Royal Netherlands Air Force

Barometric pressure equalization properties of passive noise filters used in custom communications earplugs.

SAFE Europe Hamburg 2023

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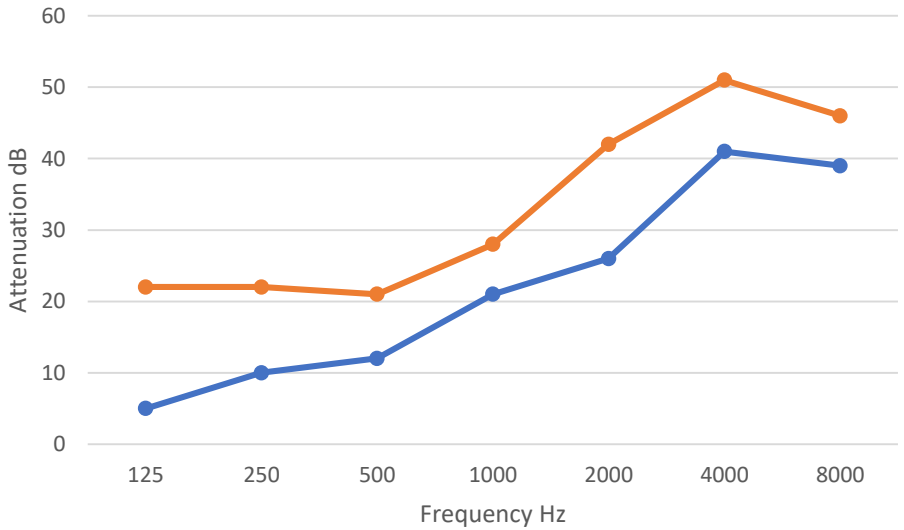
08 July 2024

Introduction

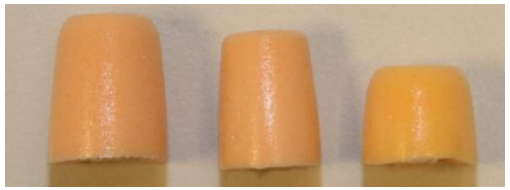
- Military aircrafts have become increasingly noisy (>100 dB)
  - Helmet noise attenuation is insufficient especially in low frequency
  - Aircrew use double hearing protection (helmet + ear plug)
    - Negatively effects speech intelligibility



Communications ear plug (CEP) – foam tips

- Pros
  - Provides extra hearing protection
  - Improves speech intelligibility

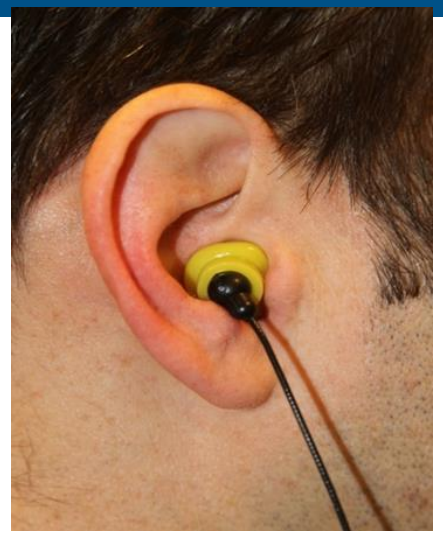
- Cons
  - Proper insertion takes too long
  - Large variation in attenuation
  - Foam tips don’t always fit (one size doesn’t fit all)
  - Pressure and irritation in ear canal
  - Increase of discomfort during long duration flights
  - Falls out
  - Hygiene

