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OCCUPATIONAL HAZARD MANAGEMENT AT THE GRINDING STATION

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Abstract
The paper demonstrates the usefulness of the Risk Score method for risk management at professional grinding stations, taking into account the nature of the station's operations. The adoption of consistent processes within a comprehensive framework helps to ensure that risk is managed effectively, efficiently and coherently across the organization. The approach described in this paper introduces the principles and guidelines for managing safety risk in an orderly, transparent and credible manner. The aim of the present study is to reduce occupational hazard at grinding stations.

Keywords
occupational hazard, grinding, Risk Score method, risk management.

Introduction

We define risk and the decision to take risk as undertakings whose result is uncertain or unknown. Commonly, we use the term in the situation where there is a possibility that something may either succeed or fail. A dictionary of foreign words defines risk as a probability of damage. And this idea was adopted as the foundation of the official definition of occupational hazard because, according to the Regulation of the Minister of Labour and Social Policy Concerning General Health and Safety Regulations of 26 September 1997 (published in *Dz. U.* 2003, No. 169, Item 1650, as later amended), occupational hazard means the likelihood of occurrence of undesirable events associated with work, resulting in losses, in particular, occurrence of adverse health effects in workers as a consequence of hazards existing either in the work environment or work methods [1]. The obligations of the evaluation and documentation of occupational hazard associated with work, with adoption of necessary preventive measures to reduce risk, briefing the employees about occupational hazard and the principles of protection against risks arise from the provisions of Art. 226 of the Polish Labour Code [2]. It should be emphasized that currently the concept of undesirable events is not reduced to adverse health effects in workers, but rather it is understood broadly and it covers material losses of the company as well [3].

The adoption of consistent processes within a comprehensive framework helps to ensure that risk is managed effectively, efficiently and coherently across the organization. The approach described in this paper provides the principles and guidelines for managing safety risk in an orderly, transparent and credible manner. Such factors as appropriate selection of personnel, adequate provision of training and thorough consideration of occupational safety and health issues help to reduce the incidence of injuries and illnesses resulting from inadequate examination of potential hazards, poor ergonomic design, equipment failure, defective products or hazardous materials. The working environment, suitability and design of equipment, staff training and legislative requirements need to be considered in that respect. Equip-

ment designed for a particular purpose must only be used as specified (e.g. one should not stand on an ergonomic chair at the caster). The equipment used in many environments allows for a certain amount of user intervention when faults occur contrary to manufacturers' instructions. Any maintenance or corrective actions beyond the scope of written instructions supplied by the manufacturer must be carried out by a qualified technician (e.g. in case of photocopiers, computers or printers). Equipment presenting obviously high risk (e.g. old-fashioned guillotines in offices) should be withdrawn from service and replaced by modern equivalents fitted with appropriate safety features. Risk management must be an integral consideration in the planning of change in all working areas. In particular, risk must be reviewed both following incidents and at regular predetermined intervals [4, 5].

Workplace characteristics

Our Institute workplace is equipped with a universal cylindrical grinder, type RUP 28-500M, manufactured by the Mechanical Works in Tarnów. This grinding machine is designed for external grinding of cylindrical, conical and shaped surfaces, both longitudinally and with the use of the plunge grinding technique. It also allows for surface grinding of face and flange shoulders and of holes owing to special attachments. The machine is equipped with a wheel cover for external surfaces and a sliding cover, partly open to the workspace. There is no aerosol extraction system, but the grinder has a device for the grinding wheel's active surface conditioning. It provides an option of direct transition from the external wheel dressing to the hole wheel dressing. There is no active control unit or timer fitted. The spindle grinding wheel has hydrostatic bearings. It allows to rearrange the grinding wheel with cover and cooling elements on the opposite side and has the option of fixed headstock rotation within $\pm 30°$. After changing the pulleys, the grinding speed can increase from 30 to 32 m/s. The application of hydrostatic guides allows for smooth travel of the fixed headstock assembly, and the hydraulic system provides continuous speed control of the grinding table and the grinding wheel feed. The grinder has a built-in monostate which turns off the grinding wheel drive when oil pressure drops below 3.5 daN/cm^2. The work piece spindle can operate at four rotational speeds obtained by relocation of the wedge belt on pulleys. The maximum grinding surface length is 500 mm, at the weight of work piece in canines of 125 daN and the fixture in the handle of only 20 daN. The grinder weighs 2400 daN, and its dimensions are 1668 mm–1920 mm–2660 mm. It is mounted within a grinder nest on vibration isolators. It occupies 20 m^2 of floor area. The hall has the height of 18 m. It is lit with lamps fixed at the height of 16 m. The grinder is also fitted with a low-voltage lamp for the grinding zone and a wooden platform in front.

