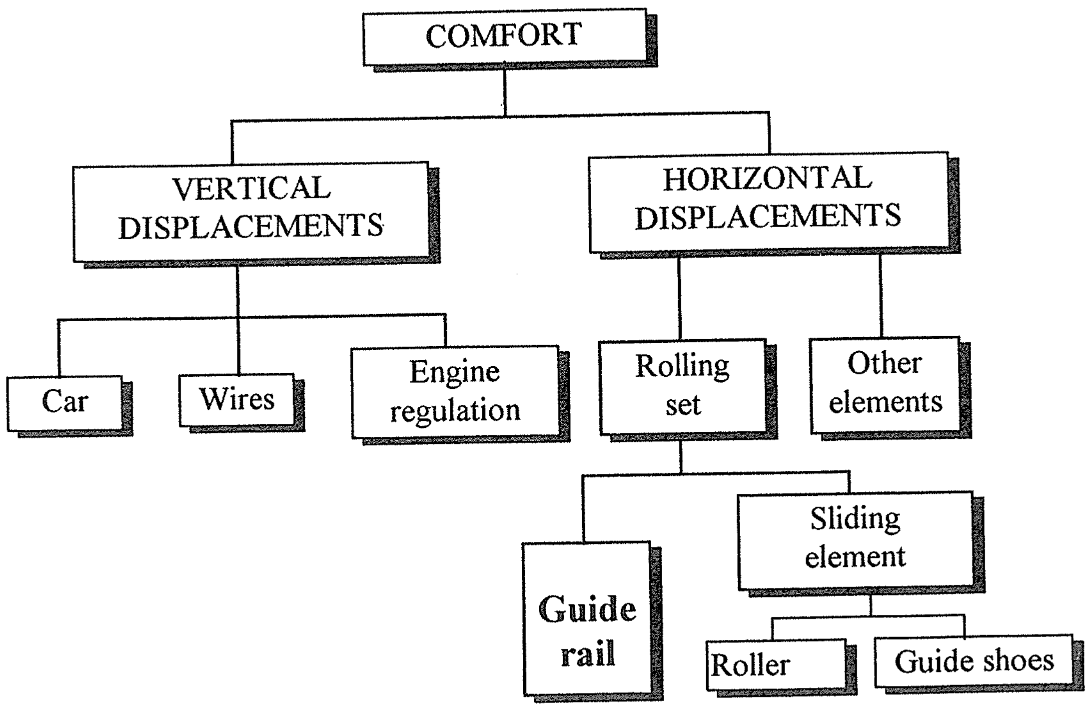
GUIDE RAILS AND THEIR INFLUENCE ON COMFORT AND ASSEMBLY COST

Jesus Sanz,
SAVERA, Navarra, Spain.

Summary :
Parameters such as guide rail straightening, smoothness of the joints and distance between the clips have an influence on ride quality, but this is rarely considered when it comes to selecting the guide rails. The usual way of solving these problems on site involves retouching ,wedges and re-alignements . Although these actions do improve the ride quality they also introduce other problems and increase installation time . The aim of this study is to encourage the designer to make a conscious decision on these matters at the time of selection .

1. PREVIOUS CONSIDERATIONS ON THE ELEVATOR COMFORT.

Within the elevator set, several elements have influence in the COMFORT and they can be clasified depending on the displacement direction .



