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ACCIDENTS AND SAFETY RISKS DURING INSTALLATION, MAINTENANCE AND MODERNISATION OF LIFTS

Abstract: *Vertical transportation is the safest transport compared to others; however, because of the enormous number of lift units, old lift stock especially in Europe, huge number of daily users, and significant number of employees in this sector, numerous serious harms and fatal accidents happen, especially during work on them. The situation in Macedonia, although there aren't satisfactory statistics, is similar and perhaps even worse than that shown in the global averages. Proper use of collective and personal protective equipment is essential. The subject of this paper is to underline safety risks and prevention associated with installation, maintenance and modernization divided as* Fatal & Serious Accidents Prevention *and* Frequent Accidents Prevention *according* ELA Brochure – Basic Safety Practices on Lifts.

Key words: lift safety, installation, maintenance, modernization, safety risk, accidents, personal protective equipment, protective means.

LIFTS – CURRENT STATE OF THE ART

The present number of lifts that are in use worldwide is estimated at 16.000.000 with the rate of newly installed units of over 500.000 to 550.000 per annum. Less than half of these, or around 700.000 with an annual increase of 140.000 units, account for Europe (The statistics of the number of lifts published by ELA for the period until 2017 inclusive was made based on incomplete data from 31 countries – Western Balkans Countries are not included). [1] The daily turnover of individual users, i.e., use of lifts – in the sense of individual trips (hereinafter referred to as "users") in Europe is estimated at about 1.000.000.000 and almost 4.000.000.000 worldwide. Hence, there is no doubt that the lift is one of the most frequently used transportation devices in the world. [6]

It is only in EU that this economic branch employs around 157.000 people and since it is mainly based in the East, the total number of employees in this sector worldwide is multiply higher than that in Europe. The employees in this sector work in two main fields of activities: a) production and installation of new lifts and b) maintenance, repair and modernization of existing lifts. Even 60% of the employees in this field are directly involved in field activities, as are installation, maintenance and modernization of lift equipment. [3] In Macedonia, the number of employees in this economic branch is around 300.

Although vertical transport by lifts is far the safest in respect to any other transportation means, due to the large number of lifts in use, their average obsoleteness, particularly in Europe, the large daily number of users and the large number of employees in this sector who are at an increased risk at most of their working places due to the nature of their work, injuries happen frequently, sometimes with serious and fatal consequences. In the Republic of Macedonia, records on injuries on and near lifts (during work on lifts and their use) are not kept in any institution. There is no precise inventory even in respect to the number of lifts. The unofficial figure ranges between 9.000 and 11.000. Several statistical analyses of injuries at work and during use of lifts in the USA and EU could therefore be of an assistance and could serve in developing strategies for improvement of safety of lifts in general and especially safety during installation, maintenance and modernisation in our country and beyond.

ACCIDENTS – STATISTIC ANALIZES

The latest study carried out by the *Engineer Research and Development Cent**re in** the USA* [4] and published in 2013 provides a detailed analysis of injuries and particularly fatalities during works on lifts and their use. In this study, data from the research and statistics carried out by the *Centre* were used. On the other hand, the *Centre* used, with a limited access, the data base of the U.S. Bureau of Labor Statistics referring to fatalities that happened in lifts and in their vicinity during work in the period 1992-2009 in which 263 fatalities on lifts and 8 fatalities on escalators are recorded. Data from the Consumer Product Safety Commission referring to injuries of passangers that happened during and beyond the working time in the period 1997-2010, were also used. According to the study, around 28 fatalities and 17.000 serious injuries happen in the USA annually during work on or in the vicinity of lifts, or their use during and beyond the working time. *Table 1* shows that 50% of the fatalities account for accidents during work on lifts or in their vicinity, around 20% account for users of lifts during working time and around 30% account for general users, i.e., users of lifts beyond the working time. *Fugure 1* shows that almost one third of the considered fatalities account for lift installers and repairers. Other professions present in fatal accidents related to lifts can be seen on the same graph. The most frequent reasons for the fatal outcome of the accidents suffered by professionals dealing with installation and repair of lifts as well as other professionals are given in *Figure 2.*

Figure 3 shows the statistics of fatalities according to performed activities.

