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Occupational Safety and Health Management at Alumina Ltd

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Abstract

Occupational safety and health (OSH) is an integral part of the organization of work, and includes measures and means necessary to achieve safe working conditions. In terms of the current Law on Occupational Safety and Health of the Republic of Srpska, among other things, the employer is responsible for drafting the Risk Assessment Act. This paper presents a risk assessment for the position of Technological Equipment Operator. The risk assessment was performed, hazards were identified and measures to reduce them were proposed using the modified AUVA method. Jobs with risk rank I and II are considered jobs with acceptable or low risk, i.e. those including risk levels 1-5, and 6-9 respectively. Jobs with increased risk are jobs with a risk rating of medium, high and unacceptable - III, IV and V, i.e. encompassing risk levels 10-12, 15-16 and 20-25, respectively was estimated that the position of the technological equipment operator is a high-risk (IV) position, i.e. a position with difficult working conditions, and a risk of the loss of working ability or impairment of health.

Keywords: health protection, occupational safety, risk assessment, modified AUVA method, Technological Equipment Operator

1. INTRODUCTION

Risks of injuries and diseases are managed in all phases of the process: from the initial development of technological processes, in each phase of production, until the end of each technological process. In order to be able to manage them, risks must be identified, quantified, ranked and evaluated. In this way, the adopted measures could eliminate or reduce potential risks (Oarga, Rațiu, & Oarga 2018). Occupational health and safety in practice refer to the totality of phenomena related to the protection of persons at work, ensuring the health of workers in the work process (Anđelković 1997). Occupational safety and health, in terms of the Law on Occupational Safety, includes a set of organized measures and activities aimed at creating conditions that ensure occupational safety, prevention and elimination of hazards and harms that can cause injuries at work, occupational and other diseases and injuries of workers at work and protection of health and working ability of workers (Official Gazzette of RS 2016). The Rulebook on Risk Assessment at the workplace and in the work environment regulates the manner, procedure and content of the Risk Assessment Act for injuries at work, occupational diseases or work-related diseases, as well as the manner and measures for their elimination. Risk is the probability of injury, illness or damage to the employee's health due to a danger (Starčević, M., & Paunović Pfar 2010). Risk assessment and measures determined by the employer are provided in accordance with the Law on Occupational Safety in order to eliminate dangers and harms at the workplace and in the work environment, i.e. to eliminate or reduce risks. Risk assessment considers the organization of work, work processes, work requirements, means of work, raw materials and materials used in technological and work processes, means and equipment for personal protection at work, as well as other elements that may cause a risk of injury at work, occupational diseases or work-related illnesses (Official Gazzette of RS 2008; 2016). Occupational safety and health is regulated by the ISO 45001: 2018 standard and the Occupational Safety and Health Act. It is essential to create a safe working environment for workers in the company, considering the possible endangerment of

the lives of employees if they do not have adequate protection. A safe working environment can also reduce potential costs related to sick leave, workplace injuries, reduced employee efficiency, etc. (Buntak, Kovačić, & Forjan 2021). The application of the ISO 45001 standard creates an environment in which the reliable functioning of the company is achieved through risk prevention. Through the continuous adjustment of the organization to legal and regulatory requirements, the risks of business interruption and property damage are reduced, and the responsibility and commitment of all those involved in occupational safety and health is demonstrated (Karanikas, Weber, Bruschi, & Brown 2022). Physical hazards encountered in bauxite processing include noise, excessive exposure to high temperatures and ergonomic problems such as vibration and contact with hazardous substances (Donoghue, Frisch, & Olney 2014; Wesdock & Arnold 2014). In alumina factories, the presence of chemicals (caustic soda), alumina dust, bauxite dust and hazardous gases can damage people's health. If inhaled or in contact with the skin and eyes, these substances can lead to side effects, or they can lead to poisoning, suffocation, burns, etc. (Lee et al. 2017).