Description of operations

The grinder operator is responsible for the proper preparation of the grinding wheel, the grinding operation performance, and the timeliness and quality of work. The operator is also responsible for the technical condition of the grinding machine and its instrumentation, the order at the workplace, and the observation of health, safety and fire regulations at the workplace. Detailed responsibilities include:

- proper storage of grinding wheels on a shelf near the grinding machine,
- before attaching the grinding wheel, visual inspection and binding agent validity check,
- tapping and sound testing of the grinding wheel,
- balancing the grinding wheel (statically and dynamically),
- attaching the grinding wheel to the spindle,
- grinding wheel profiling and dressing (conditioning),
- turning the grinding machine on and off,
- setting the grinding parameters,
- carrying out grinding operations,
- observing the grinding cycle stages,
- daily and periodic inspections, with repairs,
- cleaning and maintenance of the grinder and its instrumentation,
- attaching and removing instruments and work pieces,
- cooling lubricant replenishment, sludge cleaning,
- ensuring order at the workplace,
- observation of safety and fire regulations.

Descriptions of the Risk Score Occupational Hazard Assessment Method

The Risk Score method is based on indicators. Indicator methods are similar to quantitative methods, in contrast to qualitative ones. Indicator methods differ from quantitative methods only by the fact that the levels of reliability and risk are not expressed strictly but rather by conventional numerical scales. Risk level estimation is the result of multiplying the indicator values which determine the levels of unreliability and hazards. The risk level estimated in that way is assessed by comparison to the conventionally accepted risk level scale. The Risk Score method [6] was implemented in the U.S. Navy in the 1970's. It

was used to estimate the risk of human loss that may arise during the performance of specific tasks (operations), within the given period of time (e.g. one year). The most probable extent of losses during the period is assumed to be a measure of risk [3, 6, 7].

This risk assessment method has been adopted from two sources: William Fine [5] and G.F. Kinney and A.D. Wiruth [6] who developed a risk score calculator in which the level of risk is determined by consequence C, probability L and exposure E. The numbers assigned to each level of consequence C, probability L and exposure E are multiplied to produce the risk level. A model for determining the risk value is as follows:

$$R = C * E * L. \tag{1}$$

In this method, the value of L is considered to be the probability of a specific event, which is undesirable during the execution of the task once (single exposure). The value of E is the number of repetitions of the task during the period concerned, i.e. the number of exposures to risk occurring in the period.

The value of C is the measure of the most likely (but not maximum) human loss caused by the event. In this interpretation, the value of $E * L$ is the probability of the occurrence of an adverse event during the performance of tasks in the period under consideration. The Risk Score method assumes that the hazard during a task performance can be caused only by a specific event. It is usually an event that can cause the heaviest losses. Other events are not taken into account [8].

The values of C, E and L are expressed by means of conventional numerical scales (Tables 1–4).

After determining the indicator (as the product of estimated parameters C, E and L), we can proceed to risk estimation (always for a particular hazard at the workplace), in accordance with Table 4.

Table 1
Potential effects of the event. (The most probable outcomes in an individual exposed to hazard and incidents [3].

Values of consequences C	Loss estimation	Human losses
1	Low	First aid
3	Medium	Absence
7	High	Heavy injury
15	Very High	Single fatality
40	Catastrophic	Several casualties
100	Severe	Multiple causalities

Table 2
Exposure to hazard. (This is a measure of how often people are at risk of interacting with the hazard and specific consequences of hazard: either multiple exposures for the same person or many people exposed simultaneously [3].

