Seminar - Støy i petroleumsindustrien
Status 2019
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Lavfrekvent støy – en undervurdert helserisiko


Foto: Halvor Erikstein

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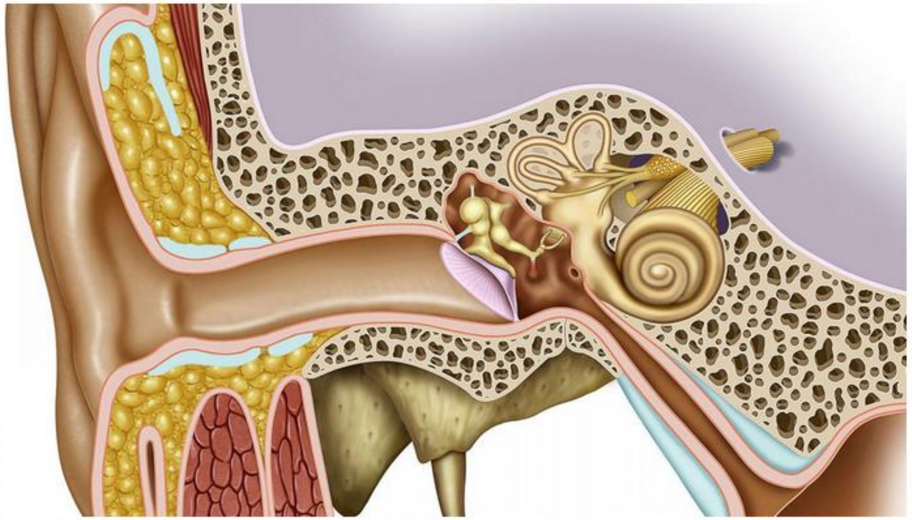

The functioning of the inner ear is at least temporarily altered by exposure to low-frequency sounds.

Alex Luengo/iStockphoto /Thinkstock

Sounds you can't hear can still hurt your ears

By Sarah C. P. Williams | Sep. 30, 2014 , 7:15 PM

A wind turbine, a roaring crowd at a football game, a jet engine running full throttle: Each of these things produces sound waves that are well below the frequencies humans can hear. But

- **A wind turbine, a roaring crowd at a football game, a jet engine running full throttle: Each of these things produces sound waves that are well below the frequencies humans can hear.**
- **But just because you can't hear the low-frequency components of these sounds doesn't mean they have no effect on your ears. Listening to just 90 seconds of low-frequency sound can change the way your inner ear works for minutes after the noise ends, a new study shows.**
- "Low-frequency sound exposure has long been thought to be innocuous, and this study suggests that it's not," says audiology researcher Jeffery Lichtenhan of the Washington University School of Medicine in in St. Louis, who was not involved in the new work.
- Humans can generally sense sounds at frequencies between 20 and 20,000 cycles per second, or hertz (Hz)—although this range shrinks as a person ages. Prolonged exposure to loud noises within the audible range have long been known to cause hearing loss over time. But establishing the effect of sounds with frequencies under about 250 Hz has been harder. Even though they're above the lower limit of 20 Hz, these low-frequency sounds tend to be either inaudible or barely audible, and people don't always know when they're exposed to them.

http://www.sciencemag.org/news/2014/09/sounds-you-cant-hear-can-still-hurt-your-ears

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Research

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Low-frequency sound affects active micromechanics in the human inner ear

Kathrin Kugler[1,3], Lutz Wiegrebe[3], Benedikt Grothe[3], Manfred Kössl[4], Robert Gürkov[1,2], Eike Krause[1,2] and Markus Drexl[1,2]

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1. Summary

Noise-induced hearing loss is one of the most common auditory pathologies, resulting from overstimulation of the human cochlea, an exquisitely sensitive micromechanical device. At very low frequencies (less than 250 Hz), however, the sensitivity of human hearing, and therefore the perceived loudness is poor. The perceived loudness is mediated by the inner hair cells of the cochlea which are driven very inadequately at low frequencies. To assess the impact of low-frequency (LF) sound, we exploited a by-product of the active amplification of sound outer hair cells (OHCs) perform, so-called spontaneous otoacoustic emissions. These are faint sounds produced by the inner ear that can be used to detect changes of cochlear physiology. We show that a short exposure to perceptually unobtrusive, LF sounds significantly affects OHCs: a 90 s, 80 dB(A) LF sound induced slow, concordant and positively correlated frequency and level oscillations of spontaneous otoacoustic emissions that lasted for about 2 min after LF sound offset. LF sounds, contrary to their unobtrusive perception, strongly stimulate the human cochlea and affect amplification processes in the most sensitive and important frequency range of human hearing.

