VDI 2566 "Acoustical design for lifts"

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In April 2008, the Acoustics, Noise Control and Vibration Engineering Standards Committee (NALS) in DIN and VDI resolved to collate topical data material relating to noise control in lift installations to form the basis for drawing forward revision of the VDI 2566 guideline. In response a number of requests were received in support of the necessity to revise VDI 2566. A number of experts also voiced their willingness to take an active part in the revision process.

One outcome of the first meeting in July 2008 was a resolution to the effect that part 1 of the guideline "Acoustical design for lifts with a machine room" could and should certainly be published once again at short notice without amendment. On the other hand, there was a consensus among all those present that revision of the guideline would be necessary in the medium to long term. An agreement was reached to the effect that noise levels of lift installations would be measured and evaluated according to a prescribed protocol with a view to gathering additional useful findings. The VFA assumed the role of project management.

Study by the Aachen University of Applied Sciences

In March 2009, Professor Martina Klocke of the University of Applied Sciences in Aachen got in touch with Achim Hütter as the VFA president in search of assignments from the field of lift technology for a comprehensive semester project. Two topic areas were considered, including the evaluation of noise measurements at lift installations. This topic was then taken up as group project with a term of 12 weeks. The VFA gave 6 students, Stefan Breunig, Christina Geismann, Stefan Mencke, Robin Neuen, Jan Pollack and Axel Schumacher – all from different fields of mechanical engineering and mechatronics – the following assignment:

The assignment comprises four parts:

3.1 Sources of noise
All possible sources of noise in respect of a lift installation (rope and hydraulics) must be collated and briefly described in a clear, concise form.

3.2 Collection of measurements
A simple, ideally computer-based system must be developed for collecting and depicting airborne and structure-borne noise value measurements and measurement series. The second step entails entry of the available data (installations) so as to ensure its comparability.

3.3 Evaluation of measurements
Cases in which limiting values are adhered to or exceeded in the existing measurements from the VDI directive must be individually reviewed and guideline. Following on from this, the next step is to find a way of linking measurement peculiarities / anomalies with the possible noise source in the form of an indicator.

3.4 Noise abatement
All possible solutions to reduce noise in respect of the 3 sources most commonly documented by the measurements must be collated and briefly described in concise terms.

Alongside the valid technical regulations, the students were also able to draw on the following documents as working tools:

- 2 scripts from the VFA-Interlift VDI 2168 seminars parts A1 and A2
- CIBSE Guide Transportation Systems in Buildings
- Thyssen Guide Elevator Technology
- AufzR 95/16/EG as 12th GPSGV "Lift Directive"
- MaschR 98/37/EG as 9th GPSGV "Machine Directive"

In order to ensure the greatest possible standardization and comparability in the presentation of data, the work of the FH project group is restricted to problems arising in rooms adjacent to lifts requiring protection such as living rooms, bedrooms and work rooms. As these pose the most stringent need for sound insulation, it may be assumed that the limiting values are not exceeded in the remaining areas of the building.

The following main sources of noise were identified: Doors, car guidance/guide rails, shaft and control systems. In rope traction elevators, these were joined by the drive and the rope itself. In hydraulic lifts, the pump was seen as the major emitter of noise.

The basis for this project were records, 32 expertises and measurement plots from different engineering consultants and structural engineers which had been collated by the VFA. The drawback of this data is that with only one exception, all the lifts had been the subject of close examination because complaints about noise had been received. Only a limited number of 19 lift installations were included (13 rope traction lifts, 6 hydraulic installations) with a total of 32 measurements. Consequently the results of the study are only conditionally statistically reliable, and represent only the tip of an "iceberg" of lifts which operate fully without problems.

The Guideline Committee is consequently very interested in obtaining additional results of noise measurements performed on lifts, which would allow it to evaluate these in the committee and to clarify unresolved questions. Please send any data you may have available to Bernd.Kunzmann@din.de. Here, the data will be anonymized and made available to the committee for further processing.

