

# TECHNICAL SAFETY ON CONSTRUCTION SITES

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## Abstract

Safety is defined as a state that gives a sense of confidence and a guarantee of its behavior and a chance for improvement. The level of safety at the construction site depends on many factors, and a significant group of them are technical factors that determine the possibility of adverse events. The possibility of adverse events occurring is called unreliability. This concept is opposed to the concept of reliability, which is more commonly used in construction. Knowledge of reliability is necessary to conduct construction works. There is a need for a structural engineer to take into account safety issues and an obligation to have general knowledge in the field of safety and technical safety. Knowledge of technical safety allows for the proper conduct of works on the construction site.

The article introduces the issues of technical safety, characterizes selected types of activities posing hazards on the construction sites and proposes ways to eliminate them.

**Keywords:** safety, construction site, technical safety.

## 1 Introduction

Technical safety refers to the development, improvement and dissemination of methods and measures aimed at rationally maximizing the effectiveness of the protection of people and the environment and includes counteracting the emergence of security threats, preparing the security system and entities for the occurrence of threats and responding to the negative effects of these threats [4,25,35,36].

Security threats can be natural, civilizational and public.

Technical safety is associated with the concept of technical safety engineering, focused on the design, construction, operation and decommissioning of technical facilities in the context of minimizing the possible negative impacts caused by them. In the considerations concerning the provision of technical safety, it is noted that the manufacturer is responsible for the compliance of the technical facility with the requirements. In turn, the user is responsible for the proper operation and operation and maintenance of the structural features of the technical facility. Practical actions for technical safety in construction are based on documents of a legal nature, transferred to the level of any organization and are the basis for the creation of internal documents in individual entities [34].

According to the Labour Code, machinery and other technical equipment should be so constructed and constructed that:

- safe and hygienic working conditions, in particular protect the employee against accidents, the effects of hot chemicals, electric shock, noise, vibration, radiation and other factors of the working environment;

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- take into account the principles of ergonomics.

Machines that do not meet these conditions should be protected in appropriate safeguards, often dependent on local brewers. This obligation rests with the construction management. It is unacceptable to equip workstations with machines and technical devices that do not meet legal requirements.

However, the basic issue is the possibility of a gap between the values professed in the organization and the assumptions contained in legal documents [18].

Among the documents of importance for the construction industry, one can mention the Construction Law, Labor Code, which takes into account in issues of fire safety, hygiene, health and the environment or safety of use of facilities. It is indicated that it is possible to maintain proper technical condition, health and safety conditions at work and conditions of safe use of facilities. Detailed issues of technical safety are also included in the regulations of the Minister of Infrastructure Regulation of the Minister of Infrastructure of 12 April 2002, on the technical conditions to be met by buildings and their location [68].

Machines and equipment should work flawlessly for a certain period of time under certain conditions. The ability to perform a designated function continuously is considered to be reliability [23]. On the other hand, the ability of machines, their components or equipment to perform the required function under specified conditions and time and without damage is formulated as non-defective [41]. Reliability can be considered as technical, technical-economic or global, containing technical-economic and sociological elements of objects. In turn the probability of restoring the object's efficiency in a defined time is referred to as repairability (described by specific measures [17]). The reliability aspect of devices plays an important role when making a purchase decision. A guide in estimating the life cycle related to the reliability of machines and devices can be the PN-EN 6030040 [4] standard.

Measures to ensure safe work include the appropriate layout and arrangement of work spaces, the improvement of manufacturing processes, ensuring technical safety, e.g. guards on machinery, the use of protective clothing and personal protective equipment, training in safe working methods [7].

## **2 Constructions places and carrying out construction works**

Constructions the place where construction works are carried out, as a result of which construction objects (buildings, structures, objects of small architecture) are created.

Depending on the type of construction object (buildings, structures, objects of small architecture), different resources are needed, generally treated as tangible (materials, machines, tools and technical devices) and intangible resources (workers).

