RESEARCH ON THE SAFETY LEVEL OF THE EXISTING ELECTRIC TRACTION ELEVATORS

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Abstract: In Bulgaria there are more than 80 000 elevator installations in operation. Each year there are a few accidents with these equipments, some of them are fatal for one or more persons. Most of these elevators are with electric traction drive with worm gear and drive sheave, manufactured in our country before more than 30 years. According to the Bulgarian legislation, all of them are under constant separated maintenance and technical supervision contracts. In the meantime both activities- supervision and maintenance are under additional control of the State Agency for Metrology and Technical Supervision in the face of their State Inspection for Technical Supervision. The legislation now contains Law for Technical Requirements for the Products with its State Regulation for Safe Operation and Technical Supervision of Lifts, where all the requirements for performing of both activities are stated. In the same time a lot of materials regarding the elevator's safety are published in different media- newspapers, television, etc. And instead of this a lot of accidents with this equipment happened.
The performed in this work experimental research shows the main reasons for accidents happened. Measures for improvement in the situation proposed.

Key words: elevators, lifts, safety, accident, incident, maintenance, technical supervision of lifts.

1. INTRODUCTION

There are more than 80 000 elevator installations in operation according to different data in Bulgaria. But other sources say that this number is more than 100 000. In the same time other organization says they are not more than 70 000. In the same time these units are of high risk equipment. Unfortunately clear and exact unitary register of the installed elevators in the entire country is still missing in the governmental institutions either in private bodies because a lot of reasons. This register has to include a few important things as information for the elevators- address of installation, technical characteristics and complete history of maintenance, supervision and repair works. Based on this, the State Agency for Technical Supervision starts making efforts to solve this problem. The way used to do this is by the means of collecting information in digital form periodically from all the privately owned companies for technical supervision (licensed according to the legislation bodies for performing of technical supervision) as well as transfer of the old paper registers of this inspection in modern digital form. The final result of all these activities have to be that State Inspection will have detailed and exact electronic register of the elevators installed in the entire country.

On the other hand each year there are a few accidents with elevators, some of them are fatal for one or more persons. Sometimes injured are elevator technicians, sometimes there are injured users or other persons. Most of these elevators are with electric traction drive with worm gear and drive sheave, manufactured in our country before more than 30 years. According to the Bulgarian legislation, all of them are under constant separated maintenance and technical supervision contracts. In the meantime both activities- supervision and maintenance are under additional control of the State Agency for Metrology and Technical Supervision in the face of their Governmental Inspection for Technical Supervision. The legislation now contains Law for Technical Requirements for the Products with its State Regulation for Safe Operation and Technical Supervision of Lifts, where all the requirements for performing of both activities are stated.

In the last years a lot of materials, interviews and reportages regarding the elevator's safety appeared in different media- newspapers, television, etc. And

instead of this public interest and legislation, a lot of accidents with this equipment happened.
For the purposes of this paper 54 units of old types were analyzed, all of them manufactured between 1965 and 1986 year.

2. THE ELEVATOR CONSTRUCTIONS DETAILS

Types of the main components used:

2.1 Machine room

These units are with machine room above the hoistway. Drive, controller, overspeed governor and positioning system are installed in this special room.

2.2 Hoistway (Shaft)

The construction is masonry, plastered from inside the shaft for the older units. Concrete constructions are often used after 1980.

2.3 Drive and roping

The drive constructions used are roped electric traction lifts with asynchronous motor with worm gear and traction sheave drives. In all the cases studied roping 1:1 is used- car and counterweight are suspended directly.

2.4 Electric motor

When the rated elevator speed is up to 0.71 m/sec one speed asynchronous three phase alternating current motors are used. In case of 1.0m/sec two speed asynchronous motors are used.

2.5 Gear

The gears used are of worm type with safety factor at least 8. The gear is self-locking mainly because of the high ratio needed to achieve the rated car speed.

2.6 Brake

The brakes used are of drum type with two independent brake levers and pressure springs. This brake acts on the fast shaft of the gear, exactly before the gear. The brake drum is used also as flywheel. Sheave brake is not used. Safety contacts for monitoring of brake operation and friction material wear are not used.

2.7 Drive sheave

Driving sheaves used are of friction type with wedge shaped with undercut or semi-circular with undercut. The angle of rope coverage is 180^0, without using of diversion sheave.

