SAFETY IN THE ELEVATOR INDUSTRY.

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ABSTRACT.

This paper will deal with the many aspects of safety to be considered in current design of elevators and also how technicians may need to be trained to inspect and or service both old and new equipment. Changes in technology, metrication and the approaches to skill training could bring about unsafe practices. In today's competitive market service contracts are often changing from the original installing company to competitors, this can increase the risk of accidents unless suitable training is carried out and correct replacement parts are available to ensure the continued safety of both service mechanic and the public.

BACK TO BASICS.

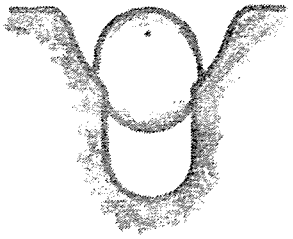
Over the last decade there have been major advances in the technology used on modern lifts (Elevators), this has been both interesting and rewarding to the industry. It is my concern that in some cases we have progressed so fast that we have ignored some of the lessons we learnt in the past. With this in mind I thought it appropriate to consider some of the dangers that can occur to persons or property if we are not careful.

MECHANICAL.

METRIC / IMPERIAL ROPES

Where countries have been using and manufacturing sheaves for metric rope sizes there is no problems, it is a different matter where companies are using both metric and imperial ropes and sheaves. Firstly, if the wrong rope is used in traction sheaves it could have the danger of less traction or too much traction. If an undersized rope is used on the wrong size parallel undercut groove for that rope it could provide enough traction to lift the car or counterweight with the opposite member landed on the buffer (see Fig. 1). Worn vee and non standard undercut grooves may have an adverse effect on ropes, particularly the wrong size ropes. Secondly, the wrong size governor rope,particularly undersized rope may not provide sufficient pull on the safety gear during governor operation.

Fig.1



BOLT SIZES

There are two main points that must be watched with regards to bolt sizes, particularly in the field. Firstly, use of bolts and nuts that are not compatible, that is the thread pitch and or thread diameters are not the same (see Fig.2). Secondly, the use of under size bolts being fitted into holes intended for fitted bolts (see Fig.3).

Fig.2

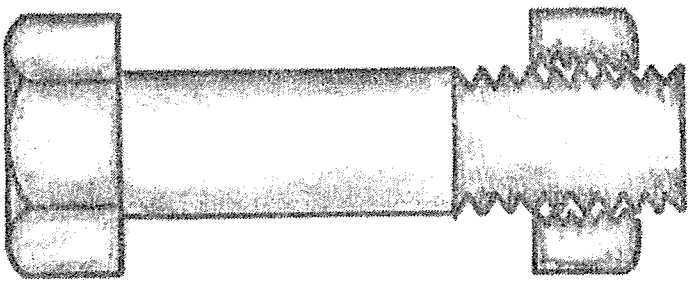
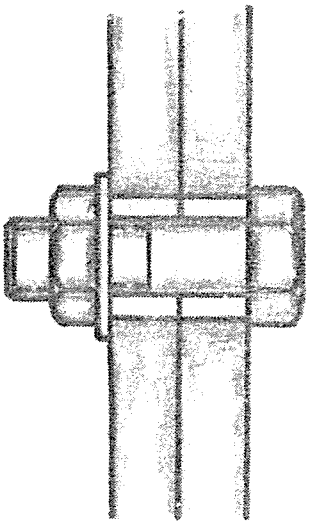


Fig.3



HIGH TENSILE BOLTS

The use of high tensile bolts to achieve the required strength or factor of safety might be acceptable in factory built equipment such as machines. In these cases the control of these special high tensile bolts is available. On the other hand the problem in the field is completely different, as it is very easy to mix standard and high tensile bolts during construction of the lift.