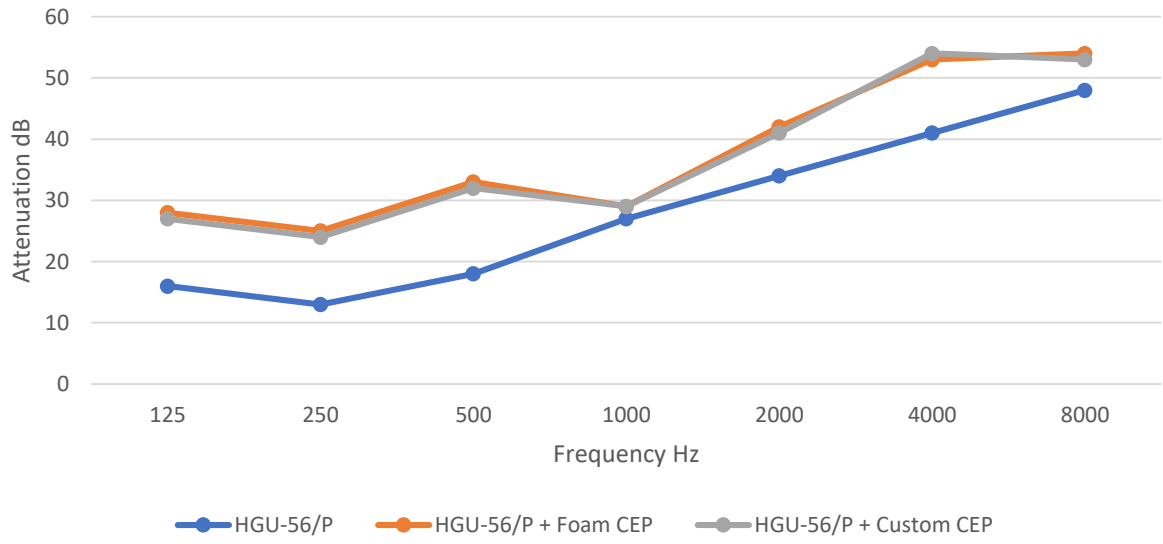


Communications ear plug – custom molded

- Pros
  - Better fitting – minimize discomfort
  - Small variations in attenuation
  - Soft and flexible
  - Fast and easy insert
  - Don’t fall easily out of the ear

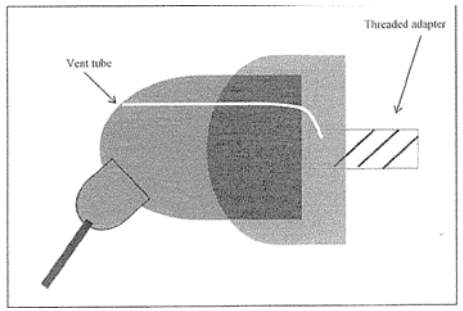
- Cons
  - Complaints over pressure build-up in middle ear cavity
  - Custom ear plug change every 3-4 years

