

anechoic chamber ...

- It gets about as quiet as it does when you enter an anechoic chamber. It feels unnatural since it is so quiet, there are no other noise sources in the room and the walls don't reflect much sound and so your eyes and ears are conflicted.
- If you are set quietly, you are startled that you can hear your heart beating, and how loud your breathing is...
- That's because the ambient in the room is so low



- By testing hundreds of people in this kind of chamber scientists can measure effects of different frequencies of sound.

Sound level loudness can be measured with a meter but sound level annoyance levels cannot.

Using A-weighting, which is more sensitive to audible sound, under measures the level of low-frequency sound

A meter can be calibrated to be C-weighted or A-weighted

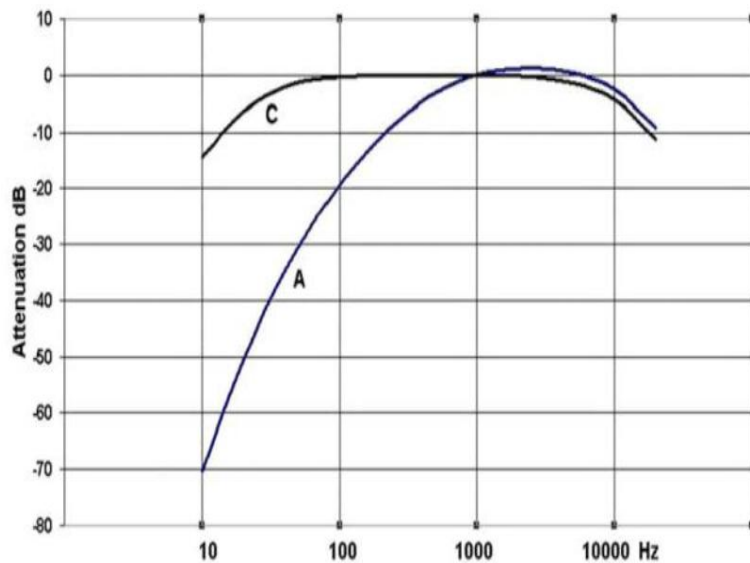
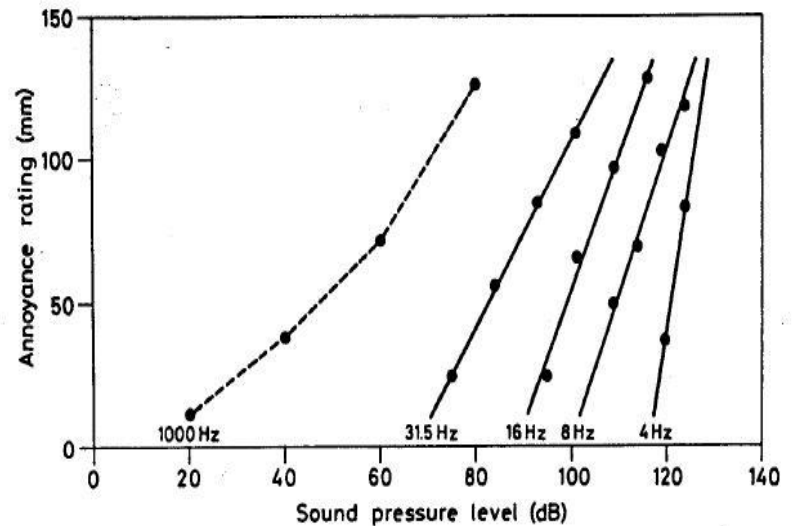


Figure 4. Sound level meter weighting curves – A and C.



Peer reviewed literature

- **There is a large collection of articles published over the course of 40+ years starting with the effects on astronauts and cosmonauts and eventually airplane and helicopter pilots and technicians.**
- Mohr GC, Cole JN, Guild E, Von Gierke HE. (1965) Aerospace Medicine, 36, 817-24. **“Effects of low-frequency and infrasonic noise on man”**
- Slarve, R.N. and Johnson, D.L. (1975) Aviation, Space & Environmental Medicine, 46, 428-31. **“Human whole-body exposure to infrasound.”**
- Col. N.A.A. Castelo Branco, MD RTO AVT Symposium on Ageing Mechanisms and Control: Developments in Computational Aero-and Acoustics held in Manchester, UK, 8-11 October 2001, and published in RTO-MP-079(I). **“Low Frequency Noise: A Major Risk Factor in Military Operations”**
- A Science & Global Security 2001 article by Jurgen Altmann [“Acoustic Weapons- A Prospective Assessment”](#) reviews 164 publications.
- James Jauchem and Michael Cook published an article in Feb 2007 entitled [“High-Intensity Acoustics for Military Nonlethal Applications: A Lack of Useful Systems”](#) includes a review 138 articles.

