Ensuring the safety and health of workers performing work at heights in the industrial sectors

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Abstract. The research study aims to implement the general principles for the prevention of professional risks at employers' level in relation to low-mobility workers in order to ensure an adequate level of safety and to ensure protection measures in support of social integration and inclusion. To prevent occupational accidents and occupational diseases at work, it is necessary to ensure the control of risks in order to improve the working conditions and to ensure the safety and health at work for the workers perform work at heights in the sectors of activity of the national economy with a high accident rate, by using compliant and safety work equipment. Managing professional risks of work equipment used for performing work at heights requires designers and manufacturers to ensure the conditions for the placing on the market of safety products with an adequate level of safety under the intended use conditions. To that end, the research study identifies the specific prevention tools needed to guarantee technical and environmental requirements, including appropriate measures and means of protection, in order to ensure an adequate level of security for low-mobility workers. The results of the research consisted in developing tools for effective risk management.

1 Introduction

Ensuring conditions for the labour market producers' competitiveness on the market and guaranteeing the free movement of Romanian products within the EU market, is guaranteed by ensuring the essential safety and health requirements applicable to all work equipment, in order to implement the policies provided by the free movement of products contained in the EUROPA 2020 strategy. At European level, guaranteeing a safe and healthy work environment for the over 217 million EU employees is a strategic goal for the European Commission, which is working closely with Member States, social partners and other EU institutions. One of the priorities of the Europe 2020 strategy is “inclusive growth: promoting a high-employment economy that ensures social and territorial cohesion”.

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Romania’s report on the practical implementation of Framework Directive 89/391/EEC, its special directives, contains the questionnaire for the drafting of practical implementation reports where the situation regarding the specific measures adopted to support SMEs in the reporting implementing the European directives by Romania, as a member state or social partners.

Occupational risk assessment is the key element of the national and community approach to the provision of safety and health of workers, representing the first step towards safer and healthier jobs and a way of reducing occupational accidents and the elimination of occupational illnesses. [1]

The need to ensure compliance with the essential health and safety requirements set out in Annex no.1 of the Machinery Directive 2006/42/EC, in conjunction with the safety objectives set out in Annex 1 of the new Low Voltage Directive 2014/35/EU as well as the minimum health and safety requirements of the Directive 2009/104/EC, the research study focused mainly on the analysis undertaken to identify the technical and security measures to be taken to increase the rate compliance with the use of machinery and devices for lifting persons or persons and objects in relation to the new safety objectives established for the low-voltage electrical equipment used in the manufacture of these categories of machinery.

Devices for the lifting of persons or persons and objects referred to in point 17 of Annex IV to Directive 2006/42/EC include the following:

(a) machinery whose main function is the lifting of persons or persons and objects such as, for example, mobile lifting platforms, masts or suspensions; elevators for construction sites for persons or persons and objects; lifting devices intended for connection to machines such as cranes or wind generators for access to workstations; machines serving fixed scaffolds covered by the Machinery Directive, such as residential lifts and lifting platforms for workers who perform work at heights.

b) devices for lifting persons or persons and objects mounted on machinery with main functions other than lifting persons. These devices include, for example, the operating, control or operating positions of the lifting function on industrial trolleys, on rack and cage machinery, on cranes or on earthworks, and so on.

There is little research on the equipment and devices needed to lift people who perform work at heights, especially for those activities that require special conditions for live working.

There is no research on the safety implications for workers in national economy activities involving lifting and moving people and/or objects at heights, mainly in the energy and construction sectors.

Because the electrical hazard is present in case of live working, it is mandatory that the equipment and devices necessary for the lifting of persons performing work at heights are of special design for live working, conditions in which they must be designed, manufactured, tested and verified periodically in accordance with the legal and technical Occupational Safety and Health regulations and the equipment manufacturer’s specifications.