The data available at the time of the study was extracted by the students from the various reports and collated in an Excel spreadsheet. The evaluation clearly shows that failed uncoupling of structure-borne sound and an incorrectly executed shaft construction are the most frequently occurring causes of continued non-compliance with limiting values. Another very important point is the noise level on acceleration and braking of the

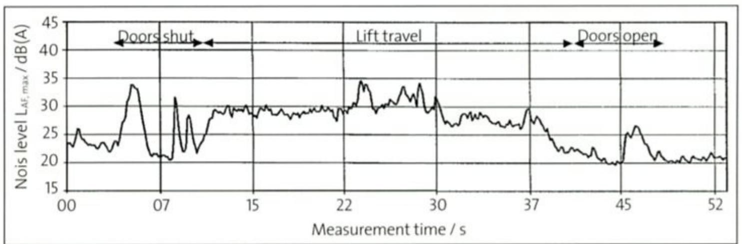

Fig. 1: Measurement plot of lift travel

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lift. The short-term level peaks which occur here have a disturbing effect.

Fig. 1 shows an example of an evaluated measurement plot of elevator travel. Here, the measurement curve can be subdivided into individual sections of the elevator's operation: [door shut] – [travel] – [door open]. By subdividing the measurement plot, the peaks at the beginning and end can be assigned to the doors. However, the maximum levels actually occur during elevator travel and cannot be unequivocally assigned. In this area, it is not clearly identifiable whether the noise is caused by the guide rails or the drive.

The causes of the noise were assigned to different lift types. An overview of the most frequent causes of noise generation in the majority of installations examined is provided in Fig. 2. In 26 of the 32 expertises under review, these resulted in contravention of the limiting values as prescribed by DIN 4109 or VDI 2566. Some of the causes of noise were encountered in all the lift types.

No.	Rope traction lifts		Hydraulic lifts
	Separate machine room	Drive in shaft	
1.	Incorrect configuration of shaft construction	Incorrect configuration of shaft construction	
2.	Incorrect mounting of guides	Incorrect mounting of guides	Incorrect mounting of guides
3.	Door noises	Door noises	Door noises
4.	Parking brake (releasing and opening)	Parking brake (releasing and opening)	No decoupling between hose and foundation and between ram and hydraulic unit
5.	Drive noises	Drive noises	Hydraulic noise in driving operation
6.	Drive system bearing	Structure-borne noise proportional to speed	
7.		Sound bridging in separating joints	
	Identical causes		

Fig. 2: Assignment of causes of noise to different lift types

A frequency analysis of six lift installations rounded off the evaluation of data. When evaluating the table, an accumulation of decibel peak values is clearly evident at the frequencies 100 Hz, 200 Hz, 315 Hz and 630 Hz. The peaks at higher frequencies are negligible, as they adhere sufficiently to minimum sound control requirements. People perceive noise in a frequency range below 100 Hz as highly disturbing in a living/working environment. This is graphically represented again in Fig. 3.

As a result of unforeseeable influences and missing measurements, it was not possible to derive a conclusive statement as to the relative proportion of airborne to structure-borne noise within the framework of the evaluations. A subsequent search for indicators from the measurement plot evaluations revealed

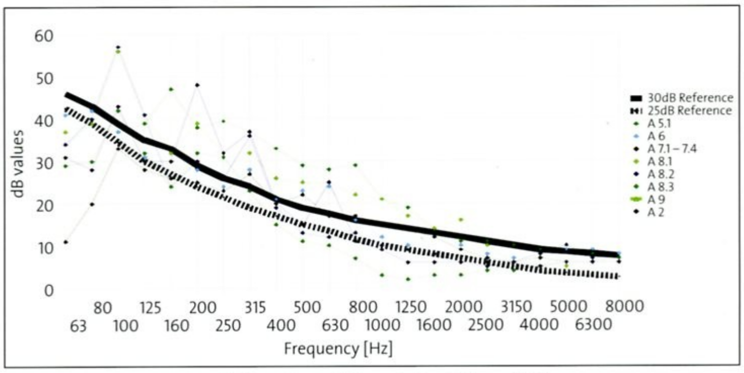

Fig. 3: Frequency spectrum of different installations during lift travel [dB]