Value of exposure E	Description of exposure
0.5	Insignificant (once a year)
1	Minimum (several times a year)
2	Occasional (once a month)
3	Sporadic (once a week)
6	Frequent (every day)
10	Permanent

Table 3
Probability of losses owing to an event. (The probability that a complete sequence of events leading to consequences will occur upon exposure to hazard [3].

Value of probability L	Description
0.1	Theoretically possible
0.2	Practically possible
0.5	Conceivable
1	Only sporadically possible
3	Very unlikely, but possible
6	Quite possible

Table 4
Risk Values [3].

Risk values $R = C * E * L$	Risk Score	Preventive measures
$R <= 20$	Acceptable Risk	Advice to control
$20 < R > 70$	Low Risk	Need to control
$70 < R > 200$	Medium Risk	Need to improve
$200 < R = 400$	High Risk	Needs immediate improvement
$R > 400$	Very High Risk	Advice to stop work

Estimation of the occupational hazard at the grinding station by the risk score method

We can conclude that the occupational hazard analysis always includes gathering of information needed to identify hazards and assess the associated risks. The risk assessment procedure complies with Part I of the algorithm shown in Fig. 1, and risk management complies with Part II of the algorithm.

Table 5 presents the occupational hazard assessment at the grinding station, using the Risk Score method.

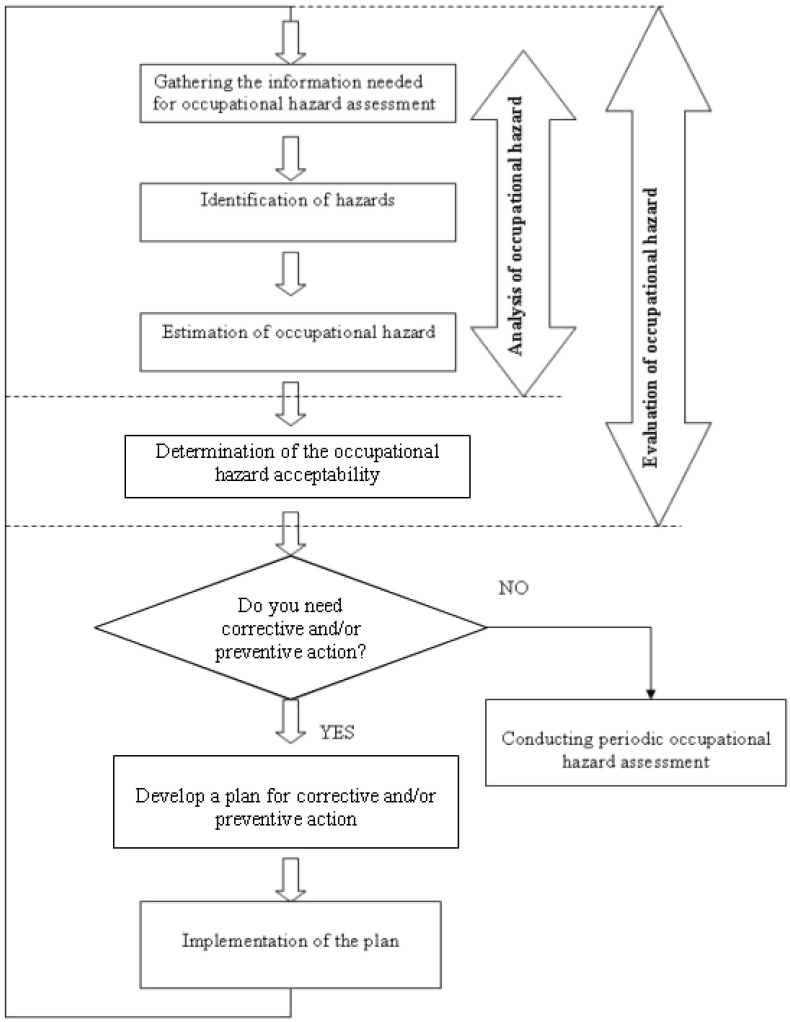

Fig. 1. The course of occupational hazard assessment at the workplace [7].