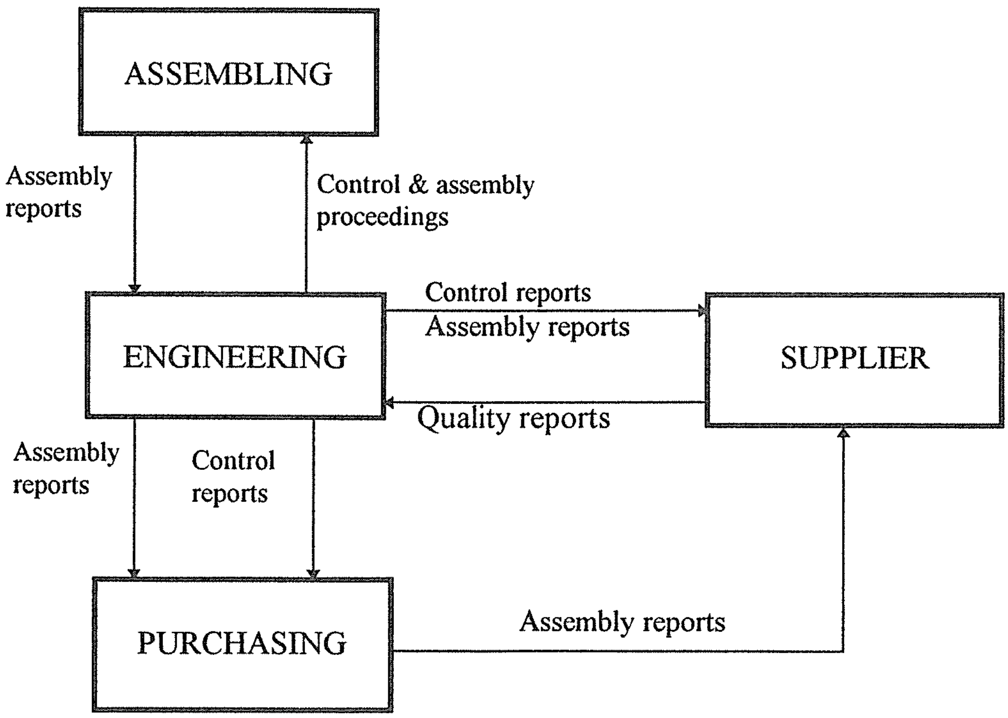
The **Guide rail,** apart from being a basic element for the elevator safety, is the element with greatest incidence in the **COMFORT** as it is the way the elevator slides along. Any irregularity, either in the manufacture or in the assembling can be appreciated by the user.

2. GUIDE RAIS IN THE ELEVATOR EVOLUTION.

For the evolution of a product, it is very important that all elements it is composed of, have a parallel evolution . In the elevator field this evolution has been, in many cases, independent due to the lack of **COMMUNICATION** between customer and supplier (one of the basic pillars of the product development).

In the elevator guide rail this communication takes place mainly betweeen the **purchasing** department and the **supplier,** without the intervention of other departments that can contribute to a great extent to the definition and development of the product.