that indicators such as an elevated noise level and/or temporary peaks cannot be unambiguously assigned to the defined elements. In the majority of cases, the statements made in the documents are based on expert experience or were concluded using the exclusion principle. Fig. 4 exemplifies how, while an excessively loud control system can be detected, these peaks cannot necessarily be distinguished from those made by the doors or brakes, as also indicated in Fig. 1.

The students envisage improvement potential to lie in the implementation of quality assurance measures in buildings in order to prevent structural defects. A second objective is to minimize the effect of the doors as a source of noise. A third suggestion made by the students is to make improvements in structure-borne sound insulation.

The study comes to the following conclusion:

Initially, the lift components were examined for their tendency to generate noise. This exercise provided an overview of potential noise sources which could afterwards be compared with the results of the evaluation. The measurement plots from the lift installations used as a basis were drawn up in accordance with DIN EN ISO 140 parts 4 and 7 as well as DIN EN ISO 717 by measurement engineers. Following evaluation of 32 measurement plots in respect of their noise development, the following tendency emerges:

It is not unambiguously possible using measurement plots without commentary to say which of the components is responsible for the noise development. On the measurement plot progression, striking points such as the relevant travel status can be marked during the recording process. Based on the peaks and their position relative to the markings, it is possible to make assumptions as to the sources of the noise. However, these are only assumptions, as they are based on the use of the exclusion method. A peak at the beginning or end of the recordings is an indication that the parking brake or door mechanism is involved. These peaks are clearly distinguished from normal lift operation.

In 26 of 33 examined measurement plots, these peaks exceeded the limiting values specified by VDI 2566/DIN 4109. There is a clearly noticeable trend for different frequencies of the causes of noise in the lift types, although these are identical in almost all the different lift types.

These include the impact noise of the doors, which is in evidence in all types of installation. It is not the noise development which creates a problem, but transmission of the structure-borne noise to adjacent rooms. This is generally caused as a result of faults in the construction and installation of the lift. Faulty decoupling of the lift

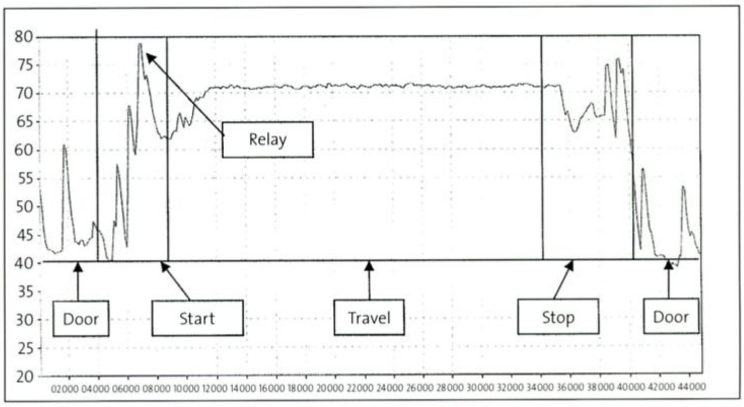

Fig. 4: Measurement plot of a lift installation

components such as guide rails and the drive unit from the shaft results in uninterrupted structure-borne noise transmission to the building.

An additional problem is insufficiently dimensioned design of the shaft construction in respect of its mass per unit area. This results in inadequate airborne sound insulation. Due to construction errors, structure-borne noise bridges or insufficient sound insulation measurements also occur. These or similar design deficiencies indicate that the applicable VDI 2566 guideline and the standard DIN 4109 were not adequately observed.