GOVERNOR JAWS

The reliability of the safety gear to operate depends on the governor rope being clamped in the governor jaws with the correct amount of force. The clamping force is dependant on the correct size of rope and the shape and condition of the jaws. If the governor operates too many times excessive wear on the governor jaws may reduce its effectiveness.(see Fig.4)

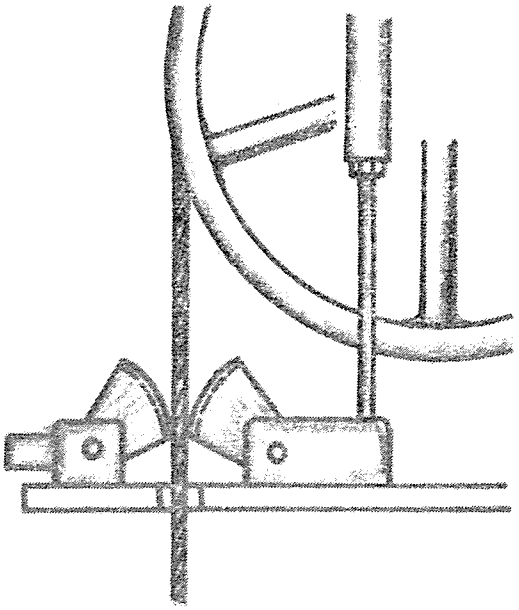


Fig.4

BRAKE SYSTEM CONDITION.

The condition of many braking systems can go undetected nowadays because the lift stopping is carried out electrically and the brake only sets after the lift has stopped. Periodic load testing of the brake should be carried out to ensure its effectiveness.

SAFETY GEAR JAWS

The wearing out of safety gear jaws or wedges can cause failure of the lift to stop in the event of either an overspeed or rope failure. The cause of jaw wear is usually from one of the following; too many operation of the safety gear due to fault conditions, incorrect adjustment of safety gear rail clearances when fitting or replacing guide shoes. Also the actuating system may be incorrectly adjusted causing the jaws to be partially set, and too close to the rail. Last but not least the wedge material may not be suitable, causing excessive wear during operation.

LUBRICATING OR NOT LUBRICATING RAILS.

The use of lubricant on guide rails must be carefully selected or prevented depending on guide shoes or rollers, safety gear type and conditions that applied at the time of test. There have been case where the service mechanic has found the rails were always dry due to the hot windy conditions. The guide shoes were the type that required lubricant, so he lubricated the rails with a molybdenum grease which helped his lubrication problem but now the sliding type safety gear would not hold the car.

CAB REFURBISHMENT

Relining of cabs should only be done under the eye of the lift designer or person competent in understanding the implications associated with not only the removal of the old lining but the change in weight associated with the new lining. The traction ratio needs to be watched during the refurbishing. Before the work starts the changes in weight must be accurately calculated and if they exceed the existing weights the following items will need to be checked. Any additions to the counterweight, strength of ropes, the limits on machine shaft loading, capacity of safety gear, brake capacity and buffer rating

BOTTOM DOOR GUIDES.

During normal operation of the lift faulty or missing guides on the bottom of landing doors are not noticed. Accidents have happened where children have been playing on the landing outside the lift and fallen against the doors. In some cases the doors have swung into the well and the children have fallen down the shaft. The addition of metal safety fins adjacent to the door guide gib have reduced these accidents, but some codes now require an independent metal plate to be fitted that is not part of the door guide assembly and does not have to be removed when fitting new door guide units.

LEAKS IN OIL BUFFERS.

The loss of all or some of the oil can cause injury to persons and damage to the equipment, some authorities around the world request different forms of protection to ensure the buffer is in correct working order. All these are not fool proof, for example a switch to ensure the buffer has reset itself at the top of its stroke after operating does not ensure that there is sufficient oil in its reservoir. A float switch can be a dual system that will detect if too much oil has been added and or if the level has fallen below the safe minimum.. None of these ensure that the oil viscosity is correct for the porting of