CORRECT COMMUNICATION FLOW

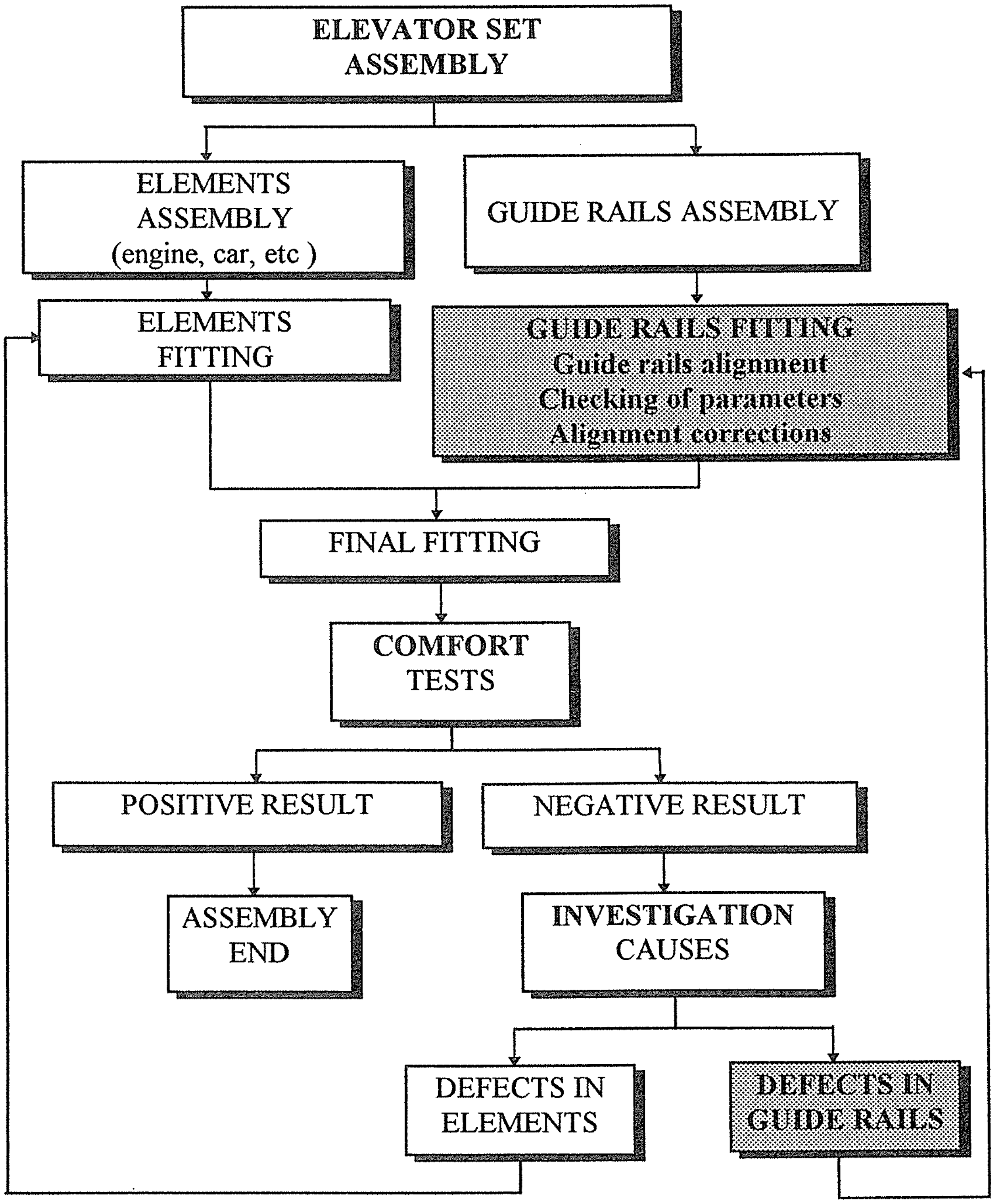


The information about the problems which arise during the assembling and starting up is extremely important to determine the guide rail requirements and the control and assembling proceedings. The fact of **defining the requirements** is very important so as to obtain the **QUALITY OF DESIGN** and for doing this there must be the necessary communication at a technical level; this will enable us to define clearly the market needs at any time.

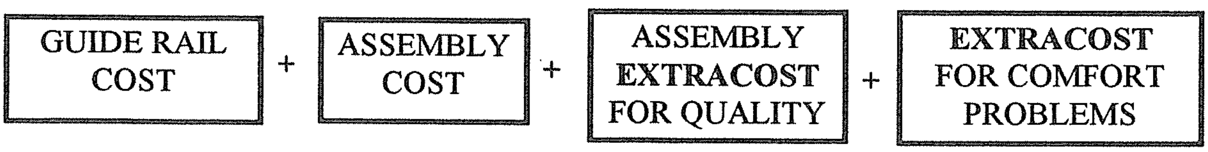
At present we find that the normative on the guide rail quality (**ISO 7465**) is not quick enough to follow the market rythm. The revision including **extraquality guide rails** has not been issued yet and the market is already demanding guide rails of a better quality.

3 . CONSIDERATIONS ON ASSEMBLING GUIDE RAILS WITHIN THE ELEVATOR SET .

The elevator assembling chart is done in most cases according to the eschema shown below:



The **Guide rail total cost** is made up of:



The guide rail cost, added to the assembly cost, gives the total cost when guide rails have the suitable quality for each type of elevator.

