ACCIDENT HAZARDS IN PROCESSES OF USING ENGINEERING SAFETY PRECAUTIONS

Joanna TABOR

Abstract: Despite the fact that engineering safety precautions (technical safety devices and equipment) are designed to protect workers against hazards occurring in work processes, they themselves may quite frequently become a source of hazards, or contribute to the occurrence of accidents. In this Chapter, a review was performed of engineering safety precautions used in work processes (primarily together with machines and equipment), and a quantitative analysis was carried out of accidents at work, with the aim to identify incidents that are non-compliant with the proper course of the work process, injury-causing incidents, and operations performed by the victim at the time of accident in cases connected with using engineering safety precautions.

Key words: means of protection, hazards, accidents at work, machinery.

1. Introduction

In compliance with the Polish Standard PN-N-18001:2004, "hazard" is a condition of work environment that can result in an accident or illness [1]. Taking into account direction and scope of development of manufacturing processes and technologies, we should adopt a broader definition of "hazard" by recognising that "hazard" can be both a factor and a potentially hazardous situation that can result in losses, i.e. not only injuries and illnesses but also in deteriorated performance properties, destruction of assets, degradation of natural environment or a combination of the above possibilities.

The notion of "hazard" is related to the notion of a "hazard factor", which constitutes a measurable physical, biological or chemical value that describes a given hazard and determines the scale of its potential effects [2].

In compliance with the Polish Standard PN-80/Z-08052 [3], factors occurring in the work process may be generally divided into the following three groups: dangerous, harmful and burdensome factors, where:

– hazardous factor is a factor whose impact upon the worker leads or may lead to an injury,
– harmful factor is a factor whose impact upon the worker leads or may lead to an illness, and
– burdensome factor is a factor whose impact upon the worker may result in ill-being or excessive tiredness, which, however, does not result in permanent deterioration of health.

Taking the above into account, hazards in work processes may be included within a group of accident hazards or a group of hazards that may result in occupational diseases [4]. In particular cases, the occupational disease hazard may transform itself into an accident hazard (in situations of excessive exposure and/or suddenly exceeding concentration or intensity levels).

Other quite frequently used classifications of hazards distinguish between:

– physical, chemical, biological and psychophysical hazards – this classification takes into account character of operations,

- kinetic hazards (moving machines and mechanisms), electrical hazards (voltage in an electrical circuit), chemical, radiational, thermal and biological hazards – this classification taking into account hazardous energy types,
- natural hazards (energy situated in natural environment), technical hazards (energy stored in technical means), and personal hazards (resulting from uncontrolled effects of operation of human muscles' strength and human body gravitation force) – this classification takes into account energy locations [5],
- measurable hazards (noise, dustiness, chemical substances, vibrations, etc.), and non-measurable hazards, in case of which quantitative measuring methods are not used in practice.

The basic group of hazards connected with making use of machinery in work processes includes mechanical hazards. The notion of mechanical hazards should be understood as all kinds of impacts of physical factors upon a human being, which may result in injuries caused by mechanical operation of machine parts, tools, objects being processed, or solid or liquid materials being discharged [6]. Basic mechanical hazards include: crushing, shearing and cutting, entanglement, getting pulled in or seized, impact, piercing, puncture, gushes of pressurised liquids, etc.

In order to eliminate or restrict the activity of hazardous mechanical factors, as well as to limit exposure towards these factors, various actions are taken at the designing stage – safe designs of machinery and their safe usage involving protective devices. Protective devices are basically used in case of hazards that could not be eliminated at the stage of design works, whereas the general principle of using protective devices is to conduct comprehensive identification of hazards and proper risk assessment.

2. Overview of engineering safety precautions

The notion of safety precautions in work processes should be understood as all ventures aimed at eliminating or minimising risks connected with the work being performed down to a tolerable level. The most general division distinguishes between the following three essential groups of means of eliminating and limiting risk:

- technical precautions,
- procedural precautions (e.g. directives, standards, regulations, instructions, etc.) and
- behavioural precautions (e.g. training programmes, motivation systems, etc.).

