doi: 10.17221/52/2016-RAE

Hazard analysis in operating of the post-harvest lines

M. Prístavková, M. Žitňák, J. Lendelová

Department of Building Equipment and Technology Safety, Faculty of Engineering, Slovak University of Agriculture in Nitra, Nitra, Slovak Republic

Abstract

Prístavková M., Žitňák M., Lendelová J. (2016): **Hazard analysis in operating of the post-harvest lines**. Res. Agr. Eng., 62 (Special Issue): S53–S60.

The aim of this study is to evaluate the hazards in operating post-harvest lines in an agricultural organization, with emphasis on pre-cleaning and drying of grain. The paper deals with a description of technology of pre-cleaning and drying grain. Risk assessments at post-harvest line were processed by using the point method. The point method is used to review the hazards for working positions in terms of safety at work. This work identifies threats, proposes measures and solutions to eliminate or minimize the consequences of each risk. Evaluations of the hazards are processed before and after the measures were taken. Based on the results, it can be stated that the risk was reduced below the level of acceptable risk after the measures were taken.

Keywords: point method; security; risk management; dust

In the past, management of health and safety at work was interpreted as a process that creates conditions for the fulfilment of the strict legislative regulations and standards. The fulfilment of safety regulations was necessary to create conditions for a safe workplace (Korenko 2012).

Nowadays, an entirely different approach is prevalent, which requires taking into consideration all workplace risks and implement the necessary measures regardless of the legislative requirements and legislative standards. It promotes the principle of prevention intensively in terms of procedures and risk analysis prior to disorder (Halstensen et al. 2013). While maintaining security, it is important to achieve a certain value of risk acceptability, or the introduction of such work organization, which allows employees to avoid risks that continually influence the workers and thus also the continuity of work process (Sinay 2011). The safety and protection of health at work is a state-regulated activity through general law and related technical standards. These documents include safety requirements for machinery, the compliance of which is mandatory when designing structures, during product placement on the market and putting them into operation, i.e. during usage (Dušanič 2004; Directive 2008/104/EC). It is known from history that substantial changes in occupational health and safety (OHS) and the safety of machines were brought about by the introduction of the Framework Directive 89/391/EEC and Directive 89/392/EEC in 1990. The purpose of these directives was to introduce systematic tools for the management of OHS, such as: policies of OHS, risk management, the need for education, monitoring activities, employee involvement in OHS issues, obligations to carry out risk analyses and many others. Existing European legislation concerning safety of machinery is defined by the Directive 45/2006/EC related to machinery (Sinay 2011). This Directive replaced previous Directives and came into force from January 1, 2010.

doi: 10.17221/52/2016-RAE

MATERIAL AND METHODS

Risk assessment of working position – operator of post-harvest line

Identifying the threats. Who comes into contact with the machines and why? It is necessary to consider improper use, including the option of machinery being used by untrained personnel or persons at the workplace. These are not only the operators but also the cleaning staff, security staff, visitors and the public.

(a) *Sorting of threats according to their severity.* The result of the threat assessment process is creation of various threats chart associated with the machine and an assessment of the severity of each threat. Every threat should be considered separately. The severity can only be estimated, risk assessment is neither an exact nor a final process. It is an endless cycle. The purpose of the assessment of threats is to provide guidance on risk reduction. The threat assessment is done by the means of Tables 1–3.

(b) *Risk reduction*. Risk reduction is defined in terms of elimination (Act No. 124/2006). The principle is that if the risk can be reduced, it must be reduced (Slovak Technical Standards OHSAS 18001:2007). It is always necessary to put it into context with the economic reality. Risk assessment process is recurring – risks must be identified, quantified and measures to reduce them must be proposed. The point method with the evaluation matrix (Tables 1–3) was used to assess the risk of working position at post-harvest line.

For the objective assessment of dust threat degree the amount of dust at working environment was determined using the gravimetric analysis.

