# Principles of Acoustic Measurements

**Exercises:**

- Basic Concepts of Sound
- Measuring Sound
- Measuring Sound in Practice
- Basic Frequency Analysis of Sound

# Basic Concepts of Sound

- **Sound Pressure Level Measurements**
  - Measurement of perceptible change of SPL
  - Pressure/temperature analogy
- **dB conversion**
- **Sound Fields**
  - Spatial Decay
  - Pressure increase at walls
- **dB ± dB**
  - Addition of dB's
  - Subtraction of dB's

# Sound Pressure Level Measurements

**Measurement of perceptible change of SPL**

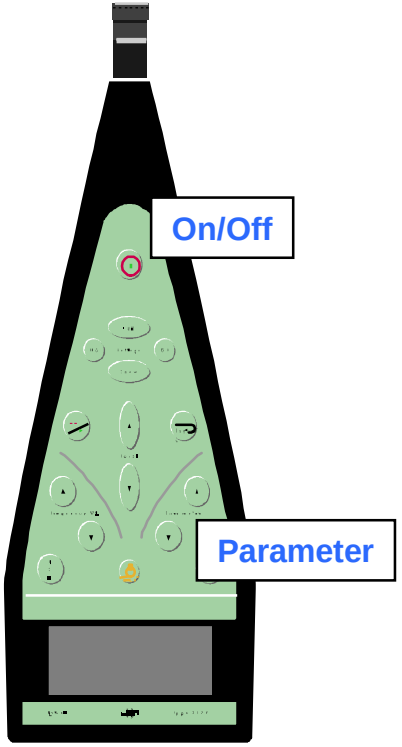
- Turn on the 2236 Sound Level Meter and point it at the radio
- Using a Parameter arrow button, select SPL
- Note what SPL you measure
- When the level is increased to a level just perceptible, make a new SPL reading
- Compare the two levels. Does it correspond to the theoretical 5 dB?

**Pressure/temperature analogy**

- Make a sketch of the lecture room
- Measure SPL for electrical drill in different positions
- Note what SPL you measure on the sketch

**dB conversion**

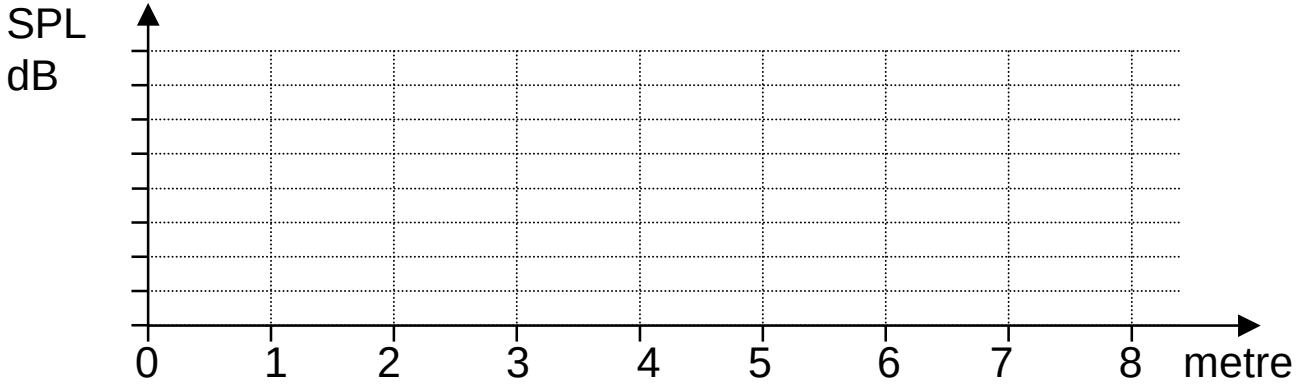
- Use the conversion chart in the lecture to convert the measured dB levels to pressure values in Pascal