An approach that is rationally justified and well-verified in practice is to make use of precautions from these three different groups at the same time.

Most generally speaking, engineering safety precautions are divided into means of collective protection and means of personal protection. The notion of means of individual protection is understood as all means that are worn or held by workers in order to protect themselves against one or several hazards connected with hazardous or harmful factors, including all accessories and additions designed for this purpose [7]. Means of personal protection comprise: means of protection of the head, lower limbs, upper limbs, face and eyes, respiratory system, hearing, means of protection against falling from height, personal skin protection means, means that insulate the entire body, and protective clothing. In practice, means of personal protection constitute the last barrier against hazardous impacts in the work environment.

The notion of means of collective protection is understood as technical solutions used in work areas and in machines and other facilities, which are designed to simultaneously protect people against hazardous and harmful factors that occur in the work environment individually or cumulatively [7]. Machinery-related means of collective protection include: fencing protective devices, non-fencing arrangements, and restricting precautions.

Engineering means of collective protection perform the following two basic functions:

- prevent from access to hazardous areas of the machinery while performing actions connected with hazards (e.g. while being used), and
- prevent from operations connected with hazards when access to hazardous areas is necessary (e.g. during maintenance).

Fencing protective devices belong to the most effective safety precautions used in machines. They include various kinds of protective constructions that preclude or restrict access to hazardous areas due to the character of work of the machine or impacts from various kinds of energy (e.g. discharge of consumables or objects being processed). Fencing arrangements are divided into guards and limiters. The notion of guards should be understood as a construction element or an assembly of construction elements used to protect human being against hazardous or burdensome impacts exerted by working parts, mechanisms and working systems of a machine or facility [7]. Guards may be fixed or moveable. Fixed guards include: covers, screens, spacer guards, adjustable guards, etc. They can be separable or inseparable in nature, and they can be made of a grid or perforated sheets or bars. To remove this type of protective devices requires appropriate tools to be used. Moveable guards include: lockable or non-lockable interlocking guards, lockable or non-lockable control guards, and interlocking guards that can be opened earlier.

Selection and making use of appropriate guards is primarily dependent upon results of analysis and risk assessment, (i.e. the problem of hazards posed by the machine and other equipment of the work stand). One must also account for the machine design, its control and supervision, and frequency of interventions required (access time). General design and construction requirements for guards are contained in the Standard PN-EN 953 *Safety of Machinery – Guards – General requirements for the design and construction of fixed and moveable guards,* and in the Standard PN-EN 1088 *Safety of machinery – Interlocking devices associated with guards – Principles for design and selection*.

The group of fencing protective devices also comprises limiters. Limiters perform the safety function by detraction – detracting limiters, or by restrain – restraining limiters for worker's hands or entire body outside the hazardous area in each working cycle of a machine.

The second group of machinery-related collective protective devices constitute non-fencing protective devices, which control employees' access towards hazardous areas without making use of physical barriers. Devices in this group are referred to as *electro-sensitive protective equipment*. Protective devices of this type comprise: sensing devices, control and/or supervision equipment and input signal switching equipment. Electro-sensitive protective devices are divided into contactless and contact ones. Contactless devices include: light and capacitor curtains, and (laser) scanning heads; whereas contact devices include: two-handed control equipment, mats and floors, ropes, barriers, boards, edges, etc. Table 1 lists some basic European Standards concerning design, selection and usage of contactless protective devices.

The last group of machinery-related collective protective devices includes restricting means. Such means comprise the following arrangements: traffic-slowing and facilities, protective caps, work permits, manual backup tools, as well as making use of appropriate solutions such as: safety distances, functions of single cycles, self-control, redundancy or suspension.