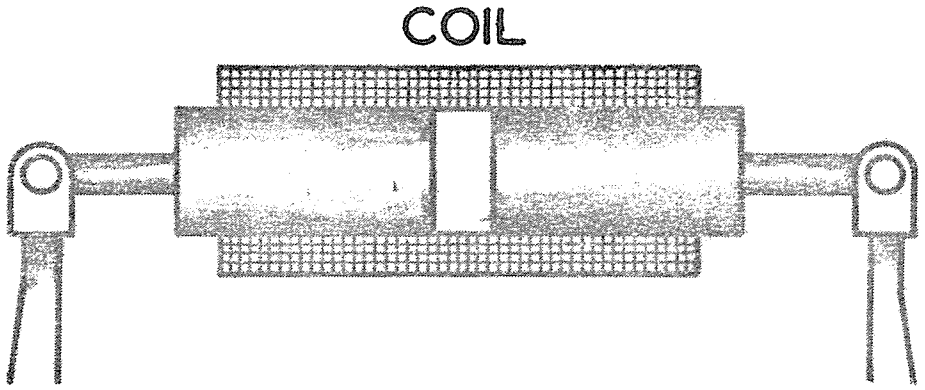
flow restriction in the buffer. There have been cases of the pit being flooded and the oil in the buffer being replaced by water due to the oil floating to the top.

ELECTRICAL.

RESIDUAL MAGNETISM

The dangers associated with residual magnetism are usually not at the design stage, in most cases they are caused by poor service. The first and most important item is the machine brake. Unless the brake is dismantled and cleaned regularly dirt and metallic dust can build up inside the core tunnel of the coil assembly (see Fig.5). If this happens and the core air gap is adjusted too small the brake can remain held off even though the power has been removed from the coil. In some assemblies of brake or switch gear magnetic systems the designer may have inserted a copper or brass ring or washer to ensure the magnetic cores never came in contact with each other. In servicing such magnetic systems ensure that the correct parts are fitted back in the same configuration as designed.

Fig.5



LAMINATED SOLENOIDS.

The problem of relays , contactors and brake magnets jamming is mainly associated with AC systems that are subjected to very high operations per hour. The high inrush currents associated with AC systems causes hammering of the cores and distortion of the lamination stack. This stack distortion can eventually cause the parts to jam . In the case of the contactors they can jam with the contacts still making, and in the case of brake assembly the distortion can cause the brake to hold off and not stop or slow down the lift.

AC/DC RATING OF PARTS

Over the past few years the control voltages on coil circuits have changed considerably and in fact have probably increased in voltage selections by 200%, many of these changes are due to electronic devices requiring different interface voltages. One of the main dangers is the supply of too higher voltage to coils., This inturn can cause a coil core or magnetic system to distort and jam in the incorrect position. In the case of hydraulic lifts it can jamb the pilot solenoid in the wrong position. In the case of traction machines it can cause malfunction of the main lift brake.

CONTROLLER "BLACK BOX".

The days of the inspector requesting safety checks on new and old installations has changed considerably. The old circuits and relay logic could be visually observed and understood by field and inspecting personnel. Today we have the "Black Box" the electronic secret made up of sealed static devices. Todays designer of lift control equipment develops circuits using these electronic devices that by the time they are in operation in the field are out of date, and a new breed of device is available. It now means that three basic things must happen and be accepted.

The designer must provide equipment and circuits that maintain the safety of the lift,and if they fail they must fail to a safe condition.

The designer must maintain records of what he has set out to do and how he has done it.

The designer must set out for the field staff and inspectors instructions on how to test the completed equipment to prove it satisfies the safety requirements.

There is no way any one person can know all the variations of design and components in this rapidly changing technology. There must be trust in the ability of the designer to complete the three steps above and maintain the records of each configuration of circuits and components.

AUTOMATIC HOMING

When working outside the lift car either in the pit or on top of the car it is very important to operate the stop switches before starting to carry out any work. It is also imperative that the circuit is tested to prove that homing control will not operate if stop switches are open. Care must be taken when returning the lift to normal service that it does not unexpectedly respond to a homing sequence.

LEVELLING CIRCUIT PROTECTION

The points on homing control applies also to the re-levelling circuits, the magnetic switch may be off the vane by say 3 mm and changing the load in the car or moving around on the roof of the car may cause the switch to operate without warning, accidents have happened because the stop switch had not been opened, and the car or counterweight had moved before the mechanic could react to open the stop switch.