The degree of vibration and noise depends on the working conditions and the type of machine. The noise level can reach 105 dB and such a noisy environment is potentially harmful to health within a radius of 10 meters. The risk of noise-related injuries is considered to be primarily related to communication interference and the inability to detect safety warning signals (Girard et al. 2009; Gopinath, Thiagalingam, Teber, & Mitchell 2011). Bauxite dust particles (particles less than 10 μm - PM10) can be inhaled during bauxite processing. There is no "safe level" for PM10 according to the World Health Organization because these particles can be deposited in the alveoli during respiration and cause respiratory and cardiovascular problems. In addition to damage to the lungs, nose and throat, the eyes and the exposed skin are endangered, as well as the gastrointestinal tract. Some people may experience an allergic reaction such as asthma or eczema (Petavratzi, Kingman, & Lowndes 2005). Although there are numerous ergonomic stressors in alumina production plants, there have not been many studies that describe in detail the nature, scope and elimination of such risks. However, when targeted ergonomic hazards are identified and systematically controlled, and the results obtained are published, a strong contribution is made to reducing the risk of injury (Cantley et al. 2013; Donoghue & Coffey 2014). Adequate and timely implementation of measures for occupational safety is necessary in order to avoid damage to human health. The system of safety and health at work is based on the application of the principles of prevention of injuries at work, diseases or impairment of health of the employee, which are carried out before the start of work at the workplace and in the work environment (Kulić et al. 2015). One of the most used semi-quantitative risk assessment methods is the 5x5 matrix based on the well-known methods of AUVA (Allegemeine Unfall Versicherungs Anstalt - method of the Austrian Association of Cellulose and Paper Manufacturers). In the first step of the modified AUVA method, two factors are considered: the exposure of employees to hazards and the fulfillment of occupational safety and health requirements. The result of the first step is the establishment of a submatrix of the probability of the occurrence of an unwanted event. The second step for risk assessment includes the analysis of possible consequences of hazards, which are expressed as injuries, occupational diseases or illness related to work. The final result of the risk assessment is the formation of a risk matrix. It determines the risk ranking as a product of the probability of the occurrence of an unwanted event and the ranking level of the severity of possible consequences. Jobs with risk rank I and II are considered jobs with acceptable or low risk, while jobs with increased risk are jobs with a risk rating of medium, high and unacceptable - III, IV and V. The paper focuses on the assessment of risk for the position of Technological Equipment Operator at the alumina factory "Alumina" LTD. The assessment was carried out using the AUVA method, and the factors taken into consideration were the conducted procedure of recording the organization of work, the safety and health protection measures implemented, the hazards identified in the workplace or the work environment, and risk ranking. Based on the results obtained, appropriate measures for the protection of workers in the workplace were proposed.

2. MATERIALS AND METHODS

Risk assessment in "Alumina" Ltd. Zvornik was performed on the basis of a modified AUVA methodology. In determining the data on safety at the workplace, the grouping of hazards according to the Rulebook on the manner and procedure of risk assessment at the workplace and in the work environment was used. The level of risk (LR) was defined as the product of the probability of an unwanted event (RP) and the rank of possible severity of the violation (RV):

$$LR = RV \cdot RP \tag{1}$$

To define the probability range, it is necessary to first determine the exposure to hazards and harmful effects during the working day and the state of the protection system/working environment (Stanković & Stanković 2013).

Table 1. Exposure to hazards in the workplace

Exposure to hazards and harmfulness during the working day (week, month, year) (%)	Qualitative ranking of exposure hazards and harmfulness	Quantitative ranking of exposure hazards and harmfulness
0 - 20 %	Very rarely	1
21 - 40 %	Periodically	2
41 - 60 %	Often	3
61 - 80 %	The majority of work hours	4
81 - 100 %	All workday	5

Table 2. Ranking of exposure to dangers and harmfulness

Occupational health and safety demands (OHS) in %	Qualitative ranking of the employment conditions	Quantitative ranking of the conditions in the working environment
OHS >80%	Satisfying	1
60% <OHS □ 80%	Medium-term necessary measures	2
40% <OHS □ 60%	Short-term necessary measures	3
20% <OHS □ 40%	Immediately necessary measures	4
OHS □ 20%	Measures for an immediate stop work procedure	5

Table 3. Probability of injury, occupational disease or work-related illness.