Tab.1. Basic European Standards concerning design, selection and usage of contactless protective devices

Symbol	Subject
PN-EN 61496-1	Safety of machinery - Electro-sensitive protective equipment – Part 1: General requirements and tests.
PN-EN 61496-2	Safety of machinery - Electro-sensitive protective equipment – Part 2: Requirements for equipment using active optoelectronic safety barriers.
PN-EN 61496-3	Safety of machinery - Electro-sensitive protective equipment – Part 3: Active optoelectronic protective devices responsive to diffuse reflection.
PN-EN 999	Safety of machinery - Positioning of protective equipment with respect to the approach speeds of parts of the human body.
PN-EN 954-1	Safety of machinery - Safety-related parts of control systems - Part 1: General designing principles.
PN-EN 954-2	Safety of machinery - Safety-related parts of control systems - Part 2: Validation, tests, list of defects.
PN-EN 954-100	Safety of machinery - Safety-related parts of control systems – Manual on how to use and apply the Standard.
PN-EN 60204-1	Safety of machinery - Electrical equipment of machines - General requirements.
PN-EN 62061	Functional safety of safety-related electrical, electronic and programmable electronic control systems.
PN-EN 13849-1	Safety of machinery - Safety-related parts of control systems - Part 1: General designing principles.

Source: own work

The Machinery Directive [8] and the Ordinance that implements the Machinery Directive [9] contain a number of requirements which must be met by means of protection.

Protective guards and devices must be of sturdy construction, must be tightly fixed in place, may not pose any additional hazard, may not be easy to override or switched off, must be placed in proper distance from hazardous area, may only cause minimum difficulties in watching the manufacturing process, and should make it possible to perform necessary works connected with fastening and replacement of tools, and maintenance works, by restricting access exclusively to the area in which a given work must be performed, as far as possible without the necessity to remove guards or to deactivate protective devices. Furthermore, as far as possible, guards must protect workers against discharged or falling materials or objects, and against emissions from the machine.

Fixed guards must be fastened using systems that make it possible to open or remove them by means of tools only. Fastening systems must remain fixed to the guards or to the machine itself in case guards have been removed. If possible, lack of fastening elements must make it impossible for the guards to remain in place.

As far as possible, upon opening removable interlocking guards, they must remain fixed to the machine. Also, they must be designed and fabricated in such a way that they can only be adjusted by means of intended operations. Removable interlocking guards must be coupled with the interlocking device, which must prevent from starting hazardous functions of the machine up till the time the interlocking guide is closed again. A machine stopping command must be issued in the event the interlocking guide remains not closed. In case the operator finds himself in the hazardous area before the risk connected with hazardous functions of a machine is over, removable guards must be connected with a locking device used to lock guards as a complementary action to the action of the interlock, in order to prevent from starting the machine's hazardous function up till the time guards are closed and locked again, and guards should remain closed and locked until such time as the risk of injury resulting from hazardous functions of a machine is over. Removable interlocking guards must be designed in such a way that lack or damage of one of its components makes it impossible to start dangerous functions of the machine, or stops such dangerous functions.

Adjustable guards that restrict access to those fragments of rotary or moving parts, which are necessary to perform the work, must be set manually or automatically, depending upon the kind of work, and easy to set without using tools.

Protective devices must be designed and integrated with the control system in such a way that rotary or moving parts cannot be started as long as they are within the operator's reach, that workers cannot access such rotary or moving parts being in operation, and that lack or damage of one of their elements makes it impossible to start such rotary or moving parts, or stops them. Safety devices must only be adjusted using intended operations.

Complementary means of protection constitute additional group of means used to improve safety in machinery operation processes. This group of guards primarily includes precautions that alleviate effects of emergency events, i.e.: emergency and alarm systems, e.g. tripping devices, and means used to release or rescue persons having been trapped e.g. inside the machine.

Emergency and alarm systems are used to warn about the upcoming danger, and to start rescue operations. These systems must be ready to use all the time, as it is not possible to predict the time they can turn out to be required. Efficiently working alarm and rescue systems may limit any possible losses to a high degree. Emergency and alarm systems comprise all sorts of elements, from small devices to very large installations. These are, for example [10]: fire- alarming sirens, fire extinguishing equipment, chemical rescue equipment, rescue team equipment, fire detecting and distinguishing installations, means of communication in the event of disaster, first aid kits and medical equipment, installations used to neutralise leaks of toxic substances.