# Sound Fields

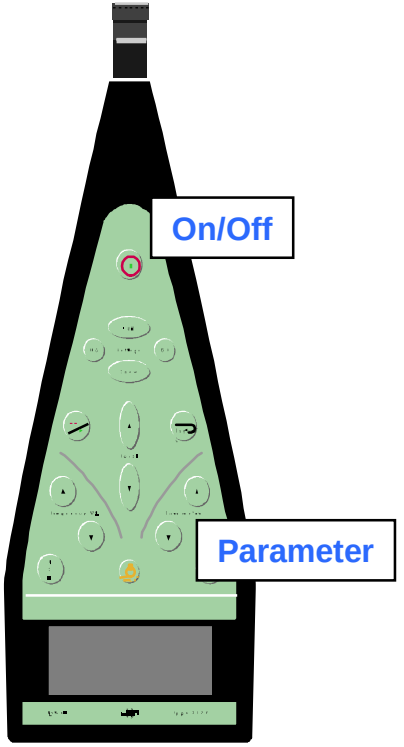
**Spatial Decay**

- Place the drill in one end of the lecture room
- Turn on the 2236 Sound Level Meter and measure the SPL at distances 1,2,4 and 8 m
- Plot the values on the chart below




**Pressure increase at walls**

- Measure noise from drill near the walls and corners vs centre of room
- Do you get the expected level increase at the walls and corners



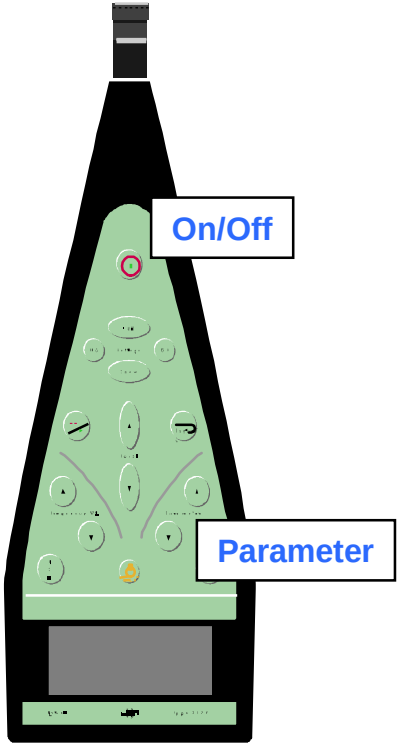
# dB ± dB

**Addition of dB's**

- Turn on the 2236 Sound Level Meter and measure the sound level from one vs two drills
- Note the different levels and compare the result to calculated values

**Subtraction of dB's**

- Switch on one of the drills and the radio to simulate a real world situation where the noise from the radio present the background noise
- Measure the noise with both noise sources on
- Switch off the drill and measure the background noise (radio)
- Calculate the noise from the drill alone using the chart in the lecture
- Compare the calculated value with the value measured earlier



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# Measuring Sound

- **Microphones**
  - Free field and Random microphones
  - IEC and ANSI
- **Sound Level Meters**
  - Time weighting - continuous
  - Time weighting - intermittent
  - Time weighting - impact
  - Crest factor

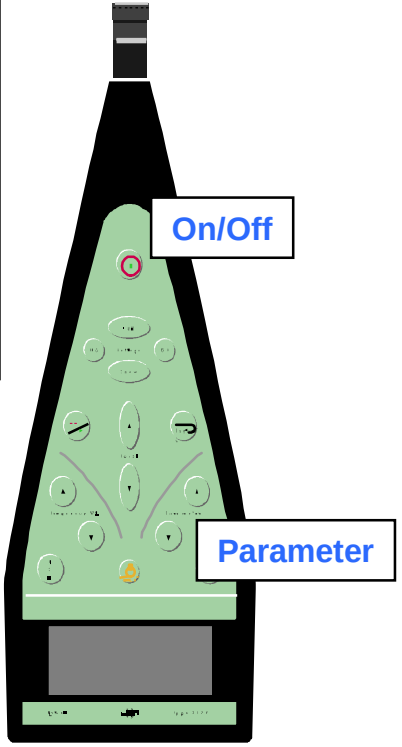
# Free field and Random Incidence

**Measure Free Field Value**

- Turn on the 2236 Sound Level Meter and point it at the drill
- Using a Parameter arrow button, select SPL
- Note what SPL you measure

**Measure Random Incidence Value**

- Place the random incidence corrector over the microphone
- Point the 2236 Sound Level Meter at the drill
- Using a Parameter arrow button, select SPL
- Note what SPL you measure