The number and type of resources should be determined before the start of construction. The design of the work technology can be helpful in the activities. The procedure for developing a typical design of construction works technology includes:

- identification of individual works occurring in the construction process,
- calculation of the number of works to be performed,
- choice of working method,
- selection of machines and equipment for the performance of individual works,
- development of machine operation schemes to ensure safe construction.

## **3 Selected activities posing hazards on construction sites**

On construction sites you can meet some universal activities, such as transport raw materials, materials and products, the use of working machines, processing of materials, or work in enclosed spaces, e.g. tanks or at heights with which classic – typical, but still underestimated threats – are located.

### **3.1 Transport**

The management of each construction site should strive to eliminate the manual movement of building materials through the use of technical and organizational solutions and introduce transport at the sites. One of the most common

devices found on construction sites that are potentially the source of many threats are devices for the so-called close, horizontal and vertical transport.

Internal transport concerns the transport of materials, building structures, etc. within the construction site itself, i.e. from the places of construction storage located on the construction site to the places where construction works are carried out [13,40,50]. The correct way to solve road transport both in terms of roads and the selection of the right type of means of transport is of great importance for the economics of construction. The requirements for transport shall be laid down in specific provisions. Although the applicable regulations define in quite detail the conditions for performing work on construction sites in a safe way when operating machinery and transport equipment, they do not take into account the specificity of individual construction sites, which should be taken into account by the construction management when developing the technology design and organization of works. It is recommended to eliminate internal horizontal transport by introducing the so-called "assembly from wheels", which consists in unloading building material directly from the means of external transport to the place of construction, bypassing storage yards. If this is not possible, road transport should be designed on construction sites. Road transport should be carried out in accordance with the provisions of the law on road traffic on public roads, taking into account the conditions of a given construction. Vehicular traffic routes, pedestrian crossings and fire roads shall be maintained in such a way as not to present risks to users and vehicle traffic shall be organised in such a way as not to cause a collision.

### 3.2 Work machines

On construction sites, machines and technical devices called "working machines" are often used, among others:

- earth-moving machines: excavators, dozers, loaders, graders, dredgers, capers, hammers, drilling rigs and specialized equipment;
- road works machinery: assemblies of machines for the production of bituminous mixtures and their unfolding, road surface milling machines, hand impact tools, vibrating compactors and rammers, road rollers, mechanical saws, mechanical snow blowers;
- machines for vertical transport: tower cranes, freight and passenger cranes, freight and passenger platforms;
- various machines and other technical devices, e.g. formwork, scaffolding, etc.

Machinery and safety components should be subject to the requirements of the MD/Regulation [20]. The Directive is not directly applicable in Polish law, but has been transferred to it by law and implementing regulations [8,16,51,52,53,54,55,56,57,58,59,60,66,67].

To operate these machines, it is required to have additional qualification (operator) qualifications received after completing specialized training and passing the test [60]. It should be remembered that during the performance of work on different construction sites, construction workers are exposed to different risks.

Examples of hazards from working machines on construction sites. in Tab.1, and the basic principles of health and safety when operating working machines in Tab.2.

Table 1. Examples of hazards from working machines on construction sites [24]

Lp.	Threat group	Type of hazard
1	When operating excavators, dozers	Injury. Fall from a dozer and excavator (bruises and injuries, Noise (hearing damage). Vibration (vibration disease). Electric shock (work on overhead lines). Fall with the machine at work near excavations, slopes, slopes (severe injuries to the body).
2	When operating construction equipment	Raptures. Being caught. Falling into trenches and hollows. Electric shock. Slips and trips. Injuries related to manual mechanical transport.

Table 2. Basic principles of health and safety when operating work machines [24].