Table 5
Occupational hazard management at the grinding station, using the Risk Score method.

No.	Hazards	Sources of hazards	Possible risk effects	Before correction				Preventive measures	After correction			
				C	E	L	R		C	E	L	R
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Surfaces on which it is possible to fall (fall as a result of tripping or slipping).	No order at the workplace and on internal roads and paths.	Injuries, limb fractures, dislocations, cuts.	3	6	6	108	Maintain order at the workplace and on roads, store materials and tools properly during work, use customized footwear, with reinforced and non-slip soles, apply caution.	3	6	3	54
2	Contact with hot and sharp micro chips.	Micro chips sprinkling from the grinding zone.	Injuries (cuts, perforations), most often on hands and face, including particularly dangerous eye injuries, even loss of vision.	7	6	6	252	Check regularly the efficiency of covers and grinding wheels. Wear safety goggles. Remove damaged covers. Work carefully. Avoid haste.	3	6	3	54
3	Hit by a work piece.	Ejection of poorly fitted work pieces in the absence of guards. Mess at the workplace and scattered tools.	Injuries (crushing, cuts, bruises), head injuries are particularly dangerous.	7	6	6	252	Adhere to manuals. Mount grinding wheels and work pieces properly. Check handle grip. Monitor the efficiency of covers. Work carefully. Avoid haste.	3	6	3	54
4	Striking by broken grinding wheel fragments.	Grinding wheels poorly prepared to grinding, poorly attached in the holder, lack of grinding wheel covers, hidden defects.	Injuries (crushing, cuts, bruises), head injuries are particularly dangerous.	7	6	6	252	Adhere to manuals. Mount grinding wheels and work pieces properly. Work carefully. Avoid haste.	3	6	3	54
5	Body or cloth catching, impact, contact with moving parts.	Grinding wheel, work piece, power transmission, grinder machine systems.	Hand injuries (usually palm injuries).	15	6	6	540	Provide reliable covers. Adhere to manuals. Avoid loose clothing, bandages etc. Do not lubricate or adjust the grinder during the operation (except as described in the instructions).	3	6	3	54
6	Impact, crush, falling objects.	Work pieces for machining (also during transport), grinder tools. Poorly stored objects at the position. Wrong handling methods.	Injuries (bruises, cuts, even crushing) of limbs, especially frequent leg injuries.	7	6	6	252	Store properly: • work pieces before and after grinding, • instrumentation. Remove and set work pieces carefully. Mount larger items with caution. Observe rules of order at the workplace. Avoid haste.	3	6	3	54

1	2	3	4	5	6	7	8	9	10	11	12	13
7	Hits against stationary elements.	Structural elements of the grinder, the workshop and equipment (especially in passages and access paths).	Injuries (bruises, cuts, even crushing) of limbs, especially frequent leg injuries.	3	6	3	54	Observe rules of order at the workplace. Do not block paths. Use gloves and protective footwear. Take necessary precautions. Avoid haste.	1	6	1	6
8	Contact with hot surfaces.	Hot surfaces of work pieces.	Burns of hands or face.	3	6	6	118	Follow instructions (no hand braking of moving parts). Operate control and measurement equipment with care. Use protective clothing and gloves. Observe rules of order at the workplace. Avoid haste.	3	6	3	54
9	Contact with rough and sharp surfaces or edges.	Grinding wheel, work pieces, materials.	Injuries (cuts and abrasions).	3	6	6	118	Follow instructions (no hand braking of moving parts). Operate control and measurement equipment with care. Use protective clothing and gloves. Observe rules of order at the workplace. Avoid haste.	3	6	3	54
10	Failure to observe grinding parameters.	Grinding wheel, work pieces.	Injuries (cuts and abrasions).	3	6	6	118	Set cutting parameters in accordance with instructions.	3	6	3	54
11	Lighting (poor lighting of the working position).	Dirty window panes, missing or wrong light sources, wrong light fixtures.	Eye damage.	3	6	6	108	Use light sources, with the intensity complying with the standards. Ensure proper daylight at the workplace. Clean windows and skylights.	1	6	3	18
12	Electric shock with voltage of up to 1 kV.	Installations and electrical equipment, including the sources of local lighting. Damaged insulation of cables. Contact with metal casing of machines which can be under voltage.	Effects of electric shock: serious internal injuries, even death.	7	6	6	252	Observe instructions and manuals. Carry out checks, inspections and measurements of: • condition of insulation and electrical equipment, • shock prevention measures. Admit only authorized personnel to operate electrical equipment.	7	6	1	42
13	Fire, explosion.	Faulty electrical systems, use of open flames near flammable and explosive materials or coolant (when grinding with oil).	Serious injuries and burns.	15	6	6	540	Observe instructions, manuals and fire regulations. Remove flammable objects to sealed containers. Do not use open fire in the factory. Inspect electrical systems. Inspect and maintain grinders by employing authorized personnel. Observe rules of order at the workplace. Provide fire fighting equipment. Train the personnel. Take necessary precautions.	7	6	3	126

