Noise and Vibration Control at High Speed Elevators

There are many sources of vibration capable of producing motion sufficient to be perceptible by the occupants of a modern building. With building structures getting lighter, mechanical equipment rooms getting smaller, and equipment running at higher speeds, problems are on the rise. In addition, the public is increasingly aware of the effects of noise and has become more “noise conscious.” Noise problems within buildings can no longer be neglected.

In view of noise and vibration control at elevator, the most appropriate lift should be hydraulic elevators. The hydraulically powered mechanism and modest operating speed of hydraulic elevators generated really little noise and vibration that no control measures required. While it’s comparatively low speed limits its application to low rise buildings at height up to around five storeys and is rarely use for city buildings.

New buildings in cities, not only commercial, but hotels and residential blocks are rising higher than ever. Architects are driven to design skyscrapers due to expensive land cost. These buildings require elevators run at super high speeds so as to save travel times within the buildings. To meet this requirement, some elevator manufacturers have in recent years developed technologies to allow elevators to achieve speed as high as 810m/min (13.5m/s). The increase in speed of elevator does not only lead to riding comfort problem for passengers inside lift car while also caused a series of problems in regards to the generation and transmission of noise and vibration within the building.

Noise problems within building arise from vibration introduced by rotating mechanical equipment mainly come from:

- HVAC equipment
- Elevator and conveyance systems
- Fluid pumping equipment

HVAC and other fluid pumping equipment vibration control are common and have already been considered by almost all consulting engineers. Whilst the most annoying source normally be overlooked by the design engineers is the elevator noise. Elevator system severs the building occupants all round the clock, and has never been possible to be controlled by means of operational measures or long period suspension for remedial measures. When vibration problem arise, the impact to users and building occupants could not easily be solved.

The quality and functions of equipment in buildings has already been improving day by day and the improvements in building development demand that elevator technology also keep up, in terms of both design and function. Today’s elevators engineers have already put riding comfort of lift car as their major concern in design considerations. While it must also be addressed that elevator operation shall harmonized with the building by keeping its noise and vibration generation at minimal to avoid possible complaints from building occupants.
Most nowadays elevators consist of an electric traction engine pulling on wire ropes attached to the top of the lift car. The motor unit is often located on top of the building in a dedicated penthouse lift room (see Figure 1). Air-borne noise from lifts has generally never been a problem. Typical noise levels inside lift plant rooms being around 70-80dB(A) for modern elevator machines. This noise level could easily be attenuated by concrete slabs and walls which make up the lift motor room.

Fig1. Typical Elevator Arrangement and Vibration Propagation Paths

- Traction Engine Vibration Control

Vibration generated at traction engine during start-up, hoisting and breaking is the major cause of nuisance. Since most traction engines are installed on steel channels base supported by four or six pieces of so called vibration isolation pads with static deflection in range of 1 to 2mm only. These pads are too hard and not efficiency in reducing vibration energy transmitted from the traction motor to the floor slab of the elevator plant room and onto lift shaft walls and connected structural elements, then eventually reached occupants inside building.

Solving this problem seems easy, as we could simply replace the “Hard” neoprene pads by a more efficient spring vibration mounts. But there is always a contradiction between the precision of lift car landing control and achieving higher vibration isolation by using softer springs at elevator base. Since the use of softer springs would induce dynamic motion problem when elevator in operation and deteriorate the riding comfort as well as the control of landing accuracy.

In reducing the dynamic motion and to elevate deflection of isolation mounting, a mass damp system is necessarily. It could be a “Mason” Jack-up Neoprene Floating Floor system (See Figure 2) designed with a large inertia block supported on jack-up neoprene resilient mounts.

Fig2. “MASON” Jack-up Neoprene Isolation System at Traction Engine Support
The neoprene mounting elements are compounded to DuPont bridge bearing specification and conform to the AASHO standard that guarantee the longevity of use. Static deflection rating of mounting element at rated load could be around 8 to 10mm. This system has proven to be not only effective for isolating motor and gear noise, but also be considerably alleviate the start-up “thud” and in turns reduced the vibration transmission at lift shaft to adjoining structures and noise sensitive areas.

In contrary, hotel guest rooms and residential bedrooms is a unique situation where occupancies are conscious on the noise level, since these places are designed for sleep with a noise criterion as stringent to NC30 to NC35, so that guide rail vibration should be considered carefully in the design stage.

Nowadays, structure-borne vibrations from the lift car rollers and guide rails has been substantially treated by elevator manufacturer by using of rubber types at rollers and more precise guide rails at the elevator system. While sound re-radiated from lift shaft walls caused due to the vibration from guide rails is still a problem when passing speed exceeded 2.5m/s. Figure 4 shows a typical noise spectrum at close proximity to lift shaft walls.

![Fig4. Typical Noise Spectrum in Octave Band Frequency close to Lift Shaft](image)

The interaction between guide shoes and rails is another major source of vibration when considering high speed elevators. In most office buildings, roller noise is not perceived as a problem at all due to higher ambient noise level. However, in residential buildings and particularly hotel blocks, lift noise in bedrooms or guest rooms common with the lift shaft can be a big problem (See Figure 3), re-radiated noise levels at common shaft wall being in the range 40 to 45dB(A) from passing lift at speed higher than 2.5m/s. At the same time, as the frequency of excitation is determined as according to the speed of elevation and the rail bracket spacing that are at constant, the induced noise problem in most cases are tonal in nature which makes the transmitted noise more annoying.

![Fig3. Noise Sensitive uses common with lift shaft](image)
To solve this problem, the simplest way is to insert a resilient vibration isolation pad at support brackets. The isolation pad has to be soft in dynamic movement for best vibration absorption and becoming hard when at overload, so as to keep the rail in position and guiding the vertical movement of elevator cars properly. To facilitate this, a quasi-linear load to deflection material called Sylomer® is used. Its non-linear deflection vs load characteristics precisely controlled the “Soft” region to cater the lift roller loads and maintaining best practical minimum movement when load is excessive (See Figure 5).

The fine cellular structure of Sylomer® allows for the necessary deflection when loaded statically or dynamically. Materials with densities between 150kg/m³ and 680kg/m³ are available for using at different loading conditions (See Figure 6).

A load-deflection curve typical for Sylomer® is as shown in below figure (See Figure 7). At low loads, the deflection increases proportional to the pressure. When permanent static load is applied to the material within this linear range, the long-term creeping effective would be very small. The material reacts “Soft” with progressive dynamic loads and allows efficient vibration damping. When loads exceeded the degressive load range, the load deflection characteristic becomes progressive, material at this load range becomes stiffer with increasing load that movements at overloads are limited.

The combination of the above vibration control system has proven to be successful in numbers of jobs locally and overseas. As the actual situation varies from case to case, our technical team is glad to provide sound advises at your request.