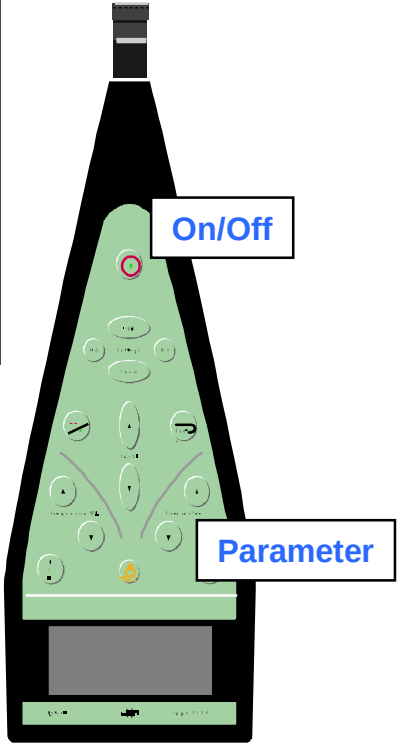
# IEC vs. ANSI

**Measure According to IEC**

- Turn on the 2236 Sound Level Meter and point it at the drill
- Using a Parameter arrow button, select SPL
- Note what SPL you measure

**Measure According to ANSI**

- Point the 2236 Sound Level Meter at an angle of approximately $70^{o}$-$80^{o}$ from the direction of the drill
- Using a Parameter arrow button, select SPL
- Note what SPL you measure

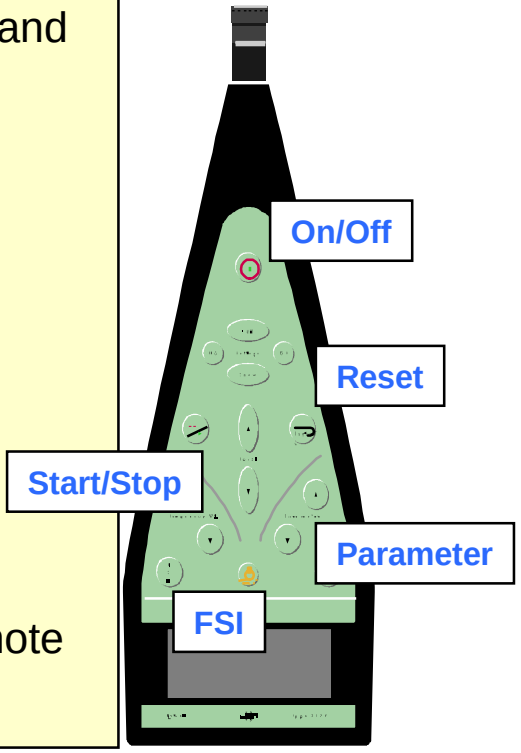


# Time Weighting - Continuous

- Turn on the 2236 Sound Level Meter
- Using the Time Weighting (FSI) button, select a Fast, Slow or Impulse time weighting and press start/stop to accept the change (**F**, **S** or **I** now appears at the bottom left of the display to indicate Fast, Slow and Impulse, respectively)
- Point the meter at the radio and start the measurement and measure for about one minute. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:

| | Fast | Slow | Impulse |
|---|---|---|---|
| – MaxP | | | |
| – MaxL | | | |
| – MinL | | | |

- Using the Reset button, reset the sound level meter
- Repeat the measurement for all 3 time weightings and note the results

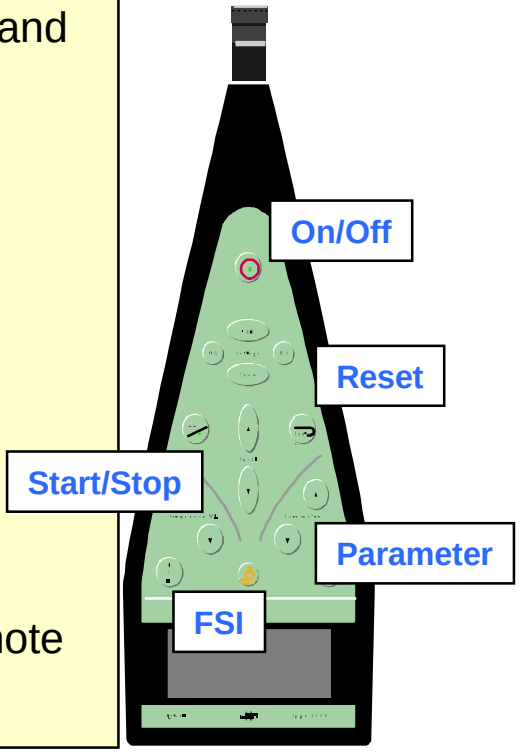


# Time Weighting - Intermittent

- Turn on the 2236 Sound Level Meter
- Using the Time Weighting (FSI) button, select a Fast, Slow or Impulse time weighting and press start/stop to accept the change (**F**, **S** or **I** now appears at the bottom left of the display to indicate Fast, Slow and Impulse, respectively)
- Point the meter at the radio and start the measurement and measure for about one minute. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:

| | Fast | Slow | Impulse |
|---|---|---|---|
| – MaxP | | | |
| – MaxL | | | |
| – MinL | | | |

