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Noise levels in apartment blocks caused by lifts; what can be done in order to reduce complaints

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Abstract

In current building practice, lifts are an important part of any multi-storey building. Machine Room Less (MRL) lifts, which have been introduced in recent years, are gaining acceptance and are being used in many apartment buildings. In an MRL configuration the lift machinery is mounted inside the lift's shaft and directly or indirectly to the shaft wall. In many cases living quarters or bedrooms are located behind this wall. It is usually only a matter of time before situations like this lead to complaints.
Because of the new generation of lifts described before and because of a lower complaint threshold, noise levels in apartment blocks caused by lifts generate more and more complaints from the tenants. Based on a significant number of measurements the conclusion must be that very many lifts do not comply with the current (Dutch) Building Code.
Experience also reveals that, even when the characteristic noise levels, caused by the lift, comply with the Building Code, inhabitants often remain unsatisfied.

In the majority of the researched lifts the measured noise in the apartments is caused by structure borne sound. Due to requirements for lift operation, regulations and codes, reduction of noise levels by use of vibration isolators is limited.
One manufacturer of MRL lifts has recently developed a low noise lift machine, which also has been measured in the field by Peutz Consultants. The specific low noise features of this new machine as well as results of the measurements will be discussed in this paper.

1. Introduction

In this paper the noise problems, which are caused by lifts in apartment buildings, will be discussed. In this case we particularly concentrate on lift installations without machine rooms (MRL lifts). This type of lifts, where the machine is mounted within the lift's shaft at the top floor, was introduced approximately six years ago, with evident esthetical and financial advantages.
However, from the introduction we have come across many situations, in which the lift has been the cause of noise hindrance, especially in bedrooms and living rooms of tenants in the top floor apartments.

2. Situation

2.1. Lift technology

Starting with the introduction of the MonoSpace by manufacturer Kone in 1995, various other manufacturers, like Otis and Pickering, have also introduced MRL lifts. In most cases the machine is mounted at the level of the top floor within the shaft, next to tenant's apartments.

The Kone lift is a gearless lift, which is mounted on the guide rails within the shaft. There is no direct contact between the lift machine and the shaft's construction. The Pickering lift (ecovator) is very similar to the Kone lift but it is equipped with a planetary gear.
The Kone lift is mounted on standard Polyurethane (PU) blocks between the lift machine and the machine supports in order to reduce vibration transmission into the building's construction. The Pickering lift standard doesn't come with vibration dampers.

The new invented, type GEN I or II, Otis lift is a conventional lift machine, with a long cylindrical layout as to fit within the lift's shaft. The lift machine is mounted on a pair of horizontal beams, which are supported by the shaft's wall.
Vibration damping is obtained by mounting rubber dampers between the horizontal beams and the shaft's construction.

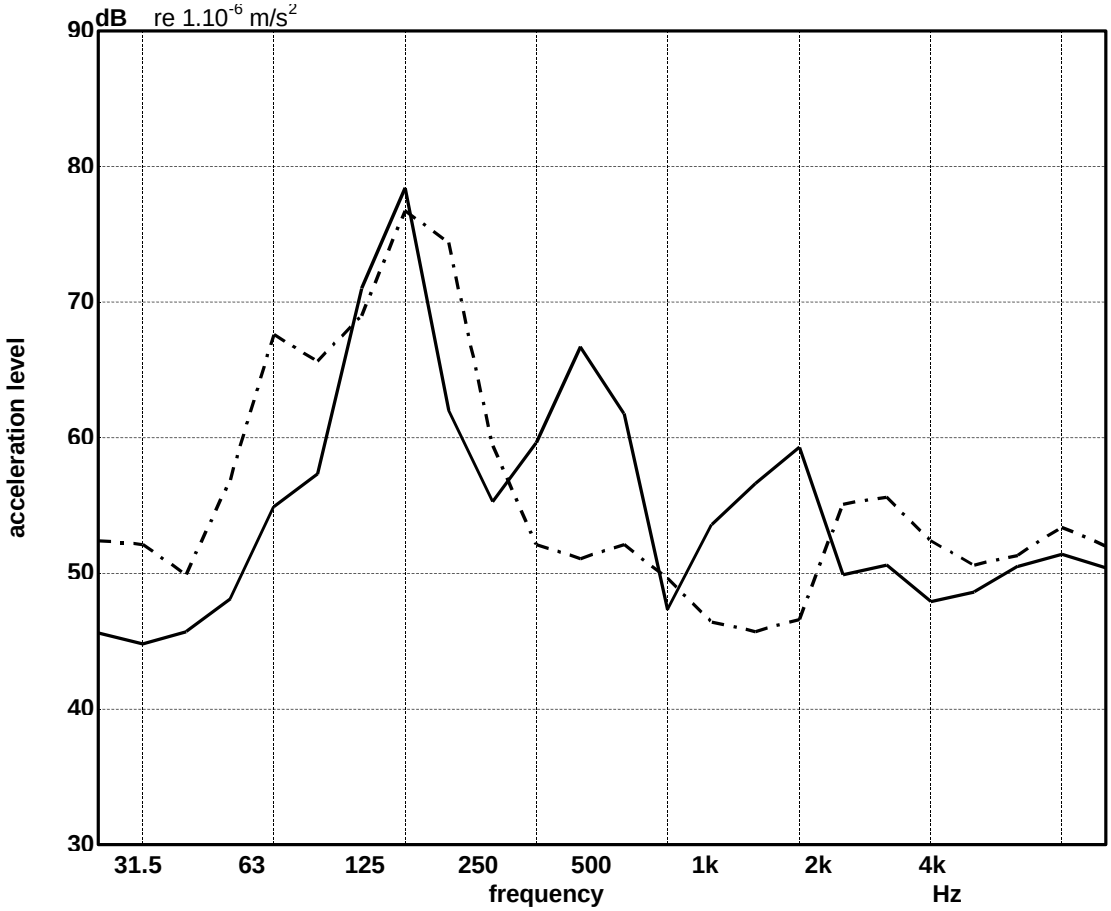

figure 1: the effect of rubber vibration dampers on the acceleration level within the bedroom wall (dotted line is the acceleration level after provisions)