In order to ensure safe and healthy workplaces and working environment, we have identified the need to develop tools that incorporate principles and guidelines relevant to occupational safety and health with regard to the management of professional risks, namely the assessment of conformity, inspection and certification of lifting machines persons or persons and objects. [2]

The methods used are:
- identification of occupational risks applicable to machinery and devices for lifting persons or persons and objects, which fall within the category of work equipment and which is the subject of the study analysis;
- establishing the essential safety and health requirements for machinery and devices for lifting persons or persons and objects in accordance with the legal provisions set out in Annex no.1 of EO no.1029/2008, which adopts the Machinery Directive 2006/42/EC and Annex no.1 of the new LVD Directive 2014/35/EU;
- establishing the technical and security methods necessary to assess the conformity, inspection and certification of machinery and devices for lifting persons or persons and objects, in accordance with the legal provisions set out in Annex no. 1 of EO no.1146/2006, adopting Directive 2009/104/EC (Work Equipment Directive) and EO no. 409/2016 laying down the conditions for making low voltage electrical equipment available on the market;
- establishing the safety and health requirements applicable to machinery and devices for lifting persons or persons and objects, in accordance with the legal provisions laid down for specific safety standards.

The novelty of the work consists in establishing obligatory steps for the evaluation of the conformity of the work equipment intended to perform the task at heights in order to ensure the safety and health at work of the workers by identifying the professional risks applicable to the machines designed for lifting the persons or persons and objects, establishing the essential safety and health requirements, relevant to these categories of work equipment and respectively the technical and security methods necessary for their conformity assessment, inspection and certification.

The contribution of the work is related to the establishment of a methodology regarding the conformity assessment, inspection and technical diagnosis of the machines intended for lifting persons or persons and objects, in particular for activities designed for live works in electrical installations, considering that at European and national level there is no rules and technical methods applicable to these categories of work equipment intended for the execution of works at height.

2 Aspects regarding the conformity assessment of the work equipment used by the workers who perform works at height

The assessment of the risks of injury and occupational disease generated by work equipment is generally done globally, by assessing the risks in the work system (worker - work load - means of production - working environment).

In this respect, a very wide range of methods for assessing the risks of injury and professional disease is used.

The EUROSTAT data analyses based on SEAM methodology (European Workplace Accident Statistics) help to identify accidents as a result of maintenance operations in several European countries.

Managing occupational hazards in the use of work equipment is achieved through specific control tools at company management level.

Technical tools and measures related to the conformity assessment, inspection and technical diagnosis for work equipment used by workers who perform work at heights are developed to manage the occupational risk management, especially for workers on construction and the energy sector that require designers and manufacturers to ensure the necessary conditions for the placing on the market of safe products with an adequate level of safety under the intended conditions of use.
3 The technical and safety requirements specific to the category of work equipment used by the workers who perform works at heights

Specific hazardous situations due to the lifting of persons include, in particular, the uncontrolled falling or movement of the carrier, the falling of the persons on the carrier, collisions between the carrier or persons in or on the carrier and the obstacles in the vicinity of the machinery; crash or overturning the lifting machinery.

The risks associated with lifting people are, generally, greater than the risks associated with the lifting of objects, in terms of the greater severity of possible injuries as a result of failures that have led to accidents, greater exposure to hazards, as people who are lifted by machinery are permanently exposed to hazards such as the falling of the carrier and the limited possibility of avoiding hazards or their consequences [3].

The assessment of conformity of machinery for lifting, certification and/or technical diagnosis shall be carried out under the assessment of compliance with the applicable safety and health requirements and the presumption of conformity with the standards applicable to this category of machinery.

The case study carried out by the team of researchers was carried out for a category of machinery, namely equipment for lifting persons and objects, which presents a danger of vertically falling from a height of more than 3 m, which are included in Annex no.4 of EO no.1029/2004, point 17 (Annex no.4 to Directive 2006/42/EC), referring to the identification of risks, situations and hazardous events that could pose a risk to lifting platforms for workers who perform work at heights. [3] [4] [5]

The applicable safety tests for a machinery subject to the EC type examination procedure (Article 12, paragraph (3), letter b) and point 3/Annex no.8 of Directive 2006/42/EC, respectively Article 13, paragraph (3), letter b) Annex no.9 and point 3/Annex no.8 of EO no.1029/2008), in order to prepare the initiation/initiation of the certification procedure for a manufactured machinery and intended to be used by a Romanian electricity distribution company.

