HSLU Lucerne University of Applied Sciences and Arts

Engineering and Architecture
B.Sc.. Energy and Environmental Systems Engineering
Bachelor-Thesis

Investigation of Noise Annoyance from HVAC Actuators and Valves

Student: Adedokun, Gbolahan Damilola

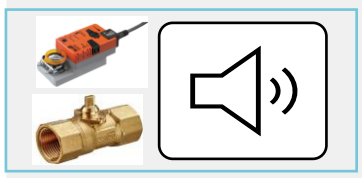
1. Introduction, Goals and Research Questions

HVAC (Heating, Ventilation, and Air Conditioning) systems are commonly used in residential, commercial, and industrial buildings to maintain indoor thermal comfort. However, besides thermal comfort, acoustic comfort is also important because unpleasant sounds can affect human well-being, concentration, and perceived indoor quality.

HVAC control devices such as actuators and valves can produce mechanical, tonal, and flow-related sounds that might be annoying. However, the subjective perception of these sounds under different operating conditions is still not fully understood.

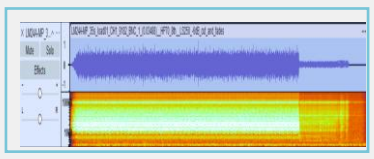
This bachelor's thesis investigates how humans perceive HVAC actuator and valve sounds under controlled listening conditions.

2. Method Overview and Materials



INPUT (SOUND SIGNALS)

- Recorded sound signals from actuators and valves



SOUND SIGNALS PROCESSING

- Sound signal inspection (Audacity software) and calibration
- Cuts with cosine fade-in & fade-out (MATLAB)
- Level adjustment (PsychoPy software)

OBJECTIVE ANALYSIS (Artemis SUITE software)

- Acoustic parameters: LAeq, LAFmax etc.
- Psychoacoustic parameters: Loudness, Sharpness, etc.

SUBJECTIVE ANALYSIS (Psychoacoustic experiment)

- Listening experiments (PsychoPy software)
- Subjective ratings

DATA EVALUATION & ANALYSIS

- Mean annoyance ratings
- Correlation and regression analysis

OUTPUT (RESULTS)

- Identification of annoying actuators and valves based on objective and subjective analysis

Figure 1: Overall workflow of the thesis, combining objective and subjective analyses to evaluate annoyance caused by HVAC actuator and valve sounds

Industry Partner: BELIMO Automation AG

3. Results and Discussion

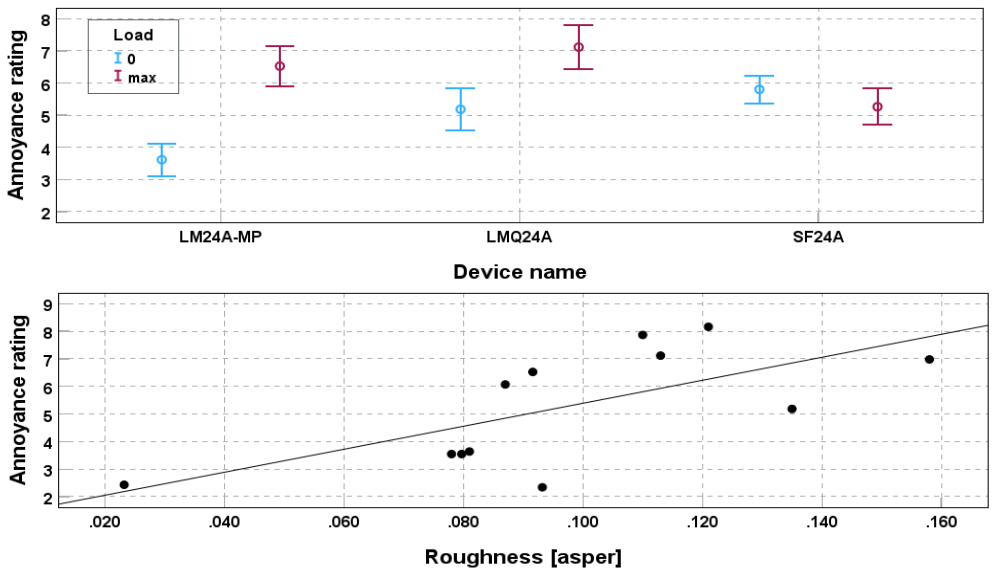


Figure 2: Actuator scenarios with higher loads generally produced higher annoyance ratings, while increasing roughness was associated with increased perceived annoyance

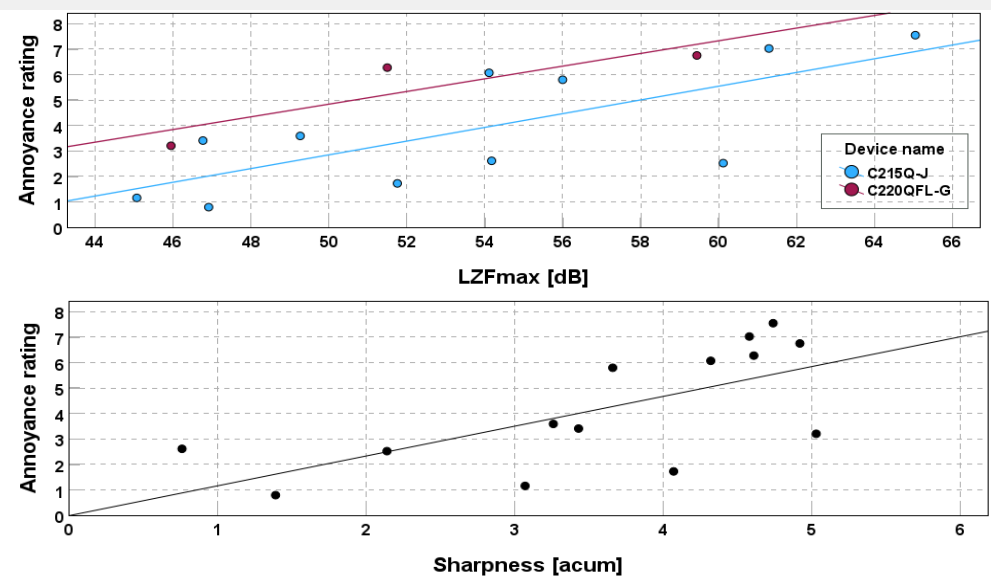


Figure 3: Valve scenarios with higher LZFmax levels generally produced higher annoyance ratings, while increasing sharpness was associated with increased perceived annoyance

4. Conclusion and Recommendations

This bachelor's thesis showed that device model as well as operating conditions such as pressure difference, actuator load, and spring recoil influenced the perceived annoyance of HVAC actuator and valve sounds.

It is recommended that future HVAC product development include psychoacoustic evaluation to support quieter system design and improve indoor acoustic comfort.

References

Horvath, K. (2025). Application of Psychoacoustic Metrics in the Noise Assessment of Geared Drives. *World Electric Vehicle Journal*, *16*(11), 1-2.

Leventhall, G. (2004). Low frequency noise and annoyance. *Noise & Health,* 6(23), 59-72.

Supervisor: Prof. Dr. Armin Taghipour
Expert: Dr. Jürg Stettbacher
Semester: Spring Semester, 2026