Finally, it must be stated that together, the VDI 2566 guideline and the standard DIN 4109 form a suitable basis for the design of lift installations. The problematical aspect is their implementation in terms of design and construction. A number of improvements are necessary for the preventive avoidance of disturbing noise emissions. Coordination between lift manufacturers and structural engineers / architects must be improved to ensure better adherence to the VDI and DIN stipulations. Detailed quality monitoring of building work would help to prevent construction defects which impact negatively on operation of the lift installation. The technical framework is in place within the regulations, but it is at the point of implementation where the problem generally occurs.

The results were outlined in a short presentation at the Aachen University of Applied Sciences, and summarized in the form of a poster (Fig. 5). The presentation was delivered again by the students in September 2009 before the Guideline Committee at DIN in Berlin, and in October 2009 on the occasion of the VFA Forum at the interlift in Augsburg. The results were received with lively interest at each of the venues, and were the subject of in-depth discussion and also controversy.

The VFA would like to take this opportunity to thank Aachen University of Applied Sciences, the involved professors and students once again for their excellent work and support for the VDI's work in establishing guidelines. This vote of thanks also relates to authorization to use text and pictures from the study in this article. The full text of the study can be ordered from the offices of the VFA on email application to info@vfa-interlift.de. The presentation by the students is available to view on the VFA website www.vfa-interlift.de.

Thanks is also due to the three engineering consultancy bureaus for the provision of anonymized expertises for evaluation purposes by the Aachen University of Applied Sciences.

Further procedure

In its meeting in January 2010, the overriding DIN Standards Committee NA 001-02-03 AA "Sound Propagation and Noise Control in Buildings, Work Places and Outdoors" voted in favour of adopting part 1 as an unchanged "white" paper with purely editorial revisions. Its publication may be expected in July / August 2010.

At the same DIN meeting in January of this year, the revision of parts 1 and 2 and their merger were also resolved. The Guideline Committee has already begun to collate initial ideas and questions relating to the revision process. The next meeting is likely to be convened directly after the summer recess. If you have suggestions relating to the VDI 2566 guideline, please send your comments to DIN, care of Bernd.Kunzmann@din.de. The committee welcomes all suggestions.

In order to gather additional information, a Noise Study is also currently being prepared by the European Lift Association ELA. Laws and regulations from our European neighbours are being collated. The committee is also seeking further-reaching literature on the topic, particularly from abroad. Please scan in any relevant articles and send them to DIN, also care of the above mail address.

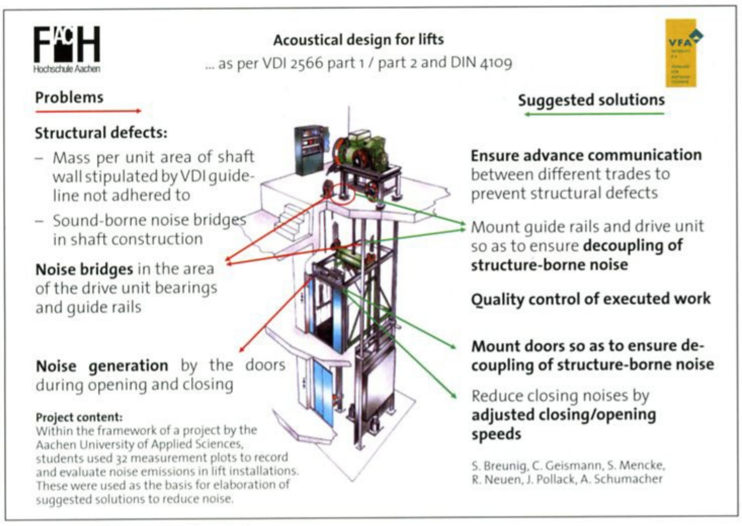

Fig. 5: Poster illustrating the study