



Analysis of industrial threats on the chosen example

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Received 27.11.2010; published in revised form 01.02.2011

ABSTRACT

Purpose: In this paper the analysis of influence of threats on the safety level in plastic processing industry was carried out. The effect of the proper risk management is increase of work safety and psychical comfort of employers. The necessity of threats monitoring and minimization of the occupational risk were showed.

Design/methodology/approach: In this article the essence of industrial safety was presented. Identification of threats on the work position and determination of the risk acceptable were talked over.

Findings: Methods of the occupational risk analysis, causes of industrial accidents and prevention of occupational disease were presented. The analysis of threats that appearance on the work positions was carried out. Moreover reduction methods of threats and ways of their prevention were showed.

Research limitations/implications: According to continuous improvement principle the necessity of supervise actions in direction to improvement of safety culture exist.

Practical implications: Applied prophylactic actions minimize possibility of occurrence of accidents in the work position and morbidity of employers on occupational diseases. Properly protected work position results in more effective work.

Originality/value: In this paper indicated that presented plastic processing industry fulfills standards in the range of work safety and takes continuous actions in direction to improvement of health and work conditions of workers.

Keywords: Industrial management and organisation; Safety and health management; Industrial threats; Occupational risk, PN-N-18002 standard

Reference to this paper should be given in the following way:

A. Kania, M. Spilka, R. Nowosielski, Analysis of industrial threats on the chosen example, Archives of Materials Science and Engineering 47/2 (2011) 117-124.

MATERIALS MANUFACTURING AND PROCESSING

1. Introduction

The working environment is shaped by many factors, harmful for the health and life also. Therefore almost every work is connected with the occupational risk, that is probability of appearance of such undesirable events, as incidents or occupational disease.

According to labour code, the employer is responsible for safety condition in organization. He is obliged to estimate and supply documentary evidence of the occupational risk connected with the work and application of the necessary preventive means reducing the risk. Informing workers about the occupational risk and protection principles before threats also belongs to the employer duties. The worker can't realize tasks or functions to

which he does not possess qualification, skills or sufficient knowledge of regulations and principles of safe conduct.

The risk assessment is detailed, exact verification and the estimation of this, what can damage or do harm to people in the work place. It gives possibility to estimate if the sufficient preventives were applied. The risk assessment also defines what is necessary to do to limit or eliminate these harmful conditions [1].

2. Identification of threats

The assurance of the safety is the man natural endeavour, understood as the condition without threat, quiet, certainty. Every man, social group or country try to influence on their environment to eliminate, or avert every kind of threats which the source are the strengths of the nature or the second man (group, nation).

The safety is not the stable condition in the real world unfortunately. This condition is subject to changes in dependence on degree of harmfulness of the environment influence on the man (group, nation, country). This means, that the safety should be perceived and considered as a process.

In the literature there are many definitions of threats. The threat is condition of the work environment causing accident or disease [1]. The second definition presents the threat as every factor having the ability of causing the loss of life or health. While the industrial threats they are sudden or incidental events occurring in the industrial plants which can lead to dangerous for life, property and environment occurrence [2].

The accident threats and disease threats are the factors creating the risk of the loss of life and health.

The identification of threats should contain the qualification of all hazardous, harmful and burdensome factors occurring on the work position. Identifying the threats can be a difficult task.

To the basic groups of dangerous for health factors belong [1,2]:

- threats from movable and loose elements,
 - threats from sharp and protruding elements,
 - threats connected with moving people,
 - threats connected with moving machines and transported objects,
 - threats from electric shock,
 - threat from the burn,
 - threats connected with works on the height or in cavities,
 - threat from fire or / and explosion,
 - threat from gases and liquids under pressure.
- We divide harmful and burdensome factors on [1,2]:
- **physical factors:**
 - noise,
 - vibration,
 - microclimate (hot and cold),
 - optical radiation (visible, infrared, ultraviolet radiation),
 - ionizing radiation,
 - laser radiation,
 - electromagnetic field,
 - electrostatic field,
 - industrial dusts.
 - **chemical factors**, that in dependence on the way of effect on the man organism we divide on [2]:

- toxic substances,
- irritant substances,
- allergenic substances,
- carcinogenic substances,
- mutagenous substances,
- substances handicapping reproductive functions.
- **biological factors:**
 - cellular microorganisms and acellular individuals (bacteria, mushrooms, viruses),
 - microorganisms modified genetically,
 - cellular cultures (multiplied in vitro the colonies of cellular isolated from multicellular organisms),
 - man internal parasites,
 - prions (infectious proteins particle similar to a virus but lacking nucleic acid; they have high immunity on chemical and physical influences).
- **psychophysical factors:**
 - physical loads (static and dynamic),
 - neuropsychic loads.

