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Lift Design: Still room for improvement

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INTRODUCTION

Despite many advances in lift technology there are several areas of lift design that are still costly for lift owners and lift manufacturers. It is intended to briefly explore these areas with some historical examples as a spur to furthering research and improving the management of lifts during their life.

Two drivers of lift design advances are ride comfort requirements and reduction of energy consumption. Maintenance is driver of cost that can be better controlled.

Lift Ride Comfort. Lift ride comfort is easily specified but can be hard to achieve on site. For many buildings, the structural design, e.g. steel frame or wood provides a flexible springy support for the lift which also has similar characteristics. Often lift systems are designed assuming that they will be installed in a stiff concrete structure. When this is the case there is little dynamic interaction between the building structure and the lift. In the case of multiple lifts in the same lift well, there may be common load bearing suspension steel work having two or more lifts suspended from it. In this case the case common suspension can make a superb but unwanted coupling mechanism between the suspended lifts which act as complex pendulums. Unwanted interactions between the lifts (pendulums) can result in uncontrollable noise and vibration. As an example, two such suspended lifts were parked at the lowest floor of the building. One person with an EVA ride comfort meter was placed in one lift. A second person then did fast squats in the second lift to get the lift car oscillating vertically. The first car started moving in resonance with the second lift with an average vertical acceleration of $0.8 m/s^2$.

In the case of wooden and steel lift well structures, both are flexible in 3 planes. The stiffness of these structures is less than that of concrete and so the lift dynamics can interact more with the building structure. Undesirable effects as the distance between guide spacing and lift to landing running clearances varying with lift loading conditions can occur. External lifts in steel supporting structures have been affected by design of supporting structures that used flexible pinned joints. This has led to expensive reworks to the structures so that they support the lift and not vice versa.

Wooden structures need careful consideration of the lift to structure interfacing components such as load bearing fixings to the structure. A possibly hidden cost is the associated training needed for installation personnel to work with, what may be unfamiliar fixing methods.

The interaction between the building and the lift is seldom analysed in order to achieve the desired results in terms of dynamic performance. A similar situation pertains to the acoustic transmission of noise between the building and lift. The acoustic transmission performance of the building fabric is not a parameter in control of the lift manufacturer. Yet, in the case of excessive noise transmission (clicks and high frequency noise), it is often the lift manufacturer who is expected to solve the problem. Lift manufacturers should be able to provide a lift equipment noise power spectrum and kinematics to architects in order to allow a planned noise transmission design of the surrounding structure of the lift where low noise is important.

Modifications to existing lift installations by changing the mass of the car, rated speed, hoisting machine rated rpm can turn an originally quiet smooth running lift into a vibrating noisy box. One example created a 50 Hertz noise in the car due to the interaction of its dimensions with the new gearbox motor rpm at the rated speed of the lift. This was only economically solved by the addition of a Stockbridge damper to the crosshead of the sling of the car.

Reduction of Energy Consumption At first glance, energy consumption reduction is a simple matter of lowering acceleration values for the lift, switching off equipment when the lift is not required to run and reducing the mains supply voltage. The first helps with achieving specified ride comfort levels but decreases passenger handling performance. An increase of 1 second in a one floor travel time can reduce traffic handling capacity by approximately 5 %. There is more to lowering acceleration values than meets the eye.

Reduction of mains supply voltage can be an issue for lift component reliability in the control system. There have been several cases of voltage reduction schemes being applied to lifts in existing buildings with promises of big energy savings as a consequence. Typically the supply voltage at the incoming supply to the building has been reduced to 400 volts or lower. Almost without exception, the lift equipment has become unreliable with an increase in equipment breakdowns and failures of variable frequency drives, contactors and relays. What has been missed is:-

1. The lift hoisting power requirement is independent of the supply voltage. Reduction of the supply voltage increases the hoisting current.
2. Low supply voltage at the terminals of the lift controller is exacerbated by the increased voltage drop in the supply cables to the lift during acceleration of the lift.
3. Contactors and relays have a quite narrow operating voltage range for correct mechanical and thermal operation. Operating outside that range consistently causes contact welding and burning due to slow contact closure on low voltage and coil burnout on high voltage.

Lifts control systems for operation consistently on low supply voltages need subtle changes in design approach for economical manufacture of a system that will also work on high voltages. The use of switch mode power supplies to provide a suitable supply to contactors and relays is necessary for high reliability. Solid state drives such as variable frequency drives need to be rated for the higher input currents associated with lower voltage operation than the nominal mains supply voltage for the country of use. The mains supply cables from the incoming mains distribution board will need to be larger in the general case to provide acceptable voltage drop.

Lifts commonly use a lot of steel. Whole life energy use (including energy used to manufacture the lift) considerations may lead to other materials being preferred. Counterweight mass reduction is superficially attractive. However it can increase maximum current demand on the supply, will increase the required maximum hoisting motor torque and power output. Maintenance of traction may also need the use of compensation which is another increase in the use of materials.

Maintenance. The lift industry has a long way to go in order to provide reliability based maintenance that is an asset to both the lift owner and the maintenance provider. Many current approaches to maintenance are based on inadequate knowledge of the maintenance needs of individual equipment designs. Maintenance by many companies is based on a “One Size Fits All” module regime where specific tasks are carried out on a rolling fixed frequency basis. This may fit their own products where they know in detail what needs to be done in order to keep the lift running reliably. It is not at all true that the same approach can be taken with another product from another company or for older technologies. A classic error is to reduce the contact cleaning regime on older open relay equipment. This state of affairs is partly due to the maintenance documentation requirements laid out in [1]. This document requires that instructions are given for safety components but does not require information to be provided for rapid fault diagnosis, design life times of components, lubrication requirements in detail for the type of lift equipment. True reliability based maintenance requires such information so that correct and timely lubrication is carried out; wearing components are changed before they are life expired and causing (random) breakdowns. Most mechanical devices wear out due to time running, not the elapse of calendar time. As an example of unacceptable failures due to lack on design life knowledge take sealed bearings in lift components such as counterweight and diverter pulleys that are “sealed for life”. It is not a normal activity in maintenance at present to take the load off these bearings to allow a check for wear and excessive play or to take a sound signature that can be compared to a good bearing sound. Consequently there have been many bearing failures leading to free fall counterweights, rope damage. The incident described in [2] in 2008 is a classic example.

Two most important components to be added to a lift for effective management of this type of maintenance are an “Hours run meter” and a “Starts counter”. Lift components only wear when the lift is moving or required to move. Contactors and relays wear out on number of operations, dependant on contact loading as well. Without the meter and counter, all knowledge about the wear state of the lift is a “guestimate”. Who pays for that lack of knowledge and timely maintenance activity? It is the lift owner in the general case.

REFERENCES

[1] BS EN13015: +A1:2008 Maintenance for lifts and escalators — Rules for maintenance instructions

[2] Technical Report on the Lift Incident on 25 October 2008 at Shin Nga House, Fu Shin Estate, Tai Po. Electrical and Mechanical Services Department