Information for employees and students working at the Faculty of Science (W&N)
This AMD information sheet regards noise, and describes the different types of noise and how to prevent hearing damage.

1 What is sound?

Sounds are everywhere. They may be soft, such as a whisper or the rustling of corn in the wind, and they may be loud, such as an airplane flying over low. When sounds are unwanted or unintended, they are often referred to as 'noise'. Sounds are produced by sources of sound (or noise) (such as a device, a human voice, a passing vehicle, etc.) that can cause a vibration in the air particles. These vibrations are transmitted into all directions by colliding air particles and transported that way through the air as a wave. You can think of this as a rock thrown into water; the ripples of the water surface yield a motion similar to the sound waves through the air.

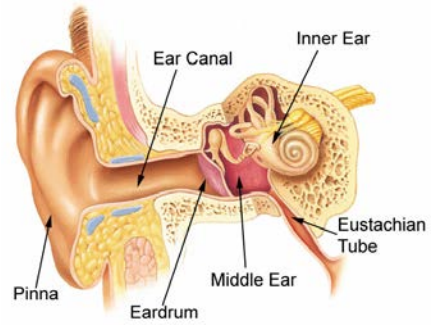
1.1 Sound: definitions

Sound occurs in different pitches (sound frequencies) and volumes (loudness). The sound frequency indicates the number of vibrations per second. For example 100 Hz = 100 vibrations per second.

The sound frequency is given in Hertz (Hz)
The sound level is given in decibel (dB)

The volume or loudness of sound refers to the changes in air pressure caused by the sound vibrations. The larger the pressure changes, the louder the sound. The unit of this sound pressure is Pascal (Pa). By comparing the sound pressure with a reference pressure, while using a logarithmic scale, we get the unit decibel (dB) for the sound level. However, the sensitivity of the human ear is not equal for all sound frequencies, which is why a correction factor is used, the so-called sound filter A. Therefore, the sound level as perceived by the ear is expressed in dB(A).

1.2 The human ear



The human ear can hear sounds between 20 and 20,000 Hz, but its highest sensitivity lies between 100 and 5,000 Hz. With age, we lose the ability to hear the higher frequencies. Zero decibel is the hearing threshold; this is the weakest sound we can perceive at 1,000 Hz. The pain threshold lies at 120 dB(A). However, sound may already cause hearing damage far below this pain threshold.

Sound waves are caught by the ears and travel through the hearing ear canal to the eardrum which they collide against, causing vibrations. The vibrations of the eardrum cause pressure changes that are converted into electrical signals by the cilia that are present in the inner ear. These electrical signals are transmitted by the auditory nerve to the brain in which they are perceived as sound. Exposure to sounds (or noises) that are too loud causes damage to the cilia, which

results in their inability to properly register and report the vibrations. Hearing damage occurs first in the most sensitive range (4 kHz), exactly where human speech is perceived. If it occurs, you will find that in a noisy environment, such as at a birthday party, it will become increasingly harder to understand people, because you will no longer be able to separate between speech and background noises. This is called noise-induced deafness, and you find several You Tube videos to test your own hearing.

2 Types of sound

There are several classifications for noise possible within a working environment. The Dutch Occupational Health and Safety Act ("Arbowet") speaks of harmful noise and annoying noise, but one may also use a classification based on frequency ranges or sources of noise.

2.1 Harmful and objectionable noise

Harmful noise: All noise above the 80 dB(A) level is considered to be harmful. The legislation (See 3) indicates what the employer and employee should do to prevent hearing damage. 80 dB(A) is considered to be a safe threshold for 8 hours of daily exposure without protection. Exceeding this threshold by 3 dB(A) may seem trivial, but the logarithmic scale of dB means that this amounts to a doubling of the loudness! Therefore, the daily exposure limit for 83 dB(A) is only 4 hours.

If you need to raise your voice to be heard at a distance of 1 meter in a noisy environment, you are probably dealing with harmful noise.

Please also be wary when installing additional equipment. When a device produces 84 dB(A) of noise, and you add a similar device of 84 dB(A), the total amounts will be 87 dB(A), which means that suddenly a lot of extra safety measures need to be taken (See Chapter 3). Perhaps in such a case a new, noise-wise improved device with double capacity might be a better option. Therefore, please take care to buy a noise-free variant when purchasing equipment. Think of: -80˚C freezers, centrifuges, pumps, and metal working equipment.