The threats can be identified on the basis of information analysis concerning: location of the work position, tasks realized, applied means of the work, requirements of legal regulations and standards relating to analyzed position, threats which were already identified, industrial accidents and occupational diseases, using protective means, etc.

Identification of threats usually requires specialist methods (methods of risk analysis) application and commitment of personnel with experience in specialist expert opinion elaboration and knowing principles of the risk management [3-7].

3. Occupational risk assessment

The occupational risk is a probability of appearance undesirable events connected with doing work, causing losses, in particular of appearance at workers of unfavourable health effects in result of occupational threats occurring in the work environment or the way of doing work (Regulation of the Minister of Labour and Social Policy of 26 September 1997 on general provisions for safety and health at work).

Definition of the occupational risk is also contained in the Directive 96/82/UE. The risk means the probability of appearance of harmful effects during the definite time or in the definite situations.

The goal of risk assessment is to reduce risk to an acceptable (or tolerable) level.

While the aim of the occupational risk establishment is the determination of threats and theirs level and also the indication of the means making possible their limitation. The risk assessment should inform the employer on what threats are the workers exposure and workers should know what threats appearance on their work positions, what are the sources of threats, what they cause and in what way they should protect before them.

The occupational risk belongs to duties resulting from the regulations and it should be realized on every work position. The basic aims of the occupational risk are [8]:

- verification if threats occurring on the work positions are identified and the occupational risk connected with them is known,

- proving both the worker and control with regulatory body, that threats analysis is carried out and proper protective means are implemented,
- accomplishment of the proper choice of the work positions equipment, materials and organization of the work,
- settlement of priorities in actions tending towards elimination or limitation of the occupational risk,
- assurance of continuous improvement of the industrial safety.

The risk assessment connected with doing work on the definite position should be always carry out when the new work positions are created, changes are introduced on the work position, introduced changes in the technological process, modified work organization or introduced changes connected with usage of the protective means. The risk assessment should be carried out for all work positions, for which the evaluation was not made and then, when in the work place the change was introduced, which has the influence on the safety and the threat appearing.

3.1. Methodology of the occupational risk assessment

The occupational risk assessment is a multistage process [9]. We distinguish in it a risk analysis and a proper estimation.

To the risk analysis included: description of an estimated object, identification of threats and estimating the risk. Estimating the risk one should decide if one can accept the risk. The result of the estimation is a basis to making decisions relating to the suitable preventive and control means introduction.

The occupational risk assessment on the work position we can “step by step” carry out realizing first the risk analysis which consists in [9]:

- description of the analyzed work positions,
- identification of threats,
- estimation of risk connected with identified threats.

The methodology of the occupational risk assessment was presented in Figure 1.

The identification of threats can be in progress on the basis of gathered information necessary to the occupational risk assessment. To the identification of threats can be used the check list method that can be elaborated, on the example, with specifications of harmful or dangerous factors using [1].

The estimation of the risk quantity requires the settlement of possible hazardous events, that can appear in connection with identified threats and qualification of quantity of undesirable results that can cause these events. Making an analysis of causes of dangerous events and the frequency of their consequence in the past is also necessary.

Estimation of the occupational risk can be in the various way carried out. It is good to choose a method to applying in which will not be required a specialist knowledge and which can be used in the simple way by persons carrying out the estimation [10].

The easy way of estimation of the occupational risk is the investigation carrying out in three-stage and five-stage scale (Table 1) [9].

Consequences about low harmfulness will be the injuries and diseases that do not cause long-lasting affections and absences in the work.

Consequences about medium harmfulness will be these, that result in low, but long-lasting or turning back periodically affections.

Consequences about high harmfulness will be the injuries and diseases that cause heavy and permanent affections or death.