2.8 Hoisting ropes

Used ropes are 6x19 Seale originally built, as well as both 8x19 and 6x19 Seale where replacement is done. The minimum safety factor for the ropes is 12 when 3 ropes are used and 16 when 2 ropes are used. Using only 1 rope is forbidden for passenger elevators.

2.9 Guide rails and fastening

Car guide rails are one pair of 2 pcs. special “T”- type steel guiding profile for elevators, counterweight guides are mainly from 4 pcs. steel wires, fixed in the overhead and tighten in the pit. Other used way of counterweight guidance is with the same type of guiding as above described for the car, but with smaller cross-section.
Few constructions of guide rail brackets and their fastening used.

2.10 Car and car frame

Cars are as standard plywood and chipwood made in all the cases, with solid wooden beams used for the floor frame. Only few units manufactured after 1986 are with steel construction cars. Car is equipped with safety floor edge as well as safety ceiling edge. It is important to mention that the older units, where car is equipped with sliding grid type door with safety contact, the safety edge on the floor is not demanded from the applicable law. These units are equipped with movable floor with function to switch-off hall calls when person is detected in the car as well as not receive a car call when child lighter than 20 kg. is alone in the car. Stop button in car operating panel is compulsory for all the units of the studied types.

The guide shoes are mainly of sliding type, made from plastic. In only few cases there where rubber roller guides with roller bearings.

Car frame is equipped with safety gear with instantaneous action. Two main types used-with roller and with toothed wedge.

2.11 Overspeed governor

The device used is of "bouncing-roller" type. Type of the groove is wedge shaped with angle of 35^0. Original rope used is 4.8 mm diameter with dry surface. Under some conditions this rope is replaced with 6.0 or 6.3 mm. The necessary pre-tension for providing the rated force for actuate the safety gear is achieved by the means of diversion sheave with weight in the pit, or, in the older units by diversion sheave with spring tension. The necessary force to actuate the safety gear is provided by the friction force between the rope and the groove of the governor's pulley.

For the overspeed governor special attention will be paid in the next pages.

Picture 1: Overspeed governor of the type most commonly used

2.12 Safety gear

Car frame is equipped with safety gear with instantaneous action. Two main types used-with roller and with toothed wedge.

This device is actuated by overspeed governor in the machine room and rope, as it is mention in 2.11. Here bellow special attention is provided for this safety device.

2.13 Controller

The types used are relay controllers, as they are manufactured in these stages of technology development. It has to consider also the aim to lowering the manufacturing cost of the units using the cheapest solutions especially in the field of controllers.

When making comparison between these units and comparable solutions of other manufacturers of the same years, the trend mentioned in point 2.13 above is clearly visible. But the practice since a lot of years shows no serious safety issues with these types of controllers. We have to mention only one safety related thing here. There is one type of the controllers used, which are without third contactor used as a safety device against contacts welding. Theoretically this is a safety issue, and according to the current legislation this is nonconformity.

Picture 2: Relay controller frequently used

3. OVERVIEW OF THE ACCIDENTS HAPPENED IN THE LAST 5 YEARS

When making any analysis in the field of safety of such used and well known passenger transport, it is really important to consider its social aspects and importance, because everybody uses this transport every day a lot of times. Also we have to consider the fact that Bulgarian society is very sensitive under this matter because for a lot of years information about these kind of accidents were not given to the public. Not only this, but the thinking is that each accident is covered by the authorities and finally nobody is judged.

Instead of general safety of this kind of transport, during the last years a few fatal accidents happened. Table 1 represents a list with 6 recorded accidents for the last 5 years with description of the causes and effects of these events in chronological order.

Table 1 Known elevator accidents in Bulgaria in the period of years 2010-2015

№	Month & year	City of accident happened	Short accident description
1	03.2010	Sofia	Elevator car falls down after overloading of the car with passengers
2	08.2014	Sofia	Hoisting ropes broken, car falls down in the bottom of the shaft
3	10.2014	Sofia	Person falls down in the shaft during try to gets out from blocked car
4	11.2014	Velingrad	Person falls down in the shaft after his try to re-open the hoistway door by the means of block the automatically closing door with leg
5	02.2015	Varna	Car travels uncontrolled downwards after frequency inverter of elevator drive fail. Safety gears block properly the car.