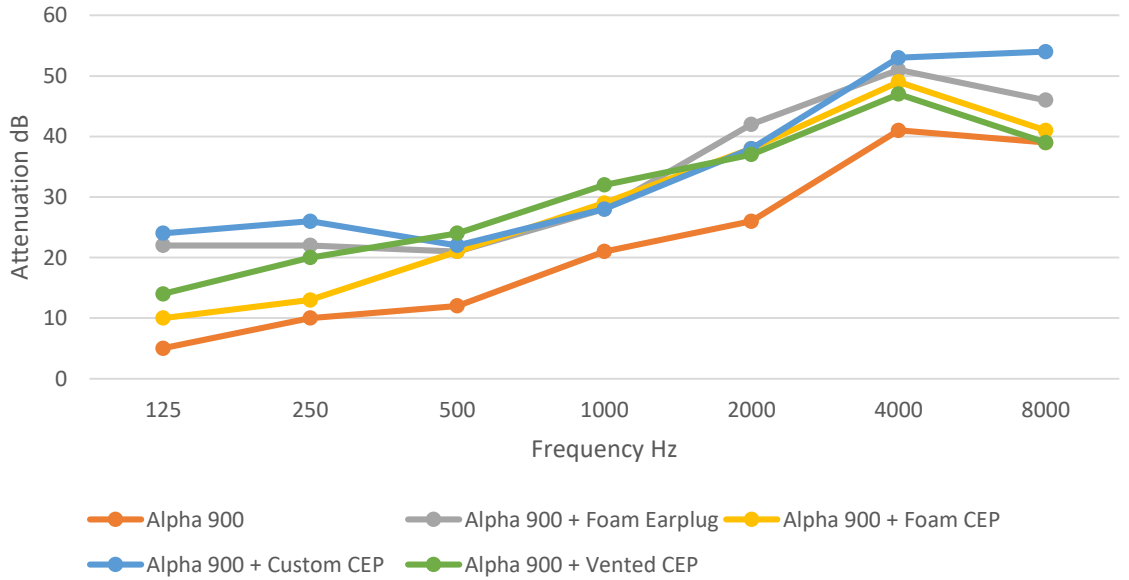




Communications Ear Plug – vented custom molded

- Minimal vent diameter – 0.3mm*
- Pros
  - Same advantages as non-vented custom molded ear plugs
  - Equalize pressure differential middle ear and ambient aircraft pressure
- Cons
  - Less attenuation at low frequencies



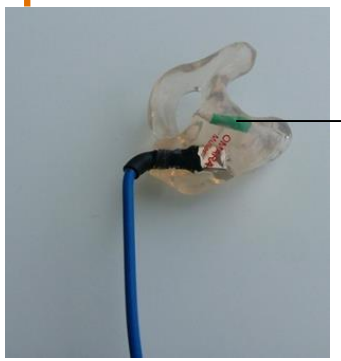


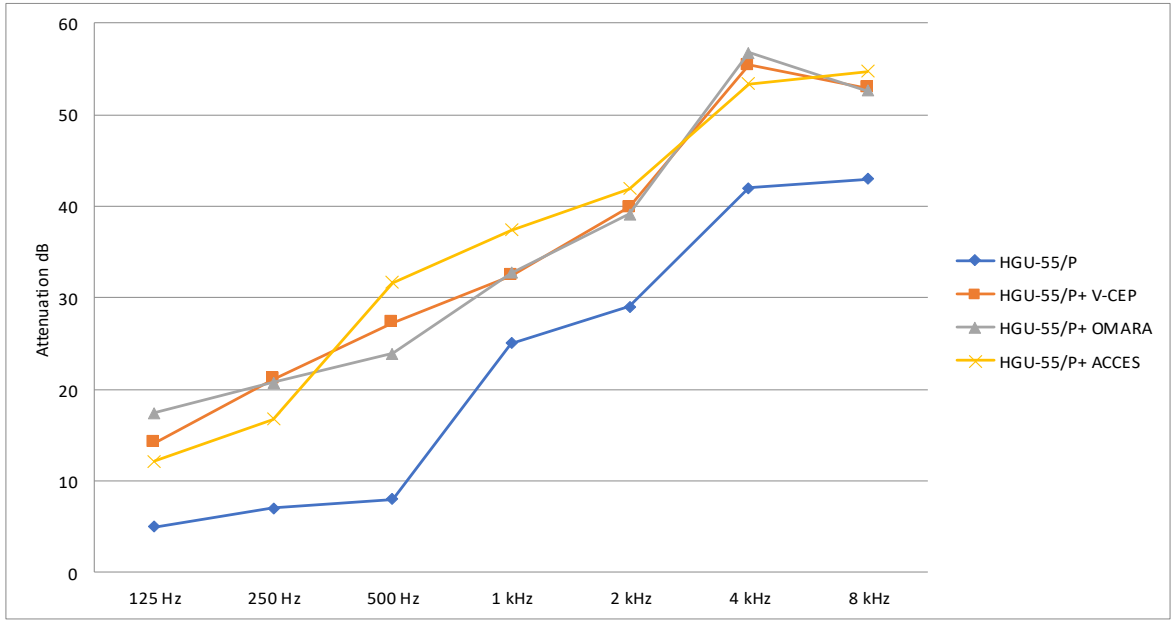
*Altitude Chamber Validation of Capillary Venting for Custom Earplugs, Air Force Research Laboratory, 2005

Communications Ear Plug – custom molded passive noise filter

- Pros
  - Improves attenuation
  - Different passive filters
  - Can be used for walk-around

- Venting canal is blocked by a passive filter – what is the effect on pressure equalization during rapid ascent, rapid descent and rapid decompression (RD)?