- Using the Reset button, reset the sound level meter
- Repeat the measurement for all 3 time weightings and note the results

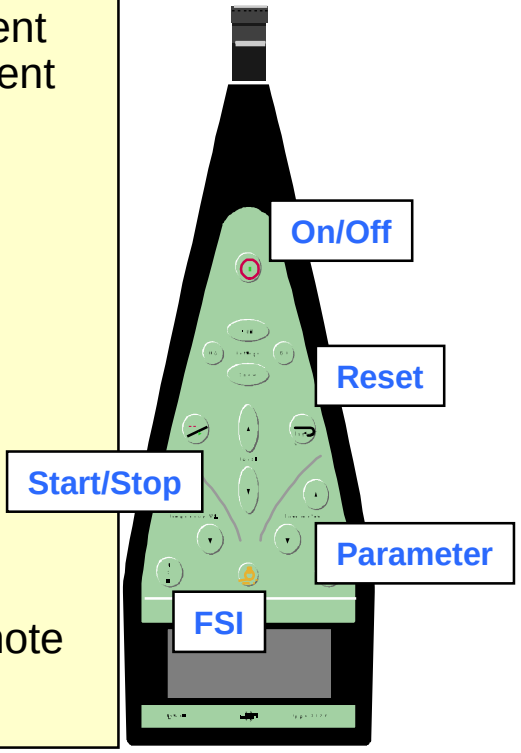


# Time Weighting - Impact

- Turn on the 2236 Sound Level Meter
- Using the Time Weighting (FSI) button, select a Fast, Slow or Impulse time weighting and press start/stop to accept the change (**F**, **S** or **I** now appears at the bottom left of the display to indicate Fast, Slow and Impulse, respectively)
- Point the meter at the hammer and start the measurement and measure for about one minute. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:

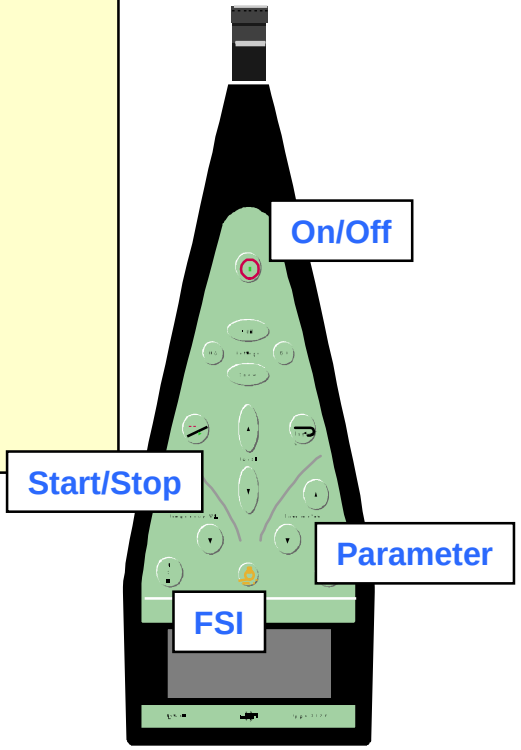
| | Fast | Slow | Impulse |
|---|---|---|---|
| – MaxP | | | |
| – MaxL | | | |
| – MinL | | | |

- Using the Reset button, reset the sound level meter
- Repeat the measurement for all 3 time weightings and note the results



# Crest Factor

- Turn on the 2236 Sound Level Meter
- Using the Time Weighting (FSI) button, select the Fast time weighting (**F**, **S** or **I** now appears at the bottom left of the display)
- Point the meter at the hammer and start the measurement and measure for about 3 hammer blows. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:
  - MaxP
  - $L_{eq}$
- Calculate the crest factor




**Crest factor =** $\frac{\text{MaxP}}{L_{eq}}$ **=** ——— **=**

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# Measuring Sound in Practice

- $L_{eq}$
- SEL
- Statistics
- Noise Dose
- Calibration
- Sound Level Meter Placement