- For the new study, neurobiologist Markus Drexl and colleagues at the Ludwig Maximilian University in Munich, Germany, asked 21 volunteers with normal hearing to **sit inside soundproof booths and then played a 30-Hz sound for 90 seconds.**
- The deep, vibrating noise, Drexl says, is about what you might hear “if you open your car windows while you’re driving fast down a highway.”
- Then, they used probes to record the natural activity of the ear after the noise ended, taking advantage of a phenomenon dubbed **spontaneous otoacoustic emissions** (SOAEs) in which the healthy human ear itself emits faint whistling sounds. “Usually they’re too faint to be heard, but with a microphone that’s more sensitive than the human ear, we can detect them,” Drexl says. Researchers know that SOAEs change when a person’s hearing changes and disappear in conjunction with hearing loss.
- **People's SOAEs are normally stable over short time periods. But in the study, after 90 seconds of the low-frequency sound, participants’ SOAEs started oscillating, becoming alternately stronger and weaker. The fluctuations lasted about 3 minutes, the team reports today in Royal Society Open Science.**
- **The changes aren’t directly indicative of hearing loss, but they do mean that the ear may be temporarily more prone to damage after being exposed to low-frequency sounds, Drexl explains. “Even though we haven’t shown it yet, there’s a definite possibility that if you’re exposed to low-frequency sounds for a longer time, it might have a permanent effect,” Drexl adds.**

http://rsos.royalsocietypublishing.org/content/royopensci/1/2/140166.full.pdf

Effects of low frequency noise and vibrations: Environmental and occupational perspectives, 2011

- Abstract
- **This article provides a current knowledge base of adverse effects due to community and occupational low frequency noise (20–200 Hz). Low frequency noise has a large annoyance potential, and the prevalence of annoyance increases with higher sound pressure levels (SPLs) of low frequencies.**
- **Low frequency noise annoyance is related to headaches, unusual tiredness, lack of concentration, irritation, and pressure on the eardrum. Data suggest that sleep may be negatively affected. In occupational environments, low frequency noise may negatively affect performance at moderate noise levels, whereas the health consequences of higher SPLs are less well known.**
- Factors inherent in most low frequency noise such as the throbbing characteristics, the intrusion of low frequencies felt when other frequencies in the sound are attenuated, and the vibration sensations sometimes felt contribute to the response.
- Measurements need to properly assess the individual exposure and include spectral, temporal, and if present also vibration characteristics.

https://www.gu.se/english/research/publication/?publicationId=150522

Nyttig artikkel

Sources and effects of low-frequency noise

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(Received 14 February 1995; revised 30 March 1995; accepted 2 January 1996)

The sources of human exposure to low-frequency noise and its effects are reviewed. Low-frequency noise is common as background noise in urban environments, and as an emission from many artificial sources: road vehicles, aircraft, industrial machinery, artillery and mining explosions, and air movement machinery including wind turbines, compressors, and ventilation or air-conditioning units. The effects of low-frequency noise are of particular concern because of its pervasiveness due to numerous sources, efficient propagation, and reduced efficacy of many structures (dwellings, walls, and hearing protection) in attenuating low-frequency noise compared with other noise. Intense low-frequency noise appears to produce clear symptoms including respiratory impairment and aural pain. Although the effects of lower intensities of low-frequency noise are difficult to establish for methodological reasons, evidence suggests that a number of adverse effects of noise in general arise from exposure to low-frequency noise: Loudness judgments and annoyance reactions are sometimes reported to be greater for low-frequency noise than other noises for equal sound-pressure level; annoyance is exacerbated by rattle or vibration induced by low-frequency noise; speech intelligibility may be reduced more by low-frequency noise than other noises except those in the frequency range of speech itself, because of the upward spread of masking. On the other hand, it is also possible that low-frequency noise provides some protection against the effects of simultaneous higher frequency noise on hearing. Research needs and policy decisions, based on what is currently known, are considered.