CHANGING FUSE RATINGS.

Assuming the fuses are the original rating when the lift was first commissioned. One must ask WHY ? when fuses start to blow. To start and increase the rating to prevent stoppages is not the answer. Increases in the fuse rating could cause an overload to the system that may cause a major fire or burn out of the controller or other equipment. Training of personnel to diagnose the cause is a safer and more economical approach.

EARTHING OF LIFT CARS.

The usual method of earthing lift cars was through the lifting ropes. Now with such items as roller shoes, rope hitch isolation, and plastic sheave groove inserts the ropes are no longer an acceptable method. Similar considerations would apply to hydraulic lifts which have roller shoes, ram isolation connections to the car frame, and plastic gland packing and guide rings in the cylinder heads.

SUICIDE FIELDS.

In the past there has been some litigation about the subject of cars moving away from the floor with the doors open. Also moving unexpectedly. This particular item deals with motor generator systems that employ closed loop armature systems. The cause of the problem is an accumulation of some of the following items; quality of magnetic material used in the generator and its residual magnetism, the types of reverse wound or reverse connected fields (or suicide fields) used to neutralise the residual magnetism in the generator when the car comes to a stop, the quality and or reliability of the contacts used to connect the reverse field at the correct time, and lastly the experience and knowledge of the adjuster and service mechanic on this type of equipment.

FAIL SAFE DOOR PROTECTION.

Although we could consider that door passenger protection systems is only a secondary safety device, there are other items that should be noted. With faster door operation and a larger range of door protective systems being installed "Fail Safe" circuits need to be provided. That is faults in the equipment, open circuits in flexible connections to moving doors should stop the operation of doors or at least place them in slow speed mode. There have been systems in operation that required the making of contacts to reverse the closing door, such items can have a fault that is undetected in normal operation.

CORRECTING CIRCUITS AFTER MODIFICATIONS.

When making modifications to lift controls the field staff often find there is a fault in the lift operation, to try and solve the problem they start to make modifications to the circuit. How often have they found that there first problem was fixed and now they have another problem ?. This hit and miss method of making changes may get the lift running in the long run but in many cases the field person has negated some of the designers safety features. It is important to have such changes authorised by the designer and recorded for future reference.

MONITORING OPERATION (WIRING)

With the addition of some monitoring systems being connected to lift wiring there have been cases where the wiring used is below the voltage/insulation standard required. The danger is that the original designer took care to ensure correct wiring and separation of electrical components was maintained to prevent accidental short circuits. Even though the monitoring equipment only needs very low current signals the wiring should not be of lesser quality than the main controller.

GENERAL.

DISMANTLING EQUIPMENT.

There have been many cases where inexperienced persons have tried to move a lift when there is either a power failure or a fault existing that prevents people being able to escape from the lift cabin. One of the common and unsafe approaches has been to dismantle parts of the machinery. Before they realise it the lift has started to move and they are unable to stop the runaway. Do not work on a machine, brake, governor or controller unless you have been properly trained in that particular equipment.

EXTENDED TOE GUARDS

Many old lifts were fitted with short toe guards (platform guards), these were originally provided the prevent persons putting their toe under the lift floor as the car moved down to floor level, or stopped above floor level leaving a space for a toe to enter. It has been found in recent times that when people try to escape from a stopped lift that is about 1500 to 1800 mm above the floor a person could slide under the car and fall down the shaft.

BUILDING COMPRESSION

The effect of building compression may not have any major effect on the building itself which goes through two main stages of compression.These compression movements can cause loads to be placed onto the the lift guide rails, such loads can cause buckling of the rails. The buckling of the rails causes poor riding conditions in the lift car. Lift engineers have developed a variety of sliding clips (see Fig.6) to allow the rail fixings to slide on the rail and so reduce the compression forces.
Also the top of the guides must have sufficient clearence under the machine room floor to allow for the estimated compression.
The two stages of compression are mainly associated with concrete building construction, firstly the drying of the concrete and the progressive increase in loads as the building increases in height. Secondly the loading of the floors as office furniture and partitions are installed.