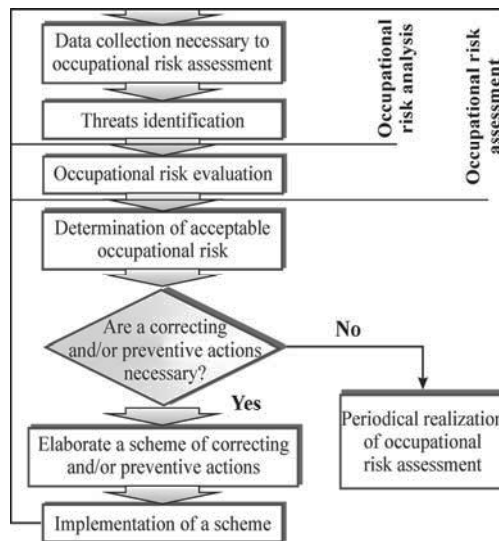


Fig. 1. Methodology of the occupational risk assessment [1]

Table 1. Estimation of the occupational risk - five-stage scale - PN-N-18002 [9]

Probability of event causing threat	Frequency of consequence (effects)		
	Low	Medium	High
Probability low	very low 1	low 2	medium 3
Probability	low 2	medium 3	high 4
Probability highly	medium 3	high 4	very high 5

The probability of the threatening event occurrence we can divide in threats which may not occur during the whole period of the worker professional activity, or these which occur not more than several times and these which can many times occurring.

Delimitation of the risk acceptability or usage of the proper means in the aim of its decrease is connected with the settlement of the assessment criteria. The basic criterion taken into consideration during decisions making about acceptance of the risk or the necessity of it decrease, there are the requirements of the law regulations in force and different standard documents.

Aiming to the improvement of the work conditions, organizations can own criteria of the acceptability of the occupational risk establish also, that are based on higher requirements than the requirements of the law regulations and different standard documents.

After estimation of the risk and after it assessment carried out one should establish if decrease of the risk is required or if the

safety was also achieved. If decrease of the risk is necessary, then proper safety means should be chosen and applied and the procedure of the occupational risk repeated [11].

Methods of the occupational risk analysis

By the notion of the risk analysis method we can understand the method applied to identifying of threats connected with the risk. The choice of the method has very essential matter. The method has to be [1]:

- compatible with obligatory regulations,
 - adapted, in the largest possibly degree, to the specific of the enterprise,
 - simple and comprehensible if possible.
- In selection of the occupational risk analysis method you should take under consideration [12]:
- kind of the analyzed object, process or position,

- expected time of the analysis carrying out,
 - accessibility of resources to the analysis carrying out.
- In the practice following methods are using [1,13]:
- What-if Analysis,
 - Hazard and Operability Studies - HAZOP,
 - Preliminary Hazard Analysis - PHA,
 - Failure Mode and Effects Analysis - FMEA,
 - Fault Tree Analysis - FTA,
 - Event Tree Analysis - ETA,
 - Process Safety Analysis - PSA,
 - Check List - CHL,
 - Method of Silesian University of Technology.

The basic properties of the risk analysis methods were presented in Table 2. In Table 3 their application in the dependence on work stage proposed.

Table 2.
Basic properties of the risk analysis methods [1]

Method	Characteristic of method	Way of object, process, position description	Scope of the analysis	Orientation time of the analysis carried out
What-if	Make possible identification of disturbances and consequences settlement	Discussion of the estimating team	Technical object, man - simple object or process	1-2 hours
HAZOP	Make possible identification of deviations from non-failure operation that may lead to threats appearance	On the basis of physical properties of analyzed object	Technical object	1-14 days
FMEA	Make possible identification of failures of particular elements that result in threats	On the basis of particular elements or technical objects modules	Technical object	1-14 days
PHA	Make possible preliminary identification of threats	Statement of well-known threats inside object	Technical object, man	about 6 hours
FTA	Lead to settlement of causes of the threats - threatening factors and present their logical connections that may put into threats appearance	Establish events, which combinations lead to culminating event	Technical object, man	1-14 days
ETA	Make possible the analysis of alternative results of the specified event causing threat appearance	Sequence of events leading from initial event to threat	Technical object, man	1-14 days
PSA	Make possible identification of threats connected with work program	On the basis of tasks realized on the work position	Technical object, man	about 6 hours

Table 3.
Usage of the threats and risk assessment methods in dependence on the work stage [1]