The main European standards relevant for the design and manufacture of lifting platforms for workers who perform work at heights for certification assess are EN ISO 12100:2010/SR EN ISO 12100:2011[3], EN 280:2013+A1:2015/SR EN 280+A1:2016[6], SR EN 60204-1:2007/AC:2013 [7], to which are added the conformity assessment process and the relevant B-type safety standards.

Also, in the study, the list of essential requirements and characteristics applicable to the assessment of the conformity of lifting equipment for persons and objects which pose a vertical falling hazard from a height of more than 3 m, as well as the safety checks to be carried out carried out in the framework of a conformity assessment process, a list which is established in relation to the essential safety requirements provided by Directive 2006/42/EC (EO no. 1092/2008), EO no.1146/2006, SR EN 280 + A1:2016, SR EN 60204-1:2007/AC:2013, to which are added the technical conditions for the design and construction of equipment and devices specially designed for live working, as well as the conditions under which these works must be performed by application live working methods in electrical installations over 1 kV [8].

Table no.1 presents, in summary, the mechanical and electrical risks identified with regard to the electrical equipment of the machines, in compliance with the applicable essential requirements provided by EO no.1029/2008, Annex no.1, chapter 1 and Chapter 6, respectively EO no.1146/2006, under the reference of the harmonized standards.
Table 1. Identifying risks in lifting equipment for people and objects that pose a vertical drop hazard from a height of more than 3 m (excerpt)

| Risk                                                        | Technical condition according to |
|-------------------------------------------------------------|---------------------------------|
|                                                             | EO no. 1029/2008 (Annex no.1) | EO no. 1146/2006 (Annex no.1) | SR EN 12100:2011 | SR EN 60204-1:2007/AC:2013 |
| 1. Risks due to machinery manipulation or its component parts | 1.1.5                          | 2.6                           | 6.2.5           | 6.3.5.5                     |
| Control devices                                            | 1.2.2, 1.2.4, 6.2              | 2.1, 2.2, 2.3               | 6.2.5           | 6.2.11                      |
| Risks due to mounting errors                              | 1.5.4                          | 2.6, 2.7                     | 6.2.3a) si b)  | -                           |
|                                                            |                                 |                              | 6.2.6           | -                           |
|                                                            |                                 |                              | 6.3.2.6         | -                           |
|                                                            | Anexa B                        |                              |                 | -                           |
| Risk from collision                                        | 4.1.2.7                        | 2.7, 3.2.4.1                 | 3.6             | -                           |
| Risk due to the transport system                          | 4.1.2.8.1                      | 3.2.4.1                      | 6.2.5           | -                           |
| Risk due to access to the transport system                 | 4.1.2.8.2                      | 2.16                         | 6.3.5.6         | -                           |
|                                                            |                                 |                              | 6.2.2.1         | -                           |
|                                                            |                                 |                              | 6.3.3.2.1       | -                           |
| Mechanical resistance                                      | 6.1                            | 2.6, 3.2.4.1, 3.2.4.2        | 6.2.3.a) and b) | -                           |
| Risk of electric shock by direct touch                    | 1.5.1                          | 2.19                         | 6.2.9           | 6.2.2.2.2, 6.3.1, Annex B    |
| Risk of electric shock by direct touch in case of failure | 1.5.1                          | 2.19                         | 6.2.9           | 6.2.2.2.2, 6.3.1, Annex B    |
| Risk of electric shock by indirect touch                  | 1.5.1                          | 2.19                         | 6.2.9           | 6.2.2.2.2, 6.3.1, Annex B    |

In the study, safety tests for lifting equipment for persons and objects have been established, which pose a vertical falling hazard from a height of more than 3 m. Equipment for lifting persons and objects must be operated from protected electrical circuits. The directional protection equipment may be preferable to differential protection equipment to protect two parallel connected transformers, especially if the both bar busses are far placed one from each other [9].

