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Warehouse Safety

Andrzej Szymonik
Lodz University of Technology

The article comprises of two parts, theoretical and practical. The first part presents the analysis of warehouse operations as a subject of a study. Hazards that may affect warehouse processes are discussed, and factors that determine the safety of warehouse management are characterized. In the second part, based on the results of the study carried out at 16 warehouses, selected problems concerning safety are evaluated and conclusions are presented.
Key words: warehouse, safety, hazard, procedures

1. INTRODUCTION

A warehouse is a system that has its structure and its dynamics. The structure is directly linked to all factors that allow the warehouse fulfil the functions that have been set for it, whereas the dynamics is strongly associated with process execution (e.g. receiving, picking, issuing) because change and transformation are inherent in it. Very frequently, process execution leading to a final outcome in the warehouse will not have been predetermined and planned because of the volatile environment, which in practice translates into a nonlinear nature of interrelations between assessed attributes (system characteristics). Importantly, a static description of internal structures (organizational, functional) is not sufficient for assessment. The dynamics of an analyzed warehouse and its environment that have a decisive effect on its processes also require consideration. Therefore, warehouse operation modelling, which is useful for logistics simulations, needs to be based on a combination of static and dynamic descriptions. Such an approach makes it possible to claim that a warehouse as a subsystem of logistics is a component piece of a larger, macro-scale system.

2. A WAREHOUSE AS A SUBJECT OF ANALYSIS AND SAFETY

The warehouse may be considered a logistics system because it is characterized by a purposefully organized and integrated spatiotemporal transformation of goods through processes such as receiving, storing, picking, issuing, warehousing. It has many important qualities, including the following:

- capacity for stable relationships with the environment (e.g. providing production lines with necessary components, products according to plan and responding to and mitigating crisis situations during floods, fires and other hazardous events);
- capacity to ‚make contact' with the environment and to have an effect on the emerging events (e.g. market research, supply and demand forecasts, analysis of needs related to hazard mitigation);
- capacity to establish relations between phenomena related to its environment and itself, owing to which a specific system is able to identify the phenomena that have an impact on its activities (e.g. customer satisfaction measurement, customer complaint volume).

The relationships between the warehouse and its environment may be conditioned internally within the system (e.g. the quantity of component

pieces ordered depends on the volume of customer demand for the product) or they may result from external factors which force or simply create these relationships (e.g. market collapse, financial crisis, competitors' activity).

A description of a warehouse system may, generally speaking, concern three of its aspects[1]:

– operation (warehouse processes), in other words, fulfilling the tasks defined by the user (e.g. providing space and time, movement of goods, ensuring that across the entire production system everything is supplied wherever and whenever there is a demand);
– morphology (structure), in other words, internal constitution, composition of elements, relations between the elements (e.g. integrating management organs, executive organs and warehouse infrastructure into one body and creating what is known as the automated warehouse);
– organization (information and decision-making processes) including the flow of information, coordinated control algorithms (e.g. integrated information technology system that uses automated identification and devices for automated customer order handling).

Within a warehouse operation system, the following may be identified:

- object –processes performed on the stock (e.g. receiving, storing, turnover, issuing);
- user – a part of the object's reality (e.g. manufacturing enterprise, service company, individual customer);
- environment – the object and the user stand in relationships to other external elements (e.g. freight forwarders in the TFL (Transport - Freight Forwarding - Logistics) sector, which may have an effect (positive or negative) on their behaviour (performance of warehouse processes);
- internal and external relations - capacity for ensuring the object (warehouse processes) and user's (e.g. an enterprise) operation, their ability to establish contact with the environment (e.g. suppliers and customers via the Internet) and to control emerging situations.

A warehouse as a system may be depicted in terms of component pieces that include the following (Fig. 1.):

- ŹW – inventory source (manufacturing enterprise, distributor etc.) that supplies stock according to agreements, planned demand or internal decisions;
- ŹN – inventory source (e.g. intermediate goods, returns from production, returns from customers, customer rejection of products non-compliant with quality standards, return of a shipment batch due to a natural disaster) beyond the warehouse control;
- W - inbound stock from ŹW sources;
- N – inbound stock from ŹN sources in the environment as quantities beyond the warehouse control;