Stage	What-if	HAZOP	FMEA	PHA	FTA	ETA	PSA	CHL
Research and development				X			X	
Conception of process	X			X			X	X
Half technical scale	X	X	X	X	X	X	X	X
Technical project	X	X	X		X	X	X	X
Construction and set working								X
Normal work	X	X	X		X	X		X
Development and modification	X	X	X	X	X	X	X	X
Accident investigation		X	X		X	X		
Repeated set working								X

Hazard and Operability Studies - HAZOP method

This method is often used to the occupational risk analysis connected with technical objects and installations realization. It depends on systematic analysis of possible deviations from the intentional course of the process. The majority of these deviations may be the threat for the safety, for product quality and the environment. The considered process consists of functional units which are analyzed separately. The intentional way of functioning every one of them is defined oneself and fulfilling parameters, e.g. temperature, flow, pressure are established.

The way of the procedure during the analysis by HAZOP method carried out was presented in Figure 2 [1].

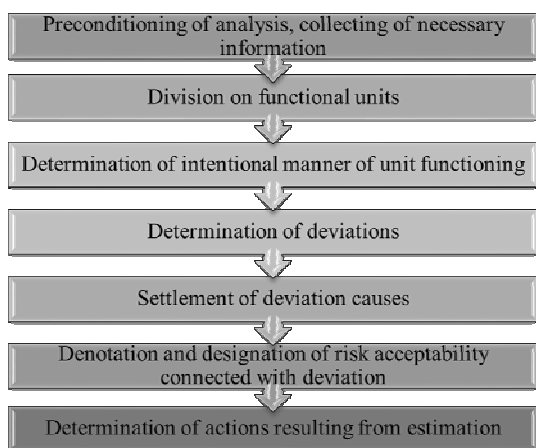


Fig. 2. Procedure during the risk analysis by HAZOP method [1]

Preliminary Hazard Analysis - PHA analysis

PHA method can be usage to the risk analysis on the work positions and during design of an object or process. To this method are taken:

- statement of known threats appearing inside the analyzed object (work position, process, production object, etc.),
- results from own analysis concerning of potential possibility of influence of object or process on the environment and the threats appearance.

General stages of the risk analysis by PHA method presented in Figure 3 [1].

The risk standard is calculated from formula [1]:

$$R = S \cdot P \tag{1}$$

where:

- S - degree of damages,
- P - probability.

The risk standard is situated in the range 1-36, e.g. for very improbable (P = 1) collective fatal accidents (S = 5) the risk standard amounts to R = 5.

Fault Tree Analysis - FTA analysis

This method is applied to qualification of relations between causes and their effects. Making the risk assessment by FTA method one should establish the culminating event (situation maximally depressing in the considered process, e.g. explosion,

person death, destruction of the object). Next, using symbols showing the relations between the elements of the studied area one should graphically present the situation leading to the culminating event.

The Fault Tree Analysis provides results which are easy to interpretation. It makes possible a settlement of factors, that appearance have a decisive meaning to a threat beginning and makes their elimination and control easy.

The FTA method is applied to the risk analysis for objects and processes that are create a high threat not only for workers but for the environment also [13].

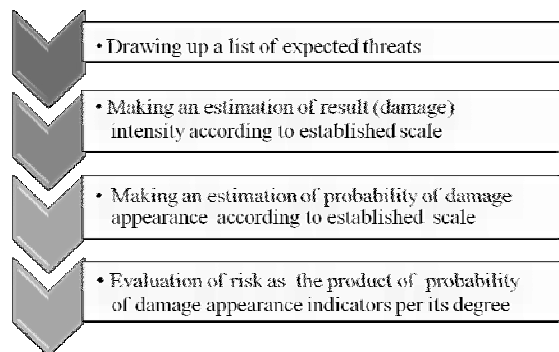


Fig. 3. Procedure during the risk analysis by PHA method [1]

Check List Analysis - CHL method

The Check Lists are the sets of the questions that concern of essentials, because of the safety, properties of the system "man - technical object - environment". Check Lists can be elaborated on the basis of requirements of valid regulations, they can also expressed different problems, characteristic for analyzed object or process. The Check Lists have more or less universal character. The questions can be more or less detailed, in dependence on the goal and the range of the analysis carried out. They have open or closed character.

During the analysis one should all the work positions control and on each of them answer on the questions contained in the Check List.