In the next points a detailed overview of the accidents will be done.

3.1 Accident in Sofia in March 2010.

This is an elevator of old type with semiautomatic hinged hoistway doors and without car door. The elevator is for 6 persons/500 kg, but it has larger than the stated in EN 81.1-1 car area according to the load. This car is large enough to accommodate more than 10 persons.

From the top floor 12 persons entering the car and elevator starts the travel to desired floor downwards. Suddenly the normal run stops and the car fall down on the car buffers in the pit. During this the safety devices such as overspeed governor and safety gears were not activated. The severity of the accident to the passengers was high, but not fatal. Finally it was not completely clear what exactly happened, there are only technical assumptions for the possible events. Instead of all one thing is clear- the elevator's speed was not much higher than the nominal speed at the moment of impact on the buffer. This is clear from the high but not the highest severity of the effect to the passengers. In anyway, from these assumptions it is clear that the speed was not high enough to actuate the overspeed governor and safety gear, where their efficiency was clearly identified as good during the court expert report.

Other thing that was clarified is the fact there is no overload system in this elevator. This elevator is probably overloaded with twice the nominal load. Facing and knowing the facts it is clear that mainly because of some features of this elevator (for example double envelop of the ropes on the drive sheave) and the safety factors used during design and manufacturing of the elevator the severity of this accident was not the highest.

3.2 Accident in Sofia in August 2014.

This is an old type elevator for 225kg/3 persons and 10 stops, machine room above the hoistway, with hinged hoistway doors and sliding grid type car door with safety contact. The unit is manufactured and installed in year 1965. The elevator is with wooden car, two ropes system, with almost all safety devices according to actual EN81.1, without overload device.

Two persons were entering the car and give a car call. After the elevator starts both ropes completely broke simultaneously and the car falls down in the pit. The safety gear and/or overspeed governor doesn't act as it has to. In the crash one of the passengers immediately died and the other one received serious injuries.

During the investigation a few facts were found. First it was found that the elevator was overhauled 2 or 3 years before the accident. Replaced are the entire machine, controller and flexible cables between machine room and car. Also car operating panel and hall operating panels are renewed. It appeared that the new machine is with drive sheave with smaller diameter and because of this deflection sheave is used. Also the diameter of new ropes is smaller than the original one as well as the minimal breaking force is smaller. The diameter of the deflector sheave of 120 mm is smaller than the required in EN81.1. Mainly because of the last problem the ropes are broken fast. But in this case the problems are much more and they are not only technical. There is serious human factors- possible leak of knowledge and inactivity of responsible persons. As the car falls down with high speed in the pit, the safety gear was not acting properly. The behavior of overspeed governor is also not known. All the facts are leading to qualification of this accident as one of the heaviest in Bulgaria ever.

3.3 Accident in Sofia in October 2014.

The elevator is manufactured in the last 15 years and theoretically has to be safer than the older ones mainly because of the fact this unit is equipped with more devices and safety interlocks required from the code. The elevator car was blocked between 4^{-th} and 5^{-th} floor of the building with 2 passengers inside. Other man, who was relative to one of the passengers inside, tries to open the hoistway door in order to free the blocked passengers by using some tool similar to the original specialized key. During these actions he falls down in the pit trough opening between the floor and the car floor. After that he died immediately. Nobody else was injured during this accident.

3.4 Accident in Velingrad, November 2014.

The elevator is newer than the last one, with automatic sliding hoistway and car doors. The elevator is installed in hotel building in Velingrad City. A man just like to catch the elevator from the lobby floor at the moment of the doors are closing. He put his leg between the door panels, but the elevator doesn’t react as it has to. The doors are not fully closed and the hoistway door not locked, but the car start its travel upwards, which results in catching the person’s leg and after that her body pull and open the hoistway door. Finally he falls down through the door in the pit. The person was seriously injured with multiple fractures and with risk for life.

This case is a little bit different from all the others. The main reason for this is the fact that the elevator travels with open and not locked hoistway door, which the investigation found that is because of bypassed safety interlocks.

