Annex 51

Acoustic Signatures of Heat Pumps

Reduction of acoustic emissions is key to further increase the acceptance of heat pumps for heating and cooling and remove barriers to their widespread installation. Aside from producing quiet heat pump components and units, proper installation, placement and operation is of utmost importance.

Key Findings

1 The acoustic theme for heat pumps starting from the fundamental concepts inherent in acoustics and then passing through the instruments and measurement methods, to a compendium of all the standards, laws, regulations and certification schemes in the European area is summarized.

2 Market figures and units covered in a round-robin test have been described. Acoustic results obtained between laboratories are compared and improved suggestions for the description of the test methods are derived (see Figures 1 & 2). A seasonal sound power level calculation is introduced.

3 Information and insights on the characteristics of different air and structure-borne noise sources and an overview of various noise control measures, which can be applied in the design of quiet heat pumps, are presented.

4 A proper understanding of the relations between heat pump types and sizes, their states of operation and their subsequent acoustic behavior is essential to minimize noise disturbances. The coupling of energetic and acoustic heat pump models is reported, transient processes are reviewed and the dependence of noise emissions on the type of heat source, heat sink, operating conditions/load levels and the control strategy is described. Pursued efforts in acoustical engineering, at the component, unit and set-up levels, paves the way for more comprehensive early-stage design processes, including virtual prototyping and reliability engineering.

5 A selection of tools is presented, which is used for calculating sound pressure levels. This includes simple formula-based tools and 2D visualization, which allows the user to see the sound pressure levels in a horizontal plane surrounding a freely placeable heat pump. The virtual placement of heat pumps using augmented reality is also introduced. This includes a description of acoustic measurements of noise sources, the aurealisation approach and the methods for calculation sound propagation.

6 Results of listening panel tests for psychoacoustics analysis showed that, in addition to the A-weighted level other acoustical parameters such as loudness, roughness, and sharpness may help to better model the perception of heat pump noise. Furthermore, the directional effects observed indicate, that the placement of heat pumps could have a relevant effect on how annoying people perceive the unit.

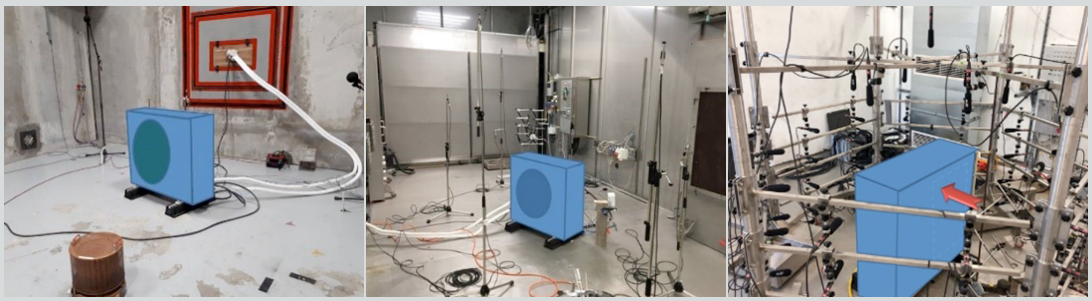

Figure 1. Ex. of the heat-pump installation in a reverberant test room (left) and climatic chambers (mid and right). A microphone array can be seen in the right image. [Source: CETIAT, France (left), ISE, Germany (mid), and AIT, Austria (right)]

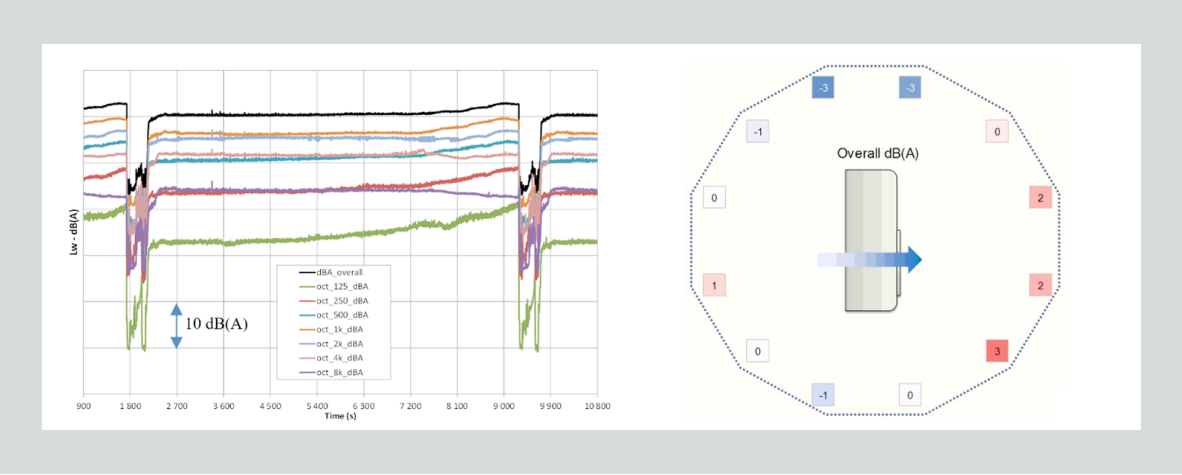

Figure 2. (left) Time dependent A-weighted sound power levels (in octave bands) between two defrosting phases [Source: see Deliverable D2.2], (right) Directivity for the overall A-weighted sound pressure level at 75 cm height [Source: AIT, Austria]

Background

To further increase the acceptance of heat pumps, the reduction of acoustic emissions is important. To minimize noise annoyance, more focus must be put on the acoustics emissions at a steady state and on the transient behavior of acoustic signatures during different operating conditions. Placement of the heat pumps is also of utmost importance, as sound emissions exhibit a pronounced directivity. Especially, air-to-water heat pumps provide a convenient and effective way to exploit potential energy savings and are often used in retrofit installations making acoustic improvements crucial due to their noise-producing components like compressors and fans. As the current legislation is globally very diverse (also serving needs of the different locations and countries), the Annex has been structured to contribute to guidance and future standards in this field. Furthermore, education and training are very important aspects of heat pump acoustics (placement, noise reduction measures, modes of control and operation) so that bad installations will not go against good acoustic design and construction of the units. The aim thus was to gather the knowledge and expertise of the participants on the different levels in order to forward this knowledge and establish recommendations and give advice.

Objectives

The objectives of this Annex were

- to further increase the acceptance of heat pumps for comfort purposes with respect to noise and vibration emissions
- to increase knowledge and expertise at different levels (manufacturers, acoustic consultants, installers, legislators)
- to provide input to national and international standardization
- to hold a workshop on the acoustics of heat pumps at the ICR2019 in Montreal
- to organize a concluding international workshop and to compile proceedings. This was realized as a webinar in November 2020 https://www.youtube.com/watch?v=tyiMwMhCuSc
- to disseminate worldwide to heat pump manufacturers
- to generate and distribute Acoustic Guidelines for the different levels (Component, Unit and Application Level)

Further information

Contact person:	Operating Agent was Christoph Reichl from AIT Austrian Institute of Technology GmbH, Austria. christoph.reichl@ait.ac.at
Participating countries:	Austria, Denmark, Germany, France, Italy, and Sweden.
Publications:	Final reports of Annex 51 and Executive Summary of Annex 51, available at https://heatpumpingtechnologies.org/publications/
Internet:	Link to Annex 51