

Analysis of system safety reliability at an example of the wooden sector

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Abstract: *Analysis of system safety reliability at an example of the wooden sector.* The objective of this work was to analyze systems' safety reliability at an example of companies from the wooden sector. In our study, we made use of the accident causing coefficient, calculated with reference to the basic groups of reasons for accidents at work that took place over the years 2009-2011. As a result of this study, some basic failure areas were identified in the particular departments of the wooden sector, and some tendencies were observed in safety failures in the area of the human factor and the technical object.

Keywords: reliability, safety reliability, accidents at work, wooden sector

INTRODUCTION

Modern industrial companies are comprehensive, complex and dynamic socio-technical systems (Rasmussen, 1997; Levencon, 2004). This follows from a number of reasons, including: diversity of objectives (comprising efficiency, safety, and credibility), diversity of interacting elements (various technical areas, various tasks, external suppliers), complexity of the social structure, complexity of modern technologies and of the environment (pressure from the market, political decisions, various statutory regulations). Furthermore, the work itself becomes highly specialized under the influence of development of various information tools and systems, and it frequently becomes potentially hazardous, both for employees and their surroundings (Orton and Veick, 1990; Vicente, 1999; Kirwan, 2001).

SAFETY RELIABILITY

Safety in work processes is affected by two groups of factors: the first one being connected with reliability, and the second one being connected with hazards that arise as a result of occurrence of adverse events, also known as "failures", and which may be physical or conventional in nature (Szopa, 2009). Reliability is a comprehensive property of an object, which characterizes its ability to perform determined functions in determined conditions and over a determined time interval without any failure; whereas the term "object" (Oziemski, 1999) should be understood as any technical object, i.e. a machine, device, apparatus, installation, building, sub-assembly of a technical object, an element of such sub-assembly, software, as well as the "man-machine" interface system, and a single human being or an organized team of people performing some determined tasks.

On the other hand, "safety" means a feature of the object, which is a condition of its safe existence and operation, i.e. a condition, in which the object poses no threat to human (not only operator's) health or life, poses no threat to itself, and poses no threat to other objects and the environment around it.

Reliability can be assessed quantitatively or qualitatively. Quantitatively, reliability of an object is evaluated using reliability coefficients that are selected and determined taking into account properties of the object, which require quantitative assessment, and manners and conditions of its operation. Reliability and its coefficients are relative in nature.

"Safety" can be shaped at the stage of designing, production and usage (operation and maintenance) of the object (Legutko, 2007). From the point of view of its user, one of the basic measures of safety is the accident rate.

Safety reliability expresses the decision-maker's (operator's) belief that the object (machine, device, system) will carry out a determined performance (operation or maintenance) task with no hazard posed towards human beings, the object itself and its environment (Będkowski, Dąbrowski, 2006). The basis for such belief may come from experience based on observation of the way objects of the same type perform in the same or similar operational conditions or from theoretical analysis coupled with operational processes simulation results.

RESEARCH METHODOLOGY

The fundamental objective of our work was to analyze safety reliability in departments of the wooden sector based upon the study of basic safety failure groups divided into the following categories of reasons for accidents at work: G1 - Inappropriate condition of the material factor, G2 - Inappropriate organization of work, G3 - Inappropriate organization of the work stand, G4 - Lack or misuse of the material factor, G5 - Failure to use protective equipment, G6 - Inappropriate, unrestricted behavior of the employee, G7 - Inappropriate mental or physical condition of the employee, G8 - Improper behavior of the employee, and G9 - Others.

The study covered years 2009-2011. In the study, we used statistical data as gathered and published by the Central Statistical Office based upon the form of the Z-KW Statistical Accident Card (Wypadki przy pracy, 2009-2011). The way the Z-KW Statistical Accident Card form is designed makes it possible to indicate up to seven reasons for accident from among nine categories. Therefore, analyzed was the course of the so accident causing coefficient, calculated as ratio of a number of reasons within a given group to a number of accidents per 1000 accidents. Concerning this statistical analysis, it should also be borne in mind that out of each nine failure groups, as many as five refer to various irregularities in the performance of work by the employee. This has a significant bearing upon results of our statistical analyses.