3.5 Accident inVarna, February 2015.

The elevator involved in this accident is quite new. It is electric traction type, with automatic hoistway and car doors, equipped with VVVF technology drive and with all the required safety devices from the code. Normally loaded car travels between the floors at the moment VVVF inverter fails. The car starts moving uncontrolled downwards; the overspeed governor activates car safety gear, which blocks the car to the guide rails. Because the safety devices involved in this case were functioning as it is purposed, this accident finally was not more than normal technical malfunction of one of the major elevator components. It is clear from the facts known that the car was achieved overspeed, where it was blocked by the safeties. Based on this, however, one of the passengers was injured and he has bruise.

Other arising question from this case is „what behavior elevators should have in cases like this- to wait the raising speed activating the overspeed governor and after that to use the car safety gear to stop the falling car, or, may be better, to follow other safety procedure"? But this question is a matter of other researches.

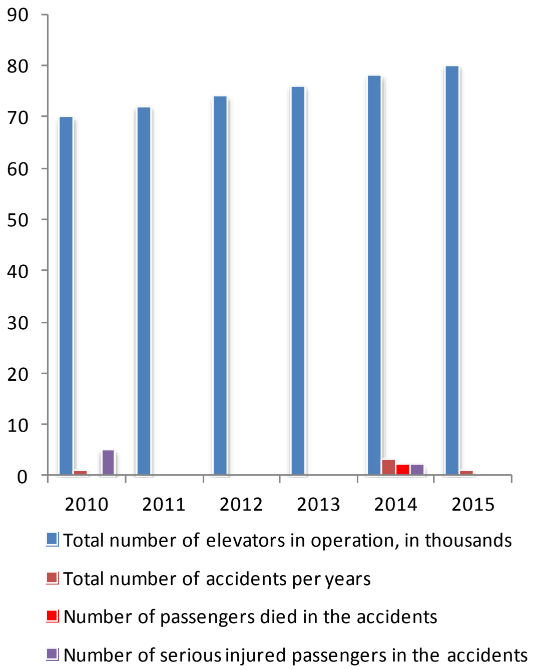

Figure 1: Last 5 years- graphical representation of the total number of elevators in operation (in thousands), number of accidents, number of deaths and number of serious injured persons

On the Figure 1 represented graphically are the total number of elevators in operation in Bulgaria, total number of recorded accidents, number of passenger died in the accidents and number of serious injured persons in these accidents. (Base of the total number of elevators in operation is information in the public from the SAMTS). It is possible to classify these accidents by their severity of harm according to BDS EN ISO 14798- Lifts (elevators), escalators and moving walks- Risk assessment and reduction methodology. Here is the place to mention that in Table C.1, Anex C of BDS EN ISO 14798 are stated levels of severity of the harm from level 1- High to level 4- Negligible. This table is represented here bellow as Table 1. Pursuant to this classification Figure 2 represents the same accidents by their number, number of seriously injured persons and number of persons died. This represents the accidents where the severity of harm according to the above mentioned standard is of the highest level 1 and level 2. The persons who receive lower level of severity of harm are excluded from this graph.

Table 1: Levels of severity of the harm according Anex C of BDS EN ISO 14798

Identify level of severity	Description
1 - High	Death, system loss, or severe environmental damage
2 - Medium	Severe injury, severe occupational illness, or major system or environmental damage
3 - Low	Minor injury, minor occupational illness, or minor system or environmental damage
4 - Negligible	Does not result in injury, occupational illness, or system or environmental damage

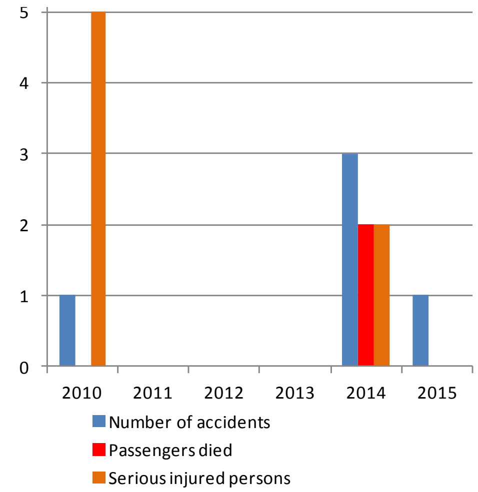

Figure 2: Last 5 years- graphical representation of the number of accidents, number of deaths and number of serious injured persons

4. COLLECTED DATA DURING THE EXPERIMENTAL RESEARCH

During the research, 54 elevators were analyzed. These units are located in one of the economically poorest regions of the country. Instead of this research, it is important to mention that all the units where safety issues were found, the owner suspend their operation immediately. The extract from the survey results are shown in tables 2, 3 and 4 here bellow.