The result of the risk analysis by the CHL method depends on the large degree of the way of list preparing and the reliability of given answers [1,13].

Method of Silesian University of Technology

This is a very good and precise method of the occupational risk assessment. It should be applied in organizations in which the occupational safety should be kept at the high quality level. During this procedure on should realize following stages [14]:

1. Choosing of the estimating team.
2. Identification of the work positions.
3. Identification of threats.
4. Acceptance of the estimation criterion.
5. Estimation of the occupational risk.
6. Determination of zones of the risk.
7. Formulation of the estimation proposals - final.
8. Selection of techniques and means of informing of the workers about the occupational risk.
9. Estimates updating.

In the estimating team should be persons who are functionally connected with doing of particular kinds of work. They should understand perfectly principles of the occupational risk assessment and they can use them to the analyzed work positions.

Next, one should separate operations and working activities for particular kinds of work.

Identification of threats consists in identification of actual and expectation of potential hazardous situations, events connected with doing of particular kinds of work and specified in them working activities that may result in appearance of distress of the workers safety.

In this method simplified procedure of the risk assessment is proposed. It is based on estimation of two parameters characterizing the occupational risk: probability of threats appearance and potential results of threats appearance (Tables 4 and 5). The third parameter characterizing exposure on threat is the time of particular work activity carrying out.

Table 4.
Probability of hazardous events appearance - P

Probability, P	Rank of probability
Large (occur once a month)	4
Meaningful (occur several times a year)	3
Not large (occur once a several years)	2
Minimum (theoretically possible)	1

Table 5.
Potential results of hazardous events (threat) appearance - S

Results, S	Rank of results
Critical	4
Serious	3
Insignificant	2
Neglected	1

Critical - fatal accident or collective accident.

Serious - grave accident.

Insignificant - light accident.

Neglected - occupational micro injury, insignificant injury mutilations.

During the estimation of the occupational risk indicators of the risk partial assessments are defined. Then, the total risk indicator WR_{CR} , generalized indicator of the risk on average weighing WR_{SW} and the indicator of a part of working activities in a particular categories of risk WU_{Ck} are determined.

Subordinating estimated working activities of the risk indicator makes possible preparing a ranking of the risk of working activities. On the basis of the risk indicator WR_{CR} , we can include estimated working activities to one of the five categories of the risk [14]:

- safe activities - risk indicator 1.00-2.00; minimum risk,
- almost safe activities - risk indicator 2.01-3.00; acceptable risk,
- dangerous activities - risk indicator 3.01-6.00; significant risk,

- particularly dangerous activities - risk indicator 6.01-9.00; undesirable risk (risk has to be reduced),
- critical activities - risk indicator 9.01-16.00; not acceptable risk (work can't be continued).

4. Identification of threats in the chosen enterprise

The analyzed enterprise specializes in the plastic processing with injection method and the assembling of the components which are technologically related with plastics. The company realizes orders making elements for manufacturers from various branch e.g. motor trade, electromechanical, electrotechnical, building, etc. Actually the organization produces approx. 1500 various elements which fulfill particular functions (mechanical, electrical, etc) and qualitative and aesthetical requirements, also. The examples of produced components are: casings, frames, stoppers, levers, sleeves, handwheels, gaskets, frames, pedestals, etc.

In the enterprise two basic technologies are using:

- production of elements from plastics using the injection method of thermoplastic materials,
- production of elements from plastics using the injection method of heat-hardening materials.

This enterprise possesses the machines and technical devices that condition is satisfactory - they have certificates and compatibility declarations.

All devices used in the organization they are appointed the sign of the safety or sign CE (Communauté Européen).

The injections moulding machines of the type Arburg and Battenfeld, being on the production hall of the enterprise, they possess the sign CE and fulfill basic requirements:

- devices protecting the workers before access to the zone of threat,
- control systems, protecting before the uncontrolled growth of temperature,
- additional shields of the cylinder, protecting the worker before burn of the hands,
- devices protecting before the opening of injection unit during the work of machine,
- closed charging hopper, protecting the worker before the breakout of covered up material.

During realization of the technological processes safe chemical substances and harmless for the health means of the work environment are using. The investigations and measurements which are carried out according to obligatory regulations testify about this [15].