		RANKING OF EXPOSURE TO HAZARDS AND HARMFULNESS				
Exposure to hazards and harmfulness		Satisfying	Medium-term necessary measures	Short-term necessary measures	Immediately necessary measures	Measures for an immediate stop work procedure
		1	2	3	4	5
Very rarely	1	1	2	3	4	5
Periodically	2	2	4	6	8	10
Often	3	2	6	9	12	15
Most of the workday	4	4	8	12	16	20
All workday	5	5	10	15	20	25

The rank of the working environment is determined on the basis of the level of compliance with the requirements of safety and health at work, as follows:

The rank of probability is determined according to Table 3:

Jobs with risk rank I and II are considered jobs with acceptable/low risk, i.e. with values of risk levels (1, 2, 3, 4 and 5); (6, 8 and 9). Jobs with an increased risk are jobs with a risk rating o medium/high/unacceptable – III, IV and V, i.e. the values of risk levels (10 and 12), (15 and 16), (20 and 25).

3. RESULTS AND DISCUSSION

Using the AUVA method for risk assessment, the position of OPERATOR OF THE TECHNOLOGICAL EQUIPMENT was analyzed.

Actions to prevent, eliminate or reduce the risk depend on the assessed risk, the established priority, while adhering to the principles of prevention, in accordance with the regulations on occupational safety and health, technical regulations, standards or generally accepted actions. Therefore, based on the analysis of the current situation, determining the degree of risk, determining omissions in the application of basic and special rules of safety at work, it was concluded that the following planned activities should be taken to reduce the degree of risk:

Table 4. Probability rank.

A measure of the probability of hazards and harmfulness	Qualitative ranking of the conditions in the working environment	Quantitative ranking of the conditions in the working environment
1, 2	Negligible probability	1
3, 4 and 5	Low probability	2
6, 8 and 9	Medium probability	3
10, 12, 15 and 16	High probability	4
20 and 25	Extremely high probability	5

Table 5. Ranking the severity of the consequences

Description of the consequence	Severity of the consequence	Injury severity rank
First aid required	Mild	A
Medical treatment with sick leave for up to 3 days	Minor	B
Treatment that includes hospitalization	Moderate	C
Permanently changed working ability	Heavy	D
Multiple persons injured and/or permanent endangerment of vital functions and/or fatal injuries	Fatal	E

Table 6. Risk level assessment.

Probability rank	Ranking the severity of the consequences				
	A	B	C	D	E
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Table 7. Risk rank

Value of the level of risk	Working conditions	Level of risk	Activities and/or measures
1, 2, 3, 4 and 5	Optimal	Acceptable (I)	No activities
6, 8 and 9	Approximately correspond to optimal conditions	Low (II)	Constant monitoring of working conditions
10 and 12	Deviate from optimal conditions	Medium (III)	Implementation of measures to reduce risk
15 and 16	Severe working conditions, risk of loss of ability to work or impairment of health	High (IV)	Work cannot begin unless the necessary risk mitigation measures have been implemented
20 and 25	Extremely difficult working conditions, imminent danger to the life and health of workers	Unacceptable (V)	Work must not begin, or must be stopped or banned

Table 8. Example of risk assessment.