Lp.	Threat area	Basic principles of health and safety
1	Operation	The operation of machines may be carried out only in an area recognized in terms of geological and ground conditions. Each time before the commencement of works , the person managing the employees should inform the employees about the rules of performing work in a safe manner and the accepted warning signals. Electrical or hydraulic lines connecting the working machine to the mains must be protected against mechanical damage.
2	Service	When operating machines , the working safety conditions provided for in the technical and operational documentation, operating instructions and workplace health and safety instructions must be observed. During breaks in work and after the end of work, work machines must be protected against accidental start-up by unauthorized persons.
3	Environment and working position of the machine	In conditions of limited visibility, the working place of the machine must be illuminated. In the case of earthworks, it is unacceptable to situate working machines in the wedge zone of the ground splinter, as well as to use them on clay soils during heavy rains. It is unacceptable to carry out other works at the site of excavations at the same time and the presence of unemployed persons. It is unacceptable for people to be within the range of the booms of working machines.

### 3.3 Storage of materials and media

Materials and other objects called building "materials" should be stored in places and rooms designated for this purpose. Among the building materials there are hazardous materials. Hazardous materials within the meaning of the regulations are chemical substances and preparations that pose a threat to health or life, including workers. It is the responsibility of construction site managers to inform employees about the properties of substances and preparations used in the work process, about the degree of their harm to the health of employees and about the rules of conduct in emergency situations. The basic principles for ensuring the safety of employees in the storage of materials and utilities are presented in Table 3, while the rules of conduct in the management of dangerous substances in Table 4.

Table 3. Basic principles for ensuring the safety of employees when storing materials and utilities on construction sites [24]

Lp.	Material type	Basic principles of health and safety
1	All	Determine the place for each stored material in such a way as not to exceed the permissible load on the ceilings and floors and the permissible storage height by appropriate selection of racks / platforms for the expected loads and displaying clear information about the permissible load on the ceilings and racks. The method of storage of materials must not endanger the safety of workers. When stored in stacks, their stability and the ability to move freely between them must be ensured. It is unacceptable to store materials under power lines at a distance of less than: — 2 m from the low voltage line, — 5 m from high voltage lines up to 15kV, — 10 m from high voltage lines above 15kV.
2	Bulk	In bulk storage, a suitable surface must be provided to preserve the executioner of the natural chute or the dam sufficiently resistant to the pressure of the bulk material. The entry of employees into the heaps is allowed only on the piers with the belay of the second employee.
3	Dusting	They should be stored in a fence / tight place with a height of at least 0.5 m above the stored material and their movement should take place only by special means of transport or in containers.
4	Prone to spontaneous ignition	They should be protected with ventilation chimneys that prevent temperature rise and often pour heaps and heaps.

Lp.	Material type	Basic principles of health and safety
5	Cand gas	They should be stored only in specially adapted and marked rooms or tanks where the use of open flames and smoking is prohibited. These premises should be accessible only to authorised persons. In the premises should be effective ventilation. Periodic checks on the concentration of vapours and gases should be carried out in the premises.

Table 4. Basic principles of management of dangerous substances [24]

Lp.	Material type	Basic principles of health and safety
1	All	Workers must be informed of the degree of harmfulness of substances dangerous to health and of the ways in which they can be used safely and handled in emergency situations. Detailed conditions for storage, handling and use should be laid down in detailed instructions available to workers. Hazardous materials should be stored in places and packaging intended for this purpose and appropriately marked in Polish. During the transport, storage and use of dangerous goods, workers should apply appropriate collective and individual protection measures to protect workers from their harmful effects. In rooms with hazardous materials where there is a fire, explosion or emission hazard, there shall be signalling devices, appropriate extinguishing equipment and agents, neutralising agents and means of collective and individual protection in accordance with the hazards involved. Labour processes involving carcinogens, biological agents with infectious effects and other hazards to the health and life of workers should in the first instance be replaced by other processes in which these agents will not be present.
2	Liquid	Storage is permitted in fixed tanks, protected against spillage and spread of the contents of the tank in the event of its damage and against access by unauthorized persons. The placement of tanks with liquid materials, hot liquids, compressed (liquefied) gases is not allowed.