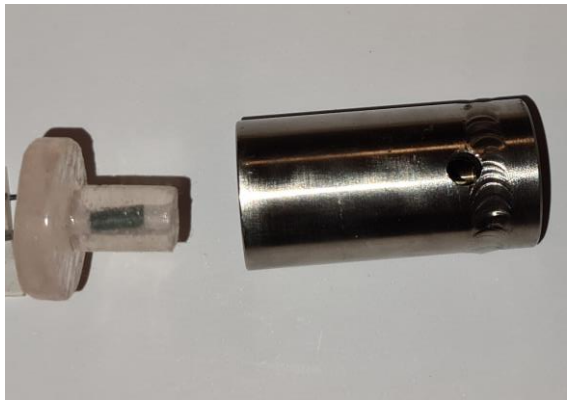


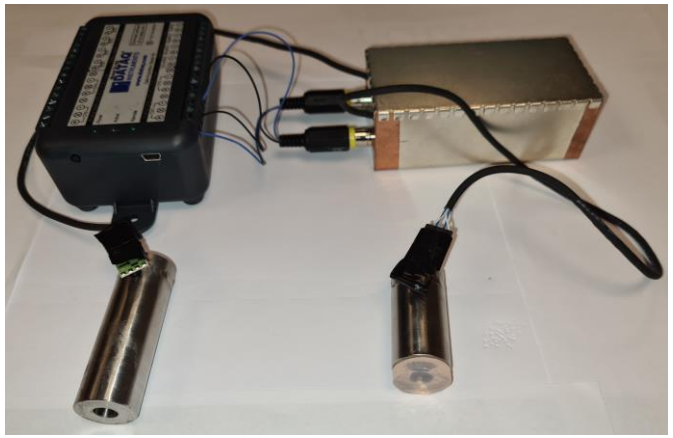
Method

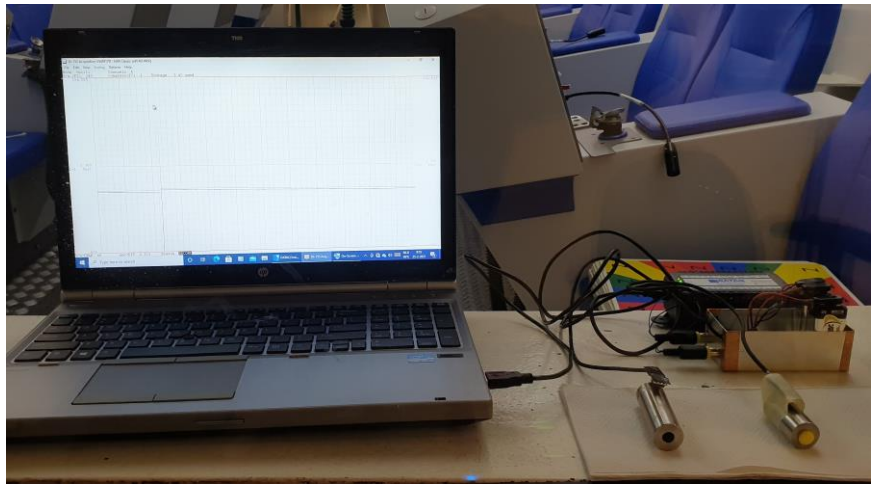
- Two passive CEP filters
- Hypobaric chamber

- Equipment
  - Two test cells
    - Mimic ear canal volume (small)
    - Ambient pressure
  - Silicone adapter for fitting the filters
  - Pressure sensors (15 PSI-AF-prime-mini)
  - Signal amplifier
  - Data acquisition unit - Dataq DI-155/HS – 5000Hz

- Procedure
  - Check for leaks in test cell
  - Ascent - 10,000 ft – 4000 ft/min
  - Descent -10,000 ft - 4000 ft/min
  - RD - 8000 to 25,000 ft in 3 sec
  - Each test repeated 3 times