Table 1. *Average annual number of fatalities 1992-2010*

a) Data on fatal accidents according to CFOI (Census of Fatal Occupational Injuries) Research File 1992-2009 in conditions of limited access to data from the reports of the U.S. Bureau of Labor Statistics.

b) Additional data on fatal accidents obtained from CPSC – Consumer Product Safety Commission for the period 1997-2010.

c) Number 28 has been obtained by taking into account the real values of the addends, not their rounded off values.

	Lifts	Escalators	Total
Working on/beside a lift	15[a]	0,4[a]	15
Users during work	5[b]	0,2[b]	5
Users beyond work	5[2]	2[2]	7
Total	**25**	**3**	**28[c]**

Installation and maintenance of lifts

The analysis of this statistics shows that almost ¾ of these 110 fatalities happened during installation or repair of lifts and involve lift installers and repairers. The remaining fatalities involve specialized technicians, engineers, construction supervisors, cleaners and other technicians.

More than 1/3 of the fatalities happened due to falling into lift shafts affecting lift installers and repairers. Most of these installers and repairers were neither registered nor trained for such work. Almost 1/3 of these workers were trapped between (between two cabins in the same shaft, between a cabin and a counterweight, a cabin or a counterweight and the wall of the shaft), while 1/5 were smashed while working in the lift shaft, most frequently by a down sliding cabin during work in the shaft pit.

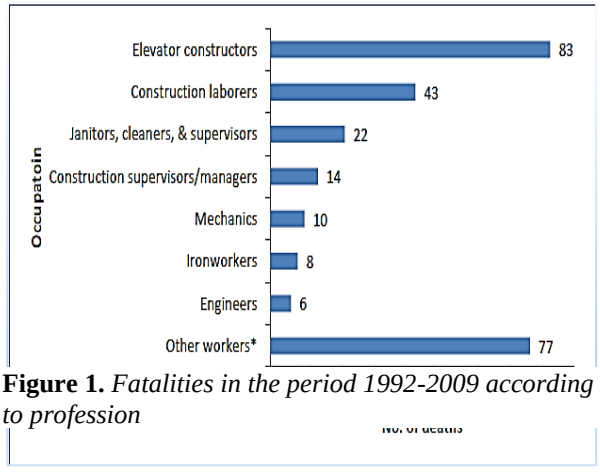


Figure 1. *Fatalities in the period 1992-2009 according to profession*

Work in the vicinity of a lift

Almost all of the 107 registered fatalities refer to construction workers and none lift installer or repairer. 49 of these fatal accidents (45 of these related to a fall in the lift shaft) happened due to unprotected openings of the lift shaft or due to their inappropriate fencing.

Work in the lift shaft or lift cabin

Forty six fatalities belonging to this category happened during activities such as taking keys that have fallen into