Two aspects restrict the effectiveness of rubber dampers. First of all the weight of the lift machine is only approximately one tenth of the total weight of the installation, including the lift cabin and the counter weight.
In order to reduce vibrations effectively, the resonance frequency of the dampers should be less than 10 Hz. This means that the deflection of the dampers must be 3 to 4 mm, related to the lift machine's weight. Assuming linear deflection, the deflection caused by the entire installation will be over 30 mm, or the dampers will be overloaded. A deflection of 30 mm or more is usually in conflict with requirements for rigidity of the lift's construction and may effect the operational reliability of the lift.
Due to above-mentioned restrictions, the application of rubber dampers does not have sufficient effect on structure born sound, especially at the determining frequency of 125 Hz, see figure 1.

2.2. Requirements

In the Netherlands the Building Code (Bouwbesluit) is applicable to all apartment buildings, which are built after 1992. This means that all MRL lifts have to meet the noise requirements laid down in this Building Code.
In the Building Code it is stated that the characteristic noise level, caused by a lift within an apartment building, should not exceed 30 dB(A) in any bedroom or living room of the apartments. The characteristic noise level is obtained by measuring the maximum sound level, during the lift's run, measured with "Slow" response of the Sound Level Meter. This maximum sound level is then corrected for the reverberation time and dimensions of the room, in order to calculate the characteristic noise level.

Our experience shows however that, even in situations in which the lift meets the Building Code's requirements, complaints still occur. We therefor often recommend specifying 25 dB(A) as requirement.

2.3. Sound level measurements

The differences between the various manufacturers are not very significant from the acoustical point of view. Peutz Consultants has measured all three lifts in different apartment buildings. In situations in which a bedroom or living room is situated behind the shaft's wall, on which the lift machine is mounted, with a dividing space like a storage room or hallway, characteristic noise levels of 35 – 40 dB(A) have been measured.

It is remarkable to see that for all three different types of lifts the sound pressure level of the 125 Hz one-third-octave band determines the total sound pressure level.
All measured sound pressure levels within the apartments are caused solely by structure born sound. This means that, in order to reduce the characteristic noise levels within the apartments, the structure born sound levels must be reduced.

3. Low noise machine

One of the manufacturers mentioned before has succeeded in developing a low noise lift machine. The low noise characteristics are obtained by two major changes of the gearless lift machine, namely:

- the lift machine is fitted with a larger amount of stator windings, which increases the specific frequency of the lift machine from 120 Hz to 160 Hz;

- the voltage build-up within the windings has been smoothened by doubling the number of voltage steps from 3 to 6, see figure 2;

- the casing of the lift machine is constructed more rigid, using FEM-techniques.

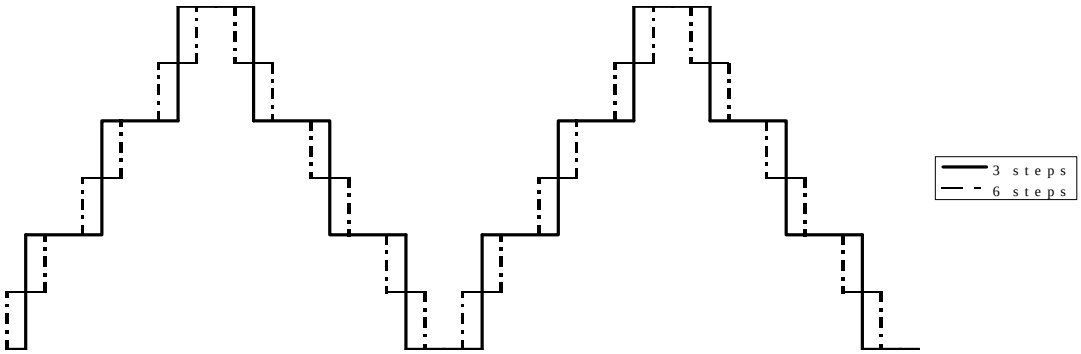

figure 2: the principle of smoothening the voltage steps

Because of the higher specific frequency of the machine, the impedance of the shaft's wall increases, which makes it more difficult for the machine to excite the building's construction. Combining this effect with a smoother phase current, leads to up to 30 dB lower acceleration levels in a concrete shaft.
The sound levels within the apartment decrease by 10 to 15 dB(A), which is also measured by Peutz Consultants in one situation in the field.

4. Conclusions

In order to minimize the chance of noise hindrance within apartments, caused by lifts, the characteristic sound levels within the apartment should be less than 25 dB(A). Up to now the new type of MRL lifts usually caused characteristic sound levels between 35 and 40 dB(A), with obvious consequences and complaints from the tenants.

The sound levels are, without exception, caused by structure born sound, which is determined by the sound level in the 125 Hz one third octave band. The recently developed improved Kone MRL lift generates up to 30 dB lower acceleration levels within the shaft's construction and 10 to 15 dB(A) lower characteristic sound levels. These results were confirmed in one field situation in the Netherlands.

5. Acknowledgements

We would like to take the opportunity to thank Kone for letting us visit their R&D and manufacturing facilities and for an open discussion on the pro's and cons of MRL lifts.