Do we compromise safety in elevator systems?

Dr. F. Celik
Blain Hydraulics

Abstract
In elevator industry, the most important design criterion is safety. Safety comprises both the safety of passengers and the safety of maintenance personnel. The safest elevator under exposed working conditions should be determined. Having made a correct choice, details of elevator design should then proceed.

In this article, safety and reliability issues will be examined for hydraulic and electric machine-room-less (MRL) elevators.

Safety

Elevator safety has three main parts. These are;

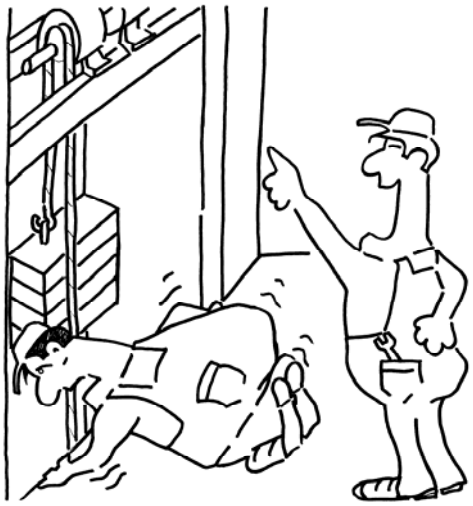
1- **Operational safety**, which considers the safety of passengers before, during and after travels,
2- **Rescue safety**, which considers the safety of passengers and resquers during rescue operations in emergency situations,
3- **Technician safety**, which considers the safety of maintenance people during servicing, repairs and inspections.

There are clearly humanitarian, legal and economic grounds for providing a safe elevator system. To satisfy these obligations, it is necessary to implement an active policy of accident prevention in elevator systems. An accident is any unplanned, uncontrolled, or undesirable event that may cause injuries (disability, pain and suffering), damages (to equipment and buildings) and losses (of life, earnings, time and image). An accident cause is an uncontrolled hazard, without which there could be no accident. Therefore, in the policy of accident prevention, every possible accident cause should be evaluated.

Elevator accidents don't just happen. Actually, the potential for accidents extrapolates from the known negligible hazards. The causes of accidents, which may be seen, experienced or anticipated in daily life, must be taken seriously if these are to be prevented in the future. It is possible to classify accident causes for elevator drives under the headings;

Building- e.g. imposing vertical loads on old buildings or weak shafts increases accident risks.
Equipment- e.g. incorrect equipment and installation methods, poor access, existence of counter weight.
Environment- e.g. dangerous working conditions, more detrimental situations for electronic and mechanical components, high noise, insufficient light.
People- e.g. careless, untrained, over-stressed.
Systems of work- e.g. poor procedures, bad maintenance.

Everyone, in the elevator industry, has a part to play in creating and maintaining healthy and safe working conditions which have the principal objective of avoiding accidents, the consequences of which are pure chance. **Accident prevention programmes**, which are the process of removing or controlling accident causes, can only be successful as long as the product obeys '**fail-safe**'design properties.



It is good that wou worked for a circus before. There is the machine that you should inspect…

Until 1995, there were traction and hydraulic elevators on the market, both with a machine room, where installation, service and rescue operations can be safely and easily performed. With the introduction of the MRL elevator, the fail-safe design criterion is compromised. That is, the machine room has been omitted and the machine is placed in the shaft, mostly in the head room or sometimes in the pit. As a result, reaching the elevator machine becomes complicated and unsafe. Therefore, serious accidents during construction and servicing of the elevator are more likely. In case the car is stuck and cannot be moved, insecure methods may need to be attempted. Besides that, the rescue of passengers during an emergency situation becomes problematic, since each type of MRL machine requires different expertise to assist trapped people to escape. MRL elevators seem to be suitable under ideal working conditions, where abnormalities do not arise. Installation of such elevators in seismic regions clearly invokes risks. MRL not only causes more fatalities during natural disasters but also results in more damage and renovation costs due to the hanging motor assembly and the counter-weight in the shaft.

Although safety is being discarded by sacrificing the machine room, conversely, elevator directives are being modified to legalise MRL elevator installations. The certification of less safe elevators cannot be justified. The need for a machine room is known; therefore the responsibilities of elevator companies, experts and code makers for promoting safer elevators cannot be abdicated.

On the contrary, hydraulic elevators are fail-safe elevators and have proved themselves in low rise buildings for over 50 years. This is because of their inherent design and being supported directly on the foundation.