WORKPLACE RISK ASSESSMENT			
The current state of occupational safety and health			
		60%<OHS≤80%	2
		40%<OHS≤60%	3
Identification of hazards and harmfulness in the workplace and possible consequences			
No.	Work activities	Identified hazards or harmfulness	Possible consequences
1.	Rotating drive parts – equipment checks	Insufficient protection due to rotating or moving parts of the equipment	Different types of mechanical injuries, wounds, cuts, bruises and amputations of body parts
2.	Production plant - cleaning and preparation of equipment for overhaul, transport equipment	Internal transport and movement of heavy equipment, vehicles, and machines	Improper movement can lead to multiple severe superficial and internal injuries to workers
3.	Production plant - Pressurized systems	Using hazardous materials that can produce explosions or fire	Various types of mechanical, superficial and internal injuries, burns of various degrees
4.	Production plant (elevation "0", "7,8" and "12,8")	Dangerous surfaces (floors and all t ypes of treads, sharp edges, spikes, rough surfaces and protruding parts)	All types of mechanical, superficial and internal injuries (dislocations, sprains, bruises, distortions, scratches, wounds, fractures, concussions)
	Activities related to:		
5.	work at height, fixing minor malfunctions, lubrication of equipment, reception of raw materials	Work at height or in-depth, in terms of regulations on protection and health at work	A fall from a height can lead to all kinds of mechanical, superficial, or internal injuries, even those with a fatal outcome
6.	Faulty installations	Danger of indirect contact with voltage	Electrical shock injuries, burns
7.	Daily work activities at the plant (liquid sodium silicate, concentrated and dilute sulfuric acid, solid sodium aluminate, precipitated silica, tetrapropylammonium bromide, zeolite powder, condensate, demi water, 7 bar steam)	Chemical damage, dust and fumes (inhalation, ingestion, poisoning, choking, burns, penetration through the skin)	Irritations of the upper respiratory organs, dermatitis, irritating skin, allergies, skin corrosion, etc.
8.	Daily work activities at the plant	Physical damage (noise)	Temporary or permanent hearing damage; extra-auditory effects are: accelerated heart rate, increased sweating, increased arterial blood pressure, contractions of all muscles, changes in breathing rate
9.	Everyday work activities	Physical damage (vibration)	General vibrations cause changes in the bones, spondylitis, intervertebral osteochondrosis, calcification of the intervertebral discs, gastric secretion disorders, peristalsis disorders, hypoglycemia, hypocholesterolemia, decreased ascorbic acid levels. Local vibrations cause damage to the peripheral circulation, nervous system, bones, muscles and joints
10.	Production plant	Adverse effects of microclimate (high or low temperature, air flow rate and humidity)	Prolonged exposure to high temperature can cause increased irritability, a feeling of exhaustion, fatigue, disorders of the cardiovascular and gastrointestinal tract, concentration difficulties. Prolonged exposure to low temperatures can lead to hypothermia and frostbite. Sudden changes in temperature and airflow can lead to colds, degenerative and rheumatic problems.
11.	Production plant (elevation "0", "7,8" and "12,8")	Non-physiological body position (standing, sitting for a long time, kneeling, squatting)	Osteoarticular disorders of the spine, static tension of the muscles of the neck, back and abdomen, poor posture, fatigue, compromising circulation in the lower extremities, varicose veins.
12.	Obligation to save energy, laboratory sampling, keeping records of production parameters	Efforts to perform certain tasks that cause psychological damage (monotony, stress)	Various forms of occupational maladaptation, fatigue, high blood pressure, heart disease, thyroid disease, diabetes and other psychosomatic diseases, anxiety-depressive neurosis, mental pain
13.	Keeping records, eliminating minor defects	Strain of certain organs (eyes, ears), mental stress	Osteoarticular disorders of the spine, static tension of the muscles of the neck, back and abdomen, poor posture, fatigue, compromising circulation in the lower extremities, varicose veins
14.	Control of parameters, using of raw materials, sampling and record keeping	Responsibility in receiving and transmitting information, use of appropriate knowledge and skills, responsibility in rules of conduct, responsibility for rapid changes in work procedures, work intensity, spatial conditionality of the workplace, conflict situations	Mental fatigue, maladaptation (smoking, drug addiction, alcoholism, prescription drug abuse, job dissatisfaction, indiscipline, conflict), mental disorder and anxiety, depression, neuroticism, psychosomatic diseases (hypertension, ischemic heart disease, asthma, endocrine disorders), gastrointestinal disorders
15.	Organization of work in the production plant	Harmfulness in the work organization: shift work, night shifts, preparedness in case of intervention	Circadian rhythm disorders of physiological, psychophysiological and biochemical functions in the body, which may lead to endocrine diseases (diabetes, hyperthyroidism, hypothyroidism, adrenal gland disorders), hypertension, coronary heart disease, ulcerative colitis, psychoneurosis, depressive endogenous psychosis

