Load control in elevators

This article offers an interesting global vision of the present state of the electronic systems for load weighing in elevators, the different applications and requirements for each installation, its basic principles and the future tendencies that the market for these devices will demand, given the importance and necessity to equip each elevator with these systems.

Nowadays, it is not rare to find elevators equipped with some electronic or mechanical system for the prevention of the overload in cabin. The appearance of new electronic systems based on load cells (as weighing sensors) has been exiling the bad image and distrust that the first mechanical detection systems created. For some years, due to these first devices, when a new system of load weighing was spoken of, the general answer was: "that does not work". But although the distrust was clear, also clear was the necessity to find and to apply trustworthy systems to give solution to this problem.

Brief history

The first mechanical systems were, in fact, micro-interrupting adjustable in their span, which settled between the chassis of the cabin and the stirrup, or in the beam of the rope hitch. This span of activation was regulated so that, when the deformation produced by the weight (corresponding to an overload) of the floor of the chassis of the cabin or the beam of the rope hitch was sufficient, this switch closed and sent the controller a signal. If in addition other additional signals were needed (like *complete* in cabin or *presence* of another person) more switches had to be installed, as many as required signals, with its consequent adjustments.
Since these deformations to be measured were neither constant nor linear in time, these systems only used to work the day of their installation and calibration. Although apparently these systems were quite cheap, the continuous incidences by misalignments and bad operation increased the price in the long run of their maintenance, ending switched off or eliminated of the installation of the elevator.

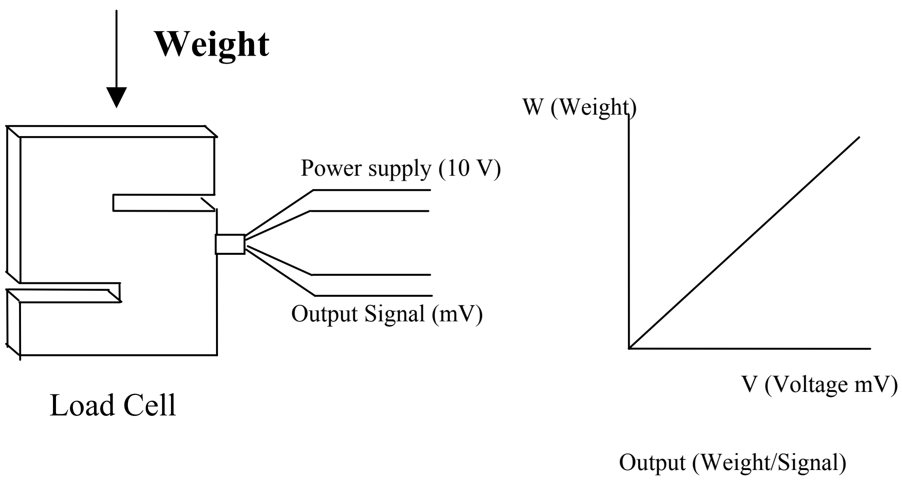


Figure 1. The resulting deformation in the piece of steel when a force is applied is almost imperceptible, and in calculation of sensors it is spoken of as micro deformations of the material.

Extensometry: load cells

The load cells are not elements of recent appearance; on the contrary, in the industrial world they are being installed since quite a long time, whenever it is needed to measure weight and force with a high precision and reliability.
Its principle of operation is based on extensometry and consists in placing strain gauges (small electrical resistors that vary their resistive value when they become deformed) within a special steel piece (stainless or alloyed steel) treated and mechanized. This piece, once instrumented with the gauges and fed with the suitable voltage, will provide us an output voltage signal, linear and proportional to the deformation undergone by the steel when a force is applied to it. In our case, the applied force will be the weight of the load in the cabin.
The geometry and size of these sensors depend, respectively, on the place and shape where they are going to be located in the application and of the maximum capacity in kg to measure (Fig.1).
The load cell is, in itself, a passive electrical element, to which - as we have previously seen - we must feed with a certain voltage (normally 10 V d.c.) so that when applying a force it gives us back an electrical signal. This electrical output signal has a very small value, reason why it is necessary to amplify it before being able to drive output relays or other devices with which to communicate with the elevator controller. For that reason, a load weighing system will always consist of one or several sensors (load cells) and an electronic control unit in charge of powering, amplifying and converting the sensor signal (fig 2)