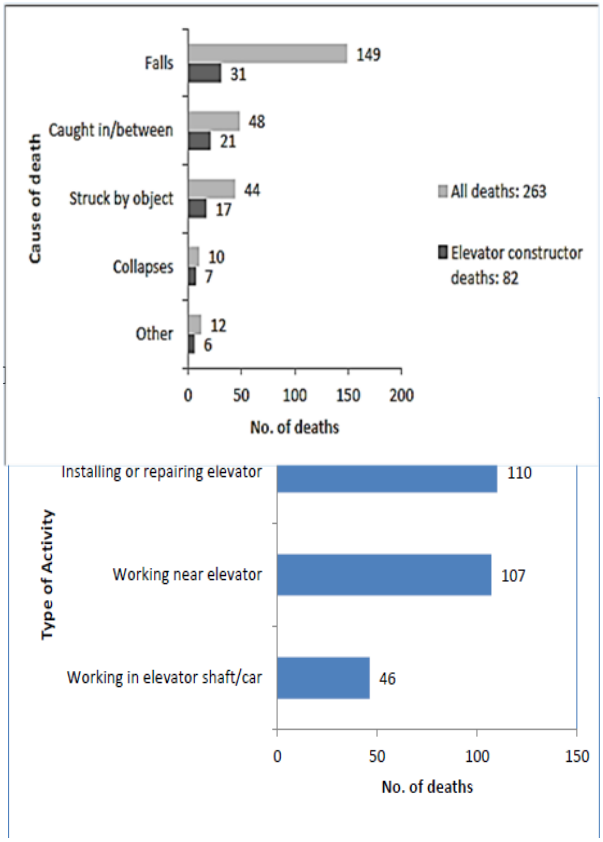


Figure 3. *Fatalities according to activities performed at the critical moment*

the lift shaft, cleaning of the interior of the lift shaft, repair of a stuck lift, falling of a cabin or a platform into the shaft pit. [6].

On the other hand, the European national associations as is the leading European Lift Association ELA does not have the best statistics of those killed and injured in lifts. ELA has engaged an independent agency to collect information from national associations in the so-called "black box" where data on accidents are stored without information on lift producers and repairers to encourage companies to provide such data by guaranteeing their anonymity. These data are necessary for getting a complete insight into the accidents related to lifts without which one cannot make a successful analysis and successful improvement of safety. Finally, ELA, have some statistics on accidents and injuries (*Figure 4*), although incomplete as they allege. These refer to the total number of accidents with slight and heavy injuries as well as fatalities according to which the most threatened are lift installers and maintainers. The reasons for these injuries are given in *Figure 5* presented as pie chart with respective percentage. The reasons for the

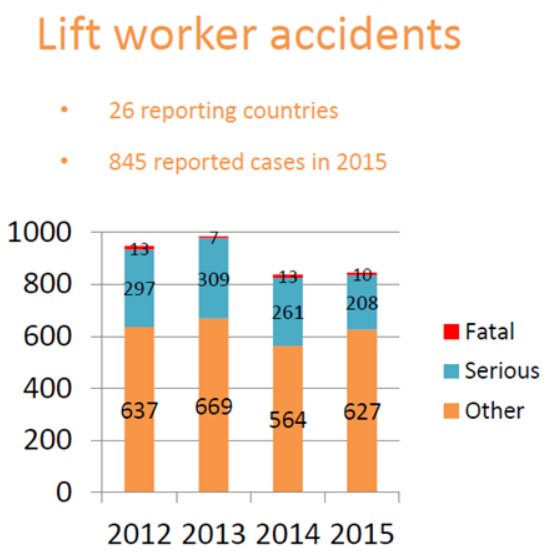
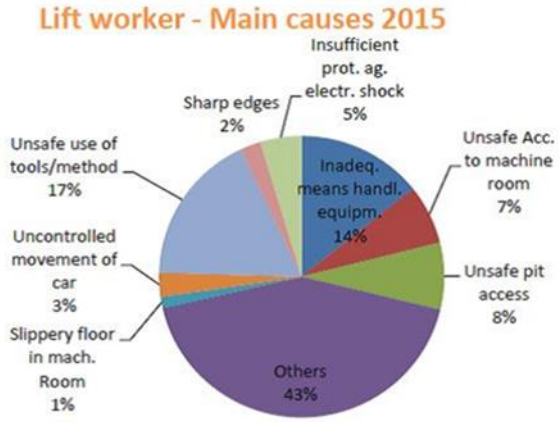


Figure 4. *Incomplete data on number of injuries related to users and injuries that happened at working place for 2015 of 26 EU countries*



accidents are classified according to the SNEL [3] list of risks (Safety Norm for Existing Lifts is a frequently used abbreviation for standard EN 81-80:2003 [8]). According to this list, the most frequent reasons for accidents are inadequate tools and methods, especially devices for hanging/lifting of the equipment in the machine room and the shaft, than unsafe access to the machine room and the shaft pit, absence of protective fence at higher levels in the machine room, etc. According to ELA, the ratio between accidents with fatal consequences and total heavy injuries is 1/92 in the case of workers on lifts is shown as pyramid (Figure 6). [7]