RISK RANKING

No.	Code	(RI)	(RO)	(RV)	(RP)	(LR)	Risk rank
1.	01	3	2	3	4	12	III
2.	03	2	2	2	4	8	II
3.	04	2	2	2	3	6	II
4.	07	3	2	3	3	9	II
5.	08	3	2	3	4	12	III
6.	16	2	2	2	3	6	II
7.	21	4	3	4	4	16	IV
8.	22b	2	3	3	4	12	III
9.	22v	2	3	3	4	12	III
10.	24	3	2	3	3	9	II
11.	31	3	2	3	2	6	II
12.	32	3	2	3	3	9	II
13.	33	2	2	2	3	6	II
14.	34	2	2	2	4	8	II
15.	35	5	2	4	3	12	III

CONCLUSION

Based on the conducted procedure of recording the organization of work,
the implemented measures of protection and health at work, the hazards and harms at work and in the work environment identified, and risk ranking, the AUVA method for risk assessment estimated that the position of the Operator of the Technological Equipment is a high-risk (IV) position.

Table 9. Planned activities to reduce or eliminate risks with deadlines.

Activities	Deadline
The employer is obliged to train workers for occupational safety and health when hiring, changing position, introducing new technology or new mens of work, as well as when introducing changes in the work process that may cause changes in occupational safety and health measures, on the basis of The Law on Occupational Safety and Health ("Official Gazette of RS", No. 01/08-13/10) and the Regulation on the Manner and Procedure for Training Employees in the Field of Safe and Healthy Work Processes ("Official Gazette of RS", No. 42/11).	Continuously
Theoretical test in occupational safety and health for all employees.	Every year
Regular health check-ups for workers with a high risk job, on the basis of the Regulation on Prior and Periodic Medical Check-ups of Employees with High-Risk Positions ("Official Gazette of RS", No. 68/08).	High-risk positions every twelve months. Medium-risk positions every 24 months
The employer is obliged to inform employees of hazards and harmfulness in accordance with the Law on Occupational Safety and Health ("Official Gazette of RS", No. 01/08-13/10) and the Regulation on the Manner and Procedure for Training Employees in the Field of Safe and Healthy Work Processes ("Official Gazette of RS", No. 42/11). Pay special attention to the harmfulness identified in the act.	Within 60 days from the moment of entry the act
Regular maintenance and testing of installations to prevent leakage of flammable, toxic and explosive chemicals.	Continuously
Training of workers in the field of fire protection and extinguishing initial fires in accordance with Article 36 of the Law on Fire Protection "Official Gazette of RS", No. 71/12).	Once in 3 years
Regular control of the integrity of initial fire extinguishers, hydrant networks and automatic fire alarm systems (within the legal deadline and in accordance with the manufacturer's instructions).	Every year
Training of workers to provide first aid in accordance with the identified hazards and harmfulness.	Continuously
Ensure the supervision and coordination of security measures.	Continuously
Making sure that the workers understand the importance of using personal protective equipment, training in proper use of PPE. Mandatory use of personal protective equipment (prescribed by regulations) at all workplaces.	Continuously
SILICA-GEL PRODUCTION PLANT	
All workers at Silica Gel and Special Zeolites plant must undergo training and testing for work with chemicals/chemical products in accordance with the regulations of chemicals.	Upon being hired and periodically every year
Writing a shift report.	Continuously
Visual inspection of the chemical tank and the pipeline through which chemical flows for any: • Signs of leakage of acid and other chemicals • Damage to the foundation • External corrosion • Leakages in the pipelines, pumps and accompanying fittings • Control of accumulation of sulfate that causes deformation of the lower plates of the tank • Damage to insulation and linings.	At the beginning of work and during the work shift
Regular visual inspection of pressure vessels and inspection of gas installations.	At the beginning of work and during the work shift
Keep a checklist of the performed examination.	Daily
Maintaing the work discipline	Continuously
Use of corrosion protection.	As a preventive measure and after observed contact of the acid with the metal
Labels and commands on machines and devices must be written in a language that the user understands.	Immediately
Evacuation signs must be at eye level.	Immediately
Fire escape stairs and an evacuation exit are required.	Immediately
Good lighting over all working and other surfaces and evacuation routes is necessary.	Continuously
A stable gas alarm device must be installed in the drying plant.	Immediately
The outer wall in the drying plant must have ventillation openings at the highest points in case of natural gas leaks.	Immediately
Drains on the floors must be at the lowest points.	Continuously
Fountains and showers with water must be provided on each floor.	Immediately