IDENTIFICATION OF SAFETY FAILURE GROUPS IN THE PARTICULAR DEPARTMENTS OF THE WOODEN SECTOR

Figs. 1 and 2 compare the wooden sector's departments in terms of identification of basic safety failure groups and their variations in the particular departments of this sector.

Failure group G1 – *“Inappropriate condition of the material factor”* covers design defects or inappropriate technical and ergonomic solutions, inappropriate workmanship, material defects and improper operation of the material factor. Failure group G2 – *“Inappropriate organization of work”* covers primarily inaccurate division of works or planning of tasks, inappropriate commands given by superiors, lack of supervision, improper co-ordination of collective work, employee performing, at the request from his or her superiors, works that do not fall within his or her scope of duties, lack of the material factor operation manual, allowing the material factor to be operated without the required maintenance inspections, superiors tolerating violations of work health and safety rules and regulations, insufficient occupational training of the employee, lack of or inappropriate work health and safety training, superiors tolerating making use of inappropriate technologies, employees being allowed to work with medical counter-indications or without medical examinations, performing works with insufficient crew manning, and performing works despite inadequate procurement of tools and raw materials. Failure group G3 – *“Inappropriate organization of the work stand”* covers inappropriate location of facilities at the work stand; inadequate passages of footpaths; inadequate placement or storage of work objects, raw materials, half-products or products; failure to remove any unnecessary objects, substances or energy; lack of personal protection equipment; and inappropriate selection of