Supplementary means of protection comprise also additional equipment connected with providing for safe access (steps, stairs, ladders, shackles, platforms) and access to the work stand and to the machine or device maintenance areas, equipment used for safe handling machines and their parts (e.g. hooks, grapples, eyebolts, guide grooves for hoist forks, etc.), as well as means used to isolate energy (e.g. lockable power disconnectors) or to diffuse energy being stored in e.g. springs or in pressure vessels.

Above all, these facilities must be fully operational and used in practice, as human lives and value of losses incurred by the company as a result of accidents at work are dependent upon such facilities.

3. Research methodology

The main objective of the research we have conducted was to assess safe use of engineering safety precautions, i.e. devices and equipment used to provide for safety in work processes – groups 16.01 to 16.99. Among other things, this group covers: protection and safety devices used in machines, means of personal protection and devices and equipment used in case of a failure.

Therefore, the share of victims of accidents at work was analysed in order to identify most frequent incidents that are non-compliant with the proper course of the work process, injury-causing incidents and operations performed by the victim at the time of accident, in connection with using such equipment.

The Z-KW Statistical Accident Chart form is designed in such a way as to make it possible to indicate a single injury-causing incident, a single event that constitutes deviation from normal faultless operation, and a single operation performed by the victim at the time of accident. Our research was spanned over the years 2005 - 2012. In it, we used statistical data as gathered and published by the Central Statistical Office [11], based upon the Statistical Accident Chart, whose manners of compiling and submitting was regulated in the Ordinances of 8 December 2004 [12] and of 7 January 2009 [13] upon the Statistical Accident Chart at work.

4. Accidents at work connected with engineering safety precautions

The accident examination model as adopted by GUS in its Statistical Accident Chart is based upon the so called statistical accident model that has been introduced by EUROSTAT. Among other things, this model comprises such elements as: operation performed by the victim at the time of accident, incident that constitutes a deviation from normal faultless operation, injury-causing incident and material factor, whereas material factor is analysed in the following three aspects:

1. Material factor that was a source of injury, i.e.: a machine, tool, device, object or an environmental factor, direct contact with which resulted in physical or mental injury.
2. Material factor connected with operation performed by the victim at the time of accident, i.e.: machine, tool, device or another object directly used by the victim at the time of accident.
3. Material factor connected with deviation from normal faultless operation, i.e.: a machine, tool, device, object or an environmental factor which was the last one to have a connection with an incident that constitutes a deviation from normal faultless operation.

Among many groups of material factors classified in clarifications attached to the Statistical Accident Chart, there also occurs a group of safety-related equipment. This group covers: machinery protection and safety devices, means of personal protection and devices and equipment used in case of failure, i.e. generally: engineering safety precautions.

Analysis of quality of a material factor as a reason for accidents at work suggests that in years 2005-2011 there occurred a significant improvement in quality of materials used, in quality of design solutions and in quality of workmanship, as well as improvement in the operation of machinery used in work processes [14].

5. Analysis of accidents at work connected with engineering safety precautions

Table 2 lists statistical data for years 2005-2012, concerning the number of victims of accidents at work, in which the analysed material factors were engineering safety precautions. Bearing in mind that collective accidents constitute 0.5% of all accidents, further in our analysis we adopted a generalising assumption that the number of accidents complied with the number of victims.

As follows from the analysis conducted, over the analysed years 2005-2012, engineering safety precautions:

– were connected with deviation from normal faultless operation in case of from 1.0% to 0.7% of accidents at work (a falling trend),

– were connected with an injury-causing incident in case of from 0.6% to 0.5% of accidents at work,
– were connected with operation performed by the victim in case of 0.4% of accidents at work.