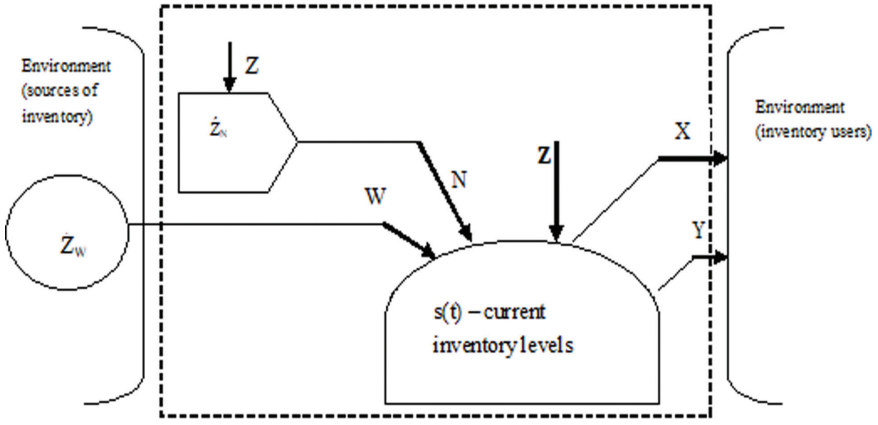

Fig. 1. The warehouse as a system of analysis
Source: author's own

[1] See: S. Paszkowski, *Podstawy teorii systemów i analizy systemowej*, WAT, Warszawa 1999, p. 19.

- X – outbound stock - planned (issued by the warehouse or collected by the user e.g. according to production schedule or agreements with customers);
- Y – outbound stock – unplanned (e.g. unfit for use, shrinkage, theft);
- S(t) – inventory level at the (t) time;
- Z – disruptions caused by hazards.
- Internal qualities of a warehouse, as of any other system (object), can be analyzed with reference to the following properties:
- capacity by the type of resource;
- optimization of inventory/resource levels;
- effectiveness (economy, productivity) of warehouse operation (receipt, storage, issuing, documentation, etc);
- process resilience to hazards;
- operational technical performance indicators;
- costs of warehouse operation;;
- others.

A warehouse, as any other economic system, should be characterized by resilience to withstand disruptions, recover and adapt to new conditions. It needs to be resistant to hazards (reliable). In the course of its operation, a warehouse should develop an ability to respond quickly to all kinds of unplanned changes in the internal and external environment. It should be a safe system that ensures and guarantees that all of its processes will be performed, and the one that allows for crisis management.

The level of warehouse safety depends on a warehouse itself, and on its immediate environment (e.g. direct suppliers and customers), as well as on its less immediate environment. In the latter case, safety depends on the extent to which cooperating participants in the local and global economic networks can withstand disruptions.

Warehouse safety is associated with: the level of preparedness - and resilience - of the system to counteract extraordinary situations (the prime focus is on identification, monitoring, data analysis and sound decision-making in the area of warehouse management); the quality of the established and operating safety system construed as a set of efforts and means providing a level of safety acceptable to the warehouse.

A specific level of safety can be achieved in many ways - not only by ensuring specific effectiveness of actions that directly counteract events that have occurred.

Controllable measures in this case include parameters characterized by factors that have an effect on the level of warehouse safety, and therefore, related to[2]: safeguarding the warehouse against potential hazards to safety, preparing the warehouse for hazardous events and situations, dealing with consequences of specific hazardous situations and events.

3. CLASSIFICATION OF HAZARDS WITH RESPECT TO WAREHOUSE SAFETY

All activities in the warehouse (warehouse management) – both in planning and in execution – entail risk that may be triggered by emerging hazards or disruptions.

The value of risk (its evaluation) in warehouse processes can be expressed with the following formula[3]:

risk = f (hazard, vulnerability, consequences) (1)

or

$$VaR = P \times Sx \times Pd \times Ex \quad (2)$$

where:

VaR – risk evaluation,

P – likelihood of risk occurrence,

Sx– value of potential loss,

Pd – risk vulnerability indicating the degree to which a warehouse is vulnerable to hazards and the level of potential consequences,

Ex – exposure coefficient indicating the degree to which a system (object) is significant with regard to the actual occurrence of a hazard.

For both formula (1) as well as formula (2), hazards that have a great impact on warehouse safety are a crucial factor, and therefore, it is necessary to predict their occurrence based on historical data, to

[2] See: E. Kołodziński, Istota inżynierii systemów zarządzania bezpieczeństwem, [at:]http://www.uwm.edu.pl, 10.08.2017.

[3] P. Sienkiewicz, H. Świeboda, Ryzyko w inżynierii systemów bezpieczeństwa, [in:] Inżynieria systemów bezpieczeństwa, ed. P. Sienkiewicz, PWN, Warszawa 2015, p. 41; P. Zaskórski, Informacja ciągłości działania determinantą bezpieczeństwa organizacji, [in:] Niebezpieczny świat. Systemy. Informacja. Bezpieczeństwo, AON, Warszawa 2015, p. 449.

detect (monitor) and identify them. Data collected in this manner, with the assistance of information technology, should make it possible to forecast consequences, predict what resources will be needed to prevent and mitigate them, and to perform corrective actions.

Mathematical models allow a quantitative assessment of hazards, whereas heuristic techniques (including expert opinions) are instrumental in their qualitative analysis.