Assembly extracost for quality. The assembly cost depends to a very large extent on the quality of the guide rail. The time needed for the assembly is very variable, depending on the quality of both the **straightening** and **joining** of the guide rail. Retouching guide rails because of lack of quality results in a considerable increase of the time needed for doing the assembly, increasing thus the **assembly cost** .

A few examples of retouching needed due to a low quality of the guide rail, which result in an **extra cost of the assembly**, are set out as follows:

- The elimination of excesive jumps at the joins.
- The edge-off of guide rail burrs.
- Repair of guide rail superficial defects.
- Correction of straightening defects when possible .
- Repair of problems related to rust.
- Etc.

Extracost due to problems related to comfort. Cost is not taken into account in the case of comfort problems since it is diluted within the assembly overall cost. Once a COMFORT problem has arisen in the tests, it is very difficult to determine during the INVESTIGATION what the real cause for the lack of comfort is. The total cost increases extremely when having to check and fit again the guide rails or other elements of the elevator, especially when it is necessary to replace the elements.
In order the results derived from comfort tests are always positive, it is necessary to count on a factor that is becoming more and more important within a quality system: **THE QUALITY OF DESIGN**

4. QUALITY OF DESIGN .

QUALITY OF DESIGN → **TO SECURE FROM THE DESIGN THAT ALL ELEMENTS INTERVENING IN THE QUALITY AND COMFORT OF THE ELEVATOR MEET THE NECESSARY REQUIREMENTS .**

As far as guide rail is concerned, the items stated below must be taken into account in order to achieve comfort in the very first test.

QUALITY OF DESIGN

- **Choice of the guide rail size**
- **Choice of the suitable quality for every case**
- **Definition of alignment instructions and verification of rails**
- **Definition of assembly instructions**

Choice of the guide rail size.- It is usually done taking as a basis only the calculation of efforts produced in both the elevator displacement and the safety gears performance, without comfort being taken into consideration. The side accelerations produced in the elevator depend on its features:

- Elevator speed
- Elevator dimensions
- Elevator Mass
- Distribution of charges

Choice of the suitable quality.- It is very important to choose the quality that best suits the elevator features . For doing this, the market of guide rails needs to count on all necessary qualities.

Definition of the assembly instructions . There must be clear instructions of procedure for the guide rail assembly .

Definition of alignment instructions and guide rail verification. There must exist clear instructions of alignment and verification of guide rail parameters, as well as to count on the appropriate elements of control.

The definition of **assembly instructions**, as well as of **guide rail alignment and verification** can and must be done in close connection with the guide rail supplier, but above all taking into account the elimination of innecessary extracosts (retouches, adjustments, etc...)
The market already offers a range wide enough to cover all requirements connected to the guide rail size.
However, we consider it necessary to provide the market with new guide rail types, which have lowest tolerances, so that **comfort** parameters can be improved and the time needed for the **assembly** reduced. In next pages we will try to show these needs.

5. ANALYSIS ON THE GUIDE RAIL TOLERANCES AND THEIR REPERCUSION IN THE ELEVATOR ASSEMBLY AND COMFORT .

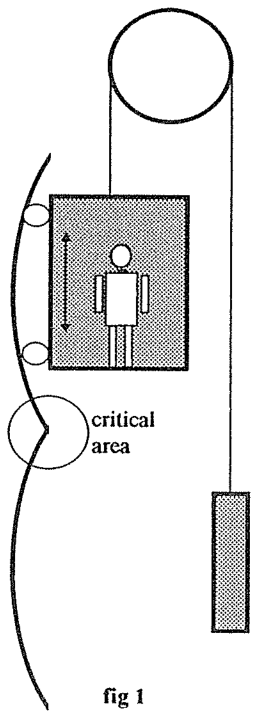


fig 1

We are going to analyse hereunder the guide rail quality taking as a basis the problems detected in the assembly and starting up of the guide rails .