Gravimetric determination of dust elements

Principle of the method. Dust particles will be captured in the head of the filter medium (membrane filter of defined size). Dust volume is determined gravimetrically as the filter gains weight in proportion to the withdrawal of the air volume. The APEX sampling pump with filter holder was used for the measurement (Fig. 1). Measurements were performed according to ISO 7708:1995 Air quality – Particle size fraction definitions for health-related sampling. Results can be seen in the Table 4. Simultaneously with the measurement of dust the noise load of operators was tested at the same places using Integrating-averaging Sound Level Meter

Fig. 1. Dust measured by a sampling pump

Table 1. Evaluation worksheet for the probability and the consequences of unwanted occurrence

Probability	Characteristic	Consequence	Characteristic
1	very low – occurrence is almost eliminated	1	neglectable – less than minor injury
2	low – occurrence with low probability	2	less significant – minor injury, start of occupational disease
3	middle – occurrence happens within the machine lifetime	3	critical – severe injury, occupational disease
4	high – occurrence happens several times within the machine lifetime	4	catastrophic – death as a consequence of workplace injury
5	very high – occurrence happens often		

doi: 10.17221/52/2016-RAE

Table 2. Evaluation worksheet for exposure

R	Risk	Characteristic
1–3	acceptable	system is safe, ordinary procedures
4–11	modest	system is safe under the condition of operators being trained, inspections, etc.
12–15	unwanted	system is dangerous – application of protective measures
16–20	unacceptable	system is unacceptable – immediate application of protective measures, system is shut down

R – range of the risk score

Table 3. Evaluation matrix for numeral risk

Multiplicity/ Consequence	1	2	3	4
1	1	4	6	12
2	2	7	11	13
3	3	10	15	17
4	5	12	16	19
5	8	14	18	20

Type 2240 (Brüel & Kjær S & V Denmark, Nærum, Denmark). By this sound level meter values of L_{AF} – level of sound pressure were measured with *A* frequency weighting and time weighting *F*, L_{Aeq} – the equivalent continuous sound pressure level with *A* frequency weighting, L_{AFmax} – the maximum sound pressure level with *A* frequency weighting and time weighting *F* detected during the measurement, L_{Cpeak} – maximum peak sound pressure level with *C* frequency weighting detected during the measurement.

For an objective assessment of the results of the risk level, it was assessed whether the working environment met or exceeded regulatory limits. At the end the results processed by the subjective and objective methods, including the assessment of the state after the introduction of security arrangements.

RESULTS AND DISCUSSION

Post-harvest treatment begins with grain intake. Cleaned material contains various additives, after weighing on the scales it is poured into one of the containers, each of which has a capacity of 25 tons. The centre also has indoor spaces available for temporary storage of wet grain with a capacity of 200 t, so the grain can be processed continuously over three working shifts. During season, the line operates continuously. From the storing tank, the grain is transported to the pre-cleaning utilizing screw and bucket conveyors that are structurally embedded directly under the tank. The performance of the PETKUS K 547 A pre-cleaner (RIN Ltd. Llc Oleg, Zaporozhye, Ukraine) is 10 t/h. After purification, the grain is transported further using a belt and bucket conveyor directly into the dryer. The dried grain goes through another set of belt and bucket conveyors and arrives into the storage tanks, in which the grain is cooled to the desired temperature.

Table 4. Measuring data of noise exposition at post-harvest line with pre-cleaning sieve

Measurement No.	Place of measurement	Noise (dB)		
		L_{Aeq}	L_{AFmax}	L_{Cpeak}
1.	between two pre-cleanings Petkus with wheat	82.4	90.6	106.9
2	between two pre-cleanings Petkus without wheat	76.8	87.5	102.4
3	between two pre-cleanings Petkus without cover with wheat	90.1	93.8	111.5
4	operating place	62.4	74.2	99.1
5	down, at belt conveyors	82.2	10.2	111.2
8	ventilator at storage	90.6	95.4	109.6

wheat was a purified crop; L_{Aeq} – equivalent continuous sound pressure level with *A* frequency weighting; L_{AFmax} – max. sound pressure level with *A* frequency weighting and time weighting *F* detected during the measurement; L_{Cpeak} – max. peak sound pressure level with *C* frequency weighting detected during the measurement

doi: 10.17221/52/2016-RAE

Table 5. Average concentrations of dust measured on the post-harvest line

Location of measuring	Dust quantity (mg/m^3)
Grain pre-cleaners with cover	3.33
Grain pre-cleaners without cover	6.39
On the intake container	6.94
Conveyors horizontally on ground	5.56
Around the drier	6.11

Because the total time for one measurement, including the preparation of filters, the filtering process itself and the evaluation of filters is relatively long, it was necessary to set appropriate places for measuring in the technological space on the post-harvest line. After inspection, locations were selected with the highest probability of dust particles escaping the line. Average values measured in respective locations of technological spaces on post-harvest lines are shown in Table 5.

The measured values are variable. In extreme cases, density of dust is so high, that it reduces the visibility during the filling of the intake container near the unshielded cleaning equipment, unshielded conveyors and around the drier.