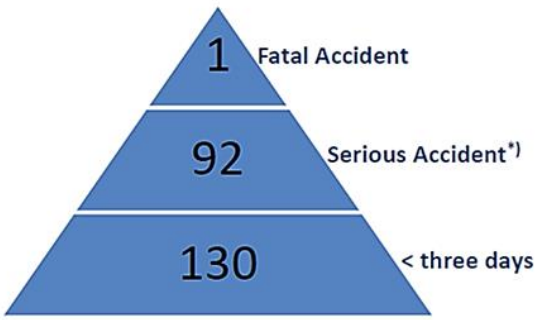


Figure 6. *Number of heavy and slight injuries in respect to a single fatality case.*

Situation in Macedonia

In Macedonia, there have continuously been recorded injuries and, unfortunately, fatalities. Within only a year, there were 3 accidents with 4 heavy injuries and a fatality. The last accidents happened to lift installers, repairers and their superiors. Injuries happen each year. As is the case in world frames, the fact that the workers directly involved in installing and maintenance of lifts are the most endangered in this sector has also been confirmed in Macedonia. If the reasons for injuries and fatalities are considered, namely falling (collapse) of lift equipment and fall of employees into lift shafts, there is again agreement with the first stated reasons for accidents in the world (fall into the shaft, caught in or between the equipment, struck inflicted by equipment or tool, collapse of equipment and other reasons). However, if the number of lifts in Macedonia and the number of accidents in this period are taken into account, the probability of occurrence of an accident and hence heavier injuries and injuries with a fatal outcome is greater than that in the EU.

SAFETY RISKS

Obviously, employees in the lift industry are exposed to risks, which if not fully identified and adequately managed, may lead to a fatal or serious accident.

The present heading, as it is defined in ELA Brochure [9] and based on SNEL list of risks, aims to help any employee and company understanding what the main risks are and help them identify effective means of protection. Following list is based on lift industry experience and knowledge of serious accidents but cannot be considered as fully exhaustive.

Fatal & serious accidents

1. *Accessing the site – New equipment – Control of mechanical energy*
   - Risk of being hurt by a falling object can occur when walking on a construction site and a worker drops a tool or materials.
2. *Access to the machine room or the pulley room – Trap access – Fall protection*

Risk of falling from unsuitable access equipment if:

- Unsafe ladder (damaged, too short or can't be secured to a fixing point);
- Unsafe trap (not robust enough, too heavy, no system to prevent accidental closing etc.).

3. *Access to the machine room or the pulley room – Access to roof – Fall protection*

Risk of falling from unprotected edge if:

- Edge is within less than 3 m from the access path to the machine room or pulley room.

4. *Work in the machine room – Fall protection*
   - Risk of falling through unprotected hole from an open trap / when lifting equipment through the trap.
5. *Work in the machine room – Control of electrical energy*

Risk of being electrocuted when:
- Taking measurements on electrical equipment;
- Replacing or repairing an electrical component or any equipment which can be powered with 110V DC or 50V AC and more (controller, selector, machine, main line switch, junction box, door lock…);
- Working in close proximity of the energized equipment.

6. *Work in the machine room – Work on rotating / moving equipment*

Risk of crushing or amputation when:
- Working on moving equipment such as ropes, sheave, selectors etc.;
- Working in close proximity of unprotected equipment.