Comprehensive identification of hazards by grouping them (classifying) while taking into account the place of their occurrence, their duration, their physical properties, and their extent has proved extremely useful for assessing their 'capacity for damage' with regard to safety of warehouse management.

These disruptions may be grouped by[4]:

- hazard location - in the subsystem of:
  - ✓ management (e.g. lack of full identification of hazards and/or their consequences, overestimating capacity, inaccurate interpretation of results, lack of tools for optimization and simulation of activities, failing to account for rising costs of energy and transport, unexpected business failure of third-party logistics, lack of oversight of employees who conduct themselves in an unethical manner, commit fraudulent acts (embezzlement or other malfeasance) e.g. when selecting suppliers, inadequate system of inventory level control, wrong demand/supply forecasting model),
  - ✓ procurement (e.g. overlong, non-optimal and requiring too much management engagement tender and purchasing procedures, inconsistent supplier selection criteria, evaluation and selection of suppliers based solely on the lowest price criterion, delays in the purchasing process, poor quality, wrong price, wrong quantity, wrong stock, bribery, corruption, inability to acquire appropriate packaging, lack of safety stock),
  - ✓ infrastructure (e.g. inadequate structure of the building, miscalculated and inadequately designed cross-docking areas, inadequate means of internal transport, inadequate stacker cranes),
  - ✓ internal transport (e.g. inadequate devices, inappropriate unit load formation, damage, shrinkage, theft, lack of qualified personnel, production stoppages, failures, fires, floods, disasters, product counterfeiting),
  - ✓ distribution (e.g. failure to notice new products or new manufacturers, theft, weather conditions, poor quality of finished products, economic crisis, disregard for customer relations management, negligence in managing material flow in the supply chain),
  - ✓ external transport (e.g. disruptions caused by fires, explosions, transport accidents, washing cargo overboard, inability to move goods due to weather conditions, non-functional means of transport, inadequate internal transport, change in transport regulations, theft, disasters),
  - ✓ inventory control (e.g. theft, loss as a result of overstocking, fires, floods, structural disasters, power outages, computer system failures, automated identification system failures),
  - ✓ packaging handling (e.g. product damage in transportation due to wrong packaging, delayed delivery of packaging due to adverse weather conditions, misplaced packaging, environmental pollution),
  - ✓ customer order handling (e.g. disruptions caused by stock shortage, wrong orders and incorrect invoices, inability to locate products, delays, and also damaged goods delivered to customers, failure to respond to complaints and delays, fires, theft, damage),
  - ✓ information (e.g. breach/loss of confidentiality, integrity and ability to dispose, natural hazards including fires, weather anomalies, electrostatics, passive and active attacks, random errors);
- duration:
  - ✓ brief, sporadic,
  - ✓ prolonged, intensifying,
  - ✓ repeated, cyclical;
- physical properties:

[4] See: P. Sienkiewicz, Teoria i inżynieria bezpieczeństwa systemów, [in] Zeszyty Naukowe AON nr 1(66) 2007, p. 254.

- ✓ material (e.g. introduction of a bioterrorism agent, poor quality of warehousing entailed by e.g. variable quality systems across the same industry),
- ✓ information (e.g. information technology system failures, automated identification system failures, inaccurate product information on product packaging),
- ✓ energy (e.g. gas, fuel),
- ✓ non-material (e.g. financial, political, social crisis);

- extent:
  - ✓ local, restricted to the logistics of a specific warehouse which is e.g. a single, separate link in the supply chain,
  - ✓ extensive – across the entire supply chain - locally or globally,
  - ✓ wide spreading (e.g.as a result of shipments of contaminated food),
  - ✓ contained (e.g. as a result of halted shipments of non-compliant products to the mass market).

An interesting typology of safety hazards, which could be used for warehouse management, is presented by P. Sienkiewicz in the article Teoria i inżynieria bezpieczeństwa systemów[5].

Safety hazards are organized into three groups[6]:

- related to human behaviour (wrongful acts – arson, theft of stored stock items, disgruntled employees, terrorists, competitors, theft of company data concerning suppliers and/or customers, and inadvertent acts - accidents caused by ignorance and/or irresponsibility);
- non-related to human behaviour (structural disasters, malfunctioning air conditioning, internal transport, racking, and computer systems, power outages);
- natural disasters (floods, hurricanes, earthquakes).