PACS numbers: 43.50.Qp, 43.28.Dm

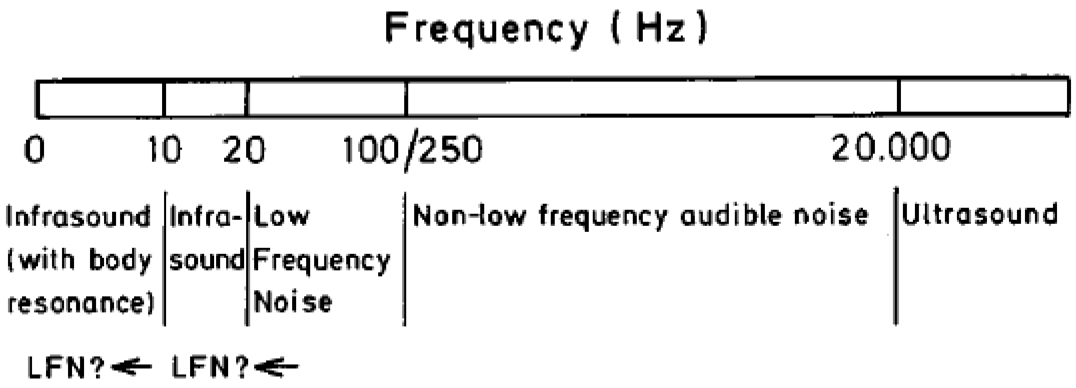

FIG. 1. The frequency spectrum of sound and its nomenclature.

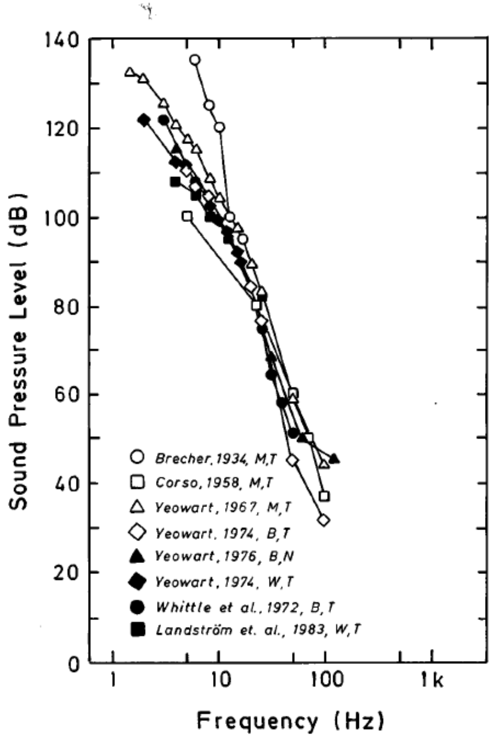

FIG. 2. Hearing thresholds as a function of signal frequency in various studies (M=monaural; B=binaural; W=whole body; T=tone; N=noise band).

http://doc.wind-watch.org/sources-effects-lfn-1996.pdf

Kartlegging av lavfrekvent støy.
Stående bølger i rommet kan gi en varisjon på 20-30 dB avhengig av hvor det måles

ON MEASURING LOW-FREQUENCY NOISE INDOORS

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ABSTRACT

Due to standing waves, the sound pressure within a room may vary 20-30 dB. For assessment of annoyance from low-frequency noise, it is important to measure a level that adequately represents the exposure that may give rise to the annoyance, rather than some room average level. Thus, mainly areas of the room with high sound pressure levels are of interest, since persons present in such areas are not helped by the existence of much lower levels elsewhere. Sound fields in rooms were investigated using numerical simulations and scanning measurements of the entire sound pressure distributions in three different rooms. Measurements were also performed in three-dimensional corners as well as according to Swedish and Danish guidelines. The sound pressure level that is exceeded in only 10% of the space of a room (L10) is proposed as a reasonable target for a measurement method. The Swedish method showed good results, however its use of C-weighting during scanning for maximum can lead to the maximum for wrong frequency components, i.e. components other than those that give rise to annoyance. The Danish method was found to have a high risk of significantly underestimating the noise present in a room, unless complainants can precisely appoint the measurement positions. It was found that a very good estimate of the L10 target level is obtained by measuring only in four three-dimensional corners.

https://www.researchgate.net/publication/5327784_Measuring_low-frequency_noise_indoors

«Stående bølger»