Peer Reviewed Literature cont'd

- In November 2001 the **National Institute of Environmental Health (NIEHS)** published a review [Infrasound Toxicological Summary](#). where they reviewed over 100 relevant studies that differed widely in their experimental design and selection of endpoints for evaluation. *“Thus, this document may serve as a starting point for determining what types of experimental toxicology research or testing may be useful for further characterizing of potential adverse health effects of infrasound exposure in humans.”*
- A May 2003 report for **Defra (Department for Environment, Food and Rural Affairs)** by Dr . Geoff Leventhall [“A Review of Published Research on Low Frequency Noise and its Effects”](#). This is an excellent review of ~200 articles. The author comments *“We do know that problems arise fairly widely, and on an international scale.”*
- **H. Ising and B. Kruppa from the German Federal Environmental Agency** published a review in *Noise & Health* 2004 Vol 6: 5-13. [Health effects caused by noise: Evidence in the literature from the past 25 years](#). They site 41 articles, and identify traffic noise as the most important source of environmental annoyance, followed by airplanes taking off and landing.

Health Effects of Low Frequency Sound

- ILFN is the term for infrasound (0-20Hz)+low frequency sound(20-500Hz)
Vibroacoustic disease (VAD) is pathology resulting from long-term exposure to ILFN. *A small number of people are immediately sensitive to ILFN, mainly through the impact on the vestibular system*, but **chronic exposure to high levels over a period of years will impact most people.**
- *"I wake up tired, I don't rest during my sleep".*
- *"I hear too much, I'm very sensitive to noise, noise drives me crazy".*
- *"Sometimes, while in a mall or restaurant I feel like I can't breathe".*
- *"I have a lot of palpitations".*
- "I have this cough and I don't smoke, my throat is constantly irritated and I get hoarse for no reason".
- Late-onset epilepsy
- Balance disorders
- Migraines
- Hypertension

WTS

VAD Team Leader

- Nuno Alvares de Abreu Castelo Branco, joined the Portuguese Air Force in 1962 and is a retired Colonel of this branch of the Armed Forces. He graduated from Lisbon University Medical School in 1971 and in 1977 was awarded the degree of Aerospace Pathology Specialist by the Armed Forces Institute of Pathology in Washington, D.C., USA and a degree in Aerospace Medicine at Brooks Air Force Base in San Antonio, TX, USA. He became a Medical Specialist in Surgical Pathology, at the Civilian Hospitals of Lisbon, Portugal. In 1979 he was promoted to ***chief medical officer at an aircraft manufacturing, rework and maintenance facility owned and operated by the Portuguese Air Force***. Since 1980, he has coordinated a team of researchers who investigate the biological effects of low frequency noise exposure, known as the *VAD Team*.