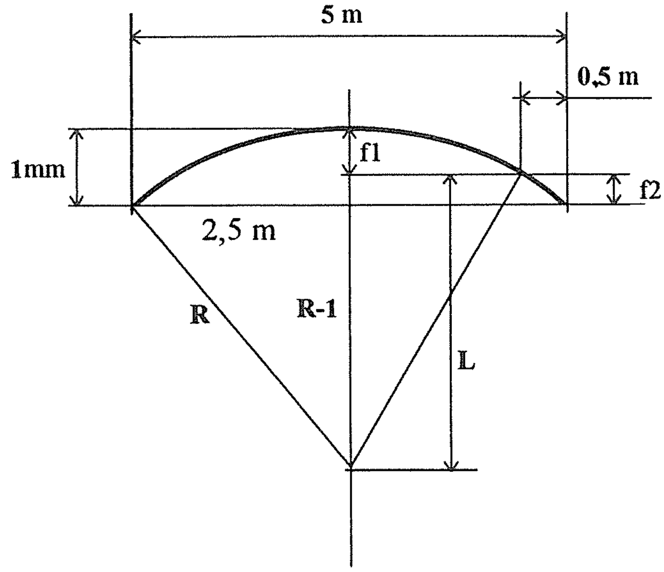
The main problems related to guide rails involve the joining of a guide rail to the next one; we will analyse these problems taking the tolerances established by the **ISO 7465 Standard** as a reference.

Guide rail parameters with influence on COMFORT are:

- **Straightening**
- **Machining of ends .**
  - Key/Keyway
  - Machined surface length for the location of the fishplate

The ratio B/A is valid for defining the straightening of only one guide rail but the problem arises when joining several guide rails during the assembling, so that, although all of them are within tolerance, the connections between them do not keep B/A parameters.

Fig. 1 shows two guide rails assembled with the bending in the same sense. The parameters resulting from this joining are higher than those of guide rails measured individually, as it can be seen below.



A guide rail with a uniform bending of 1mm maximum deflection (extraquality guide rail) is considered here.

$$R^2 = (R-1)^2 + 2500^2$$

$$R = \frac{2500^2 + 1}{2} = 3.125.000{,}50 \text{ mm}$$

$$R^2 = L^2 + 2000^2 \quad L = \sqrt{R^2 - 2000^2}$$

$$L = 3.124.999{,}86$$

$$f1 = R - L = 0{,}64mm$$
$$f2 = 1 - f1 = 0{,}36mm$$

As it can be seen in the table, the A/B data at the joining almost duplicate the rest of the guide rail.

	f / 0,5m	B/A
Cold-drawn guide rails	1,26	0,0025
Standard planed guide rails	0,90	0,0018
Extraquality planed guide rails	0,36	0,00072