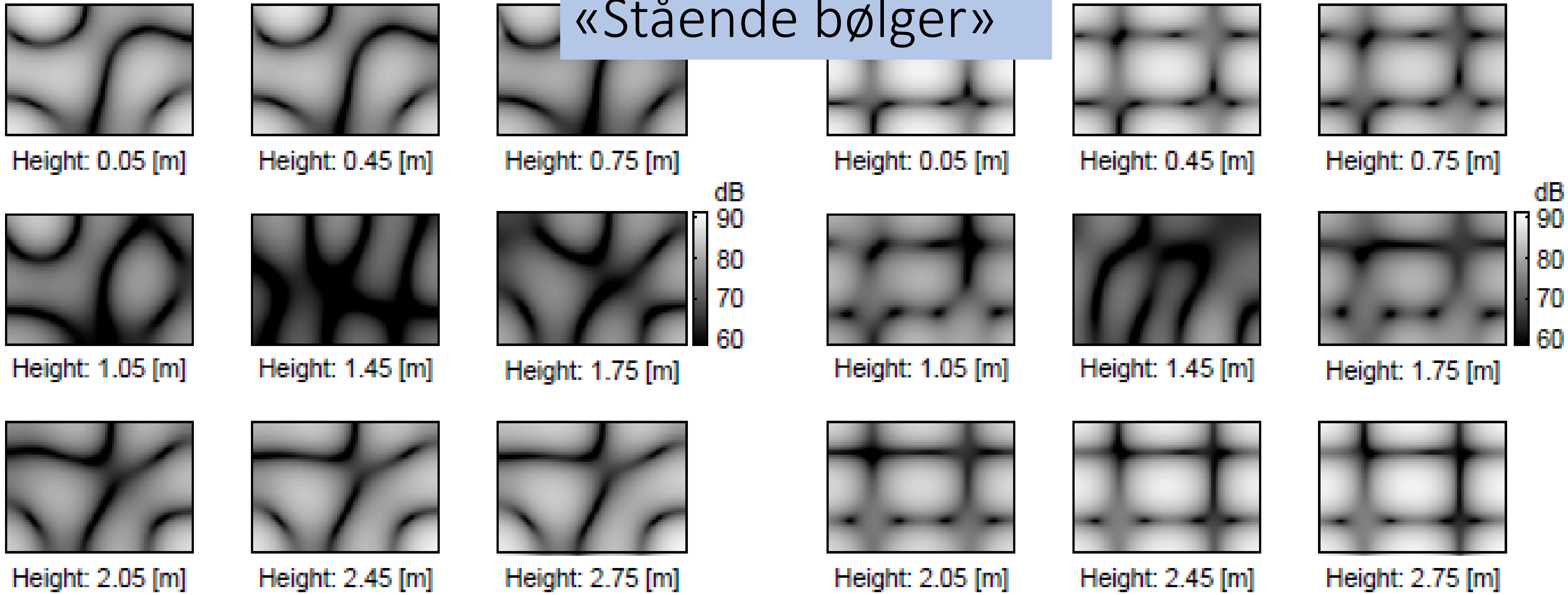


Figure 1: *Sound pressure distribution in a 5.7 m by 3.8 m by 2.8 m (L x W x H) room. Left: Sinusoidal sound wave at 114 Hz. Right: Sinusoidal sound wave at 124 Hz (mode 2,2,1). Sound generated by piston in lower left corner indicated by rectangle. Simulated using FDTD with 0.1 m cell size and 6 kHz sampling frequency.*

https://www.researchgate.net/publication/5327784_Measuring_low-frequency_noise_indoors