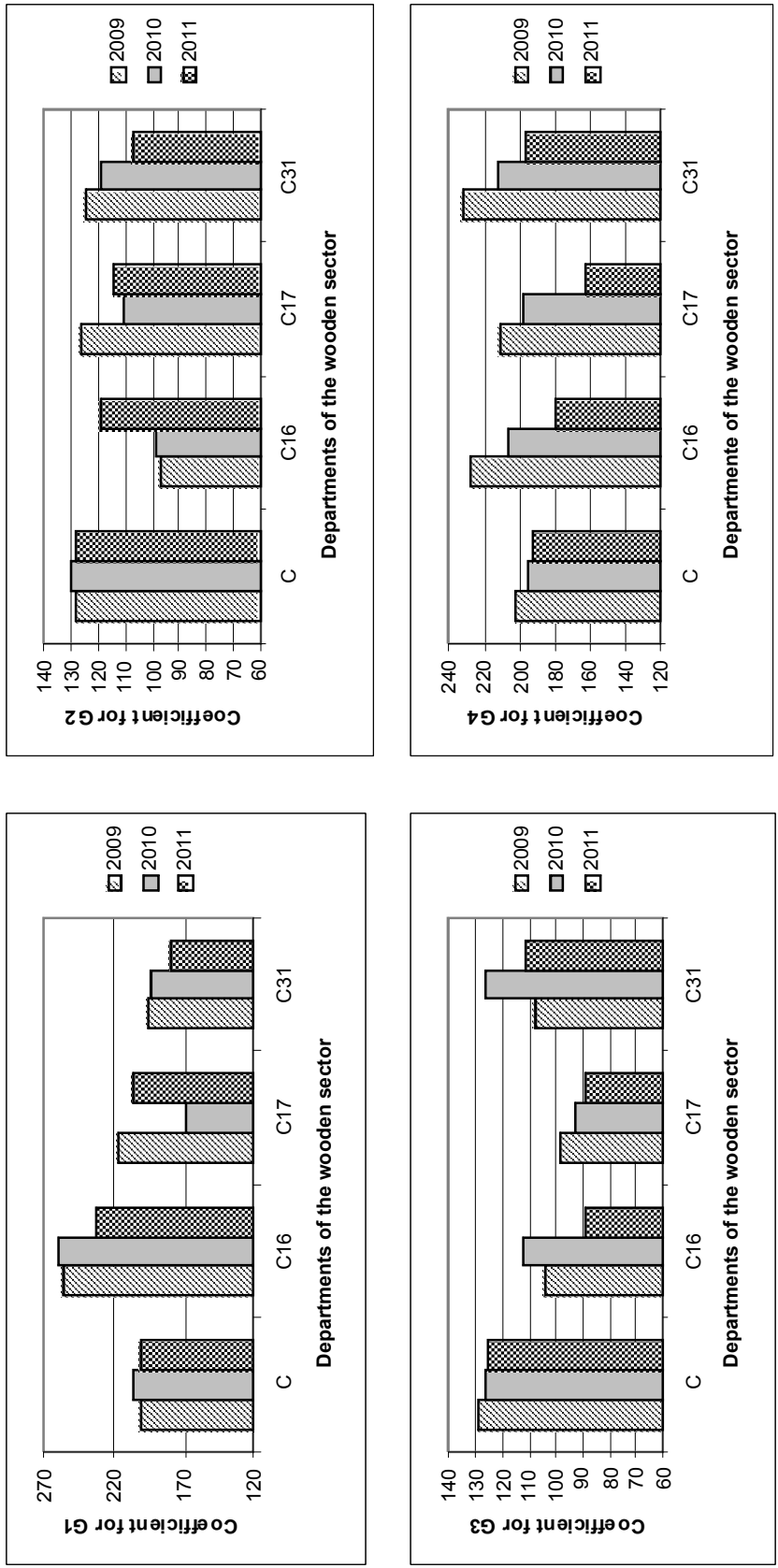
personal protection equipment. Failure group G4 – “*Lack or misuse of the material factor*” covers primarily: making use of a material factor that is inadequate for a given work; performing works manually rather than using a material factor; making use of the material factor while anybody is present in the hazardous area; material factor being improperly secured; employee making the material factor available to an unauthorized person; misuse of the material factor; employee improperly grasping or holding the material factor; or employee improperly installing, fastening or hanging the material factor. Failure group G5 – “*Failure to use protective equipment*” covers primarily the employee’s failure to use his or her own personal protection equipment, safety devices and collective protection measures. Failure group G6 – “*Inappropriate, unrestricted behavior of the employee*” covers primarily: performing works that do not fall within the employee’s responsibilities, walking into, driving into, or presence in restricted access areas, walking or driving into the hazardous area without having made sure that there is no danger in it, performing works without having removed hazards, reckless driving, employee improperly manipulating his or her limbs in the hazardous area, as well as employees joking or fighting. Failure group G7 – “*Inappropriate mental or physical condition of the employee*”, which does not provide for safe performance of work, covers primarily a condition that is due to sudden illness, physical indisposition, chronic or acute mental disorder, fatigue, nervousness, drinking alcohol, taking intoxicating drugs or psychotropic substances. Failure group G8 – “*Improper behavior of the employee*” covers behaviors that primarily result from: unawareness of hazards, work health and safety rules and regulations; employee neglecting hazards or commands received from his or her superiors; insufficient concentration of attention upon the work being performed; employee getting startled by an unexpected event; inappropriate pace of work; and lack of experience.

Table 1 lists, in the descending order, average values of the accident causing coefficients for the particular departments of the wooden sector, and also in the descending order - departments of the wooden sector from the point of view of analyzed coefficients.