It is clear the number of units with safety gears affected is 3 and the units with overspeed governor affected are 2. But the total number of units where the complete system of overspeed governor and safety gear not works as it is purposed is the sum of the above, so the total number of the affected units is 5. This is based on the fact that in order to have properly working system it is necessary all the components inside to work properly. Or with other wording, if we have to have the car not falling down in case of ropes broken, it is necessary all the components in the related system to work in the proper manner. In this system the overspeed governor appears as the activation device for the safety gears and the safety gears are the device which has to be actuated from the governor's rope.

Table 2: Number of units with safety devices affected by type of device

Total number of units in the research	Number of units with safety gears affected	Number of units with overspeed governor affected
54	**3**	**2**

Table 3: Total number of units with safety devices affected and percentage from the total number of units in the research

Total number of units in the research	Total number of units with safety devices affected	Percentage of safety affected units from the total number of units in the research
54	**5**	**9,26 %**

Table 4: Total number of units with other technical issues where the safety is not directly affected and percentage from the total number of units in the research

Drive sheave wear	Broken wires in the ropes	Worm gear wear	Others	Total number of units with other technical issues	Percentage of units with other technical issues
3	**1**	**3**	**6**	**13**	**24,07 %**

Other part of this research is shown in Table 4. Here are represented the results in the part of the general technical issues of the units. The number of units with drive sheave wear is 3, the number of units were broken wires in the hoisting ropes is 1, the number of units were the worm gear have wear is 3. The number of units in cell other represents issues such as car and counterweight guide shoes wear, door dampers not properly working, stored materials in the machine room, etc. Because these issues are related mainly to the technical condition of the units and not to the general safety, these units are still in operation with notes in the corresponding papers according to the legislation. In these cases the owner and the maintainer of the units has to act as soon as possible in order to solve these technical issues.

5. IDENTIFIED SAFETY ISSUES

The main identified problem in the face of safety is the not working safety gears of one of the types used. The problem type is toothed wedge safeties, as it was described in 2.12. Picture 3 illustrates the key part of this type of safety gears- toothed wedge, which have to react with the guide rail.

Picture 3: Toothed wedge

The construction of this wedge contains two parts, as it can be seen from this picture as well. They are steel toothed body and bronze sliding part, bolted on the back. The toothed part is the working surface of the safety block while the bronze sliding part is in contact and is purposed to glide with the safety block body. The condition for proper work of this device is to provide self wedging. This is possible when the coefficient of friction between the toothed part and the rail is bigger than the one between the safety block body and the bronze slide. On the Figure 3 is shown schematic of acting forces of this type of wedge safety block. Here bellow are the formulas for force analysis of this type of safety gear and finally the explanation why this dependence of coefficients of friction has to be fulfilled.

The condition for self wedging is to have positive resulting vertical force on the wedge, or this force to act in upwards:

$$F1 - N2.\sin\alpha - F2.\cos\alpha > 0 \ (1)$$

From the equality of horizontal projections of the forces follows:

$$N1 + F2.\sin\alpha - N2.\cos\alpha = 0 \ (1)$$

And if we consider the following from Amonton's law:

$$\mu1.N1 = F1$$
and
$$\mu2.N2 = F2$$

Self wedging can be achieved if:

$$\text{tg}\ \alpha < \frac{\mu1 - \mu2}{1 + \mu1.\mu2} \ (1)$$

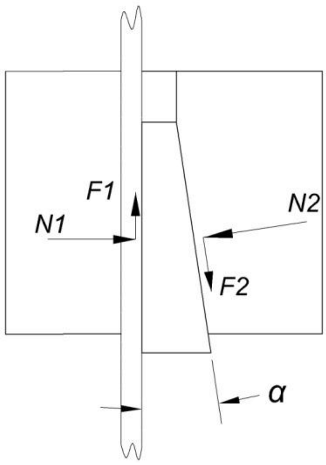

Figure 3: Schematic of forces of wedge type safety block

The last well known formula explains why the dependence of both coefficients of friction has to be fulfilled in order to have working device. Also, in order to achieve the higher coefficient of the working surface in most cases the wedge is toothed or channelled, as well as hardened to achieve higher wear resistance. The last thing is very important in the long term like in this case with elevators of more than thirty years old.