Stående bølger i rommet

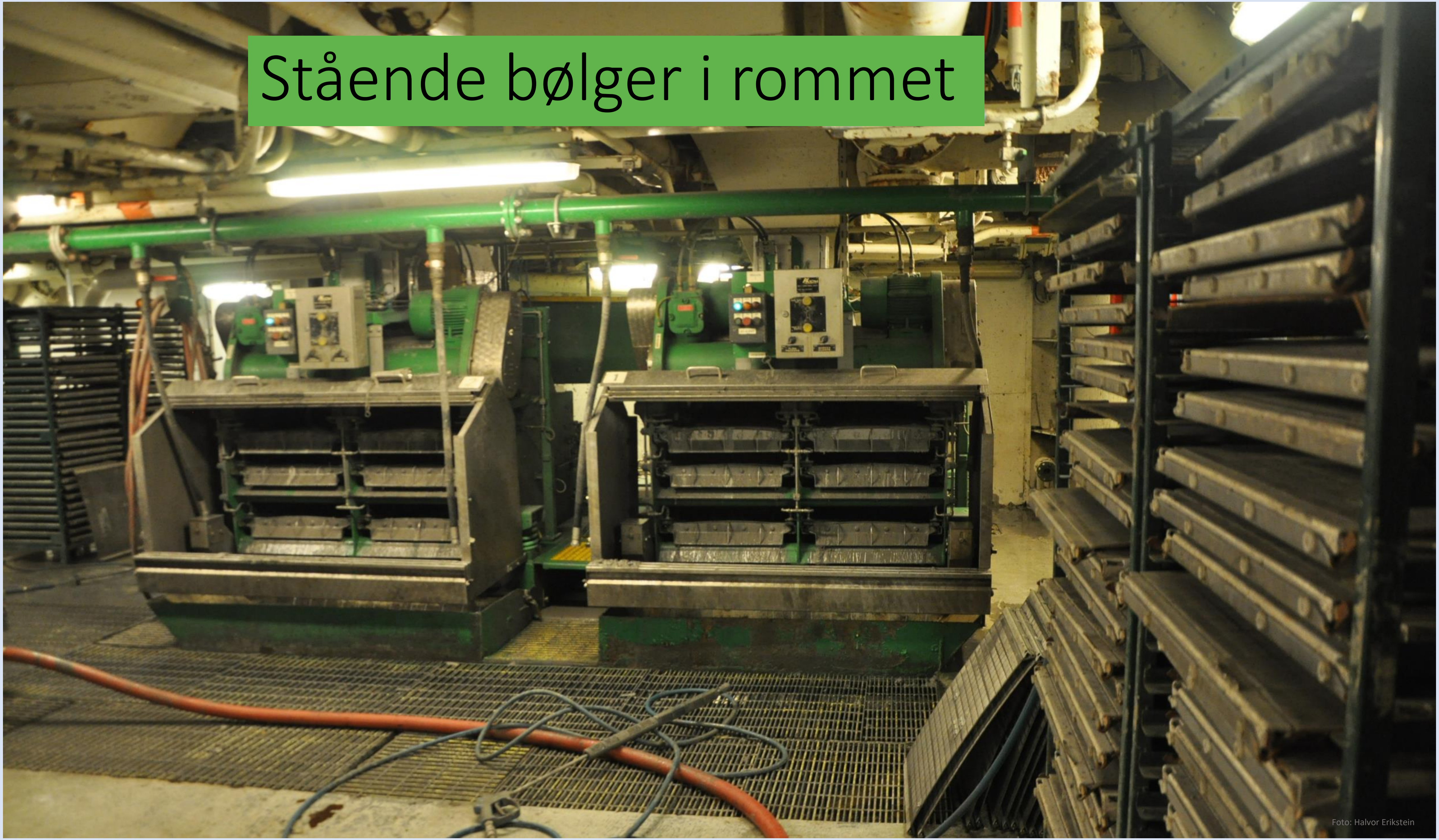


Foto: Halvor Erikstein

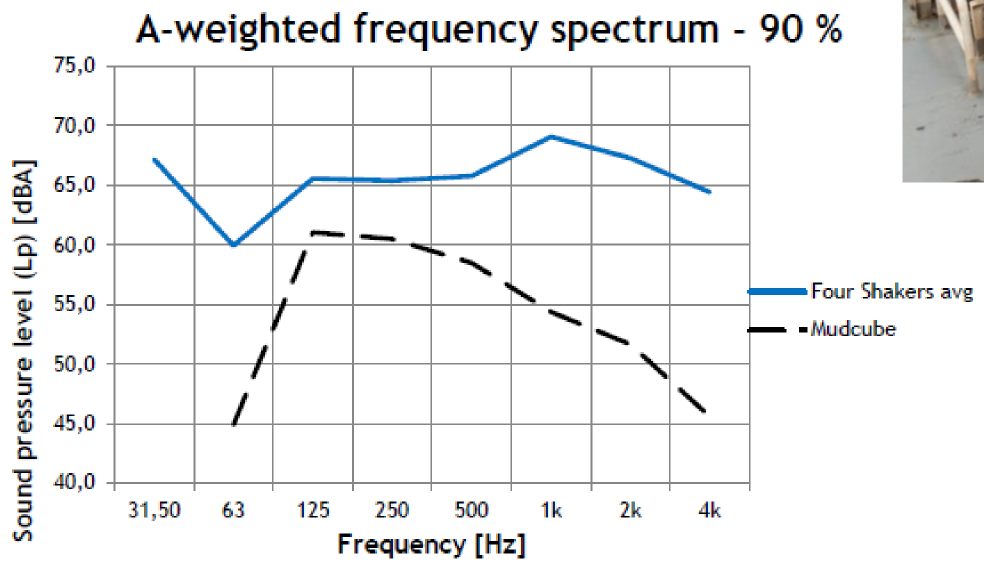
FROKOSTMØTE HØR! MUD CUBE – MINDRE STØY OG LIKE GOD YTELSE SOM VANLIGE «SHAKERE» 15.03.13

Støy fra shaker og MudCube

Norskolje&gass

Shakerrom preges av mye lavfrekvent støy
Siktene drives av eksentermasse med frekvens ca 30Hz.