7. *Work in the machine room – Work on the brake control of mechanical energy*
   - When working on the brake, the movement of the sheave is free and can lead to an uncontrolled movement of the car.
8. *Work on the landing – Service & renovation – Fall protection*
   - Risk of an employee or a member of the public falling through unguarded opening when the landing door is open and the car is not behind.
9. *Work on the landing – Work on moving / rotating equipment*
   - Risk of crushing or amputation when working on moving equipment such as the car door operator, landing door panels or car doors.
10. *Work on the landing – New equipment – Fall protection*
    - Risk of an employee or a worker of the construction site falling through the unprotected hoistway opening.
11. *Access the hoistway – Access the top of the car – Control of the elevator*
    - Risk of being crushed in the hoistway when working on the top of the car.
12. *Access the hoistway – Access to the pit – Control of the elevator*
    - Risk of being crushed by the car or the counterweight when accessing and working in pit.
13. *Work in the hoistway – Top of the car / inside the car – Fall protection*
    - Risk of falling from the top of the car;
    - Risk of falling from inside the car when exposed to a fall hazard.
14. *Work in a hoistway – Moving in the hoistway – Control of the mechanical energy*
    - Risk of being crushed by an equipment when moving the car in the hoistway (counterweight);
    - Risk of being crushed on top of the hoistway if insufficient space on the top of the hoistway.
15. *Work in a hoistway – Adjacent units – Control of the elevator*
    - Risk of being crushed by an adjacent running unit or any other equipment which may be moving (adjacent counterweight etc.).
16. *Work in a hoistway – Work on the hydraulic lifts – Control of mechanical energy*
    - When working on the hydraulic system, on the pipe or cylinder, the risk of having a free fall of the car is significant, potentially resulting in crushing hazard if the employee is working in pit.
17. *Work in a hoistway – Work on a ladder – Fall protection*

Risk of fall from the ladder in case:
- The ladder slips if not adequately secured;
- The ladder is not in good condition;
- The risk can occur typically when working on the top of the counterweight or deflection sheave on top of the hoistway in repair or renovation.

18. *Work in a hoistway –Falling objects (renovation & new equipment) – mechanical energy*

Risk of injury by a falling object can occur when:
- Working in the hoistway while an object falls through unprotected holes in the hoistway;
- Working in the hoistway while a colleague is working above in the machine room or on the top of the car and drops a tool or equipment;
- Working in the hoistway while another colleague installs a lift in the adjacent hoistway not being protected by a screen or other means.

19. *Work in a hoistway – Work on ropes (renovation & new equipment)*

When working on the suspension system e.g. replacing ropes, this can lead to:
- Free fall of the car;
- Free fall of the counterweight.

20. *Control of high risk activities – Hoisting and rigging activities*

Risk of falling equipment if hoisting practice is inadequate:
- Car or counterweight insufficiently secured;
- Damaged sling or hoisting equipment.

Risk of fall with the car if rigging practice is inadequate:
- Gravity centar insufficiently identified.

21. *Control of high risk activities – Scaffold*
    - Risk of fall from the scaffold;
    - Risk of falling with the scaffold if inadequately built.
22. *Control of high risk activities – Temporary fixed working platform*
    - Risk of fall from a temporary fixed working platform;
    - Risk of falling with the temporary fixed working platform if inadequately built or inadequate guardrails.
23. *Work in a hoistway – Car used as a temporary moving platform – (renovation & new equipment)*
    - Risk of fall from the moving platform;
    - Risk of fall with the car if inadequately built**.**
24. *Control of high risk activities – Defeating a safety circuit*
    - Risk of being crushed when accessing/working/ egressing the hoistway;

- Similar risks exist for members of the public in the situation that the landing door safety has been disabled.

25. Control of high risk activities – Asbestos

- Asbestos in brakes – risk of severe health effects if brake lining are removed without precautions;
- Asbestos on hoistway walls – risk of severe health effects if put in contact or removed without precautions.

Hopefully, fatal and serious accidents represent a minor proportion of the accidents reported by the companies.

Frequent accidents

This chapter aims to present the risks that are the source of the most frequent accidents, which occur. These accidents are, most of the time, not specific to lift work. Although not usually fatal, they can still lead to painful injuries.