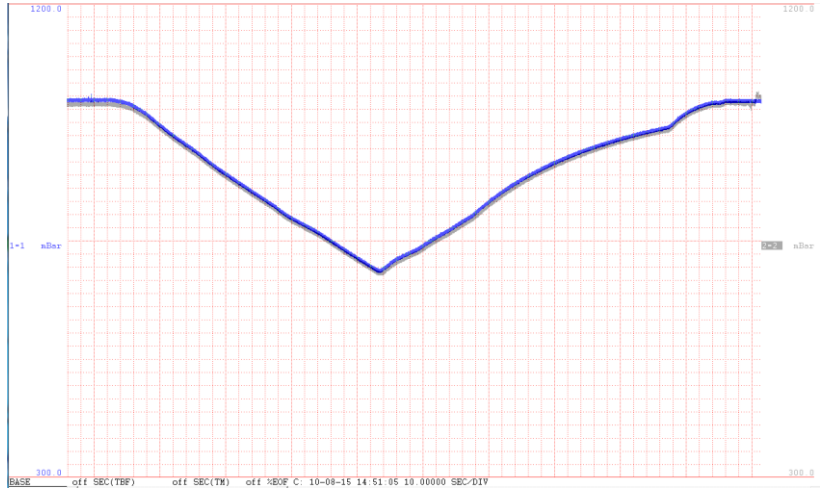




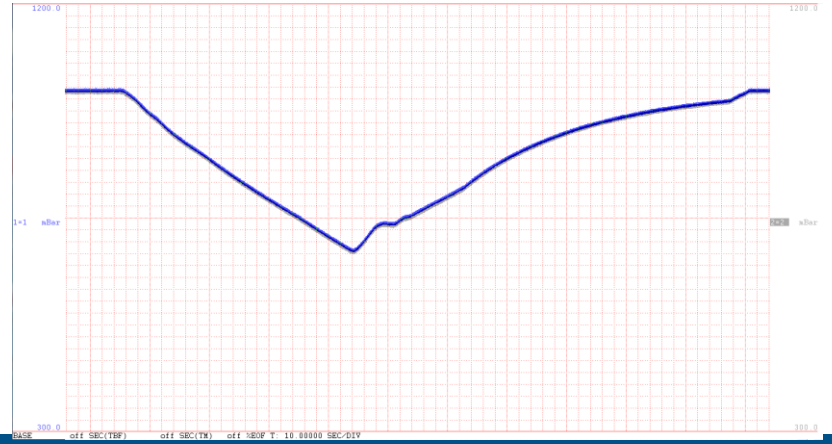
Results - rapid ascent and descent

In both filters the pressure in the test cell was able to follow the pressure in the hypobaric chamber.