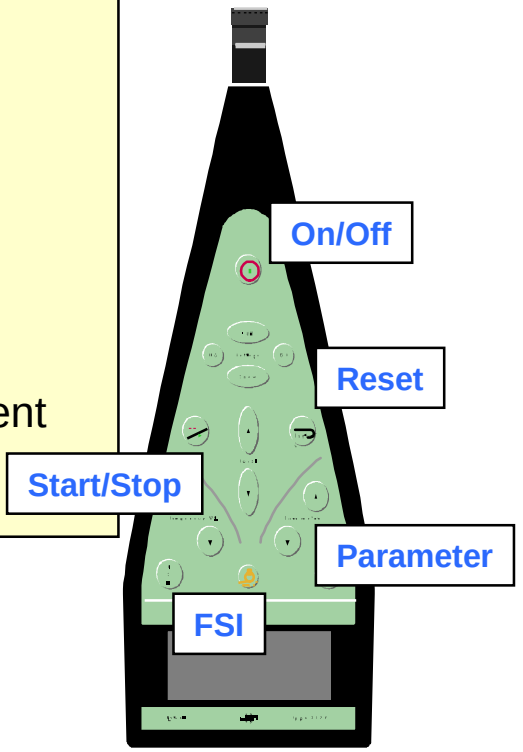
# $L_{eq}$

**$L_{eq}$ for a Continuous Noise**

- Turn on the 2236 Sound Level Meter
- Using the Time Weighting (FSI) button, select the Fast time weighting (**F**, **S** or **I** now appears at the bottom left of the display)
- Using a Parameter arrow button, select $L_{eq}$
- Point the meter at the radio and start the measurement
- Note how the $L_{eq}$ changes during the measurement

**$L_{eq}$ for an Event (Impacts)**

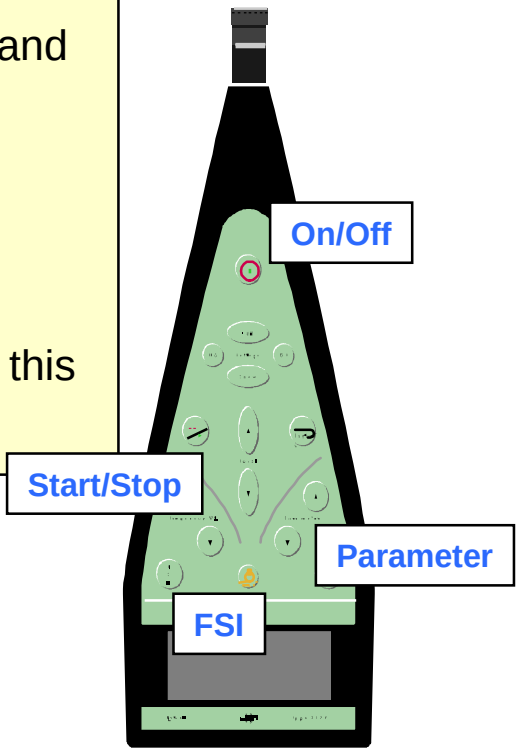
- Using the Reset button, reset the sound level meter
- Point the meter at the hammer and start the measurement
- Note how the $L_{eq}$ changes during the measurement



# SEL

- Turn on the 2236 Sound Level Meter
- Using the Time Weighting (FSI) button, select the Fast time weighting (**F**, **S** or **I** now appears at the bottom left of the display)
- Using a Parameter arrow button, select $L_{eq}$
- Point the meter at the radio and start the measurement and measure for about 10 seconds. Stop the measurement (**PAUSE** appears on the display)
- Note the $L_{eq}$ you measured and the measurement time
- Calculate the SEL
- Using a Parameter arrow button, select $L_{AE}$ (another expression for SEL) and compare the calculated SEL to this figure

