 66 / NEMA 4X enclosure
- Operating Temp.: -40°C to +60°C

#### HHA Sensor Functionality

- Detects ultrasound created by partial discharge
- Converts 40 kHz to audible range
- 24/7 monitoring
- Transmits ultrasound and location data to a gateway
- Gateway transmits data and confidence level of type of partial discharge



UL101 in the hands of an astronaut on the ISS

Benjamin Fried  
CTRL Systems, Inc.