VAD – Vibroacoustic Disease

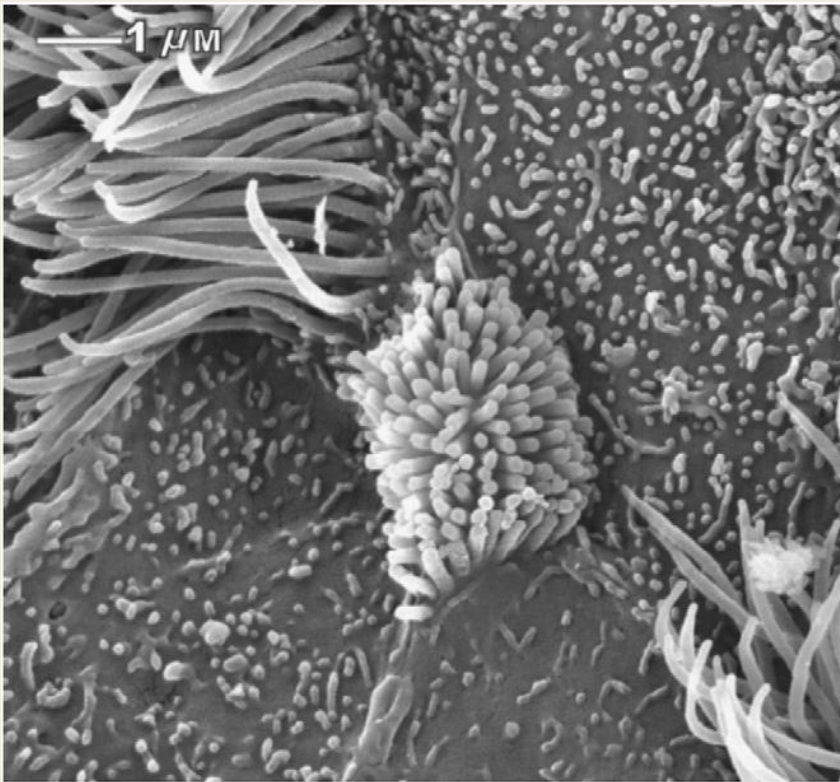
Echocardiographic Measurements

Measurement Group	Mean Score (SD)	# Cases
Mitral valve		
Group I <70 dB	0.43 (0.50)	48
Group II 70-90 dB	0.88 (0.34)	113
Group III >90 dB	1.49 (0.55)	324
Aortic Valve		
Group I <70 dB	0.25 (0.43)	48
Group II 70-90 dB	0.49 (0.51)	113
Group III >90 dB	1.02 (0.53)	324

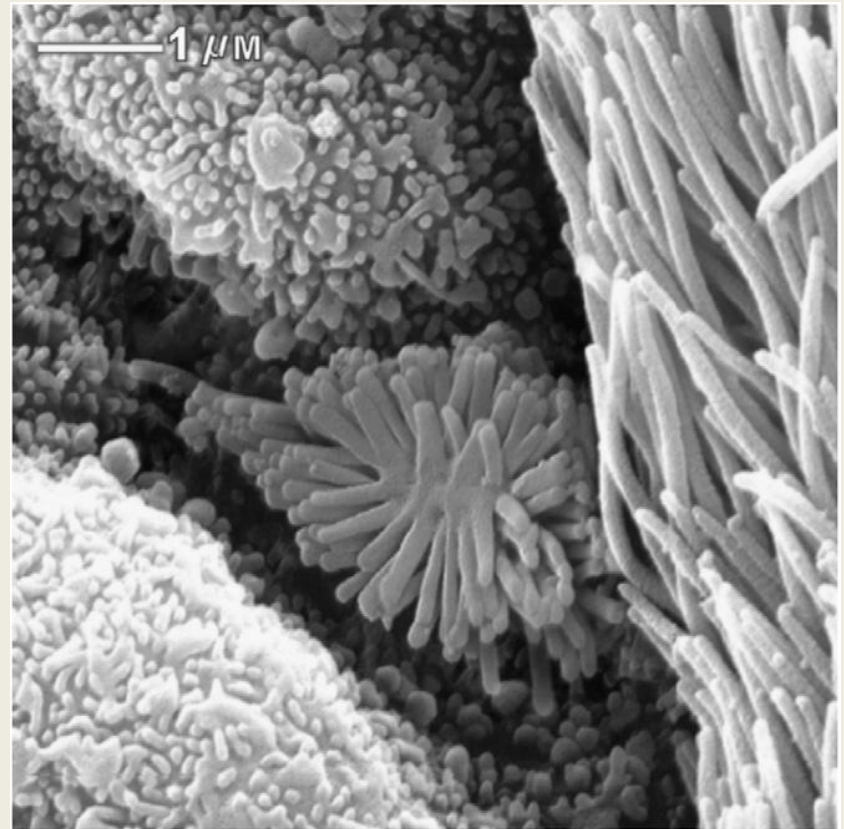
- Initial VAD studies focused on occupational settings within a military aeronautical plant. In late 1980's, they expanded to military fixed- and rotary winged aircraft then expanded to other occupations with significant exposure to low frequency sound. The results of these studies were the finding of heart, blood vessel and respiratory tract ILFN effects.
- VAD involves an abnormal growth of elastin and collagen within the extracellular matrix surrounding multiple organs and tissues of VAD patients. Exposure to low frequency noise results in changes in biomechanical forces involved in a wide range of cellular processes.
- Through the use of this tension-dependent building system, mechanical forces applied at the macroscale produce changes in biochemistry and gene expression within individual living cells. This structure-based system provides a mechanistic basis to explain how the application of physical impacts, such as low frequency sound, might influence cell and tissue physiology.

Brush cell microvilli respond to ILFN

Non-exposed rat bronchial epithelium.