Tab.2. Victims of accidents at work connected with engineering safety precautions (in absolute numbers and in %)

	Number of victims of accidents at work over the analysed years							
	2005	2006	2007	2008	2009	2010	2011	2012
In case engineering safety precautions were connected with an incident that constituted a deviation from normal faultless operation	843	791	800	835	659	604	630	616
Which constitutes the share in the number of victims in total accidents	1.0 %	0.8 %	0.8 %	0.8 %	0.8 %	0.6 %	0.6 %	0.7 %
In case engineering safety precautions were connected with an injury-causing incident	543	640	661	649	567	534	539	485
Which constitutes the share in the number of victims in total accidents	0.6 %	0.7 %	0.7 %	0.6 %	0.7 %	0.6 %	0.5 %	0.5 %
In case engineering safety precautions were connected with the operation performed by the victim at the time of accident	328	389	365	442	324	371	376	353
Which constitutes the share in the number of victims in total accidents	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %	0.4 %

Source: our own work based upon annual GUS reports concerning accidents at work [11]

6. Engineering safety precautions connected with deviation from normal faultless operation

The first part of the study is focused upon the number of victims of accidents at work connected with engineering safety precautions in case such means were connected directly with an incident that constitutes a deviation from normal faultless operation. Incident that constitutes a deviation from normal faultless operation is an event that is non-compliant with the proper course of the work process, which caused the accident. In line with clarifications attached to the Statistical Accident Chart, incidents that deviate from normal faultless operation include: deviations connected with electricity, explosion, fire, discharge, leak, emissions of harmful substances, damage, rupture, cracking, slipping, falling, breaking of a material factor, loss of control over the machine, means of transport, carried load or tool, object, slipping, stumbling, falling, movement of the body with and without physical effort, shock, fear, violence, etc. Table 3 lists statistical data for years 2005-2012, concerning the number of victims of accidents at work, connected with engineering safety precautions, with division into basic groups of incidents that deviate from normal faultless operation from the point of view of the number of victims.

Tab.3. Victims of accidents at work, connected with engineering safety precautions, with division into basic groups of incidents that constitute a deviation from normal faultless operation (in absolute numbers)

Deviation from normal faultless operation	Number of victims of accidents at work over the analysed years							
	2005	2006	2007	2008	2009	2010	2011	2012
Breakage, bursting, splitting, fall, collapse of Material Agent	253	208	211	213	176	154	153	133
Slipping, stumbling, fall of persons	142	156	161	154	143	121	142	152
Loss of control of machine, means of transport or handling equipment, handheld tool, object	114	112	137	129	102	105	81	87
Body movement without any physical stress	104	118	105	130	89	71	90	85
Body movement under or with physical stress	92	71	78	69	56	70	55	67
Other	138	126	108	140	93	83	109	92

Source: our own work based upon annual GUS reports concerning accidents at work [11]

On the other hand, Figure 1 presents variations in the structure of victims of accidents at work depending upon incidents that deviate from normal faultless operation while making use of engineering safety precautions.

As follows from the analysis we have conducted, over the analysed years 2005-2012, statistically most frequent accidents connected with making use of engineering safety precautions were caused by incidents that were non-compliant with the proper course of the work process, such as: damage, rupture, cracking, slipping, falling, breaking of a material factor – on the average 25.8%, slipping, stumbling, falling of a person – on the average 20.5%, and loss of control over the machine, means of transport, carried load or tool, object – on the average 15.0%.

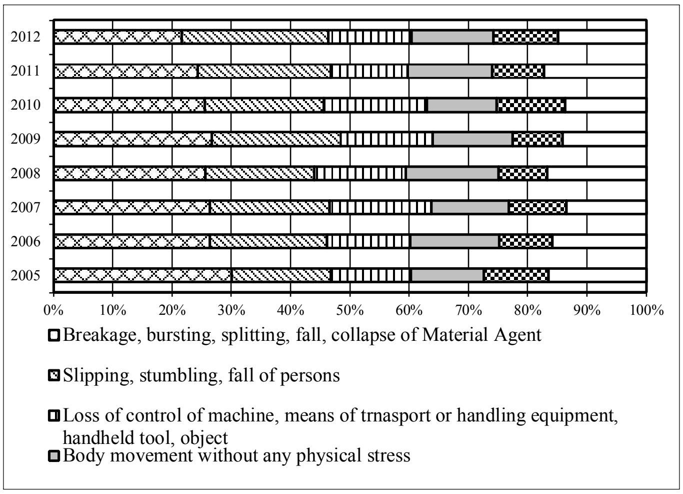

Fig.1. Structure of victims of accidents at work depending upon incidents that deviate from normal faultless operation while making use of engineering safety precautions (in %)
Source: our own work based upon annual GUS reports concerning accidents at work [11]