1	2	3	4	5	6	7	8	9	10	11	12	13
14	Strain of the musculo-skeletal system or arduous body movements.	Lifting or turning of work pieces, grinding wheels or tooling elements.	Injuries (strain on muscles and tendons, dislocation of joints), musculo-skeletal system ailments, hernia.	7	6	6	252	Observe handling instructions and lifting standards and methods. Use auxiliary equipment and protective gloves. Take necessary precautions. Avoid haste.	3	6	3	54
15	Chemicals.	Coolant, cleaning materials, grinding sludge.	Poisoning, respiratory tract and eye irritation, skin allergies.	7	6	6	252	Use wheel and work piece guards. Use goggles. Immediately remove pads and rags soaked with chemicals. Control ventilation.	3	6	3	54
16	Dusts and aerosols.	Dust from worn grinding wheels and work pieces.	Respiratory tract and eye irritation, skin allergies.	3	6	6	108	Use dust masks and/or goggles. Control ventilation.	3	6	3	54
17	Forced posture.	Standing position, forced bent position.	Injuries and diseases of the musculo-skeletal system, varices, degeneration.	7	6	6	252	Alternate operations. Adjust the level of the platform and the chair.	3	6	3	54
18	Noise.	The grinding process, the grinder's power transmission system and machine tools used at the adjacent positions.	Damage to hearing, fatigue, neurosis.	3	6	6	108	Provide correct foundations of machines and equipment. Use only technically efficient machines. Use hearing protections. Measure the work environment factors (intensity and concentration) regularly.	1	6	3	18
19	Quality control during grinding.	Grinding wheel, work piece, the grinder's power transmission system.	Injuries of hands (usually palm).	15	6	6	540	Adhere to manuals. Observe measurement instructions during machining.	3	6	3	54

Source: authors' elaboration.

Conclusions

The paper demonstrates the usefulness of the Risk Score method for risk management at professional grinding stations, taking into account the characteristics of work at such stations. The grinding station is characterized not only by the severity of the consequences of serious accidents (caused e.g. by grinding wheel fractures), but also by a high probability of accident occurrence which was found when preparing the description of the grinding station and machining operations. Many workstation hazards identified during the analysis of the occupational hazard at the grinding station are well characterized by the high average risk factor: $R = 235.58$.

After developing a corrective action plan, briefing of the operators and upgrading the station's equipment, the value of the average risk factor dropped to $R = 50.84$. In particular, that result was attained owing to regular checks of the grinding machine's efficiency, use of protective elements (goggles, footwear, gloves, dust masks, hearing protections etc.), proper observation of grinding manuals, regular measurements of the work environment factors and implementation of measures to reduce haste.

Improvement of such factors as appropriate selection of personnel, adequate provision of training and thorough consideration of occupational health and safety issues have helped to reduce the injury and illness incidence resulting from inadequate examination of potential hazards, poor ergonomic de-

sign, equipment failures, defective products or hazardous materials.

Owing to the options of adjusting and changing the risk assessment levels, the Risk Score method provides better risk management and substantial and gradual reduction of the risk level at professional grinding stations.

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