$$SEL = L_{eq} + 10 \log\left(\frac{t}{1s}\right) = \quad + \quad =$$

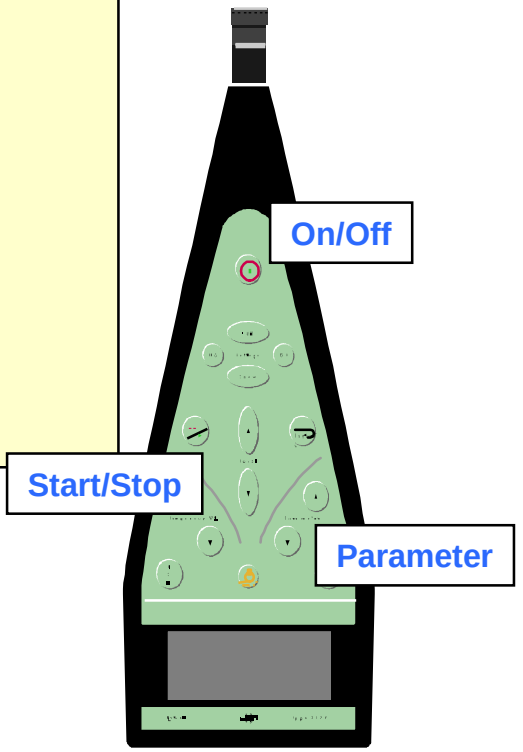


# Statistics

- Turn on the 2236 Sound Level Meter
- Point the meter at the radio and start the measurement and measure for about 10 seconds. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:
  - $L_{10}$
  - $L_{50}$
  - $L_{90}$

| |
|---|
| |
| |
| |

- Note: $L_X$ may have different settings in the actual sound level meter



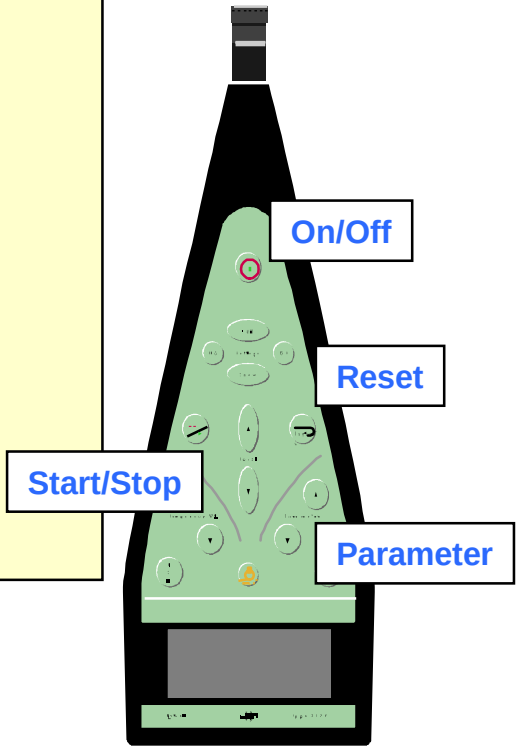
# Noise Dose and Exposure

- Turn on the 2236 Sound Level Meter
- Point the meter at the radio and start the measurement and measure for about a minute. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:
  - Peak
  - $L_{EP,d}$

| |
|---|
| |

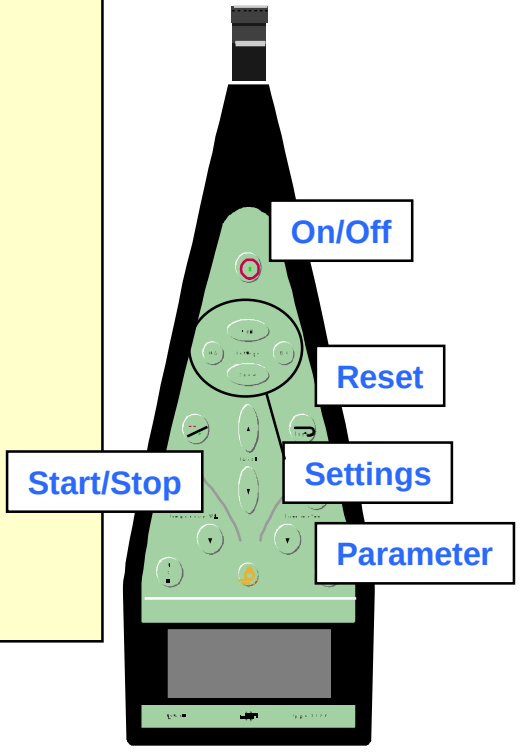
- Using the Reset button, reset the sound level meter
- Repeat the measurement for another measurement (exposure) time and note what you measured for:
  - Peak
  - $L_{EP,d}$