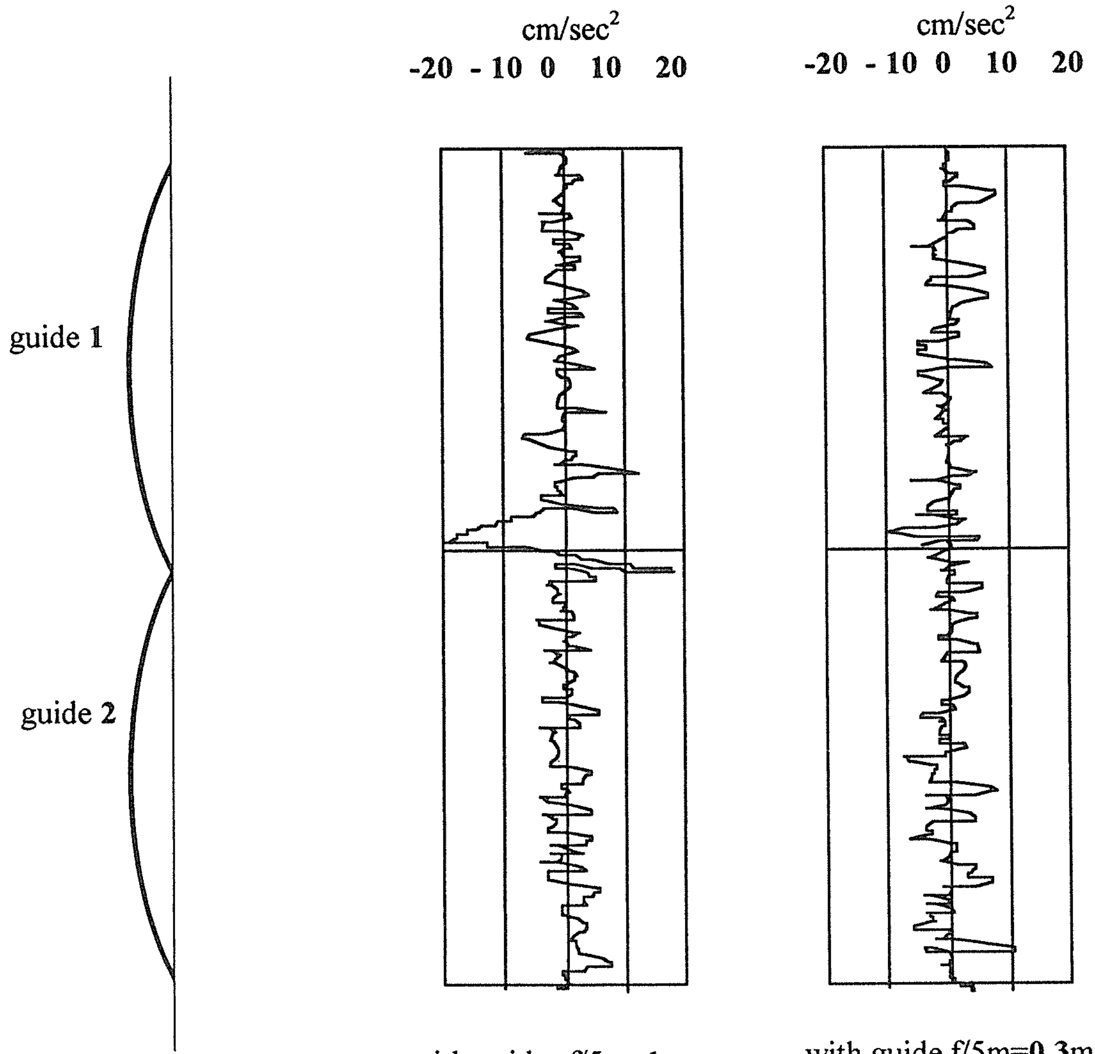
Therefore, in order to keep the straightening parameters at the joinings, the total guide rail deflection must be reduced to the following values:

	f / 5m
Cold-drawn guide rails	1,9
Standard planed guide rails	1,4
Extraquality planed guide rails	0,5

These results have been checked by using a study made with the **CEIT** (Centro de Investigaciones Técnicas de Guipúzcoa) dependent on the **University of Navarra** . The model simulates the dynamic behaviour of the elevator on the guide rails . Calculations are made with MATLAB programme.

In a first stage it has been made a model in which guide rail has been considered as a stiff element and in next stages the model will become more complicated .

From the results obtained up to now, we have detected that the accelerations produced at the joints of guide rails with total deflection at the maximum levels of the Standard, are triplicated.



with guides f/5m=1mm
speed= **3** m/sec

with guide f/5m=**0,3**mm
Speed= **3** m/sec.

We have also verified that as speed increases, the accelerations are bigger because of 5m/deflection. Nevertheless, COMFORT is not influenced significantly. Where problems are originated is at the joints when assembling guide rails with the bending in the same sense.

The total deflection problem can be partially modified during the assembling in two different ways:

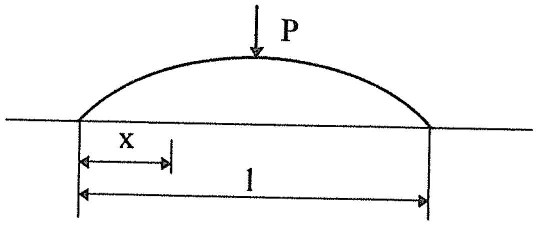
1 - Forcing the joining of guide rails by trying to align the union.