The classifications discussed above include a broad and multifaceted spectrum of adverse activities that may affect warehousing processes. From the vantage point of functions and levels of management, disruptions can arise from the following, among others:

- fallacious premises for strategic planning, incorrect assessment of strategic options;
- tarnished reputation and image of a socially responsible organization due to incidents that provoke continual criticism from government agencies or international mass media;
- unsuitable or unreliable internal processes, technologies of production, warehousing, and distribution, employees' actions, malfunctioning processes;
- external, unpredictable actions of customers, suppliers, competitors, new market actors, substitutable services as well as changes in the external environment;
- poor relations with interested parties, relations strained because of unsatisfactory assignment of authority and responsibility as a result of an inappropriate organizational structure, lack of or flawed code of conduct for employee and managerial level employees;
- non-compliance with general legal regulations, internal rules and obligations under agreements;
- inadequate physical safety level of assets and persons;
- unsatisfactory or unfit telecommunication resources (outdated information technology, inconsistent information and communications strategy, disruptions in the operation of information and communications infrastructure);
- failure to abide by OHS rules and regulations;
- unsatisfactory operation and maintenance of internal transportation and other devices the warehouse is equipped with (air conditioning, measurement instruments, fire safety equipment, etc.);
- impact on the natural environment - permanent major damage to the environment;
- loss of commercial, recreational or conservational utility resulting in serious financial consequences for participants of the supply chain including the warehouse.

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[5] See P. Sienkiewicz, Teoria i inżynieria systemów, [in:] Inżynieria systemów bezpieczeństwa, PWE, Warszawa 2015, p. 9.

[6] Ibid, p. 10.

4. DETERMINANTS OF WAREHOUSE MANAGEMENT SAFETY

Warehousing is relevant not only for production and services but also for the maintenance of different supplies including strategic reserves to satisfy the demand (of power and authority agencies, public services, emergency and rescue services, others requiring relief) for materials in time of peace, crisis and war.

Warehousing includes three major phases: increasing the level of stock - the period from the introduction of a product to the market until reaching a stock norm; stock maintenance - the period of stock management including the control of proper location of stock, its quality etc., withdrawing products no longer wanted or needed by the user (e.g. technical/technological or moral obsolescence)[7].

Crucial for the operation of a warehouse is its safety that as a subject of analysis can be defined as[8]:

- a quality of the warehouse that characterizes its resilience to emerging dire situations (hazards) where the main focus is on the unreliability of the warehouse or in other words its vulnerability to emerging hazardous scenarios;
- capacity for safeguarding stocks and infrastructure against external hazards.

The safety of a warehouse depends on the following three groups of factors: technical, legal, and human.

Technical factors that have an effect on warehouse safety are related to appropriate equipment and infrastructure which provide for proper warehousing, internal transport, order picking, sorting, shipping, and security of the facility. The infrastructure is what the safety of warehouse workers and material resources stored there depends on.

Infrastructure includes: office buildings (e.g. management and administration offices); warehouse buildings and structures that enable storage and protection of inventories; warehouse equipment (racking systems, devices for movement of products, measurement and control instruments, fire safety equipment and others); means of transport for the movement of products within the enterprise and from suppliers to customers; loading and unloading devices; access and internal roads mainly for vehicles but also for trains; packaging which fulfils protective, warehousing, movement, information and marketing functions; multiple use load units such as pallets or containers; buildings and offices related to auxiliary and additional functions (e.g. service stations, filling stations, break rooms and other social facilities, banking services, insurance services); devices and facilities related to safety such as for example ESFR sprinkler systems, ventilation holes, emergency exits, emergency power systems - battery rooms, smoke and fire detectors, 24/7 security - monitoring that takes advantage of theft and burglary alarm systems, vision monitoring systems, fire alarm systems.

In the era of information technology and electronics, it is impossible not to mention all that supports online monitoring and control of inventories with regard to their quantities, value, types, expiry dates. Useful tools and instruments of this kind include: pick-to-light systems; RFID (radio-frequency identification) – a technique that utilizes radio waves for data transmission and supplying power to a system which constitutes the object's label by the reader to enable the object's identification; voice systems - voice technologies provide for as easy, bidirectional communication between a computer system, e.g. WMS, and its user - a warehouse worker; barcode readers otherwise known as scanners - devices which turn light reflected off the surface of the barcode into a signal understandable for a cash register or a computer; RF terminals - online wireless communication devices that rely on radio signal transmission, such terminals frequently have inbuilt bar code scanners; computers installed onboard vehicles and mobile computers - have an advantage over handheld devices (larger displays, larger keyboards), have a user friendly GUI interface(in general, devices installed onboard vehicles tend to use external - wireless or cable - bar code readers for data processing).

Currently, 24/7 security services utilize CCTV (Closed Circuit TeleVision), which stands for a set of technical and software means for monitoring, detecting, recording and signalling conditions indicating that there is a risk of damage or that people and/or property may be harmed. The CCTV

[7] *Doktryna Logistyczna Sił Zbrojnych Rzeczypospolitej Polskiej DD/4*, Sztab Generalny, Warszawa 2004, p. 26.

[8] See P. Sienkiewicz, *Teoria i inżynieria systemów* … op. cit., p.

may be treated as a separate surveillance system or may be a part of a larger system of theft and burglary alarm systems or access control systems.