7. Engineering safety precautions as a source of injury

The second part of our study concentrates upon the number of victims of accidents at work, connected with engineering safety precautions in case such means constituted a source of injury resulting from a determined injury-causing incident. The injury-causing incident is used to describe the way the victim incurred a (physical or mental) injury caused by a material factor, in this case, by engineering safety precautions. In line with clarifications as attached to the Statistical Accident Chart, injury-causing incidents include: contact with electrical current, temperature, hazardous substances and chemical preparations, drowning, burying, confinement, crashing with / hitting against a stationary or moving object, contact with a sharp or rough object, getting trapped, crushing, physical load or psychological burden, displays of aggression, etc.

Table 4 lists statistical data for years 2005-2012, concerning the number of victims of accidents at work, connected with engineering safety precautions, with division into basic groups of incidents which resulted in victim injury, from the point of view of the number of victims.

Tab.4. Victims of accidents at work connected with engineering safety precautions, with division into basic groups of injury-causing incidents.

Injury-causing incidents	Number of victims of accidents at work over the analysed years							
	2005	2006	2007	2008	2009	2010	2011	2012
Struck by object in motion, collision	160	197	213	202	184	166	158	136
Horizontal or vertical impact with or against a stationary object	144	198	157	179	135	152	176	131
Contact with sharp, pointed, rough, coarse Material Agent	85	88	94	82	90	73	70	56
Physical or mental stress	40	42	47	51	52	43	27	47
Trapped, crushed, etc.	41	48	66	48	39	22	40	44
Other	73	67	84	87	67	78	68	71

Source: our own work based upon annual GUS reports concerning accidents at work [11]

On the other hand, Figure 2 presents variations in the structure of victims of accidents at work depending upon injury-causing incidents while making use of engineering safety precautions.

As follows from the analysis we have conducted, over the analysed years 2005-2012, statistically most frequent victims of accidents connected with engineering safety precautions incurred injury as a result of getting hit by a moving object – on the average 30.6%, crashing with / hitting against a stationary object – on the average 27.6%, and contact with a sharp or rough object – on the average 13.8% of all accidents at work.