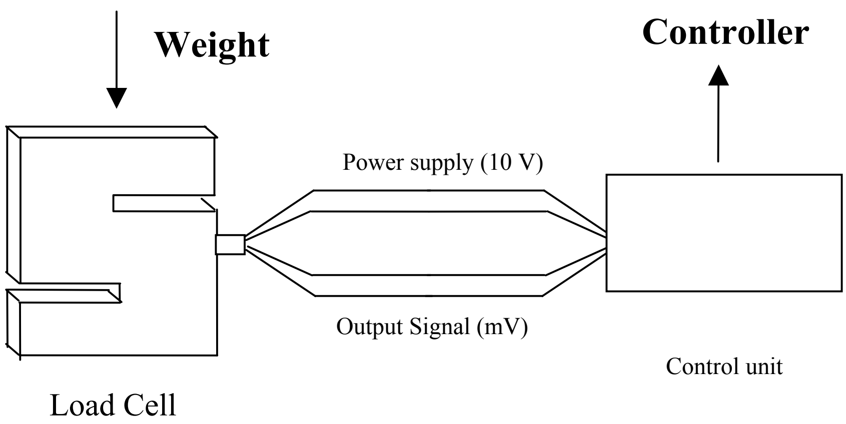


Figure 2.

Types of sensors

As all the installations are not the same, nor require the same precision levels or number of outputs, several types of sensors and electronic control units exist to cover each necessity satisfactorily.

- Sensor for traction wire ropes (ILC3 & LMC): This sensor is a rectangular metal casing which consists of a clamp and two cylinders where the traction cables lean, once we make them pass through the clamp and have fully tightened the clamp.

- Philosophy of operation. Without interfering in the security of the wire ropes, it measures the resultant of the increase of tension experienced in the wire ropes that is, as well, proportional to the increase of the weight registered in the cabin by the entrance of people (Fig.3). The sensor will always be installed in the cabin, at a sufficient distance from the rope hitch so as not to damage the wire ropes, and not too far away from it, so that the sensor does not hit the ceiling of the shaft in the last floor.

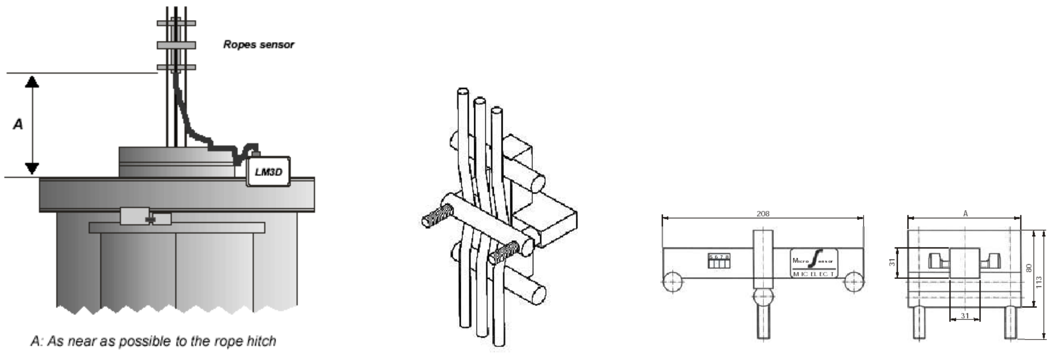
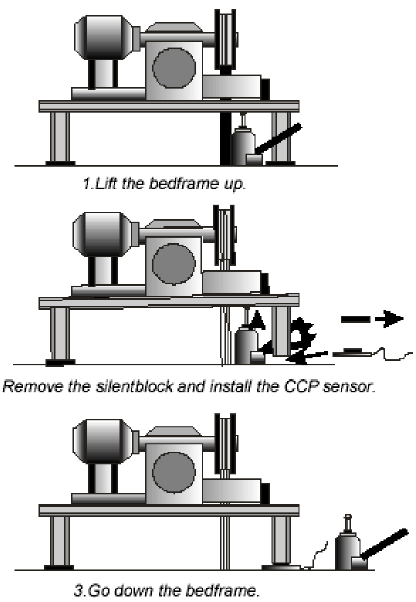