Mye av støydata er oppgitt som A-veidenivåer:
Tradisjonelle shaker 75-80dBA ved 1m 90% kapasitet
MudCube 68dBA ved 1m 90% kapasitet
Begge fritt felt – ingen refleksjoner fra rommet, kun 1 enhet



LIFETEC AS

https://www.norskoljeoggass.no/drift/arbeidsmiljo/stoy/moter-seminarer-mm/mudcube/

NORSOK S-002N Støydatablad

Krever ikke data på infralyd.
Standarden må få innkravet!

NORSOK S-002N:2017

D.5 Støydatablad

STØYDATABLAD (NDS)

Side: av
Dato :
Rev. :

Dokumentnr.

Merkenr.	Plassering/modul
Enhet	Antall
Funksjon	Forespørselsnr.
Størrelse og type	Tilbudsnr.
Leverandør	Ordrenr
Produsent	Jobbnr.
Modell	Serienr.

1 **KONSTRUKSJONSDATA**
2 Beregnet ΔL = Lw - Lp ___ dB
3 Virkningsgrad ___ %
4 Utstyrsstørrelse (l x b x h) ___ m — Motortype ___
5 Effekt ___ kW — Motorhastighet ___ rpm
6 Kapasitet ___ — Rotasjonshastighet for utstyr ___ rpm
7 Utløpstrykk ___ bar — Girtannkontaktfrekvens ___
8 Innløpstrykk ___ bar — Strømningsfrekvens for blader/vifteblader ___ Hz
9 Utstyrsvekt ___ kg — Forholdet mellom antall statorer/rotorskovler ___
10

			Senterfrekvens i oktavbånd, Hz / uveid nivå, dB								
11	**SELSKAPSSPESIFIKKE DATA**										
12	Støynivågrenser [1]	A-veid	31,5	63	125	250	500	1000	2000	4000	8000
13	**Lw komplett maskin**										
14	**$Lp_{average}$ @ 1m / L'p**										
15	**Lp_{max} @1m dist. & 1,6m over gulv**										
16											

17 Spesielle krav
18
19
20 Krav til støyprøving — Ja O — Nei O — Valgfritt O
21

			Senterfrekvens i oktavbånd, Hz / uveid nivå, dB								
22	**LEVERANDØRDATA**										
23	Deklarerte og/eller garanterte nivåer [1]	A-veid	31,5	63	125	250	500	1000	2000	4000	8000
24	**Lw komplett maskin**										
25	**$Lp_{average}$ @ 1m / L'p**										
26	**Lp_{max} @1m dist. & 1,6m over gulv**										
27	**Beregnet eller deklarert K**										

28 Smalbåndskomponent — Ja O — Nei O — Frekvens/oktavbånd: ___ Hz
29 C-veid nivå > 130 dB(C) PEAK: — Ja O — Nei O
30 Metode for støynivåprøving
31 Beskrivelse av iverksatte tiltak for støykontroll / annen informasjon
32
33
34

31,5 Hz

			Senterfrekvens i oktavbånd, Hz / uveid nivå, dB								
35	**SOM BYGD-STØYDATA**										
36	Målte støynivåer [1]	A-veid	31,5	63	125	250	500	1000	2000	4000	8000
37	**Lw komplett maskin**										
38	**$Lp_{average}$ @ 1m / L'p**										
39	**Lp_{max} @1m dist. & 1,6m over gulv**										
40	**K for som bygd-måling**										

41 Metode for støynivåprøving
42 Spesiell informasjon
43

44 Merknad 1 Lp: Lydtrykknivå ved 1 m avstand frifeltforhold over en reflekterende flate (dB re. 20 µPa)
45 Lw: Lydeffektnivå (dB re. 1 pW) — L'p: Lydeffektnivå målt i felt (dB re. 20 µPa)
46 K: Måleusikkerhet

Figur D.1 — Støydatablad

NORSOK S-002 N:2018 Standard — NOK **1 441,00** (eks. mva)

Arbeidsmiljø. Utgave 5, 2018

Språk: Utgave: **5** (2018-03-19)