| |
|---|
| |



# Calibration

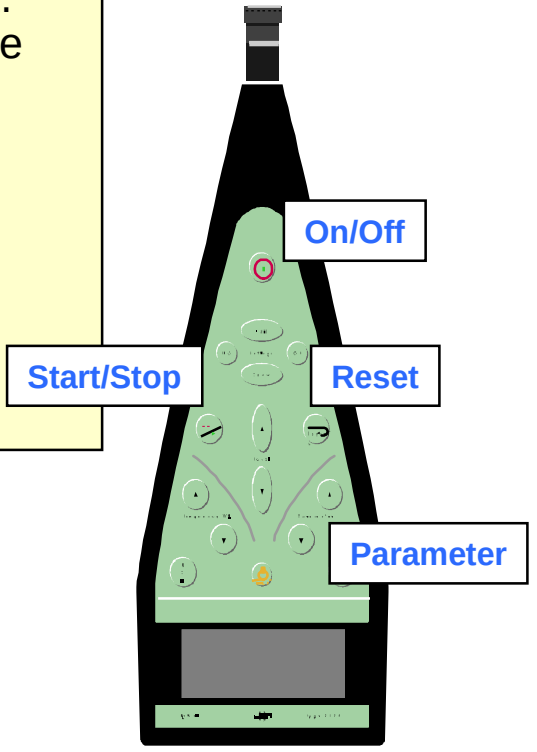
- Check the calibration of the sound level meter Turn on the 2236 Sound Level Meter
- Mount a 4231 Sound Level Calibrator on the microphone of the meter
- Press the Show Settings button 2 times (**CALIBRATION** appears on the display)
- Press the Edit Settings button and select 94.0 dB
- Switch on the calibrator
- Press OK
- The sound level meter now checks its calibration
- Press OK to use the new calibration
- Press NO to return to the main display
- Using a Parameter arrow button, select the SPL
- Note what you measure
- Remove the calibrator and listen to its signal



# Position of the Sound Level Meter (1 of 2)

**Correct Placement**

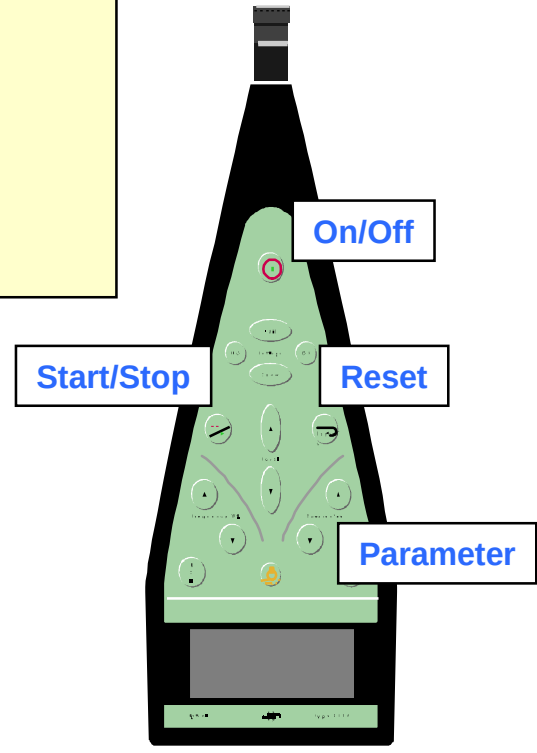
- Stand in a position away from reflecting surfaces (see handouts)
- Turn on the 2236 Sound Level Meter
- Point the meter at the radio and start the measurement. Hold the sound level meter at arm's length and measure for about a minute. Stop the measurement (**PAUSE** appears on the display)
- Using a Parameter arrow button, select the following parameters and note what you measured for each:
  - MaxL
  - $L_{eq}$



# Position of the Sound Level Meter (2 of 2)

**Incorrect Placement**

- Using the Reset button, reset the sound level meter
- Stand in a position close to reflecting surfaces and repeat the measurement holding the sound level meter close to your body
- Select the following parameters and note what you measured for each:
  - MaxL
  - $L_{eq}$



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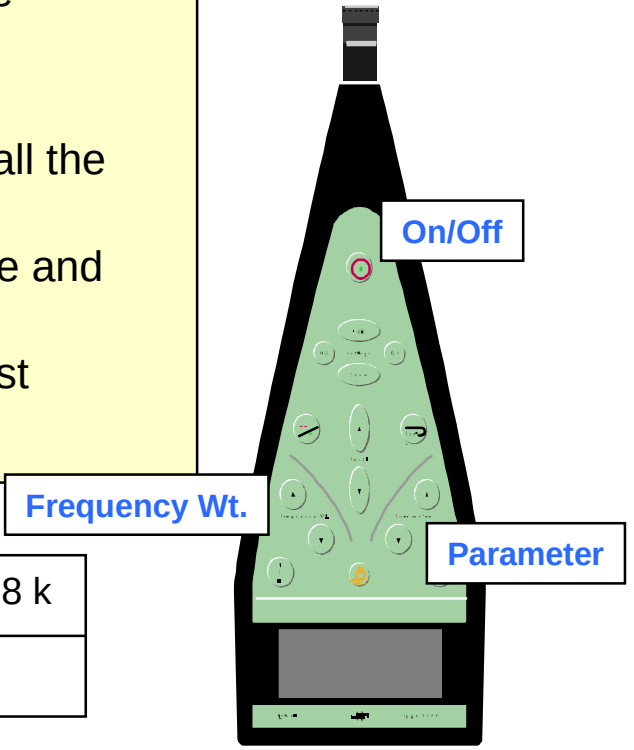
# Basic Frequency Analysis of Sound