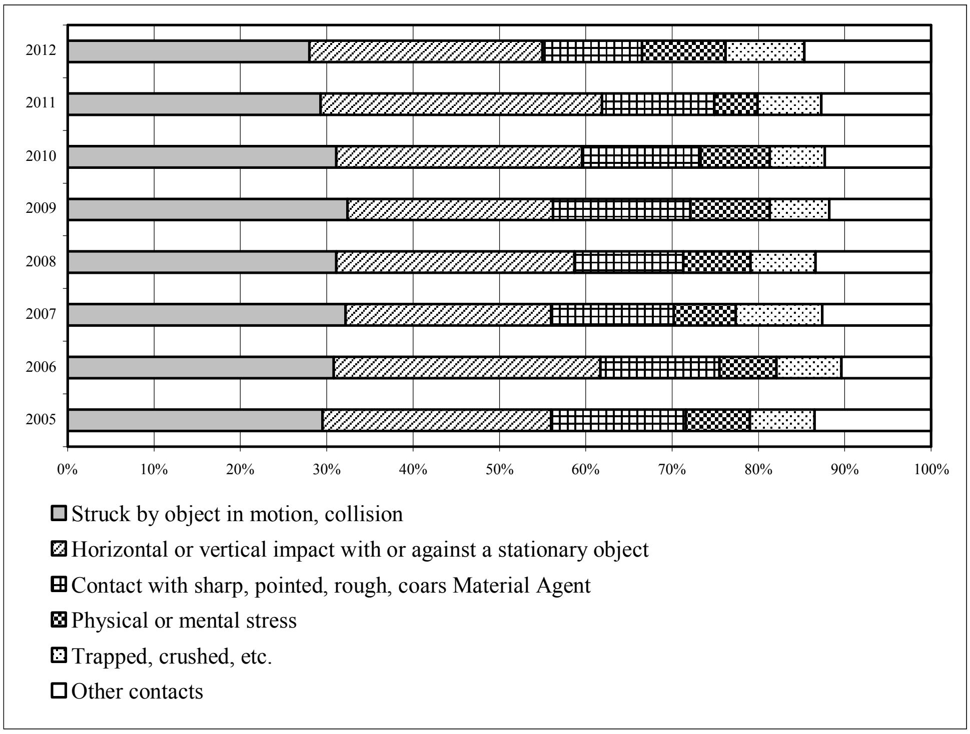

Fig.2. Structure of victims of accidents at work depending upon injury-causing incidents while making use of engineering safety precautions (in %)
Source: our own work based upon annual GUS reports concerning accidents at work [11]

8. Engineering safety precautions connected with an operation performed by the victim at the time of accident

The third part of our study concentrates upon the number of victims of accidents at work, connected with engineering safety precautions in case these precautions were directly used by victims at the time of accident in connection with the operation they were performing.

Operation performed by the victim at the time of accident is the operation that was performed in the intended manner right before the accident. In line with clarifications as attached to the Statistical Accident Chart, operations performed by the victim at the time of accident include: operating machines, works performed using manual tools, driving / being carried by means of transport, operating rotary / moving machines and other devices, handling objects, manual transport, moving or walking around, etc.

Table 5 lists statistical data for years 2005-2012, concerning the number of victims of accidents at work, connected with engineering safety precautions, with division into basic groups of operations performed by victims at the time of accident, from the point of view of number of victims.

Tab.5. Victims of accidents at work connected with engineering safety precautions, with division into basic groups of operations performed (activities) at the time of accident (in absolute numbers)

Operations -activities	Number of victims of accidents at work over the analysed years							
	2005	2006	2007	2008	2009	2010	2011	2012
Handling of objects	101	127	143	141	121	134	127	119
Movement	90	115	83	129	96	115	100	102
Carrying by hand	47	42	40	61	40	53	52	49
Operating machine	34	37	49	37	25	26	44	23
Working with handheld tools	21	27	28	35	16	24	22	22
Other physical activities	35	41	22	39	26	19	31	38

Source: our own work based upon annual GUS reports concerning accidents at work [11]

On the other hand, Figure 3 presents variations in the structure of victims of accidents at work depending upon performed operations while making use of engineering safety precautions.