Reliability

With the current pressures to reduce cost and the tendency towards increased complexity, the probability of a product failing within its anticipated working life is likely. As reliability is an exceedingly important aspect of competitiveness, there is a need to **design reliability into** products. The testing of a design to assess its reliability can be difficult, sometimes impossible, and the designer must therefore invest in any insurance which is practicable. Some methods towards assuring reliability are:

(a) use proven designs
(b) use the simplest possible design; the fewer the components and the simpler their designs, the lower the total probability of failure.
(c) use components of known or high probability of survival.
(d) design to ‘fail-safe’
(e) specify proven manufacturing methods.

All these requirements apply particularly to elevators. Contrary to the above rules, MRL elevators are more complicated, consist of more components and are difficult to install.

Don't worry, we will get you out by tomorrow...

Reliability of an elevator drive system may be assessed by measuring the average time between two breakdowns or failures for a period of time. No-failure or minimum failure condition can be provided in two ways;

1- by means of a more reliable design in which case, elevator system will be more expensive.
2- by providing frequent servicing for early detection of failures in which case, charges for spare-part changes and labour would make the annual cost of elevators excessive.

Therefore, in some cases, where continuous operation is provided through frequent servicing, low failure records of an elevator may not indicate directly that the elevator is reliable or safer.

Today, MRLs are introduced as the biggest technological innovation to the elevator sector. The improvement in permanent magnets and also design and manufacture of synchronous motor technology of related industries cannot be denied. However, the main discussion point here is that how these developments have been reflected on the elevator industry. **Is it true that a technological improvement has been succeed by placing the elevator machine in the shaft?**

It has been stated by notified bodies and technicians that elevator safety has declined with MRLs. The May 2006 forum by the European Notified Bodies–Lifts (ENB-L) revealed that most of the recommendations for use (RFU), which were suggested during the forum, were directed towards improving on the questionable safety of the MRL installations. Those recommendations overlapped criticisms that were published in previous technical articles. In addition, a presentation on recommendations for use by Mr. Miles at the European Lift Congress, held in Heilbronn on October 2006, clearly indicated weak points of MRL's in terms of safety(1).

When these points are raised, MRL manufacturers fail to give satisfactory explanations, instead, claiming other gains of MRLs, such as saving machine room area, less energy consumption and environmental issues. These points are not as advantageous as they imply, and certainly cannot be directly related to the safety of elevators. So, let us investigate these points.

The claimed saving of space through the MRL is an exaggeration. Hydraulic elevators already save the machine room area in the head room. Furthermore, the necessities of the counterweight in traction elevators requires the shaft to be larger than for a hydro, taking away expensive area at each floor level compared to the inexpensive but far more practical machine area at ground floor.

The main reasons for avoiding machine rooms in buildings are the restriction on building heights by local authorities and architectural arguments. These objectives however cannot justify the use of less safe elevators. On the other hand, hydraulic elevators have the best safety records and automatically satisfy the other conditions through the flexibility to place the machine room anywhere in the basement or at the entrance level of the building.

(1) M. Miles, 'European Horizontal Co-ordination of Notified Bodies – Lifts', 2. European Lift Congress, October, 17-18, 2006, Heilbronn.

Who will protect us from 'MRL protective maintenance'?

Among design criterion of elevator drives, energy consumption of the drive unit is a modest 4 to 6 percent of the total energy consumption of the building. Another fact is that the cost of operating an elevator is considerably less than the cost of servicing it. Therefore, knowing servicing and spare-part costs in advance is very important. A component price is proportionally related to the energy consumption of the component manufacture. Therefore, while comparing the energy consumption of different elevator types, assessments over the number of components and prices of components would give more realistic figures. The most expensive spare-part price of MRLs is approximately 30% of the total elevator price however; this is about 6% for hydraulic elevators.

Elevator companies, who have the policy of obtaining their profit through service strategies, dictate their servicing methods in the name of 'protective maintenance' and allow no other servicing alternatives to elevator owners. This strategy is hidden in the directives where, original part use has been dictated. It should be clear that 'protective maintenance' is a part of 'Total Productive Maintenance-TPM' which evolved at the end of 1960's in Japan. In this philosophy, the system's working condition is standardised such that failure can be predicted before happening and productivity kept at the highest level. The necessary conditions for the TPM concept to succeed are to provide a consistent manufacturing environment, to simplify part designs, and to provide easy access and easy changeability. Namely, improved working conditions for higher reliability is required. Unless such improvements are in operation, one cannot talk about implementation of protective maintenance. This can only be judged as an attempt to exploit the name of protective maintenance in order to justify frequent part changes and service obligations.