Produktinformasjon — Overvåk standarden

Skriv ut på papir

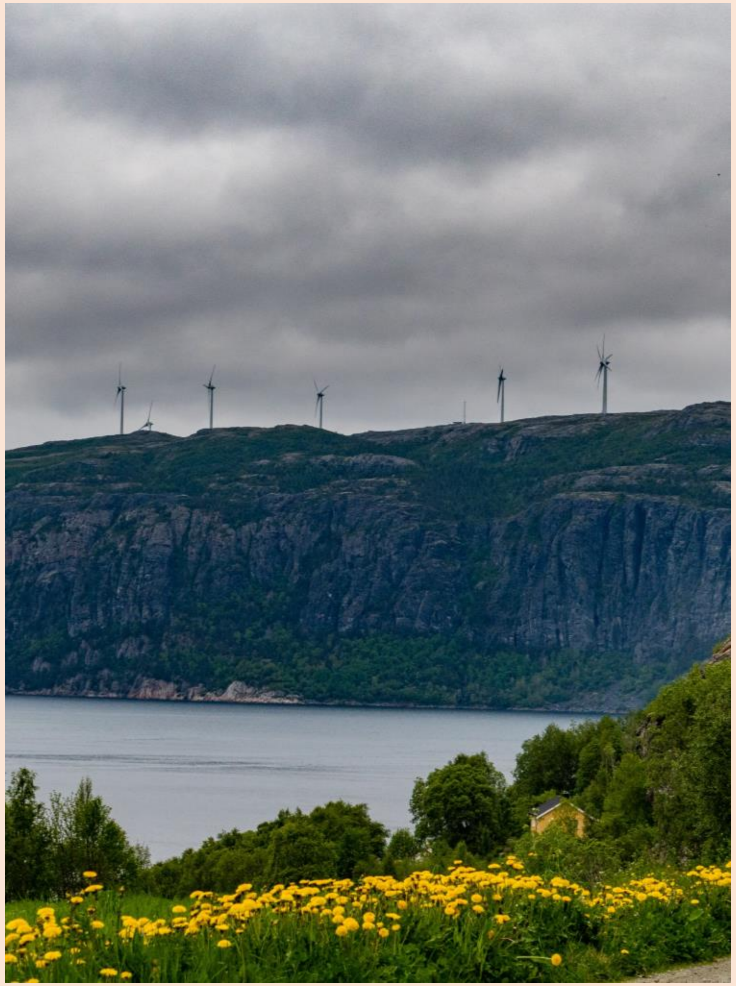
Trykket og innbunde

Laveste C på et piano 32 Hz

https://www.standard.no/no/Nettbutikk/produktkatalogen/Produktpresentasjon/?ProductID=968037

«Det grønne skiftet» må inkludere hensynet til Helse, Miljø og Sikkerhet!

The Problems With “Noise Numbers” for Wind Farm Noise Assessment



Abstract

Human perception responds primarily to sound character rather than sound level. Wind farms are unique sound sources and exhibit special audible and inaudible characteristics that can be described as modulating sound or as a tonal complex.

Wind farm compliance measures based on a specified noise number alone will fail to address problems with noise nuisance.

The character of wind farm sound, noise emissions from wind farms, noise prediction at residences, and systemic failures in assessment processes are examined.

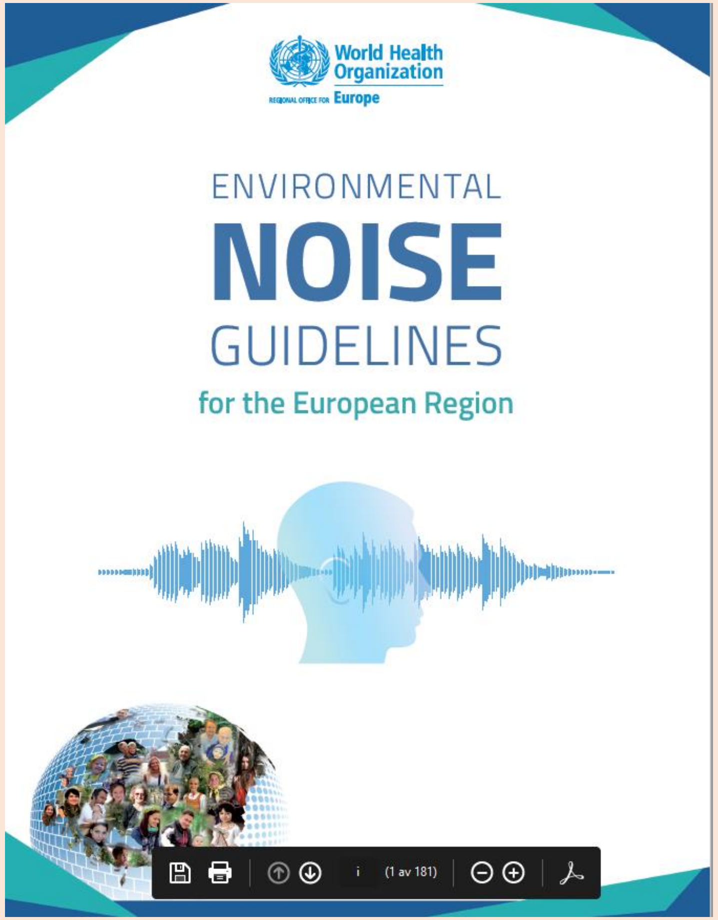
Human perception of wind farm sound is compared with noise assessment measures and complaint histories. The adverse effects on health of persons susceptible to noise from wind farms are examined and a hypothesis, the concept of heightened noise zones (pressure variations), as a marker for cause and effect is advanced.