- This can be easily done when guide rails are small. But when it comes to big guide rails the efforts are too big and, apart from the fact that special elements are needed, the union fishplate-guide rail must bear the effort continously.
- The **assembling cost** increases considerably .

2 - Aligning guide rails by acting at the joints

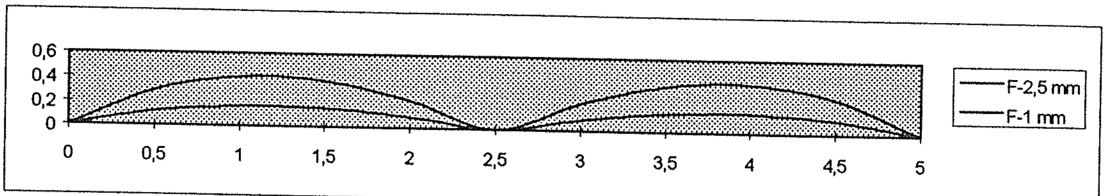
- To operate on the guide rail, more fixations must be placed and, besides the cost that it represents, guide rail does not get as perfect as it may seem.
As an example we are going to analyse the deflections resulting from deforming a 5 meter guide rail with regular bending at the middle.

The graphic has been made up taking 2.5 and 1 mm regular bendings as starting point and discounting the bending produced by the equation of elasticity in a specific deformation.



$$f = \frac{P \times l^2 \times x}{16 \times E \times I}\left(1 - \frac{4 \times x^2}{3 \times l^2}\right)$$

	0	0,5	1	1,5	2	2,5	3	3,5	4	4,5	5
F-2,5 mm	0	0,29	0,41	0,38	0,23	0,00	0,23	0,38	0,41	0,29	0
F-1 mm	0	0,12	0,16	0,15	0,09	0,00	0,09	0,15	0,16	0,12	0



As it can be seen in the graphic, when forcing the guide rail in the middle so as to straighten it, what we are doing is to create 2 curves that, although with lower values, can have negative influence.

5.2 ENDS MACHINING.

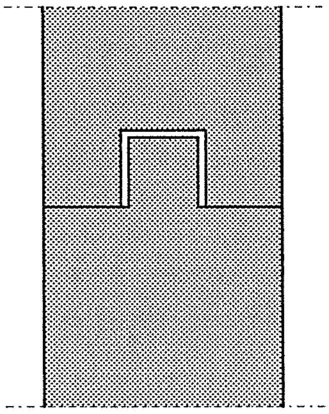
5.2.1. Key and keyway.

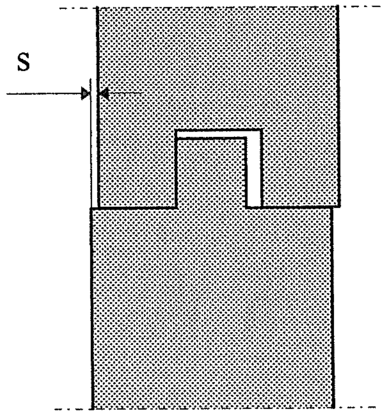
Key and keyway tolerances, according to ISO 7465 Standard, are as follows:

mm

GUIDE RAIL TYPES	centring	Key thickness	Keyway thickness	maximum free play
Cold-drawn	0,10	$e^{+0}_{-0,06}$	$e+0,05^{+0,06}_{-0}$	**0,17**
Standard planed	0,10	$e^{+0}_{-0,06}$	$e+0,03^{+0,06}_{-0}$	**0,15**
Extraquality planed	0,05	$e^{+0}_{-0,03}$	$e+0,03^{+0,03}_{-0}$	**0,09**

The **centring** tolerance is correct but it is very much affected by **maximum possible free play** between key and keyway. As it can be seen in the table, the free play figures are too high and can produce jumps between the guide rails even if the centring is perfect.





GUIDE RAIL TYPES	s jump
Cold-drawn	**0,085**
Standard planed	**0,075**
Extraquality planed	**0,045**

The normal tendency during the assembling is that the free play goes to one side and that jumps can be produced in the middle of the free way (s) .