Filter 1

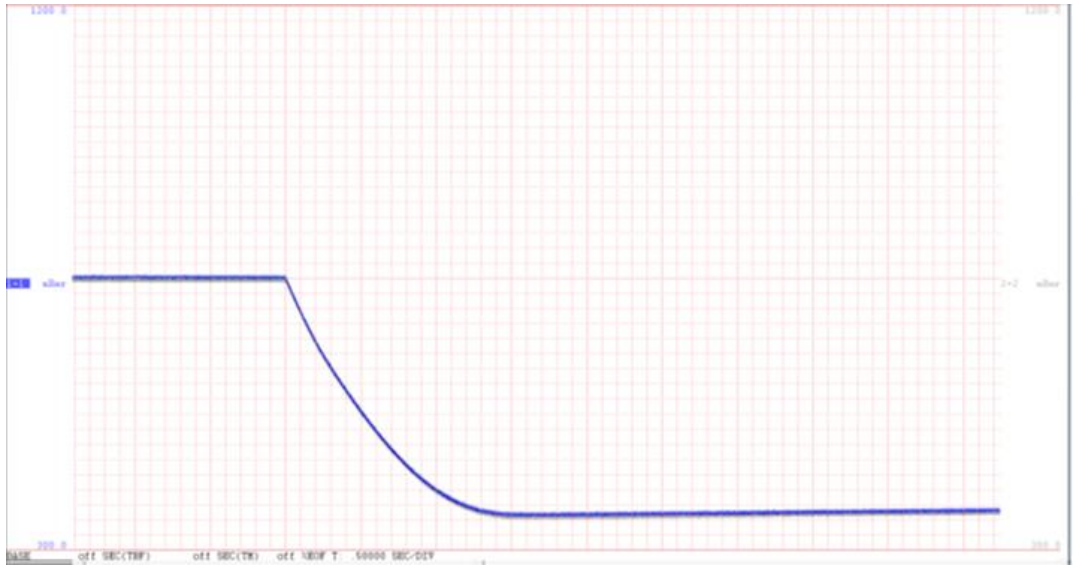


Filter 2



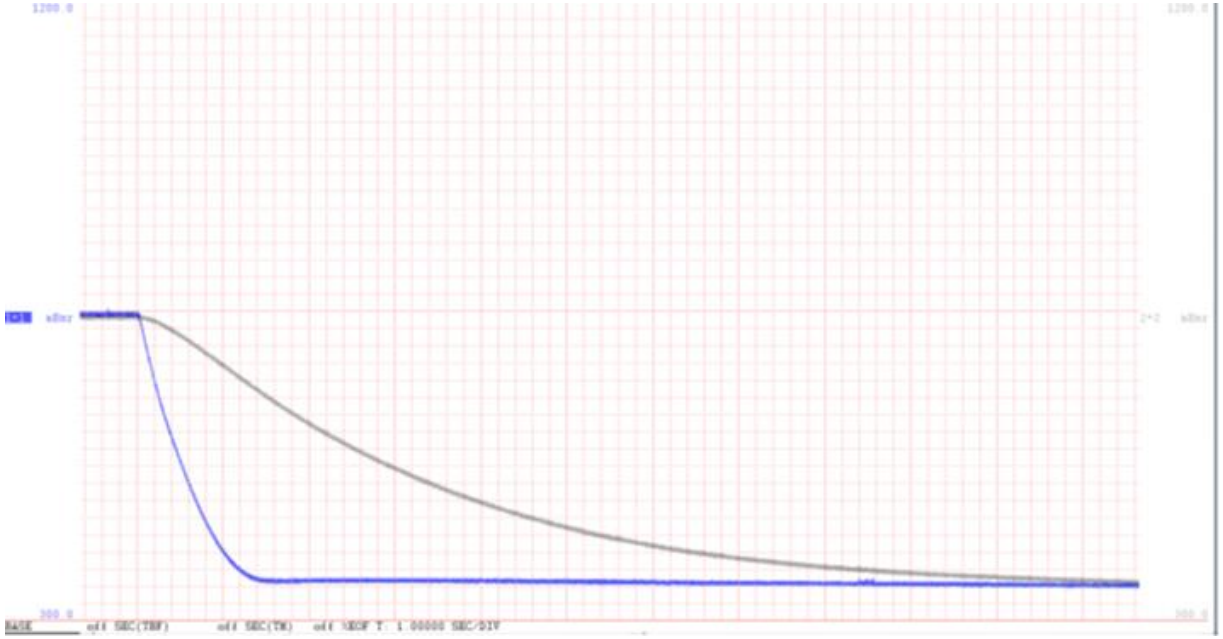
Results – RD filter 1

- No lag in trapped volume venting in the test cell when using filter 1 during RD test.



Results – RD filter 2

- A lag in trapped volume venting in test cell when using filter 2 during RD.
  - Peak pressure difference between 115 mbar (86 mmHg) and 215 mbar(161 mmHg)
  - Pressure equalization after ~50 sec
- Sever pain, nausea and occasionally vertigo, in some cases otologic barotrauma.



Conclusions

- No significant pressure differential was found in both filters during rapid ascent and descent (4000 ft/min).
- No significant pressure differential was found in filter 1 during RD
- A significant pressure differential was found in filter 2 during RD
  - Filter 2 was inadequate to equalize the air volume trapped behind the earplug.
  - Can have a significant physiological effect
- CEP passive attenuation filters need to be designed to allow free flow of air even during extreme pressure changes.