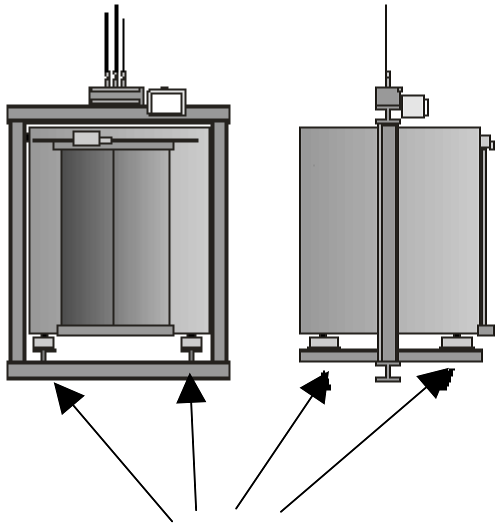
Figure 3.

- Sensor for machine bed frame (CCP): This sensor is a steel disc equipped with a rubber silent block to absorb vibrations.



- Philosophy of operation: We replaced one or two of silent block of support of the legs of the machine bed frame of the motor closest to the vertical movement of the cabin. Because in a typical machine bed frame of four legs of support, the weight of all the hanging masses of the system (cabin, machine, machine bed frame, cables, counterweight, etc.) is supported by these four legs, when instrumenting two of them with load cells, we are able to register all increase in weight of the system. This increase in weight (since all the previously enumerated masses are fixed) will be the increase produced by the entrance of people in the cabin.

- Sensor for cabin (CAB): This sensor is made up of a metal plate, a load cell, rubber silent block to avoid vibrations and a spiral screw with nuts and washers.



CAB Sensors

The installation of the sensor is made normally for new installations, given the complexity of its positioning. The cabin chassis support silent blocks are replaced from the stirrup by these sensors; the number depends on how large the cabin is, on the maximum weight to support and the number of points of support. Although it is the most complex to install, it is the most precise, since we make a scale of the cabin, where there is no influence of external mechanical agents, as the guides or the compensation chain.

Other extensometric sensors

The three previously described models of sensors are those that - to our knowledge and after our acquired experience - solve the problem of measuring the load in elevators more satisfactorily. This because in an 80% to 90% they depend on their intrinsic precision, which is very controlled (repeatability, linearity, hysteresis of the sensor). Applications exist where sensors are placed in the beam of the rope hitch to measure the deformation produced by weight inside the cabin. The problem arises because the beam where the sensor is located is not an element controlled in its elasticity at the levels necessary to give a precision in weight and, simultaneously, is subject to expansions and contractions due to the changes in temperature which produce misalignments in the system difficult to resist. (Fig.4)
Other applications install a beam-handle welded to the machine bed frame of the motor, in order to divert a small percentage of the reaction of the weight in the leg of the machine bed frame to this small beam. Later, in the other end of the beam-handle a load cell is placed, fitting the distance of the cell to the beam-handle with a screw.
The problem is very similar to the previous case: the deviation of the weight to the beam-handle is very small, since it is not a direct measurement but a reaction of the weight supported by that leg of the machine bed frame on the beam-handle, fit by a screw. In addition, the beam-handle is not an element controlled in elasticity and expansions, subject to variations with time. (Fig.5)

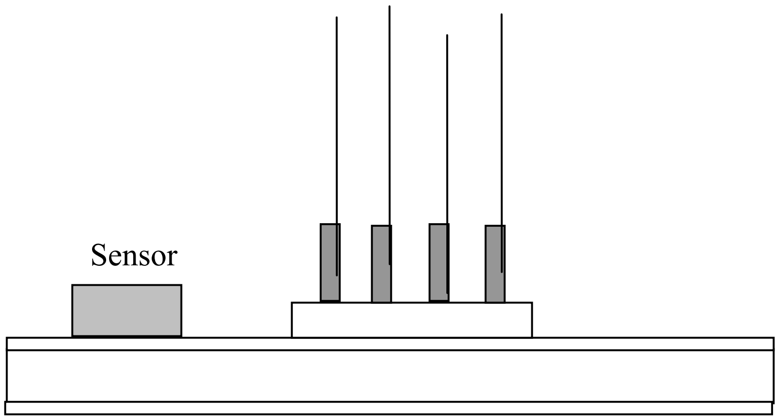


Figure 4.