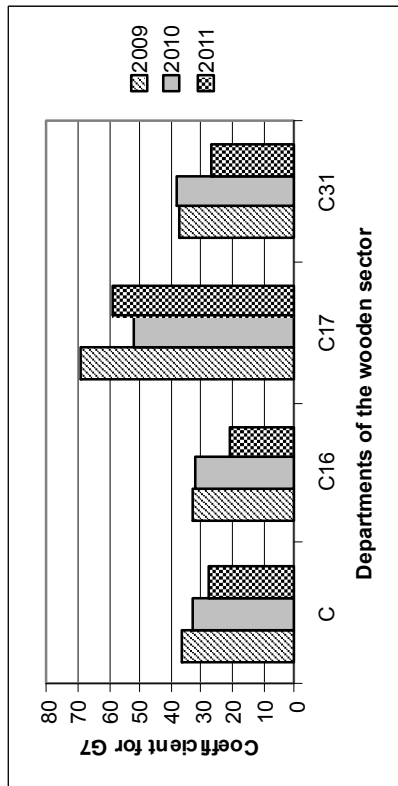
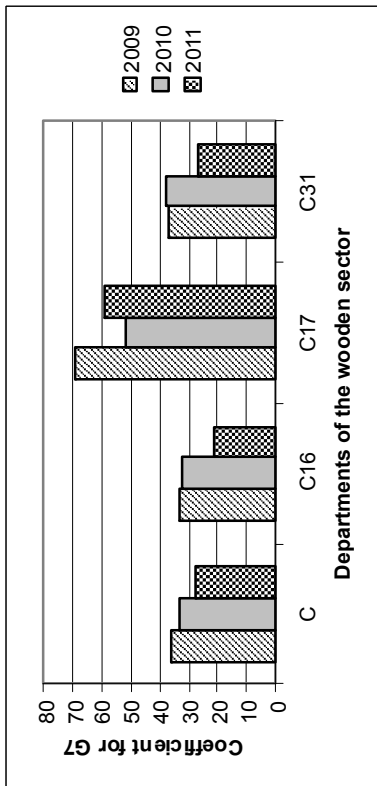
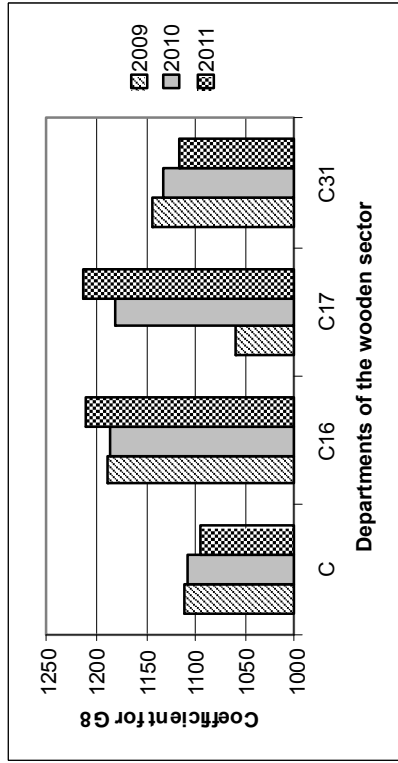
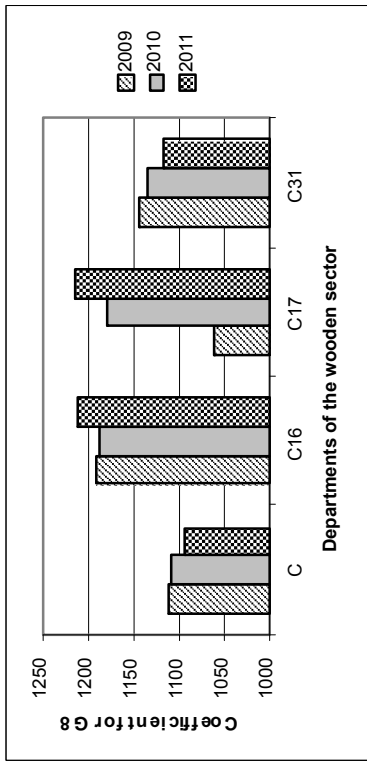
Tab. 1 Summary of the study of accident causing coefficients in the wooden sector

| By department | Accident causing coefficients | | | | | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|-----|-----|-----|-----|-----|-----|-----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| C Manufacturing | WG8 | WG1 | WG4 | WG6 | WG2 | WG3 | WG5 | WG7 |
| C16 Manufacture of wood and product of wood, cork, articles of straw and plaiting materials | WG8 | WG1 | WG6 | WG4 | WG2 | WG3 | WG5 | WG7 |
| C17 Manufacture of paper and paper products | WG8 | WG6 | WG1 | WG4 | WG2 | WG3 | WG7 | WG5 |
| C31 Manufacture of furniture | WG8 | WG6 | WG4 | WG1 | WG2 | WG3 | WG7 | WG6 |
| By coefficient | Departments of the wooden sector | | | | | | | |
| | WG1 | WG2 | WG3 | WG4 | WG5 | WG6 | WG7 | WG8 |
| 1 | C16 | C | C | C31 | C17 | C16 | C17 | C16 |
| 2 | C | C17 | C31 | C16 | C | C31 | C31 | C17 |
| 3 | C17 | C31 | C16 | C | C16 | C17 | C | C31 |
| 4 | C31 | C16 | C17 | C17 | C31 | C | C16 | C |
| G1 - Inappropriate condition of the material factor, G2 - Inappropriate organization of work, G3 - Inappropriate organization of the work stand, G4 - Lack or misuse of the material factor, G5 - Failure to use protective equipment, G6 - Inappropriate, unrestricted behavior of the employee, G7 - Inappropriate mental or physical condition of the employee, G8 - Improper behavior of the employee. | | | | | | | | |