It was surely proven by the survey and tests that in all the cases where the bronze slide was clean and properly oiled or greased and the toothed surface was clean and without grease and dirt the safeties works as it is necessary. On the contrary, in all the cases where the toothed surface was dirty or greased the safeties doesn't work at all. During the tests it was not possible to activate them even after 5 attempts.

In order to analyze the reason it is necessary to mention other aspect of the problem. The dust and dirt on the toothed surface is mixed with oil from the rails. In the problem cases this dirt covers completely the entire height of the teeth. This new surface provides different coefficient of friction than the designed one, definitely lower one. In the same time on the back we have again dust and dirt from the years of operation and again we have different coefficient of friction than the necessary according to the design. As it was cleared from the formulas above, the reason for not working safety gear of this type in these conditions is in the non realizing the self wedging process because of reduced coefficient of friction between the working surface of the wedge and the rail, and in the same time the changed (most probably raised) coefficient of friction between the bronze slide and the safety block body. Because of all these changes, the self wedging is not happening and the wedge just sliding on the rail.

The next thing cleared from the analysis is the requirements of the applicable instruction for maintenance and repair of these types of elevators. This instruction is the leading document for the proper maintenance of these elevators, and this is as standard for each type of machine. In this document special attention is paid for the safety of the elevator and to the measures to provide it. There under yearly maintenance procedure is stated dismantling, cleaning and greasing/oiling of the safety gear blocks, as well as adjustment and test for proper work after assembly. In the problem cases it is visible that this procedure was not followed for a long period of operation. The result of this is not working elevator's safety device- the component which stops the elevator car in case of exceeding the nominal speed. This problem leads the unit to really dangerous situations where the car will not be blocked in case of need. Also these units are dangerous for operation as it is specified in SRSETSL.

Other key safety component is the overspeed governor. First problem ascertained is the missing seal on the adjusting screw. The tripping speed of the device is not guaranteed in these conditions. During the research it was proven that where the seal is missing these governors are not tripping at the necessary speed. If we consider the braking distance of well working safety gear of only few centimeters, we have to pay special attention on this fact. The reason is the limitation on the acceleration levels during the emergency stop of the car by the means of the instantaneous safety gears used. This limit is average 25 m/sec^2, and peak value of 30 m/sec^2 according to the requirements at the times of design and manufacture of the units. As experimentally is proven that the braking distance is 15 mm approximately, these limits means that the maximal tripping speed and maximal nominal speed of lifts when using this type of safety gears are limited to the following values:

Maximal tripping speed:

$$\mathrm{Vtr} = \sqrt{2.\mathrm{a.s}} \approx 0.95\mathrm{m/sec.}$$

Maximal nominal speed:

$$\mathrm{Vnom} = 0.68 \div 0.83\ \mathrm{m/sec}$$

From these values the danger from the higher than the necessary tripping speeds is clear. In the case of higher than the above values of speed together with the same braking distance means that the acceleration goes to the higher and dangerous values of much more than 30 m/sec^2. These values are really dangerous for health and even the life of passengers inside the car.

The other safety related problem found during the research with the system of the overspeed governor was the missing tension of the governor rope mainly in one of the types of diversion pulleys used. The affected type of the diversion pulley is with spring force and without safety contact used. The problem is based on elongated rope and as a consequence exhausted move of the tension mechanism. In this case the necessary tension in the rope of the system is not provided and thus the system is not working at all. This again represents serious danger for the users and these units are dangerous for operation as it is specified in SRSETSL.

6. ANALYSIS ON THE REASONS FOR THE NONCONFORMITY OF THE UNITS

When making this analyze we have to be very careful. The reason is the sensitivity in the Bulgarian society when talking about the elevator safety.

6.1 Safety gears.

It was proven the main reason for this is the not performed operations according the manufacturer’s instructions. The safeties with the wedges were not clean and properly oiled. The frequency of appearance is high- each of the problem units has this problem. The related risk is also very high- in case of need this safety device will not block the car to the guide rails.