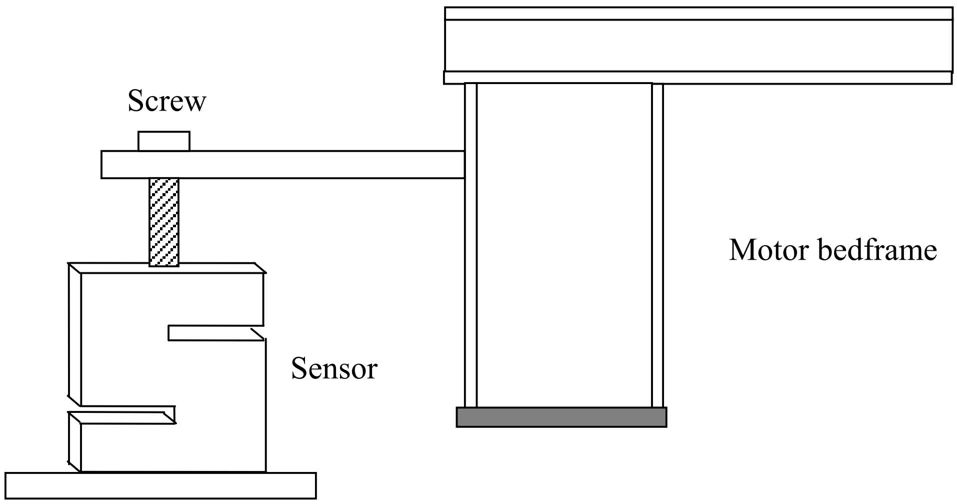


Figure 5.

Electronic Control Units

The electronic control unit is the one in charge to power and amplify the signal provided by the sensors and to provide to outputs for the controller providing them the load registered in the cabin. Normally, the connection with the controller is made by means of relays equipped with inverter contacts, free of potential. Generally, the control units have three output relays; each one of them is assigned to a determined load level in the cabin: presence detection, complete, overload. But also there are control units available with more than three output relays to provide more levels of information to the controller (in VVVF systems it is very useful to know the load in the cabin to optimize the engine efficiency). Two types of electronic power stations exist:

- Analog Control Unit (old LM3): The analog control units consist, for the adjustment of the zero and adjustment of each one of the levels of activation of the outputs, of

precision potentiometers. When the system - either a wire rope sensor, a machine bed frame sensor or a cabin sensor – is installed for the first time, the electronic control unit registers a determined signal level, due to all the weight of the cabin in the wire rope sensor, or the cabin-counterweight-machine bed frame-motor system in the machine bed frame sensor, or of the chassis in the cabin sensor. At that precise moment we must calibrate the equipment to make a zero of the system and, from here, to only consider the increase of weight produced by the people. Once the zero is calibrated, the different levels of the relays will be adjusted with their respective potentiometers.
The analog control units have several disadvantages. One of them is the occasional difficulty of the adjustment, since in most occasions, if there is no system to compare the signal to - for example the voltmeter -, the installer must place weight progressively inside cabin until each one of the output relays is set. And another one is the presence in the installation of compensation chain. When the wire rope sensors or machine bed frame sensors are used, these also register an increase of weight depending on the floor in which they are; this increase is not produced only by people, but produced by the compensation chain. As analog control units have no "intelligence", they amplify all the signal registered by the sensor, occurring that, between the highest and the lowest floor the increase in weight produced by the chain can be equal or greater than the weight produced by a person who entered the cabin.

- Digital Control Units or Micro processed (LM3D and LM6D): These control units are based on microprocessor and equipped, for the adjustment of the zero and output levels of the relays, of buttons and display, with interactive programming menus.
Also, internally they have a special software developed to compensate the increases of weight produced by the compensation chain. In addition, they also have options like analog 0-20mA current output and a RS485 communications port.

Tendencies

Given the precision and reliability reached by these systems, we do not have to leave aside all the possibilities of an electronic system based on the extensometry. Being able to have additional signals for complete and presence in cabin offer great improvements in the optimization of the traffic of selective controllers or interconnected elevators. Also, the implementation of VVVF controls for the drive of the motor is more usual, where a weight control system equipped with the necessary outputs to adapt to the controller, like continuous 0-20mA current signal or advanced protocols of software as RS485 or RS232, make of it an essential tool to create a loop of information between the energy provided to the motor and the load that travels inside the cabin, not only at maximum speed, but also during acceleration and deceleration.