GUIDE RAIL TYPES	s total jump
Cold-drawn	**0,185**
Standard planed	**0,175**
Extraquality planed	**0,095**

If we add to this jump the one corresponding to the centring operation, very high jumps are produced as a result.

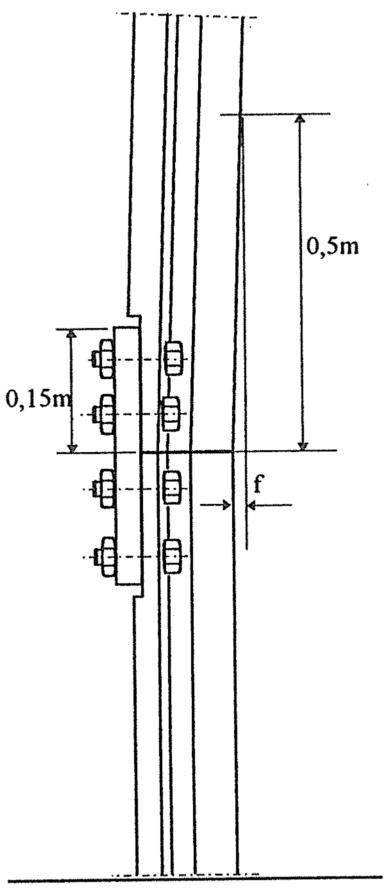
Tolerances should be reduced to the levels stated below, since the jumps that can be obtained are high for an adequate comfort level:

GUIDE RAIL TYPES	centring	key thickness	keyway thickness	maximum free-play
Cold-drawn	0,10	$e^{+0}_{-0,03}$	$e + 0,03^{+0,03}_{-0}$	**0,09**
Standard planed	0,07	$e^{+0}_{-0,03}$	$e + 0,03^{+0,03}_{-0}$	**0,09**
Extraquality planed	0,03	$e^{+0}_{-0,02}$	$e + 0,02^{+0,02}_{-0}$	**0,06**

5.2.1. Machining of the surface length for the location of the fishplate.

The base parallelism parameter is very important as it can produce an effect similar to the straightening at the joint area. The ratio A/B, because of this machining, is higher than allowed for the straightening.

$$f = \frac{0,5 \times p}{0,15} \quad p\text{=parallelism}$$



GUIDE RAIL TYPES	*p*	f	A/B
cold-drawn	0,20	0,66	0,0013
Standard planed	0,20	0,66	0,0013
Extraquality planed	0,10	0,33	0,00066

If we want to keep the A/B ratio within the limits established by the ISO 7465 Standard, the parallelism tolerances of planed guide rails need to be reduced.

GUIDE RAIL TYPES	*p*
Cold-drawn	**0,20**
Standard planed	**0,15**
Extraquality planed	**0,07**

This defect can be corrected by means of wedges between the guide rail and the fishplate but, as it happens when the quality is low, this has a direct efect on the cost of the assembly and starting up of the elevator.

6. CONCLUSIONS.

- Elevator guide rails are a vital element for the elevator **COMFORT** .

- It is necessary to insist on **THE QUALITY OF DESIGN** of the elevator in order to choose both the most suitable guide rail and all other elements.

- It is essential that the market counts on sufficient **guide rail qualities** so that they can meet the needs of every situation, thus guaranteeing the necessary COMFORT and reducing the high costs derived from assembly.

- It is necessary to have more technical communication between the elevator companies and guide rail manufacturers, so as to be able to fix, by mutual agreement, the rails requirements as well as to always count on the suitable guide rail for every elevator.

- A greater speed in developing **Standards** is also necessary, so that their evolution goes parallel to the market needs.

Author biographical details
Jesus Sanz has been working for SAVERA for 25 years, during which time he has been in charge of various areas, such as Quality Control, Engineering and Technical Management. He is presently Industrial and Quality Assurance Manager and responsible for the total quality system.