Consequently, these risks must not be neglected and appropriate measures as suggested in the examples shall be taken. Again, this list is not exhaustive and it is the responsibility of every company and employee to conduct a proper risk assessment and to comply with the communicated rules.

1. Access the hoistway – Access to the pit

Risk of falling, slipping when accessing or egressing the pit if:

- There is no ladder for pit > 1 m;
- Ladder is not adequate;
- Ladder is not used;
- Floor is slippery.

2. Slip, Trip, Fall

- Risk of falling on stairs when there is poor lighting or stairs are in poor condition;
- Risk of falling when the ground is wet, uneven, with a small step etc.

3. Safe use of hand tools

- Risk of slipping of tools if the spanner, screwdriver or bolt is in poor condition.

4. Safe use of electrical portable tools

- Risk of dust in the eye, risk of cuts, laceration, flying particles and fire;
- Risk of cuts, laceration when using cutting tools.

5. Safe use of chemicals

- Risk of loss of conscious, disease or health issues in case of use of dangerous products;
- Risk of explosion if flammable product is used in close proximity to hot work or lit cigarettes.

6. Manual handling

- Risk of back injuries when lifting equipment;
- Risk of cuts, laceration if the load falls down;
- Risk of falls or slips when handling the equipment.

Other risks that have not been developed in this paper but which can be relevant are:

- Risk of a fire;
- Risk related to welding activities;
- Risk related to the specificity of the site (nuclear plant, chemical plant, explosive atmosphere etc.);
- Risks related to the use of vehicles.

SAFETY (PROTECTIVE) MEASURES

There are few tools as standards, technical specifications, codes of practice, and other official documents, which integrated can improve safety at work on lifts after their implementation (MKC EN ISO 14987:2013, MKC EN 13015+A1:2009, MKC EN 81-80:2008, BS 7255:2012 etc.). However, under this heading will be presented only characteristic, most important and frequently applied protective measures and equipment for listed safety risks.

Two types of protective equipment and means are necessary:

- The personal protective equipment, which protects the body from an injury;
- The means of fall protection, which prevents the employee from falling from heights.

The personal protective equipment that protects the body from an injury includes: safety helmet, safety shoes (anti-slip, anti-perforating, toe protection), working clothes (protect against cuts, dirt), required gloves (heavy duty gloves when doing manual handling, cut protective when performing repairs, using tools, etc., electrical gloves for work on potential live equipment, chemical gloves when using chemical products).

Primary protection means: the balustrade or guardrail.
Guardrail or balustrade shall be installed if a risk of fall exists as defined in the local regulation (for example, gap>30 cm and working area >2 m):

- On top of the car;
- On top of temporary working platform;
- On a scaffold;
- On edge of a building;
- In hoistway/shaft opening.

Secondary protection means: fall arrest system or fall restrain system.

Fall Arrest System: STOPS the fall and includes:

- Body harness EN 361;
- Short lanyard EN 355 with shock absorber;
- Connectors to attach the harness EN 362.

Fall Restraint System: PREVENTS a fall and includes:

- Body harness EN 361 or Belt EN 358;
- Adjustable lanyard EN 355;
- Connectors to attach to harness EN362.

All fall protection equipment:

- Is individual: every employee exposed shall be provided with one;
- Must be formally inspected yearly by a competent person (supplier or any trained person);
- Must be checked before each use.

Hooking points.
The car beam is generally considered as an adequate hooking point for the fall arrest system.
When working on the car:

- Attach after accessing;
- Detach before egressing.

This is to prevent still being attached when putting the unit back in service.

Other situations: the life line.

The life line shall be fixed to an adequate hooking point with the right capacity as per local regulation. The life line shall be protected against sharp edge.
Use life line when working on:

- Temporary platform;
- On a car when ropes have been removed;
- On a car partially assembled, suspended by chain or hoisting device.
- A ladder when working on top of counterweight.

CONCLUSION

Application of few actual tools we already have, as standards, technical specifications, codes of practice, and other official documents and recognizing safety risks in working procedures and especially proper use of adequate protective means and personal protective equipment can lead to higher level of safety for workers in lift sector.