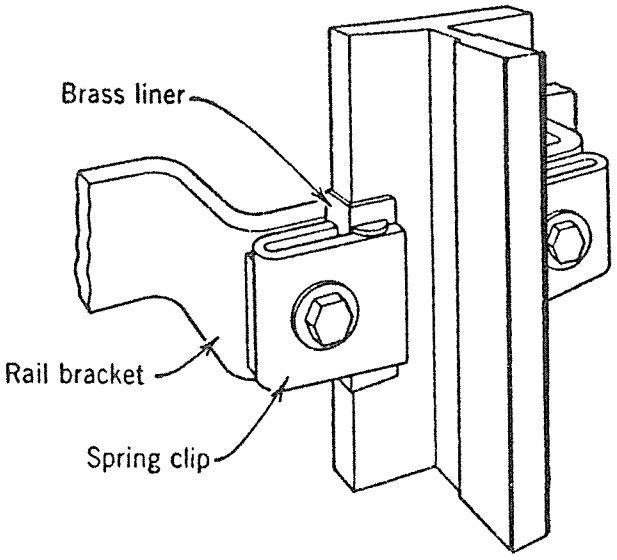


Fig.6

WATER IN SHAFT

There are a few problems associated with water entering the lift shaft. Firstly, that of short circuiting electrical equipment which can stop the lift unexpectedly at any point in its travel, and if passengers are in the lift they will need rescuing. Secondly, the water increases the chance of electric shock to either the person in the lift or the service mechanic.
Thirdly, the water can cause rusting of the safety gear and other normally static parts. Careful inspection must be carried out or these faults may go undetected until these parts are required to work at some time in the future.
Some of the main causes of water damage are the fire sprinklers operating due to accidental damage or some small local fire in the lobby. Another way for water to be introduced into the lift shaft is overenthusiastic cleaners using buckets of water or hoses to clean down the lobby area. Flooding has also filled the lift pits and after pumping out the water there has not been adequate clean up and inspection of pit equipment. Some lifts could have been parked at the lower floor and had the safety gear immersed in the water.

VANES IN SHAFT

The installation of metal vanes in the shaft for operating magnetic switches does increase the dangers for a mechanic working on top of the lift car. In some countries these metal vanes are required to be painted a contrasting colour, or have some continuous wire or rope running down their leading edge. It is always better to keep the metal vanes as far away from the car roof line as possible, and then project the inductor mounting off the side of the car to reach the vanes.

COUNTERWEIGHT IN PIT

Guarding the path of counterweights in the pit area the designer needs to consider several things such as ; clearances to the car and counterweight when either comes down into the pit area, that the guard protects a person standing in the pit from being struck by the counterweight which can be very quiet as it approaches the buffer, and there should be sufficient observation spaces to inspect the buffer and shoes without the need to remove the guard.

SMALL CARS IN LARGE LIFTWELL

The space around a lift car between the edge of car roof and the walls of shaft needs to be considered as a potential danger for the service mechanic working on the top of the car. There is some degree of confusion as to what is the dimension of an unsafe distance or running clearance. Also the equipment mounted in this space such as counterweights, well switches and vanes make it hard to have a hard and fast rule. With the increased use of flat roof area over the whole car area along with better shaft lighting, this has reduced peoples concerns. Extensions to the roof area or addition of hand rails (where permitted) could reduce the risk of persons falling down the side of lift car.

COMMUNICATION.

Communication between lift construction or service personnel is an area to watch, particularly where there is high ambient noise either in the machine room, on the landings or in the lift well. The availability of low priced phones and intercom systems have helped considerably. Language problems have contributed to accidents because the other party though you said !!!. If in doubt it is always important to double check the message. The danger comes when the other person was trying to say "stop" or " turn off the power" waiting to check the message might cause a more serious accident, not because you would not have understood the examples but because you did not hear the message.