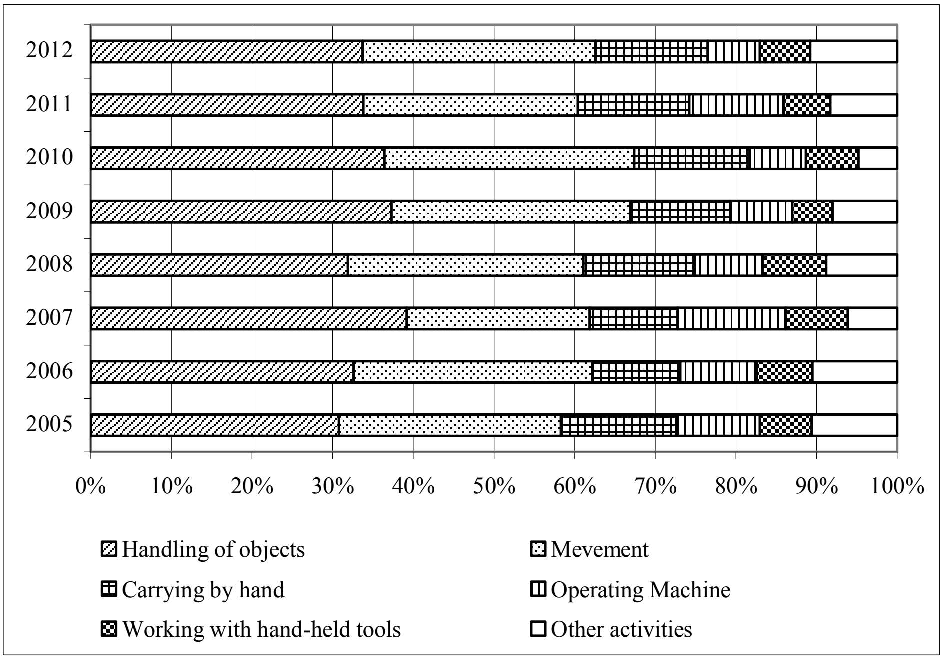

Fig.3. Structure of victims of accidents at work depending upon performed operations (activities) while making use of engineering safety precautions (in %)
Source: our own work based upon annual GUS reports concerning accidents at work [11]

As follows from the analysis we have conducted, over the analysed years 2005-2012, statistically the highest number of accidents connected with engineering safety precautions took place while handling objects – on the average 34.5%, while moving or walking around – on the average 28.1% and during manual transport – on the average 13.0% of all accidents.

9. Summary

Some of the most effective actions aimed at alleviating hazards in work processes, in particular using machines and devices, include making use of design solutions, which, above all, can eliminate or limit several hazards at the same time, as well as decrease the number of operator interventions required in particular in direct machine operation hazard areas.

On the other hand, in case of hazards not eliminated by design solutions, protective devices should be used, i.e. facilities that perform at least one of the following functions [7]:

- prevent from access into hazardous areas,
- restrain the movement of hazardous elements before the worker enters the hazardous area,
- do not allow for hazardous elements to be activated when the worker is present in the hazardous area,
- prevent from normal conditions of machinery operation being violated,
- do not allow for any other hazardous or harmful factors to be activated.

Despite the fact that protective devices are designed to secure the worker against effects of hazards that may occur in work processes, they themselves may also quite frequently contribute to the occurrence of accidents. Guards, for example, may pose hazard due to the way they are built (e.g. sharp edges, corners or the materials used), as well as due to their motion (self-driven guards or guards that may fall under their own weight). Therefore, it seems quite proper to conduct research in the above-mentioned area.

The main objective of the research we have conducted was to assess safe use of devices and equipment used to provide for safety in work processes, in particular using machines and devices.

As follows from the analysis we have conducted, over the analysed years 2005-2012, engineering safety precautions were connected directly:

- with an event that resulted in accident at work: from 1.0% to 0.7% of accidents – a falling tendency was observed with this respect,
- with an injury-causing incident: from 0.6% to 0.5% of accidents, and
- with an operation performed by the victim at the time of accident: 0.4% of accidents at work.
- Furthermore, statistically most frequent accidents connected with making use of engineering safety precautions:
- resulted from incidents that were non-compliant with the proper course of the work process, such as: damage, rupture, cracking, slipping, falling, breaking of a material factor, slipping, stumbling, falling of a person and loss of control over the machine, means of transport, carried load or tool, object,
- resulted in an injury in consequence of getting hit by a moving object, crashing with / hitting against a stationary object and as a result of contact with a sharp or rough object, as well as
- took place while handling objects, while moving or walking around, and during manual transport.

Results of our research may be useful for managers, so that they can properly streamline their preventive actions in organisational and behavioural areas, in particular in the form of training programmes and motivation systems that could modify their employees' attitudes towards accident hazards, and exert some bearing upon their employees' proper perception of risky behaviours in work processes, even in situations when means of protection are used indeed.

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Dr inż. Joanna Tabor
Zakład Systemów Technicznych i Bezpieczeństwa Pracy
Politechnika Częstochowska
42-201 Częstochowa, ul. J.H. Dąbrowskiego 69
tel. (34) 32-50-216, 609-460-906
e-mail: joanna.tabor@interia.pl