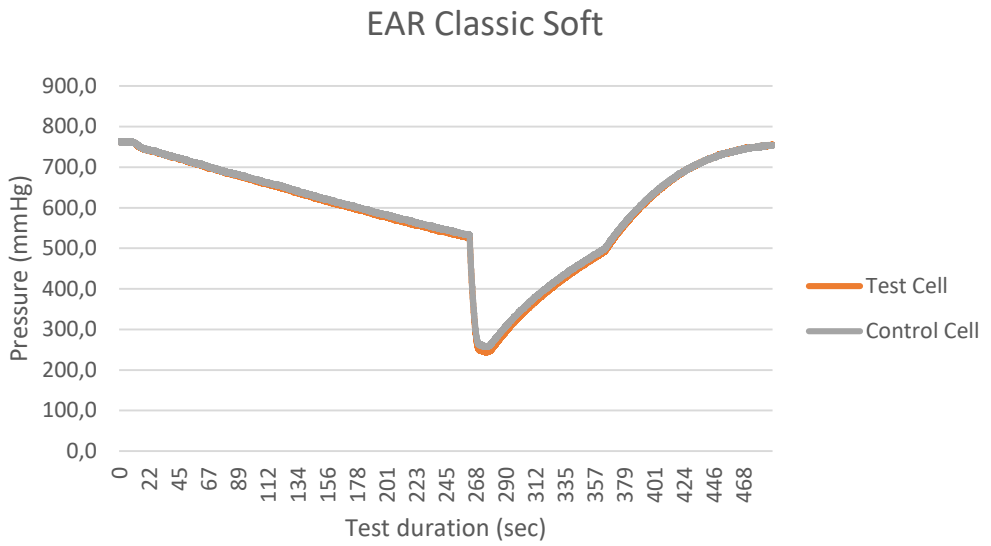
Determination of pressure equalization properties foam ear plugs

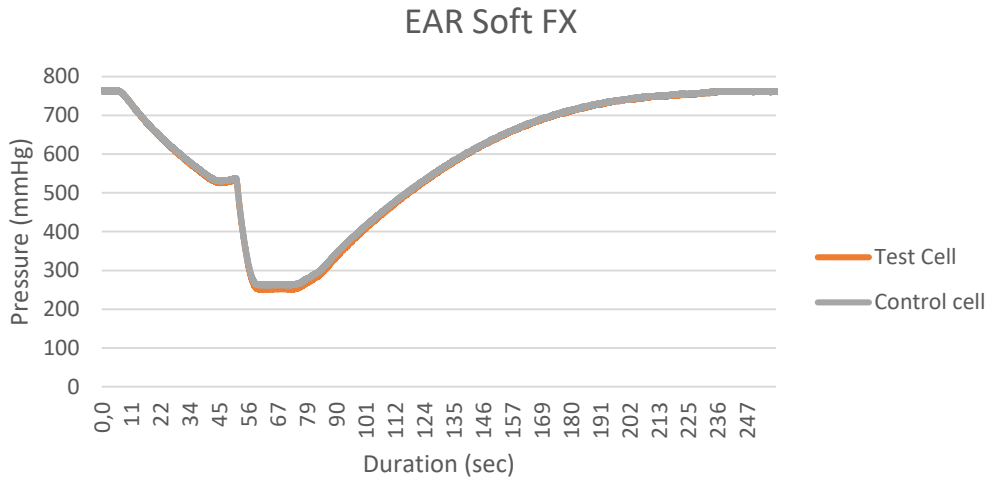
- Diffetent types of foam ear plugs used by aircrew
  - Exposed cell surface texture or coated
  - Different shapes
  - Different insertion depth

Results + conclusion

- No significant pressure differential was found in the different foam ear plugs during rapid ascent, rapid descent (4000 ft/min) or RD.

- Foam ear plugs approved for flight in aircrafts with risk of RD





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