Solid aerosols – dust

Long-term exposure to high concentrations of any dust may contribute to the development of chronic bronchitis and subsequent pulmonary disease.

Sources of danger on post-harvest line: Work on the post-harvest line in a part of storage bin during cleaning of parts with missing covers, drying, filling of tower stores, removal from storage and during disinfection may impose danger to operators.

The employer must comply with the provisions of Section 39 of Act No. 355/2007 Coll., Government regulation SK No. 355/2006 Coll., on the protection of workers from risks related to exposure to chemical factors at work, as amended.

Exposure limit (NPEL – absolute acceptable limit of exposure), solid aerosol grain

When NPEL was assessed comparing measured values in Table 1 with the legal value of 6 mg/m^3, the places around the revenue tray dryer and pre-cleaning without cover do not meet the legal requirements.

Noise

Sources of danger on the post-harvest line were power tools, hand tools, cleaning machines, conveyors, ventilators for aerating grain, handlers driven by an internal combustion engine, rolling grain, etc. The employer must comply with the provisions of § 32 of Act No. 355/2007 Coll., Government regulation SK No. 115/2006 Coll., on the min. health and safety requirements to protect workers from the risks related to exposure to noise, as amended.

As seen in Table 4, differences can be found out between the equivalent levels of acoustic pressure crop processing and without crop processing, at wheat up to 5.6 dB.

Employees who work in environment with higher levels of noise are endangered by chronic disorders of the sense of hearing (Table 5). In case the employee works at noise over 85 dB for a certain period of time, it can cause reduction of sensitivity to noise. After few hours in a quiet place, the sensitivity of hearing it will be resumed. If exposure of noise effects on human is longer, it can cause higher reduction of sensitivity to noise. (Lumnitzer et al. 2007).

Vibrations

Sources of danger on post-harvest line were: cleaning machines mainly with oscillating movement, conveyers, ventilators for aerating grain, handlers driven by an internal combustion engine, rolling grain, power tools, hand tools, etc. Vibrations can cause different forms of diseases, too. The employer must comply with the provisions of § 33 of Act No. 355/2007 Coll., Government regulation SK no. 416/2005 Coll., on the min. health and safety requirements to protect workers from the risks related to exposure to vibration, as amended.

Chemical factors

Government regulation SK No. 355/2006 Coll., on the protection of workers from risks related to exposure to chemical agents, defines a chemical agent as a chemical element or compound that can be included in mixtures, occurs in the natural state or it is produced, used or released in any activity, including waste generated regardless whether or not it is made deliberately, or whether or not it is marketed.

doi: 10.17221/52/2016-RAE

Sources of danger on post-harvest lines: Work with coating substances and paint thinners during painting safety coatings and signs, and work with technical lubricants during maintenance works and repairs. Handling fuels (diesel) when working with handlers, and petrol when working with hand power tools e.g. mower, hedge cutter etc. The employer must comply with the provisions of § 39 of Act No. 355/2007 Coll., Government regulation SK no. 355/2006 Coll., on the protection of workers from risks related to exposure to chemical factors at work, as amended.

Factors causing professional skin diseases

Sources of danger on post-harvest line: cleaning offices/workplaces using common detergents and disinfectants.

The employer must comply with the provisions of § 39 of Act No. 355/2007 Coll., Government regulation SK No. 355/2006 Coll., on the protection of workers from risks related to exposure to chemical factors at work, as amended.

Biological factors

Biological factors are microorganisms, including those that have been genetically modified, cell cultures and human endoparasites, which can cause infectious diseases, allergies or are toxic to the human organism. Any change in occupational environment can influence exposure of the checked employees.

Sources of danger on post-harvest lines: mice, rats, mould, dirty hands and other

The employer must comply with the provisions of § 42 of Act No. 355/2007 Coll., Government regulation SK No. 338/2006 Coll., on the protection of workers from risks related to exposure to biological agents at work (indicative guideline 00/54/EHS).

Physical load

Physical strain is a strain of musculoskeletal, cardio vascular and respiratory systems with reflection in metabolism and thermoregulation in the context of work performed.

Sources of danger on post-harvest line: Work performed during post-harvest processing with proportion of dynamic and static muscular work, work during which torso, upper and lower extremities are in unacceptable positions especially whilst repairing work machines.

Manipulation with loads during disinfection of seed

The employer must comply with the provisions of § 38 of Act No. 355/2007 Coll., Government regulation No. 281/2006 Coll., on the min. health and safety requirements for work with loads (indicative guideline 90/269/EHS).