Low-level nuisance noise: All noise below 80 dB(A) that you perceive as, or consider to be, objectionable and/or causes concentration loss. Often this applies to noises over which you have no control yourself, such as continuous rattling, clanking, ticking, or beeping. Therefore, this may be a soft humming noise in the ventilation system, or mumbling people in a silent zone, which causes irritation. Effects may be, among others: diminished functioning, loss of concentration, and stress symptoms.

Contact noise is often objectionable, but sound peaks may cross the 80 dB(A) threshold. It is caused by vibrations in equipment and is transmitted by other objects, such as metal parts in a building. Examples are the noise of the ventilators of fumehoods placed on another floor, and a loose metal plate that

resonates with a rotating centrifuge.

Many harmful and objectionable (contact) noises may be prevented by sufficient maintenance, such as the regular tightening of screws that are loosened by vibrations or the timely lubrication of moving parts in contact, or the installation of sound-absorbing material.

2.2 Inaudible noise

In addition to frequencies audible to man, there are two more types of sound vibrations we cannot perceive, and which are, strictly speaking, not sounds. However, we do need to be careful with them:

> *Ultrasonic, as well as infrasonic noise may cause harm to the unborn child. This is why pregnant women should avoid these types of noises. In this regard, think of laboratories in which work is done with sonicators.*

Ultrasonic noise: Is noise caused by sound waves with frequencies higher than 20,000 Hz. These frequencies cannot be perceived by the human ear. Cats, dogs, and dolphins do hear these sounds. These sounds are used in echography (sonography) and in dog whistles. In dentistry these sounds occur during drilling and scaling. In laboratories, ultrasonic vibrations are applied in sonicators and ultrasonic baths.

Infrasonic noise: Is noise that is caused by sound waves with very low frequencies (0.001 to 17 Hz). These frequencies are inaudible to the human ear, but may be felt. These are very slow air vibrations caused by, for example, storms, avalanches, large explosions, and communication by some of the larger animals (whales, elephants, rhinoceroses).

3 Noise legislation

Employers are obliged (by law) to prevent (hearing) damages to their personnel. Hearing damage is caused by exposure to harmful noise.

The noise legislation provides guidelines to the employer, as well as the employee, in regards to the noise levels someone may be exposed to at his/her working place, and the measures that must be taken.

The phrase *daily noise dose* refers to the exposure to noise in the course of a 8 hour working day.

The law states the following rules regarding noise at the working place:

- In case of exposure to a daily dose above 80 dB(A) the employer must provide hearing protection.
- In case of a daily exposure to a dose above 85 dB(A) employees are obliged to wear hearing protection.
- In case of exposure above 85 dB(A) a Policy (“Plan van Aanpak”) must be developed to reduce harmful noise.

- When the threshold of 87 dB(A) is exceeded (as measured in the ear, thus taking the hearing protection into account), measures to bring the noise below this threshold must be taken immediately.
- Employers are obliged to sufficiently inform their personnel on the dangers of noise.
- Employees have a right to a hearing test to determine if the measures taken are effective.

4 Preventing exposure to objectionable or harmful noise

There are a number of ways to diminish or end exposure to objectionable or harmful noise. Below, you will find the possibilities ordered according to the hierarchy of controls :

- Elimination: Purchase of a noise-free device or choice for a different working method that produces no/less noise.
- Technical: Placing the noise producing equipment in a separate room (pumps in a pump hall) or insulating this equipment (encasing).
- Organisational: Limiting the work near this equipment. (Reorganising the work.)
- Personal protection: Wearing hearing protection.

You can find more information regarding hearing protection in AMD information sheet RhL020 Safety equipment.

There are three kinds of hearing protection:

- Ear muffs that are worn like headphones. When these properly enclose the ears, a muffling of 30 dB(A) is possible. Wearing the ear muffs may cause overheating of the ears. Isolation from the environment (as well as resonation of noise of one's own movements) may also be undesired side effects of wearing ear muffs.
- Ear plugs of several types are often improperly inserted into the auditory duct, which causes insufficient muffling and thus may lead to hearing damage. They are not always that hygienic too, which may be the cause of health complaints.
- Otoplastics are custom molded ear plugs that may offer muffling up to 30 dB(A). However, they are usually tuned to the muffling level required at the work place, to avoid more muffling than necessary. This increases wearer comfort. However, otoplastics do need a yearly checkup for leakage and sufficient muffling properties.

Rooms in which wearing hearing protection is mandatory, are indicated with the pictogram shown to the right.