The production hall is illuminated the natural and artificial light. The carried out measurements of the intensity of lighting show that „parameters of electric lighting” fulfill the requirements of PN-84/E-02033 standard. The measurements of electric installation did not show departures from acceptable values and they are carried out according to Polish standards.

All employers in the analyzed enterprise are trained in the range of industrial safety and fire-fighting protection. According to the definite standard they also receive means of the individual

protection e.g. earplugs, ear muffs, protective gloves, safety goggles, clothes and protective shoes.

In the enterprise are determined escape and transport routes leading outside of the building.

The work position of the injection moulding machine operator is the most exposed to the hazardous, burdensome or harmful factors. To the basic threats are included:

- **dangerous factors:**
 - threats from electric shock,
 - threats connected with wrong application of materials (injuries, concussions, bruising, cut of the fingers or hands),
 - threats connected with the chemical properties of applied materials (emission of harmful substances),
 - threats from fire or explosion (failure of electric system, covering with fire dust),
 - threats connected with moving machines and people (unlabelled transport routes, slippery floors, improper lighting),
 - threats connected with burn (touch of hot articles or injection moulding machine).
- **physical factors - harmful:**
 - bad lighting,
 - high noise level (above 85 dB),
 - improper temperature.
- **chemical factors:**
 - materials to production.
- **burdensome factors:**
 - physical loads,
 - work position,
 - improper organization of work and work position,
 - inappropriate microclimate of the work position,
 - bad lighting.

In the aim of limitation and counteract appearance of threats in the enterprise, every worker should apply the principles of the work safety. In the organization forbid the injections moulding machine operator to do:

- during break down of the injection moulding machine or during moulds cleaning the injection moulding machine can not be connected to electric energy,
- cleaning or lubrication of the tool during the work of the machine,
- removing of protections or shields, during the work of the machine,
- starting of the machine, when in the area of tool work there are the operator or other workers hands,
- causing of soil of the injection moulding forms,
- leaving the machine in the movement without supervision,
- storing of details or position equipment close to the machine, what makes difficult its safe service,
- repairing, without authorization, electric installation or the injection moulding machine,
- operating the machine by outsiders,
- operating the machine with inadequate lighting of the working position,
- disregard of principles and regime of the technological process,

- drinking of alcohol on the working position or on the area of the enterprise.

For the control of the threat level on the chosen position, the enterprise employs the expert from the occupational health and safety management area. This is the person who is responsible for identification and defining of threats in the analyzed enterprise. The BHP expert the occupational risk assessment carrying out is numbered also to his duties. To the estimation of the work position are applied two methods: SCORE RISK method or method according to PN-N-18002 standard. The selection of the method is not imposed by any regulations in the enterprise. However more often is applied SCORE RISK method because it is easy to carrying out and it has larger transparency.

In the Score Risk method the risk valuation is calculated from formula:

$$R = S \cdot E \cdot P \quad (2)$$

where:

- R - risk,
- S - potential effects of threat,
- E - threat exposure,
- P - probability of threat appearance.

To the estimation of the risk is accepted the following scale:

S - 1-100 points,

E - 0.5-10 points,

P - 0.1-10 points.

Whereas the occupational risk (R) is estimated according to the following criteria:

- | | |
|----------------|---|
| R=20 | without risk; acceptable probability, |
| 20 < R <= 70 | low risk; advisable directing the attention, |
| 70 < R <= 200 | significant risk; improvement necessary, |
| 200 < R <= 400 | high risk; immediate improvement necessary, |
| R > 400 | very high risk; think over stopping the work. |

5. Conclusions

The necessity of the risk analysis on the work positions results from provisions of the labour code and Regulation of the Minister of Labour and Social Policy on general provisions for safety and health at work. The aim of the occupational risk assessment on the work position is realization the employers and the workers the threats that occur on the individual work positions. Identification of these threats and their scale make possible effective protection. The good physical and psychical condition of the workers has an effect on advantageous organization functioning.

There is no doubts, that the working environment (internal environment) has the influence on the external environment (natural). That is why the identification of threats (and their reduction) on the work positions has the essential influence on the environment and its degradation [16].

The workers employ in the analyzed enterprise are trained in the range of occupational health and safety and fire-fighting. They get, according to the definite standard, individual protective inherent them. The enterprise periodical inspections of the threat level on the work position and the systematic occupational risk assessment carries out.

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