Contrary to MRL propaganda, the effect of hydraulic elevators to environment is extremely low. Hydro oil tanks usually contain 100-400 liters of oil, which is replaced approximately once every 10 years. The used oil is collected for re-cycling so that there is minimum waste. The danger of spillage with the hydraulic elevators minimum since these tanks are located in sealed concrete wells and everz possible leakage is drained to the tank. Compare this to the oil that is used and misused in trucks, trains, cars and planes, and especially the contamination of the seas due to carelessness of marinal practices.

Comparison of Hydraulic and MRL elevators

In the following table, hydraulic and MRL type elevators are compared with respect to various design constraints in low rise buildings. Total assessment mark of 3 is divided among the two elevator systems for each design constraint and the percentage marks for safety, cost, other and total points are shown in a graph. The points awarded for different conditions may vary for among assessors but the general trend would be unlikely to change.

The comparison: Hydro vs Electric Machineroomless

The most common lifts are for offices-appartments-homes / 4 person • 2 – 4 stops

Safety Advantage	**Points**	**Hydro**	**Points**	**MRL**
Installation & Maintenance	2	Driving equipment safer, easier and quicker to install in a compact machine room.	1	Drive assembled in the shaft, or in the top floor corridor. Passers-by and mechanics are exposed to danger.
Rescue operation	3	Simply operated 'lowering' knob or 'raising' hand pump for safe and quick rescue in either direction.	0	Expert lift mechanic must be found and directed to emergency location. Insecure rescue methods may be attempted in the shaft. Valuable time is lost.
Earthquake & Fire	3	Lift carried on the shaft foundation by a rigid cylinder. Machine room safely accessable at the lowest floor.	0	Attached at the top of the shaft. The drive is precariously placed. A swinging counterweight adds to the danger.
Relative Safety	**8**	**Safety %** **89 %**	**1**	**Safety %** **11 %**
Cost Advantage	**Points**	**Hydro**	**Points**	**MRL**
Equipment	2	Equipment for a typical 4 stops - 4 person lift costs approx. € 16.000.	1	An equivalent MRL lift costs 10 to 30 % more unless subsidised by higher servicing costs which is often the case.
Installation	2	Installation costs are lower due to the convenient location of the power unit in the machine room.	1	Through inconvenient positioning of the drive, the installation costs are about 25 % higher than with Hydros.
Maintenance	3	Costs are moderate with the motor-pump drive operating ideally under oil in a disturbance-free machine room.	0	Equipment is inconveniently placed costing extra preparation and maintenance time. Replacement parts are expensive.
Energy	1	The insignificant energy cost for 1 year is between € 60-130.	2	The MRL electrical costs are typically between € 40-80 per year. Comparison; a family car energy cost can be over € 3000 per year.
Environment	1,5	Most energy is used in manufacturing the cylinder. Hydraulic oil lasts for over 10 years and it is then recycled. Environmental harm is negligible.	1,5	Increased number of components and complexity. Most energy is expended in manufacturing extra parts and the counterweight rails. Oil and grease lubrication has a negligible effect on the environment.
Relative Savings	**9.5**	**Cost %** **63 %**	**5.5**	**Cost %** **37 %**
Other Advantages	**Points**	**Hydro**	**Points**	**MRL**
Noise	1,5	The machine room damps out most of the noise from the power unit.	1,5	The noise of the MRL motor in the shaftway is more disturbing than when the drive is in a machine room.
Ride comfort	1.5	Similar to that of the MRL.	1.5	Similar to that of Hydros.
Speed	1	The ideal speed of a 4 stop, 4 person Hydro is 0.4-0.6 m/s (max. 1 m/s).	2	The ideal speed of MRL's is about 0.6-1.0 m/s (max. 1.6 m/s).
Car space	2	Larger car size fits in same shaft.	1	Smaller car size due to counterweight space.
Mechanics opinion	2	90% of mechanics prefer working conditions on Hydros	1	Unpopular.
Relative Advantages	**8**	**Other %** **53 %**	**7**	**Other %** **47 %**
Relative Value	**25,5**	**Hydro Total** **65 %**	**13,5**	**MRL Total** **35 %**