Other identified reason was in the not proper adjustment of the activation levers of the safeties. But we have to consider that this reason was found in only one case of all the studied units, so the frequency of appearance is very low and it is related to the not followed instructions as it was described above.

6.2 Overspeed governor

The first problem with this safety device is the tripping speed. The seal on the tripping speed adjustment screw is missing. The real tripping speed is quite higher than the needed one in few cases. The related risk is high- in case of need the acceleration caused from the activation of the safeties will be higher than the limits. Not only this, but there is additional risk based on the fact that the safeties have maximal tripping speed and their proper work is not guaranteed for higher speeds.

Other serious problem is with the not enough tension of the governor rope because of elongated rope and as a consequence exhausted move of the tension mechanism. In this case the problem is the same- again the safety gears were not activated during the tests.

7. CONCLUSIONS FROM THE RESULTS

1. This research proves that the safety level of these elevators is like it was required at the time when these units are designed and manufactured in the conditions of proper maintenance and service provided. In this relation it is confirmed generally

that these units meet the corresponding legislation safety requirements.

2. In few cases, some units and the places they work have issues, which are not directly related to the general safety of the elevator operation, but in fact these issues represents discrepancy of the current legislation.

3. There were few cases with safety affected. But in all of them the reason for this fact was in the field of the proper maintenance and adjustment of the safety devices and their activation mechanisms and not in the constructional or design part.

4. In all the problem cases there were necessary very few efforts in order to achieve the proper level of safety of the elevator. These efforts containing simple operations like dismantling, cleaning, assembling, adjustment and testing of some safety devices.

5. It was found during the research that the use of spring tensioning device of oldest type is not safer enough mainly because of short possible move until exhausting of only few centimetres, compared with the other types possible as well as the not present safety contact for the rope elongation/breaking. Even in case of proper maintenance it is still possible to have not properly working device, which combined with the not present safety contact for the rope elongation/ breaking directly concerns the safety of the units affected.

6. During the research it was found that the Bulgarian State Agency for Metrological and Technical Supervision is failing during the last years in the field of accidents preventing activities, as well as public activities in the field of information campaigns on the safety issues. It appears this organization as a rule of the last years is acting and informing in public only when something happened or somebody is died. But in the same time in the public there is lack of knowledge, information and transparency under this matter. In the same time other European countries have different practises. There as a standard these organizations performing informational and prevention campaigns in the field of safety and not only their control and supervisory functions. The results from these campaigns are much more than sufficient. That is why SAMTS has to break this old behaviour model of performing only control activities and to establish new model with accidents preventing and informative campaigns in the public, as well as starting to be more transparent when doing all the related activities in Bulgaria.

8. MAIN PROPOSED MEASURES TO BE TAKEN

This research proves the importance of proper and reliable maintenance, repair and services, as well as the reliable, independent and free of any bias technical supervision of elevators. Also the results prove the importance of the proper maintenance and repair instructions, which have to be strictly followed during the works on the elevators, even for newer units. Finally the following measures on few levels are proposed:

1. Provide a proper internal supervision of the maintenance and repair works. As a base ISO 9001 family standards can be used.
2. Provide proper control and reporting methods for the licensed companies for technical supervision as part of their integrated quality management systems according to ISO 9001, which is already compulsory for these companies. Reporting system for these activities also is proposed in order to make the work of the technical supervisors more transparent and reliable.
3. Improvement and strengthen the SAMTS supervision and control activities to the licensed bodies for technical supervision in order to achieve the necessary and higher level of safety of these units.
4. Changes in the terms and conditions of the knowledge and the related certification of the lift technicians, which performing maintenance and repair works on these machinery. As a part in these changes, the related license of these persons has to be validated for example each 2 years and not unlimited.
5. Replacement of the old spring type governor rope tensioning devices with the newer one, where tensioning weight and safety contact are used in order to achieve higher safety level and to decrease the possibility of failure of the overspeed governor work.
6. It was proven that the level of awareness of the users and in some cases the maintainers is low. The Bulgarian SAMTS has to establish new model of activities in the field of accidents preventing and informative campaigns in the public, for supervisory bodies, for maintenance companies and for owners and users of elevators. In the same time this organization has to be more transparent when doing all the related activities.

7. Information for the accidents happened- reasons, actions, effect and harm has to be public, not hidden in some institutions. Register with open access has to be established immediately.

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