Technical factors that have an influence on warehouse safety also include mechanical safety measures such as any type of fixed, permanent dividers (structures, walls, gates, fire safety and security doors). Their additional function is to protect particularly important (valuable or dangerous) stock items stored there.

Legal (organizational) factors include the development and implementation of documentation, and establishment of procedures. Full compliance with the established procedures minimizes the risk of accidents or material losses.

It is extremely important during the development of documentation to consider what will be stored in the warehouse (types of supplies, stock) and what regulations and legal requirements apply to the storage of the warehoused resources. Documentation includes: job specifications for warehouse workers; warehouse fire safety instructions; occupational safety and health instructions; warehouse information sheets; warehouse maintenance instructions; humidity and temperature measurement manuals; warehouse ventilation manuals; manuals concerning alarm signals and their types; evacuation handling hazardous substance spillages; warehouse operation rules and regulations; a full name list of persons authorized to approve warehouse turnover documents; humidity and temperature monitoring logbook (also electronic); seal templates; a register of people entering the warehouse; a warehouse control reports book; a register of property issued for repairs (maintenance); a book of deposits; others (as required).

Appropriate procedures are not without significance for warehouse operation to ensure its smooth operation by effective and efficient prevention of hazards and response to those that have occurred, which means taking actions that minimize their adverse effects (consequences).

Typical organizational procedures related to warehouse operation include[9]: technical conditions of operation of the warehouse and warehouse equipment, fire safety, anti-burglary protection, personnel work safety, receiving and issuing material goods, taking stock of warehouse inventories, inventory records, documents related to receipt and issue of goods, other information activity.

Procedures should minimize the risk of accidents that may happen at the warehouse due to: problems with operating lifts; recklessness and irresponsible behaviour of workers; haste - under the pressure of

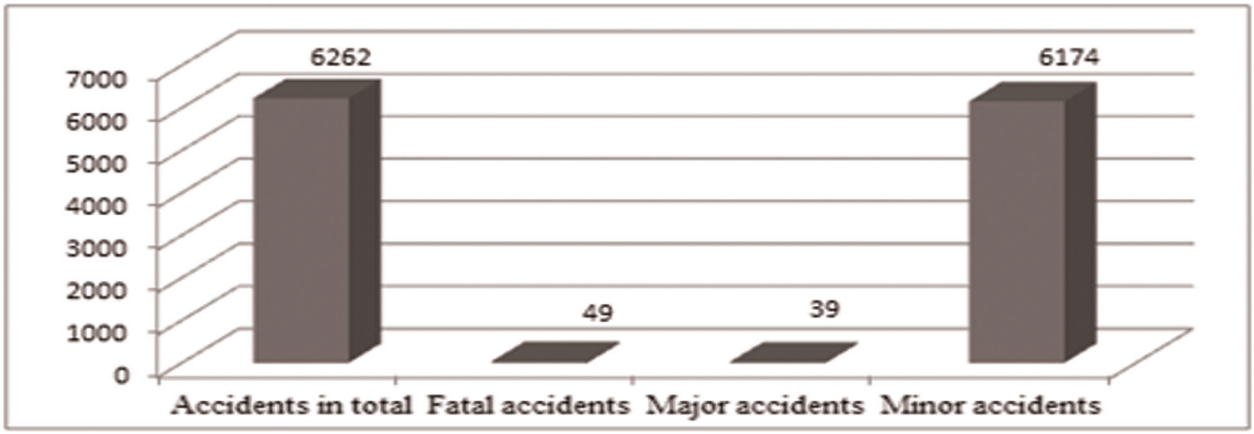

Fig. 1.1. Accidents in 2015 in transport and warehouse – numerical summary
Source: Monitoring rynku pracy. Wypadki przy pracy w 2015 r., Główny Urząd Statystyczny (GUS), Warszawa, 21.03.2016, p. 2.

plans for property stored at the warehouse; the composition of an emergency and rescue team (people and resources required for the evacuation of property); itemized lists of warehouse equipment quantities (PPE only); warehouse layout; warehouse datasheets with current data; procedures for time; poor work organization - failure to obey work rules and regulations; delayed reaction (lack of

[9] See C. Skowronek, Z. Sarjusz-Wolski, *Logistyka w przedsiębiorstwie*, PWE, Warszawa 2008, p. 141.

foresight) to actions of co-workers or other transport routes' users; uncomfortable body position of fork lift operators or excessive exertion - improper limb ergonomics affecting worker alertness level or ability to manoeuvre the device.