CANTILEVER CARS.

The increase of cantilever cars over the last twenty years has been very dramatic. The importance of secure rail bracket fixings and construction of suitable walls must not be underestimated. The car frame needs to be fitted with independent safety brackets to ensure that loss of a car roller or guide shoe does not allow the car to move too far out of its intended position. Where a car frame has not been fitted with safety brackets changing or adjusting of guide rollers or shoe has allowed the car being dislodged far enough to damage inductor switches and vanes,limit switches and lock rollers. And in the case of side ram direct hydraulic lifts could bend the ram.

CO 2 EXTINGUISHERS

Some authorities have requested that CO 2 extinguishers be provided in lift car for the safety of passengers in the event of fire. If in a panic a passenger was to accidentally drop a CO 2 extinguisher and damage the valve there would be enough gas to kill the occupants. Any extinguishing equipment or fire prevention systems must be checked out to ensure that they will not add to the dangers.

MOVING PARTS.

The dangers associated with moving part is more from the point of view of the installer or service mechanic. In some countries moving parts are required to be either guarded or painted distinctive colours. Typical items in the machine room are sheave, brake drum, motor hand winding disk, speed governor or mechanical selector. The lift shaft has items such as vanes, diverter sheaves, 2:1 sheaves on the top of the lift car, compensating sheaves and bottom governor tension wheel in the pit.

GUARDS.

Guards are for the safety of persons working near moving parts. If they have to be removed to make some adjustment ensure the power has been turned off first. After the work has been completed replace the guards as soon as possible. The danger is usually caused when the guards are remove and not replaced. Poor design of equipment often requires the guards to be removed repeatedly to allow access for adjustment or repairs, after a while the service man often decides to leave it off altogether.

THINKING YOU ARE THE ONLY PERSON ON SITE.

How many times have you thought you were the only person on site,and not taken precautions to prevent others trying to operate the lift you are working on. In some countries or states persons are not permitted to work on their own, and every effort is made to ensure there is an assistant. But "Murphy's" law takes over and your assistant goes home sick or goes out to buy lunch and you are on your own - protect your self and lock off power to stop unauthorised interference.

THINKING AN ITEM IS IDENTICAL.

As a lift becomes older the replacement parts will be harder to obtain and in some cases no longer available. Care must be taken to ensure that you are maintaining the original safety designed into the lift. Check the specifications carefully as the item may look alike but may not perform the same way as the original.

READING THE SIGNS.

We need to read the signs that tell us there is a problem existing now or will in the future. Some of these signs are;
Changes in noise, excessive noise, oil leaks that can be seen, loss of oil but reason not known, metallic dust, discolouration, heat, fuses blowing, circuit breaker tripping, continual re adjustment of the same part, small screws or nuts on the floor of machine room or pit, and parts that are wearing out too quickly.

OTHER ITEMS.

Space does not permit all items of safety to be covered, the following are some that should be kept in mind;Traction ratio, vision windows in landing door panels, high pressure in telescopic cylinders, captive valve adjusting screws, gland seal replacement, bridging out of electrical safety items, wrong grades of oil, electro magnetic interference, oil/dust fires, rope attachments, condensers, software changes, single fault protection, colour blind electricians, humidity and lifting ropes, rescue of trapped people, sprinkler systems, atrium lifts, landing door unlocking devices, contactors welding in, emergency generator control, low pressure valve on roped hydro's, lock down compensation, earthquake requirements.

Biographical notes;

John Inglis, OAM, has been in the lift industry for over fifty years, the last twenty four years he has been a member of the Australian Standards Lift Code committee's. Several of the sub-committee's and working groups are still chaired by him. His formal training was carried out at Sydney Technical College. He has been involved in all facets of the industry in both electrical and mechanical design and manufacturing. He has been granted patents for several mechanical and hydraulic components including fire doors. For twenty years he has been involved in the design,manufacture and testing of fire doors for lifts. He specialises in hydraulic lift equipment and code matters,having lectured on these matters to conferences and Sydney University.