Table no.2 summarizes the list of safety tests for electrical risk to be carried out in a conformity assessment and certification process, a list which is established in relation to the essential safety requirements of Directive 2006/42/EC (EO nr.1029/2008), EO nr.1146/2006, SR EN 60204-1:2007/AC:2013.
Tabel 2. Electrical safety tests (excerpt)

| item | Test                                           | Technical condition according to | Test method according to |
|------|-----------------------------------------------|----------------------------------|--------------------------|
|      |                                               | EO no. 1029/2008 (Annex no.1)    | EO no. 1146/2006 (Annex no.1) | SR EN 60204-1:2007/AC:2013 | SR EN 60204-1:2007/AC:2013 |
| 1    | Verification of the electrical machinery installation operation | 1.2. | 2.1, 2.2 | 4.3 | 18.6 |
| 2    | Verification of the control device and its operation | 1.2 | 2.2, 2.3, 2.4 | 9.2 | 10 | 18.6 |
| 3    | Verification of the emergency stop device and its operation | 1.2.4 | 2.1, 2.4 | 9.2 | 10.7 | 18.6 |
| 4    | Verification of the control system in the event of a power failure and a failure of the control system | 1.2.6 | 2.3 | 9.4 | 18.6 |
| 5    | Dielectric tests                              | 1.5.1 | 2.19, 3.3 | 6 | 18.4 |
| 6    | Verification of correspondence with electrical drawings | 1.7 | - | 17.6 | 18.1 |
| 7    | Verify the existence, content and durability of markings | 1.7 | 2.1 | 16 | 16 |

Electrical equipment of the machine must be immune to electromagnetic field emissions so as not to pose a risk to workers who carry medical devices (cardiac pacemakers). The effects of human exposure to electromagnetic fields is a problem still unsolved, but well-known. [10]

This is an analysis of the studies and current research on the effects of electromagnetic fields on people health in the context of conflicting results encountered lately. It is also essential to lay down requirements for electromagnetic field emissions in order to prevent interference with medical devices (including pacemakers) carried by people with medical problems [11].

The research study revealed the need for machine manufacturers to implement integrated management systems based on EN ISO 9001, EN ISO 14001 and ISO 45001 at the company level in order to ensure a high level of safety and technical progress in the design and manufacture of equipment for lifting persons and objects.

The strongest point of the triad represented by ISO 9001, ISO 14001 and ISO 45001 is the similar structure of these standards, based on the ISO 10 core clauses of the High-Level Structure. This characteristic leads to a high potential for integrating quality, environmental and occupational health and safety requirements into a single integrated management system [12].

The research study has taken into account the special conditions that must be ensured by designers and manufacturers of work equipment and devices intended for live working according to the provisions of National Energy Regulatory Authority (RO: ANRE) Order
no. 23/2011, category in which the work equipment used by workers who perform work at heights in the energy sector and have to be certified in terms of safety and health at work, certification that is carried out at national level in relation to Romanian legislation on safety and health at work.

The research study has taken into account the principles related to the conformity assessment of machinery, principles implemented by the competent certification body (INCDPM), developing a set of modern technical conformity assessment tools and certification of these machineries using 3EV methods: evaluation - test - certification.

The research study reveals the need to approach all the obligatory steps for conformity assessment and certification of machinery, regardless of the sector in which they are intended to be used.

4. Conclusion

The work equipment used by the workers who perform work at heights are machineries intended for lifting persons and objects, which present a danger of falling vertically from a height of more than 3 m, are subject to a conformity assessment procedure established by the Machinery Directive 2006/42/EC.

Machinery serving fixed landings can also be used as working platforms for accessing positions in the area of travel, so their use by workers who perform work at heights is recommended.

In order to prevent occupational accidents and occupational diseases at work, it is necessary to ensure the control of risks in order to improve the working conditions in the sectors of activity of the national economy and to ensure the safety and health at work for the workers performing the activities at a height.

Managing occupational risk management of work equipment used by low-mobility workers requires designers and manufacturers to ensure the conditions for the placing on the market of safe products with an adequate level of safety under the intended use conditions.

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