Procedures concerning logistics processes in large-area warehouses are supported with information technology e.g. warehouse software application WMS which executes tasks related to[10]: recording receipt of goods from external suppliers and returns to the warehouse, recording goods issue from the warehouse; updating and managing inventory levels according to predetermined criteria; designating location for the storage of delivered goods, location of stock items and picking stock items according to orders; generation of documents of receipt and issue; generating orders; checking receipts/issues against the documents; inspection of loading of external means of transport; control of the warehouse turnover process; identification and localization of goods; inventorying stocks; selecting means of transport to complete shipments.

Procedures concerning employee material responsibility for property under their care are also of substance for warehouse safety.

Two types of employee material responsibility have been singled out: individual and joint responsibility.

Apart from the rules of law, it is important to make sure that warehouse workers who are materially responsible for the property in their care have suitable qualifications, professional and moral skills and competences, and specific work experience. Persons appointed as warehouse workers should not have any addictions (alcohol, hazard) and should not have been convicted of theft, fraud and other financial crimes.

For warehouse safety, procedures included in the warehouse security plans are also important. It appears an optimal solution that a contract be signed for the protection of persons and property with professional companies such as SUFO (Specialized Armed Security Force) which are obliged to cooperate with the Police, State Fire Service, City Guard. When on duty, SUFO employees have the right to: ask for a proof of personal identification (within the area they protect), to detain suspects, to use force as a coercive measure, use other direct coercion measures such as rubber batons, handcuffs, incapacitating gas, tasers etc., and to use fire arms. Employees of such security firms provide the ongoing monitoring of warehouse entries and exits by warehouse workers, third parties, and vehicles.

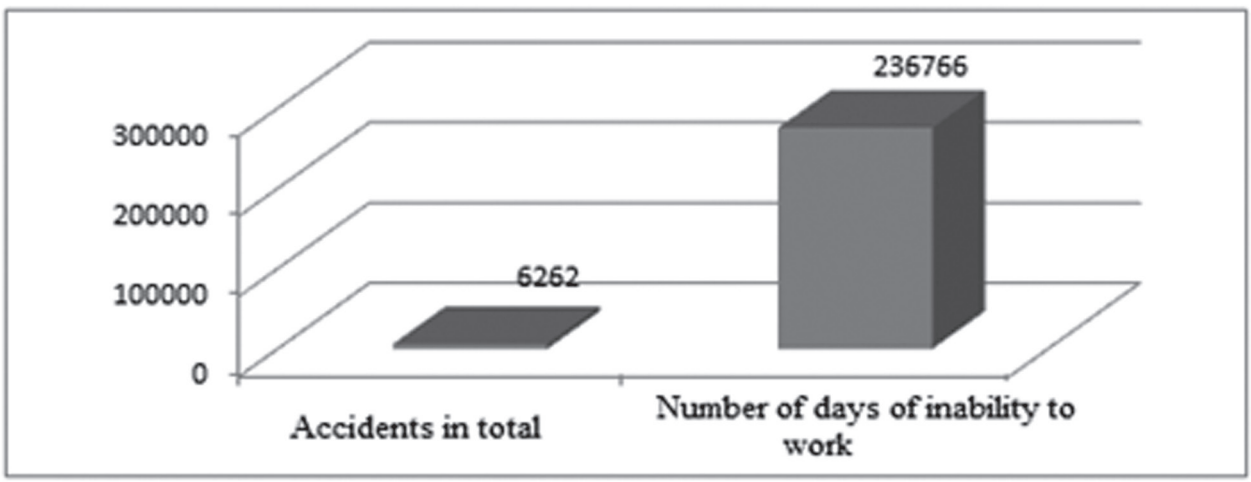

Fig. 1.2. Accidents in 2015 in transport and warehouse management - total number of days of accident-related inability to work Source: *Monitoring rynku pracy. Wypadki przy pracy w 2015 r.,*Główny Urząd Statystyczny (GUS), Warszawa, 21.03.2016, p. 2

What is an exceptionally important factor for warehouse safety are the personnel that work there. Warehouse personnel are a group of people who work in warehouses and perform duties directly related to warehouse operation. According to the

[10] Instrukcja o zasadach i organizacji przechowywania oraz konserwacji uzbrojenia i sprzętu wojskowego DD/4.22.8, Inspektorat Wsparcia SZ RO, Bydgoszcz 2013, p. 30.

qualifications tariff, positions in the warehouse include: warehouse manager, senior warehouse worker, warehouse worker, and labourer. The number of employees and their qualifications depend on the purpose and the size of the warehouse. In recruiting warehouse workers, the following should be considered: competences, qualifications, and experience; whereas, when they are already employed, providing employees with opportunities for continual professional training should not be neglected.

Another crucially important factor for warehouse safety is compliance with OSH regulations by warehouse personnel and by other persons using it (e.g. drivers who deliver and collect shipping loads to and from the warehouse). Numerical data (Figures 1.1 and 1.2) compiled by GUS with regard to transport and warehousing accidents show that it is a significant problem from the social and economic point of view.