REFERENCES

[1] Ebru Gemici-Loukas: General Assembly ELA Annual Conference 2018 - Lifts & Escalators in a Sustainable Future, 17 April 2018, Stockholm, http://www.ela-aisbl.eu/index.php/infodesk/library/brochures.

[2] ELA European Lift Association, SNEL White Paper, ELA 2013, http://www.ela-aisbl.eu/index.php/main-themes/safety.

[3] Michael McCann, PhD, CIH, "Deaths and Injuries Involving Elevators and Escalators", CPRW - The Center for Construction - Research and Training, Silver Spring, MD, USA, 2013.

[4] Goran Sekovski, B. Stavreska, K. Tanevska: "Increasing Safety of Lifts, Escalators and Conveyors" (in Serbian), Proceedings 10th National Conference with International Participation –Tara 2013, Faculty of Technical Sciences, Novi Sad, Serbia, 2013 pp. 112-122.

[5] NEII Safety Committee: "Field Employees' Safety Handbook for Elevators Industry", Elevator World, Inc. Mobile Alabama, 2015.

[6] European Lift Association: ELA News e–Newsletter 2012-2018, http://www.ela-aisbl.eu/news.htm, ELA 2009-2018.

[7] MKC EN 81-80:2008 Safety Rules for the Construction and Installation of Lifts – Existing Lifts – Part 80: Rules on Improvement of Safety of Existing Passenger Lifts and Lifts for Transport of Goods.

[8] ELA Editing Team: "Basic Safety Practices For Lifts", ELA 2013, http://www.ela-aisbl.eu/index.php/infodesk/library/brochures.

[9] Goran Sekovski: "Safety risks during installation, maintenance and use of lifts", Mechanical Engineering – Scientific Journal, Faculty of Mechanical Engineering, Skopje, Vol. 33, No. 3, 2015, pp. 233-240;

BIOGRAPHY of the first author

Goran Sekovski was born 25.12.1966 in Skopje, Macedonia. He received the diploma in mechanical engineering from the Ss. Cyril and Methodius University in Skopje, Faculty of Mechanical Engineering and the M.Sc. degree in Earthquake Engineering from Institute of Earthquake Engineering and Engineering Seismology (IZIIS) in Skopje at the same University.
Since 1992, he has worked in Institute of occupational safety, fire protection and commodity inspections - Skopje on technical inspections of machine equipment, including vertical transportation equipment, on other OHS issues as consultancy, risk assessment and inspections of work equipment. From 2003, he is Managing director at the same company and from 2016 he establish Institute of Technical Inspection and Safety Engineering – ITI Skopje, dealing with OHS, Environmental protection and Technical inspection issues and he is General manager there.

NESREĆE I BEZBEDNOSNI RIZICI PRI MONTAŽI, ODRŽAVANJU I MODERNIZACIJU LIFTOVA

Goran Sekovski, Blagoja Bogoevski, Biljana Stavreska

Rezime: *Vertikalni transport je najbezbedniji transport upređen sa ostalima, međutim, zbog enormnog broja liftova, starog voznog parka, posebno kod nas i u Evropi, velikog broja dnevnih korisnika i značajnog broja zaposlenih u ovom sektoru, dešavaju se nesreće sa teškim i fatalnim posledicama na radu na liftovima. Statistika u Makedoniji je takođe nepovoljna čak, možda i nepovoljnija nego evropski prosek. Adekvatna upotreba kolektivnih i ličnih zaštitnih sredstava i opreme je suštinske prirode. Predmet ovog rada je potenciranje bezbednosnih rizika i adekvatna zaštita radnika koji rade na montaži, održavanju i modernizaciju liftova u suglasnosti sa ELA brošurom.*

Ključne reči: bezbednost liftova, montaža, održavanje, modernizacija, beybednosni rizici, nesreće, lična zaštitna sredstva, kolektivna zaštitna sredstva.