A sound level of LAeq 32 dB outside a residence and above an individual’s threshold of hearing inside the home are identified as markers for serious adverse health effects affecting susceptible individuals.

The article is referenced to the author’s research, measurements, and observations at different wind farms in New Zealand and Victoria, Australia.

https://stopthesethings.files.wordpress.com/2014/12/bull-sci-technol-soc-2011-thorne-262-90.pdf

WHO Environmental Noise Guideline, 2018



Contents

http://www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf?ua=1

Offshore vindturbiner

Hvordan blir arbeidsmiljøet til de som skal overvåke og vedlikeholde?
Finnes det verneutstyr som kan beskytte?

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RESEARCH ARTICLE

Altered cortical and subcortical connectivity due to infrasound administered near the hearing threshold – Evidence from fMRI

Markus Weichenberger, Martin Bauer, Robert Kühler, Johannes Hensel, Caroline Garcia Forlim, Albrecht Ihlenfeld, Bernd Ittermann, Jürgen Gallinat, Christian Koch, Simone Kühn

Published: April 12, 2017 • https://doi.org/10.1371/journal.pone.0174420

Abstract

In the present study, the brain's response towards near- and supra-threshold infrasound (IS) stimulation (sound frequency < 20 Hz) was investigated under resting-state fMRI conditions. The study involved two consecutive sessions. In the first session, 14 healthy participants underwent a hearing threshold—as well as a categorical loudness scaling measurement in which the individual loudness perception for IS was assessed across different sound pressure levels (SPL). In the second session, these participants underwent three resting-state acquisitions, one without auditory stimulation (no-tone), one with a monaurally presented 12-Hz IS tone (near-threshold) and one with a similar tone above the individual hearing threshold corresponding to a 'medium loud' hearing sensation (supra-threshold). Data analysis mainly focused on local connectivity measures by means of regional homogeneity (ReHo), but also involved independent component analysis (ICA) to investigate inter-regional connectivity. ReHo analysis revealed significantly higher local connectivity in right superior temporal gyrus (STG) adjacent to primary auditory cortex, in anterior cingulate cortex (ACC) and, when allowing smaller cluster sizes, also in the right amygdala (rAmyg) during the near-threshold, compared to both the supra-threshold and the no-tone condition. Additional independent component analysis (ICA) revealed large-scale changes of functional connectivity, reflected in a stronger activation of the right amygdala (rAmyg) in the opposite contrast (no-tone > near-threshold) as well as the right superior frontal gyrus (rSFG) during the near-threshold condition. In summary, this study is the first to demonstrate that infrasound near the hearing threshold may induce changes of neural activity across several brain regions, some of which are known to be involved in auditory processing, while others are regarded as keyplayers in emotional and autonomic control. These findings thus allow us to speculate on how continuous exposure to (sub-)liminal IS could exert a pathogenic influence on the organism, yet further (especially longitudinal) studies are required in order to substantialize these findings.

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0174420

OPEN ACCESS

Trends in Hearing

A Review of the Possible Perceptual and Physiological Effects of Wind Turbine Noise

Simon Carlile, John L. Davy, David Hillman, more...

First Published August 7, 2018 | Review Article

https://doi.org/10.1177/2331216518789551

Abstract

This review considers the nature of the sound generated by wind turbines focusing on the low-frequency sound (LF) and infrasound (IS) to understand the usefulness of the sound measures where people work and sleep. A second focus concerns the evidence for mechanisms of physiological transduction of LF/IS or the evidence for somatic effects of LF/IS. While the current evidence does not conclusively demonstrate transduction, it does present a strong prima facia case. There are substantial outstanding questions relating to the measurement and propagation of LF and IS and its encoding by the central nervous system relevant to possible perceptual and physiological effects. A range of possible research areas are identified.

https://journals.sagepub.com/doi/full/10.1177/2331216518789551


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