- **Frequency and Wavelength**
  - Diffraction
- **Frequency Analysis**
  - Continuous broadband noise
  - Intermittent noise
  - Continuous noise (tones)
  - Spectrum and dB(L)
- **Perception**
  - Frequency weighting
  - Parallel and serial analysis

# Frequency and Wavelength

**Diffraction**

- Turn on the 2236 Sound Level Meter and point it at the radio at a distance of app 1 meter
- Using a Parameter arrow button, select SPL, Fast
- Press the Frequency Wt. ↑ until the first octave centre frequency is displayed
- Note what SPL you measure and fill in the table
- Press the Frequency Wt. ↑ and measure the level in all the octave bands
- Shield the signal path from the radio to the microphone and repeat the measurements
- Note the frequencies where the binder gives the largest attenuation of the signal



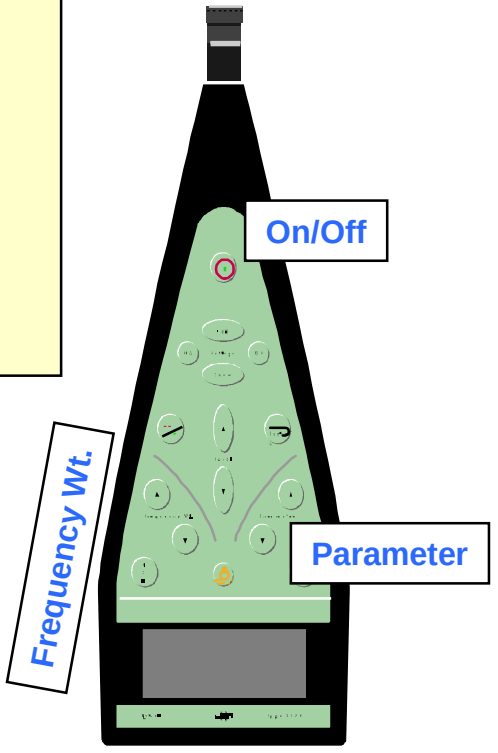

| **Freq. band** | 31,6 | 63 | 125 | 250 | 500 | 1 k | 2 k | 4 k | 8 k |
|---|---|---|---|---|---|---|---|---|---|
| **Level in dB** | | | | | | | | | |

# Frequency Analysis

**Spectra of continuous and intermittent signals**

- Set the radio to play music as an example of intermittent noise
- Turn on the 2236 Sound Level Meter and point it at the radio at a distance of app 1 meter
- Using a Parameter arrow button, select SPL, Fast
- Measure the spectrum from the intermittent noise in octaves
- Switch off the radio, turn on the drill and repeat the measurement
- Turn off the drill and measure the spectrum for repeated hammer blows

| **Freq. band** | 31,6 | 63 | 125 | 250 | 500 | 1 k | 2 k | 4 k | 8 k |
|---|---|---|---|---|---|---|---|---|---|
| **Intermittent** | | | | | | | | | |
| **Continuous** | | | | | | | | | |
| **Impact** | | | | | | | | | |



# Discussion of Results

- Comment on the difference and usefulness of the serial octave measurement compared to the previous measurement of white noise for
  - Intermittent noise from radio
  - Continuous noise from drill
  - Impact noise from hammer blow

# Frequency Weighting

**Frequency Weighting**

- Set the radio to play white noise
- Turn on the 2236 Sound Level Meter and point it at the radio at a distance of app 1 meter
- Using a Parameter arrow button, select SPL, Fast
- Using the Frequency Wt. arrow button and measure the parameters listed in the table below

| | |
|---|---|
| **dBA** | |
| **dBC** | |
| **dBL** | |