### 3.4 Material processing

On construction sites there may be machines and equipment for woodworking, e.g. circular saws, drills, lathes or grinders, and for metalworking, e.g. shears, welding machines, cutting machines or grinders. Machining machines can be used by individual workers or can be equipment, carpentry or reinforcement room.

Machines used on construction sites cause hazards of various types of injuries to the staff, as well as to workers staying in the vicinity of the working machine. The reduction of these risks can be achieved by training employees on strict adherence to the principles of occupational safety and concentration of attention on the activities performed. Depending on the machining, workers are exposed to: captures, pulls, impacts, entanglements, touches, ejection of the processed material, electric shock or noise and vibration. The basic rules of conduct in the operation of machinery and technical equipment for woodworking and metalworking coincide and concern:

- equip clamping and pressing devices to protect workers from injuries as a result of accidental recoil or ejection of the workpiece;
- ensuring effective protection against electric shock and ventilation and mechanical protection;
- the use of appropriate protective devices, e.g. guards wherever there is a risk of the worker coming into contact with cutting tools, moving parts or workpieces;
- equip machinery with braking devices to ensure the safe stopping of work units, especially in emergency situations;
- equip and ensure that workers operating machinery use coverings that completely cover their hair and workwear without protruding and loosely hanging parts;
- equip noise workers with hearing protectors.

### 3.5 Particularly dangerous work

On construction sites there are a number of works that pose a particular threat to human health and life that are widely considered dangerous, such as:

- for power equipment,
- performed at height,
- inside tanks, boilers, silos, technological equipment, under-surveillance equipment,

works which, due to their universality, are often not taken into account when planning individual works, e.g. performed with the use of hand tools with electric drive, performed at height, in tanks, earth (in excavations, recessed), welding, repair / modernization [27,28,33].

Construction site managers should specify, for particularly hazardous work, the detailed health and safety requirements to be observed when carrying out these works [5,6].

### 3.6 Work performed with electric hand tools

Electric tools are found on almost every construction site and are applicable to various works. Depending on the way they are used, power tools can be distinguished: operated on a casual basis, usually several times during one working shift, which are returned to the rental company; often operated continuously by many working shifts; installed permanently, e.g. in carpentry or off-site reinforcements. These tools should be regularly tested to protect users from electric shock and mechanical injuries. For this purpose, each of the employees using power tools should be familiarized with the instruction manual as well as the requirements of control tests, deadlines for their conduct, procedure and basic protection measures to ensure the safety of employees. However, before starting work, the user should make an external inspection consisting mainly in checking whether: the elements of the external housing and handle are not damaged (crack, crushed, broken off), the plug is not damaged (cracked, burnt, dowels are not deformed), the connection wire is effectively protected against tearing out of the plug and whether there is no damaged insulation (cut, crushed, tanned), handle controls (buttons), the guards are not field and damaged [1,2].

### 3.7 Work at height

The term "work at height" should be understood as work (works) carried out on scaffolding, platforms, platforms, fixed galleries, poles, masts and other elevations, which are located at a height of at least 1.0 m above ground level or floor level. Work at a height is not included if it takes place on a surface which is sheathed on all sides up to 1,5 m high by full walls, windows or equipped with other fixed structures or devices to protect workers from falling from a height.

Risks of falling from a height may occur with:

- erecting the structure of building objects, during the installation of columns, ceilings, walls, roofs,
- installation of gears and disputeres of staircases, platforms and balconies as well as during the assembly and disassembly of protective barriers and balustrades,
- performing façade works from scaffolding and working platforms,
- when working in places where it is possible for various objects, tools and building materials to fall from above [24,35,36].

Employees who:

- have received periodic and basic ohs training and on-the-job instruction familiarizing them with the nature of work at heights, with the risks associated with their activities, the possible effects of hazards and the main causes of accidents,
- have a current medical certificate on the absence of contraindications to work at heights,
- are able to use the personal protective equipment and safety devices assigned to them,
- are able to safely handle basic horizontal and vertical transport services, including appropriate qualification qualifications [31].