This situation necessitates compliance with many different acts of law at once starting from OSH requirements to industry-specific regulations to technical standards, and in many cases, also good practice principles for warehousing. General requirements concerning broadly construed transport and warehousing activities are specified in Chapter 4 of the Regulation of the Ministry of Labour and Social Policy of 26 September 1997 on general provisions for occupational safety and health[11].

Knowledge relevant to the identification of hazards and implementation of appropriate preventive and corrective measures to mitigate consequences of hazards is also important. Regulations related to warehouse structures, confined warehouse spaces, warehouse transport devices, principles of storage and warehousing for different types of materials are specified in numerous acts of law and technical standards, especially those

Table 1.1. Warehouse fires in Poland iWn 2010–2015

Description	2010	2011	2012	2013	2014	2015	Average
In total, including:	1,086	1,253	1,134	976	979	1,117	1,090
small	904	1,022	907	796	783	891	884
medium	149	186	166	146	144	167	159
large	34	32	47	20	36	42	35
very large	9	13	14	14	16	17	14

Source: Biuletyny informacyjne PSP [at:] http://www.straz.gov.pl/, 26.09.2017.

The number of accidents in transport and warehouse management equal to 6 262 and the number of days of inability to work equal to 236 766 (the data changed insignificantly in the previous year) - prove that there is a great deal of room for improvement in OSH with regard to organization and procedures.

For people organizing work in warehouses, and responsible for the safety of warehouse workers (and also for the safety of third parties) it is consequential that warehouse-specific occupational safety and health regulations and requirements have not been laid down.

concerning safety in the following areas[12]:structural and OSH requirements for confined spaces in the warehouse, lighting and heating in the warehouse, requirements for warehouse roads, general requirements for fire safety, warehouse equipment

[11] Rozporządzenie ministra pracy i polityki socjalnej z 26 września 1997 r. w sprawie ogólnych przepisów bezpieczeństwa i higieny pracy (Dz.U. z 2003 r. Nr 169, poz. 1650 ze zm.).

[12] See L. Zieliński, *BHP w magazynie*, Wiedza i Praktyka, Warszawa 2015, p. 78.

- safe storage rules, safety regulations for open and semi-enclosed warehouses, OSH regulations for warehouse transport, organization of mechanized activities in the warehouse, technical gas storage, storage of liquid gas in bottles, storage of hazardous chemical materials.

Table 1.2. Frequency of fires in commercial warehouses (enclosed and roofed structures) in Poland in 2005, 2009, 2012, 2015

Description	2005	2009	2012	2015	Average
Number of enclosed and roofed warehouse structures	32,302	29,947	30,302	29,562	30,528
Number of warehouse fires	1,258	1,197	1,134	1,117	1,176
Frequency of warehouse fires	0.039	0.040	0.037	0.038	0.038

Source: Statistical Yearbook of the Republic of Poland 2015, Central Statistical Office (GUS), Warsaw 2016, p. 557 Biuletyny informacyjne PSP [at:] www.straz.gov.pl/, 26.09.2017.

Table 1.3. Number of fires in industrial structures and warehouses in 2005, 2010, 2014, 2015 in thousands

Year	2005	2010	2014	2015
Industrial structures and warehouses	3.7	3.3	3.2	3.5

Source: tatistical Yearbook of the Republic of Poland 2015, Central Statistical Office (GUS), Warsaw 2016, p. 144

Appropriate fire safety organization is an important factor that has an effect on the safety wThe material discussed above concerning warehouse fires draws attention to a number of important aspects: each fire is a safety hazard to people and property in the warehouse, each fire means material loss and disruption of the warehouse management processes including supply chain operation; on average in Poland, there are ca. 1 100 warehouse fires every year.

5. FIELD RESEARCH ON WAREHOUSE SAFETY

Research in the area of warehouse safety is very complex due to the breadth of structural and functional relationships and legal constraints, which are a result of multifaceted and variable activities that are characterized by[13]:

- multi-functionality resulting from the fact that, in view of safety, sets of different requirements are formulated that are grouped in anticipation of a future, planned operation of a warehouse (e.g. elimination or reduction of stoppages, smooth movement of goods, optimization of warehouse process zones, lowering costs of warehouse process execution, minimization of losses);
- complex structure of the warehouse that includes space, organization, information;
- a large number of subsystems making up the system of warehousing that are in various relationships (relations, couplings), and a large number of various relations with the immediate and the more remote environment, e.g. suppliers, customers, formal and legal requirements;
- the nature and dynamics of processes taking place in the warehouse and external influences (forces) of random - stochastic - nature that include potential hazards (unplanned activities);
- extended spatial range of the systems, lack of definite boundaries caused by globalization and the free movement of goods, one example of which are logistics centres (e.g. Amazon, IKEA, Auchan, Geant Distribution Centre) that have become links in international supply chains;
- dispersed system of control of information and decision-making processes caused, among others, by a dynamic growth of the number of warehouses that have a large field of coverage and provide a broad range of services (logistics centres);
- complex, open and extensive infrastructure (machines, buildings, internal transport devices, information technologies) that is in a state of permanent development.