Own source: C-Manufacturing, C16-Manufacture of wood and product of wood, cork, articles of straw and plaiting materials, C17-Manufacture of paper and paper products, C31-Manufacture of furniture, G5-Failure to use protective equipment, G6-Inappropriate, unrestricted behavior of the employee, G7-Inappropriate mental or physical condition of the employee, G8-Improper behavior of the employee.



C-Manufacturing, C16-Manufacture of wood and product of wood, cork, articles of straw and plaiting materials, C17-Manufacture of paper and paper products, C31- Manufacture of furniture, G1-Inappropriate condition of the material factor, G2-Inappropriate organization of work, G3-Inappropriate organization of the work stand, G4-Lack or misuse of the material factor.
 Fig. 1 Accident causing coef? cients for failure groups G1-G4 in the analyzed departments of the wooden sector (Source: Our own study, based on annual GUS statistical information concerning accidents at work)



C-Manufacturing, C16-Manufacture of wood and product of wood, cork, articles of straw and plaiting materials, C17-Manufacture of paper and paper products, C31-Manufacture of furniture, G5-Failure to use protective equipment, G6-Inappropriate, unrestricted behavior of the employee, G7-Inappropriate mental or physical condition of the employee, G8-Improper behavior of the employee.

Fig.2 Accident causing coefficients for failure groups G5-G8 in the analyzed departments of the wooden sector (Source: Our own study, based on annual GUS statistical information concerning accidents at work)

CONCLUSIONS

Identification of reasons and identification of activities, which are necessary to eliminate such reasons, constitute basic elements of accident investigation, and thereby – of work safety management processes in companies. Thus, reasons for accidents are an input category in considering safety reliability issues in companies as complex systems.

As a result of this study, it was observed that regardless of the department of the wooden sector, the basic failure group over the studied years 2009-2011 was improper behavior of the employee (G8). Average values of the accident causing coefficient for this group were higher than values of the conversion factor, which means that these failures were indicated at least once in connection with each accident at work. At the same time, improper behavior of the employee (G8) and inappropriate, unrestricted behavior of the employee (G6) were failure groups with accident causing coefficients being higher in the wooden sector than the average in the Industrial Processing section.

On the other hand, a reverse situation was observed in case of inappropriate organization of work (G2) and inappropriate organization of the work stand (G3). In case of these failure groups, accident causing coefficients in the wooden sector were lower than the average for the entire Industrial Processing section.

It should be noted as well that in case of the technical factor, in all departments of the wooden sector a statistically meaningful fall was observed in the value of the accident causing coefficient, connected with lack or misuse of the material factor, i.e. a machine, a device or a tool (G4), and with inappropriate condition of the material factor (G1).

Thus, very broadly speaking, the statistical data analysis results as presented above point towards a higher failure rate in the area of the human factor, and a lower failure rate in the area of the technical object. Therefore, preventive actions in the area of safety reliability improvements in the wooden sector should be oriented towards improving human reliability in work systems.

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Streszczenie: *Analiza niezawodności bezpieczeństwa systemu na przykładzie sektora drzewnego.* Celem pracy jest analiza niezawodności bezpieczeństwa systemów na przykładzie przedsiębiorstw sektora drzewnego. Do analizy wykorzystano wskaźnik przyczynowości wypadkowej, liczony w odniesieniu do podstawowych grup przyczyn wypadków przy pracy, które miały miejsce w latach 2009-2011. W wyniku badań zidentyfikowano podstawowe obszary zawodności w poszczególnych działach sektora drzewnego oraz określono tendencje, w zakresie zmian zawodności bezpieczeństwa w obszarze czynnika ludzkiego oraz obiektu technicznego.

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