Detailed requirements are included in the legal regulations for work at the height of [3,28,29,31,64,67,69,70].

### **3.8 Work in tanks**

The term work in "tanks" should be understood as work in: tanks, canals, wells, sewer manholes, inside technical devices and other closed rooms with rooms, the entrance to which is carried out through manholes or openings of small size or is otherwise difficult.

Work in tanks, as particularly dangerous works, may be carried out only on the basis of a written permit issued in the manner adopted on a given construction site, with constant supervision. The person issuing the order to perform the work should check whether the organizational and technical preparations ensure that the work is carried out in a safe manner.

When working in tanks, when starting to perform it, one should familiarize oneself with the regulations and principles of safe work [44,45,69].

### **3.9 Work in excavations and hollows**

Earthworks are particularly dangerous works and can be carried out only after discernment: the category of soil in which they are to be carried out, the existing underground utilities and after applying appropriate trench protection. Otherwise, work in excavations and hollows may result in a severe, even fatal accident caused by backfilling with earth in an unprotected trench or electric shock due to the interruption (damage) of an electric underground cable. Before starting work in excavations, you should familiarize yourself with the legal requirements and rules in this respect [9,11,12,14,15,19,21,22,30,32,33,35,38,39, 46,47,61,66,67,69].

### **3.10 Welding work**

Welding work includes welding, surfacing, soldering, welding, thermal cutting of metals and plastics with a flame of combustible gases or an electric arc. Welding and cutting of metals can be performed only by persons with theoretical and practical training in the field of welding (basic and non-basic electrical or gas qualifications) confirmed by an exam or a document authorizing to perform welding work (welder's booklet). Welding and cutting metals should take place in specially prepared rooms, separated from other workstations. If welding takes place in an open area, the workstation should be protected against weather conditions and its surroundings protected against the harmful effects of an electric arc or flame. Before starting welding work, you should familiarize yourself with the requirements of the law [37,42,48,49,62,65,71].

### **3.11 Renovation / modernization works**

In the construction process, renovation is defined as the performance in an existing construction work consisting in the restoration of the original state, and not constituting current maintenance, while the use of construction products other than those used in the original state is allowed. An example of renovation is, for example, the restoration of the façade of a building [71]. On the other hand, renovation should be considered all expenditures related to maintaining or restoring the use value of the building object - the original state, through, for example, repair or replacement of worn elements, provided that it does not change the nature and function of the object.

Appliances and energy installations or parts thereof at which renovation, modernization or maintenance works will be carried out should be excluded from traffic, free of hazardous factors and effectively protected against their start-up and marked.

All work performed on / or at energy devices, regardless of their scope, may be carried out only with the knowledge and consent of the supervisory employee conducting the operation. In every workplace, in a team of employees, a team leader should be appointed.

Where workers employed by different employers work in the same place at the same time, their employers are obliged to cooperate with each other and appoint a coordinator to supervise the health and safety at work of all employees employed in the same place.

In order to prevent the exposure of workers to the risks occurring during renovation or modernization works, it is necessary to act in accordance with the law and the principles of safe work [5,6,10,26,27,32,43,61,62,63,67,69,71].

## 4 Conclusions

In order to ensure technical safety on construction sites, it is necessary to know the law and the principles of safe conduct of construction works. All participants in the investment process: investor, designer, contractor and future user, each in their scope and area of activity (planning, execution and operation) should be aware of this. Lack of knowledge about technical safety can have tragic consequences during works on construction sites. In the era of rapid development of technology, knowledge about technical safety in construction becomes at least an urgent issue. Useful tools in ensuring technical safety on construction sites are the Safety and Health Protection Plans, the so-called BIOZ plans and Instructions for safe Execution of Works – IBWR instructions. These are documents that are intended to protect the health and life of employees by informing about ways to prevent risks associated with the performance of specific construction works and how to deal with these hazards.

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