The objective of the conducted field research which was based on a survey questionnaire and interviews with experts was to diagnose and analyse activities related to warehouse safety with regard to the possibilities of application and utilization of currently available solutions:

- legal as regards compliance with and abiding by the procedures for safety management;

[13] See H. Świeboda, Zagrożenia informacyjne bezpieczeństwa RP. Ph.D. Dissertation, AON Warszawa 2009, p. 89.

- compliance with the requirements of national and European standards;
- functions responsible for safety in the organizational structure;
- modern organizational management required for ensuring an adequate level of safety and directed to its continual improvement.

Employees of companies involved in warehouse management took part in the study. Activities in warehouses of manufacturing enterprises, service companies and logistics centres (distribution centres) were assessed.

Presented below are selected results of the study.

Question 1.

With regard to warehouse safety, participants were asked about implementation of legal requirements for warehouse safety management.

In general, in 10 of the analyzed warehouses (which is 62% of the sample) legal requirements for warehouse safety management have been implemented, whereas for 38% (6 warehouses) the problem has not been solved.

Question 2.

Has compliance with the current legal requirements and the organization's internal documentation supporting unplanned situation management been ensured?

Of the analyzed warehouses, 75% (12 organizations) have ensured compliance with the current legal requirements and the organization's internal documentation supporting crisis management, while 25% of the companies (4 organizations) have not.

Question 3.

Is the structure of costs (losses) of safeguarding against consequences of hazards to (disruptions of) warehouse processes identified and analyzed?

Out of the total number of responses to the question seeking confirmation of activities encompassing identification and analysis of the cost structure of measures safeguarding against consequences of hazards 11 organizations (69%) provided an affirmative answer. Whereas 5 of them (31%) do not perform such activities - they do not identify costs nor do they balance them.

Question 4.

Have procedures for managing the risk of loss of business continuity of the warehouse been implemented?

As the results of the study show, procedures for managing the risk of loss of business continuity of the warehouse have been implemented in 11 organizations (69%). In 5 organizations (31%), business continuity procedures have not been implemented.

Question 5

Are there any safety monitoring systems in the warehouse: physical (group 1), vision (group 2), safety performance indicators (group 3)?

Out of 16 organizations, 6 (38%) used all types of monitoring. In all warehouses, group 1 and 2 monitoring solutions operated 24/7.

Question 6.

In the organizational structure of the system of warehouse management, is there a function (person) responsible for safety?

Among the studied warehouses, only four had such functions. In 12 warehouses, there was no such function, which means no one was responsible for processes controlling the safety system in these organizations.

Question 7.

Have procedures for interactions with the external environment to ensure effective management of the safety of the logistics system been implemented?

Within the group of the 16 analyzed organizations, 13 (80%) have implemented procedures for interactions with the environment in contrast to 3 of them (20%) who have not.

Question 8.

Do international seasonal/temporary workers ensure the expected level of safety of warehouse processes?

The results of the study clearly divided the respondents into two 50% groups, which rendered any conclusive assessment rather difficult.

Question 9.

Are there training programmes related to warehouse safety in the organization?

Out of the general number of respondents, 15 (93%) reported that such trainings are regularly organized.

CONCLUSIONS

In the article, problems related to warehouse safety have been described and evaluated with particular attention drawn to 4 issues in the following areas.

The first issue. The warehouse should be treated as a dynamic object operating in a turbulent environment. Even the best laid plans do not guarantee a final outcome due to emerging, in different dimensions, unplanned, unforeseen situations resulting from deliberate and random hazards brought about by humans or adverseweather conditions.

The second issue. The presented methodology of identification of warehouse system hazards, determination of the level of vulnerability to hazardous situation emergence allows for the rationalization of selection of measures to ensure operation (according to the intended use) of the system in a hazardous environment.

The third issue. The safety of any warehouse depends on three groups of factors: technical, legal and human. They constitute a system of activities that need to be continually improved due to the fact that innovative solutions, new requirements, and unprecedented hazards do not cease to emerge.

The fourth issue. The results of the study show that there are different approaches to problems related to warehouse safety. The situation is satisfactory in some areas, for example risk management, loss of warehouse business continuity (69%), organization of monitoring (physical and visual monitoring is operational at 100% of respondents), interaction with the environment (80%), training programmes (93%). However, absence of a function responsible for the safety of warehouse processes ,may result in situations for which no-one is responsible'.

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Prof. Andrzej Szymonik PhD

Department of Production Management and Logistics, University of Lodz, Poland