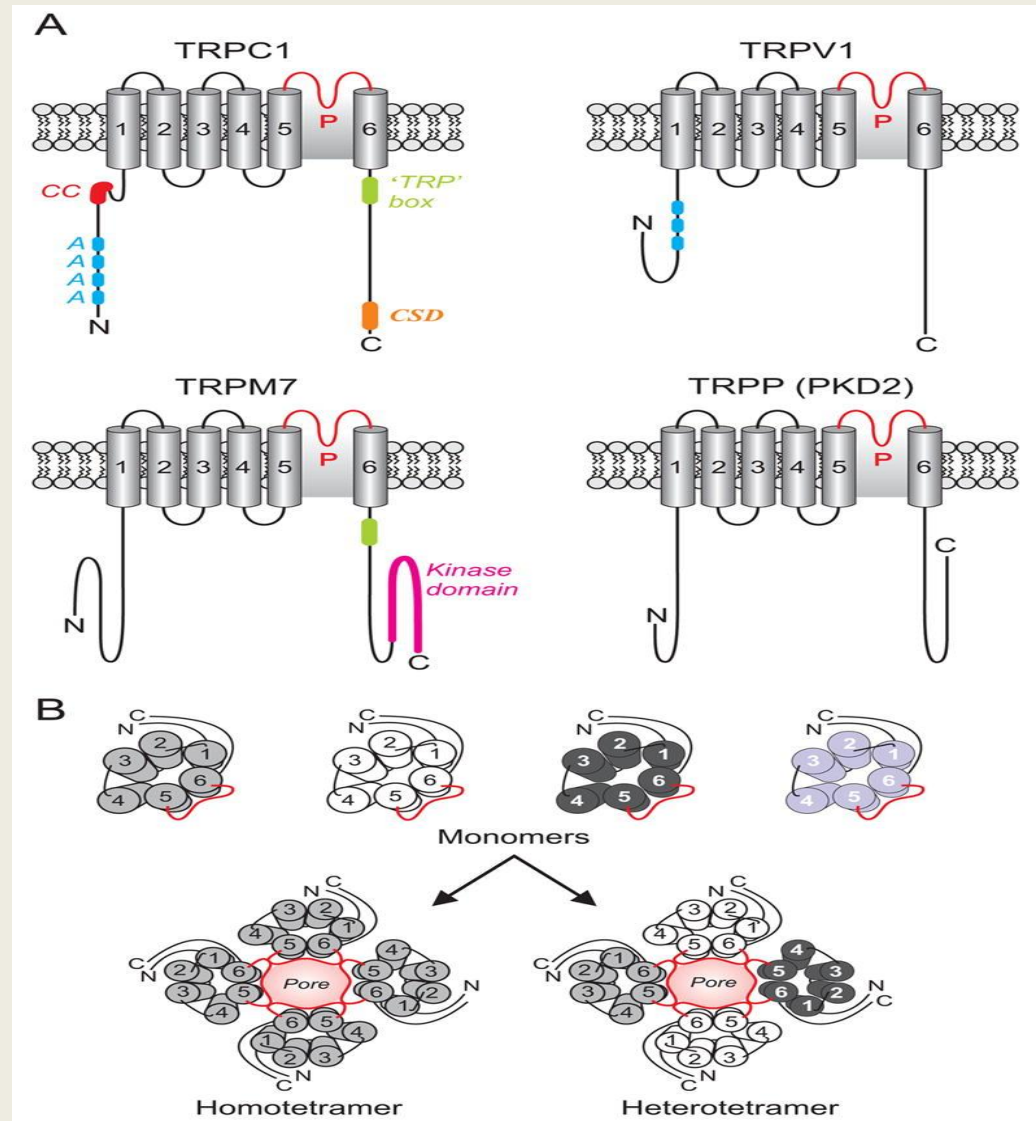


Rat bronchial epithelium exposed to 90 days of ILFN



TRP Channels

Transient Receptor Potential Channels belong to the super-family of cation channels. At least 30 different mammalian genes have been identified. They represent a novel class of non-selective cation channels and have **emerged at the forefront of research into hypertension**. They are also involved in some systemic diseases due to their role as targets for irritants, inflammation products and xenobiotic toxins and mechanical stress.



World Health Organization publication on **Community Noise (Berglund et al., 2000)**

- *" It should be noted that low frequency noise, for example, from ventilation systems can disturb rest and sleep even at low sound levels"*
- *"For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended"*
- *" When prominent low frequency components are present, noise measures based on A-weighting are inappropriate"*
- *"Since A-weighting underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting"*
- *"It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health"*
- *"The evidence on low frequency noise is sufficiently strong to warrant immediate concern"*

Alice H Suter

Noise and Health January 2009

- It has been ***twenty-five years*** since the final version of the Hearing Conservation Amendment was issued by the Occupational Safety and Health Administration in the U.S. Department of Labor. Since that time, ***some things have changed*** and ***others have stayed exactly the same....*** Some of the noise regulation's provisions are embarrassingly outdated, some are in dire need of improvement, and others, such as ***the requirements for engineering noise control, are not being enforced.*** Sadly, there seems to be little progress in reducing overall noise exposure levels.