Load by heat and cold

Hydrothermal conditions of working environment are determined by temperature, relative humidity and air velocity. Warm period of the year is a period with average daily outdoor air temperature

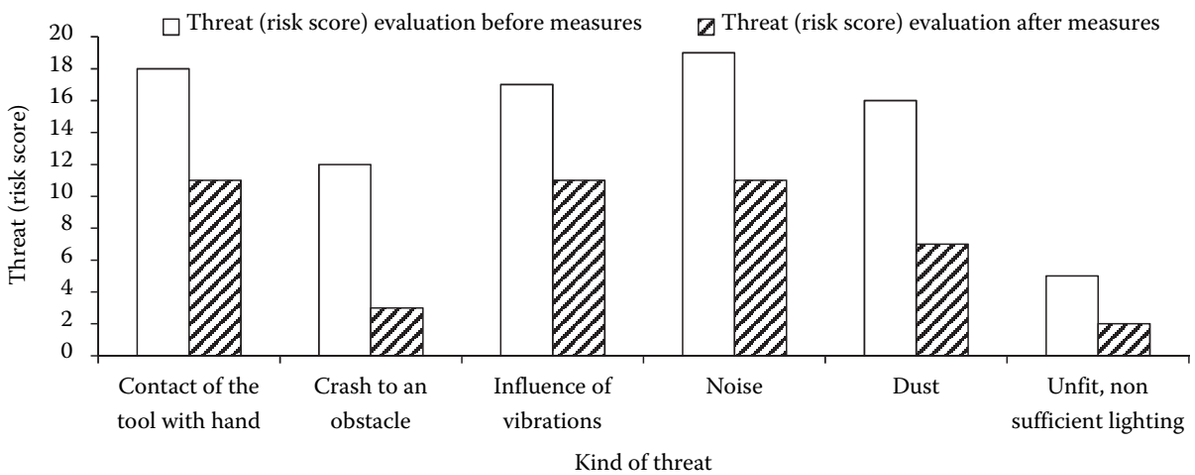

Fig. 2. Hazard analysis in operating of the post- harvest line

Table 6. Risk assessment of working position - operator of post-harvest line

Danger	Threat	Definition of threat	Before measurement			Safety measures	After measurement		
			P	*R*	*I*		*P*	*R*	*I*
Hand tools	contact of the tool with hand (adherence of indictive guideline 89/655/EHS)	– gash, stabs, cutting injury, lacerated wounds, callosity, bruises, in case of an inappropriate contact of a tool with hand (general danger for all sorts of tools) during service	5	3	18	– praxis, ability, training, usage of adequate sort, size of tools; – secure option of selection of a suitable tool, adherence of prohibition to use damaged equipment; – to provide suitable gloves	2	3	11
Work environment	crash to an obstacle (adherence of indictive guideline 92/58/EHS)	– crash to an obstacle (temporary, fixed constructions and other), as a consequence of unsuitable arrangement of technical equipment, furnishing in buildings, cramped/diminished spaces (limbs injuries, bump to a head)	4	2	12	– to keep all communications constantly clear, clean, do not narrow by building constructions, production and operation equipment, materials, products and so on; – passages and the other reduced spaces must be visibly marked and sufficiently lit; – work footwear	3	1	3
Cleaning machines mechanised tools, electric and pneumatic	influence of vibrations (adherence of indictive guideline 2002/49/EHS)	– whole-body vibration – vibration transmitted on hands with impact on different tissues, damage of bones, joints and tendons, vascular disorders, nerves diseases – these damages of health are manifested by degenerative changes, which are caused by direct mechanical effect of impacts; – traumatic vibration vasoneurosis at a long term work with some sorts of tools,	3	4	17	– work footwear with anti-vibration sole – to keep tools in good technical state; – to keep safety resting breaks in line with operating rules ;	2	3	11

P – probability, *R* – risk, *I* – impact

Res. Agr. Eng. Vol. 62, 2016, Special Issue: S53–S60
doi: 10.17221/52/2016-RAE

doi: 10.17221/52/2016-RAE

of 13°C or higher; if the average daily temperature during two consecutive days is under 13°C, the environment is evaluated by the values for the cold season of the year. Extremely warm day is a day in which the outside air temperature measured in the shade reaches more than 30° C. Extremely cold day is a day in which the outside air temperature drops below –15°C.

Sources of danger on post-harvest line: The outdoor work in any weather conditions throughout the whole year.