Activities	Deadline
All fire extinguishers and neutralization boxes must be accessible and visibly marked.	Continuously
Neutralizing agents should always be in sufficient quantity and in appropriate places (red and blue boxes).	Continuously
Containers with sodium bicarbonate should be placed in all dangerous places.	Immediately
Protective curtains must be installed in all hazardous places where chemicals / chemical products are splashing.	Immediately
Containers with the appropriate absorbent and neutralizing agent must be placed at sulfuric acid transfer stations (preferably sodium bicarbonate for neutralization, and sand as absorbent).	Immediately
The hose for sulfuric acid discharge from the tank truck must be kept in a dry place, protected from the weather. A spare drain hose must be provided.	Immediately
Visual inspection of the sulfuric acid discharge hose is required before use. The hose must be monitored during use, and inspected and stored properly after the discharge.	Continuously
The plant must have a road for the tank truck with sulfuric acid in order to prevent backward movement of the truck during discharge.	Immediately
The road for the tank with sulfuric acid must be marked.	Immediately
Telephone connection and intercom must be provided.	Immediately
Tanks and pipelines with hazardous substances must be inspected periodically.	Once in 3 years (outside) Once in 6 years (inside)
All damage to welded joints should be repaired by grinding and welding. Finished welds should be grounded to the surface of the surrounding metal. An ultrasound examination is then necessary.	Continuously
Sampling and analysis of sulfuric acid for the content of iron and other metals (chromium, manganese, nickel) should be performed, as follows: • Analysis of the receiving sulfuric acid • Analysis of the sulfuric acid from the metal tank R01 • Analysis of the sulfuric acid from plastic tanks.	Once a month
Electrical and lightning protection installations need to be inspected.	Every year

4. CONCLUSION

The Law on Occupational Safety and Health (Official Gazzette of RS 2016) defines occupational health and safety as an activity of special social interest and regulates the persons/entities responsible for its implementation and improvement, their rights, obligations and responsibilities, as well as other issues related to occupational safety and health. Occupational health and safety include a set of organized measures and activities aimed at creating the conditions which provide:

- safety at work
- prevention and elimination of dangers and harms that can cause injuries at work, occupational and other diseases and damage to the health of workers
- protection of health and working ability of workers (Official Gazzete of RS, 2016).

Occupational safety in "Alumina" Ltd. is regulated by the following documents:

1. Regulation on Occupational Safety and Health,
2. Regulation on Personal Protection Equipment,
3. Rules of Conduct of Third Persons Act,
4. Workplace and Work Environment Risk Assessment Act,
5. Various guidelines for work safety and health,
6. Guidelines on how to report an accident at work,
7. Guidelines for the amendments to the Risk Assessment Act,
8. Work safety and health training program for workers,
9. Guidelines on the manner and procedure for practical training of workers in the field of occupational safety and health,
10. Notes on the general training of workers in the field of occupational safety and health, etc.

Operator of the Technological Equipment at a silica gel plant and special zeolites plant was chosen as an example for risk assessment. Jobs with risk rank I and II are considered jobs with acceptable / low risk, or the values of risk levels (1, 2, 3, 4 and 5); (6, 8 and 9). Jobs with increased risk are jobs with a risk rating of medium / high / unacceptable - III, IV and V, or the values of risk levels (10 and 12); (15 and 16); (20 and 25). The AUVA method was used for risk assessment, and, based on the conducted procedure of recording the organization of work processes, the occupational health and safety measures implemented, the hazards and harmful effects identified in the workplace or the work environment, and risk ranking, and it was estimated that the position of the Operator of the Technological Equipment is a high-risk (IV) position, i.e., a position with difficult working conditions, danger of loss of working ability or impairment of health. Based on all the above, it was concluded that preventive measures (planned activities) should be taken to reduce the degree of risk, i.e., the danger of damaging the health of workers. Also, in future research, the modified AUVA method will be applied to other critical workplaces in the factory in order to identify and reduce hazards.

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