The employer must comply with the provisions of § 37 of Act no. 355/2007 Coll., Ministry of Health SK Decree no. 544/2007 Coll., on details of health protection from heat and cold load at work.

The degree of threat at working position – operator of post-harvest line (Table 6) was successfully reduced. Risk reduction was achieved by introducing security measures namely definition of good work practices and use of personal protective equipment. The selected personal protective equipment (Table 6) includes gloves for handling tools, disposable ear-plugs, industrial protective overalls, work boots with anti-vibration and anti-slip sole. These are used during work activities such as line operator and maintenance worker. In some threats the risk was reduced by two degrees (Table 2) as shown in Fig. 2, in case where there was a danger of contact of the tool with hand, vibrations, dust and noise, this degree of threat was reduced from unacceptable risk to mild risk, which can be considered as more than satisfactory result.

By the right choice of equipment and tools risk can be reduced. For successful elimination of the risk in post-harvest processing, it is therefore necessary not only to evaluate risk and devise security measures, but also to ensure their adherence and continuous review. Pačaiová et al. (2009) report that it is employees' responsibility to realise that the use of personal protective equipment is not only a requirement of the employer in order to fulfil the legal requirements, but that this equipment is there mainly to protect their health from work accidents and occupational diseases, and therefore it is in their own interest to use personal protective equipment.

CONCLUSION

Conducted and processed measurements and reviews revealed the main sources of worsening of the working environment in the areas of post-harvest lines. Based on the conclusion, it is necessary to modernize the engineering-technical part of the post-harvest lines together with the construction works. In terms of a dust decrease, it is necessary to do the following:

– to prevent the escape of dust particles from technological devices such as pre-cleaning, to take cleaner from places where bin is filled and from uncovered conveyors
– to fully use hooded pre-cleaners and cleaners with ventilated cleaning area during modernization of lines for post-harvest treatment. To prevent airflow in the areas of post-harvest lines, mainly away from places where dust particles are released from by means of construction of anti-dust walls that separate technological and handling spaces.
– to increase the efficiency of aspiration by incorporation of separators and filters with orientation on decentralization of aspiration system.

Due to the fact that the highest concentrations of dust have been found in areas of pre-cleaners, for the immediate elimination of this source of dust it is recommended to carry out construction work, which will separate space of pre-cleaners and cleaners from other areas of post-harvest lines and local aspiration of such created spaces will be introduced.

To reduce exposure to noise, it is very important to apply the following principles:

(1) Choice of the appropriate low-noise equipment;
(2) Informedness: advice about equivalent levels of acoustic pressure at each place;
(3) Reducing of risk by technical equipment;
(4) Service of the occupational environment.

In case the measures are ineffective, it is necessary to use personal protective work equipment. Hearing protection have to be provided if lower values of exposure $L_{AEX,8h,a}$ = 80 dB and L_{CPk} = 135 dB are overrun (indicative guideline 89/391/ EHS).

Based on the results of risk management, it is essential that by means of measures taken (Table 6) it was possible to reduce all risks below the acceptable levels (Fig. 2) which were set for an organisation based on commitments to the current legislation and with respect to the health and safety policy approved by the management of the organisation.

References

Dušanič R. (2004): Bezpečnosť strojných zariadení z pohľadu súčasných právnych predpisov a technických noriem.

doi: 10.17221/52/2016-RAE

Available at http://www.atpjournal.sk/buxus/docs/atp-2004-05-18_21.pdf

Halstensen A.S., Heldal K.K., Wouters I.M., Skogstad M., Ellingsen D.G., Wijnand E. (2013): Exposure to grain dust and microbial components in the Norwegian grain and compound feed industry. Annals of Occupational Hygiene, 57: 1105–14.

Korenko M. (2012): Manažérstvo kvality procesov. Nitra, Slovenská poľnohospodárska univerzita.

Lumnitzer E., Badida M., Romanová M. (2007): Hodnotenie kvality prostredia, vyd. Košice, Technical University.

Pačaiová H., Sinay J., Glatz J. (2009): Bezpečnosť a riziká technických systémov. Košice, Technical University.

Sinay J. (2011): Bezpečná technika, bezpečné pracoviská – atribúty prosperujúcej spoločnosti. Košice, Technical University.

Received for publication April 22, 2016
Accepted after corrections December 7, 2016

Corresponding author:

Ing. Martina Prístavková, Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Building Equipment and Technology safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic; e-mail: xpristavkova@is.uniag.sk