TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 68, Issue III, September, 2025

ACCIDENTAL, ERGONOMIC AND CHRONIC RISK ASSESSMENT TOOLS WITHIN GAÏA FRAMEWORK IN A MULTINATIONAL MANUFACTURING COMPANY

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Abstract: *In Romania the quasi-generalized use of a single indigenous developed method has greatly reduced the effectiveness of the risk assessment approach, not allowing the particularization of techniques used to the variety of concrete situations and conditions encountered in organizations. This instrumental limitation generates in the cascade multiple disadvantages. This paper summarizes the results of research that illustrates the existing experience in a multinational industrial company, on the complementary application of several methods of risk assessment to achieve the level of excellence of safety culture development. Results obtained are benchmarks for effective guidance of OHS practitioners, experts, risk assessors and managers, in planning, organizing, conducting and capitalizing on the process of assessing occupational risks.*

Key words: *Occupational Health and Safety (OHS), risk assessment, Gaia framework, accidental, ergonomic and chronic risk, safety barrier*

1. INTRODUCTION

In all systems and in all workplaces, the employer has a general obligation to ensure the state of safety and to protect the health of workers [1]. The purpose of the occupational risk assessment is to enable the employer to take appropriate prevention / protection measures, with reference to [3]:

- Occupational risk prevention;
- Training of workers;
- Informing workers;
- Implementation of a management system that allows the effective application of the necessary measures.

During the assessment and, subsequently, the application of safety measures, it is essential to pay special attention to the impossibility of transferring risk, i.e. the solutions adopted do not create new problems [4]. For example, the windows of a double-glazed office will not be fitted to reduce noise if no measures have been taken to ensure proper ventilation. It is also important that the risk is not shifted from one area of the system to another, such as the evacuation of toxic substances that may endanger people in another building or the outside population [5].

Incomplete understanding of the hazards, especially in relation to their nature and magnitude, has contributed to the occurrence of catastrophic events in the industry, both in the past and in the recent past [6]. In some cases, the hazard was identified but not understood, and as a result specific risks were underestimated, resulting in an unacceptable level of residual risk and inadequate control measures [7].

As it is well known and documented, despite the fact that hundreds of tools for analyzing and assessing occupational risks are available worldwide, in Romania the quasi-generalized use of a single indigenous developed method has greatly reduced the effectiveness of the risk assessment approach, not allowing the particularization of techniques used to the variety of concrete situations and conditions encountered in organizations [8].

This instrumental limitation generates in the cascade multiple limitations and disadvantages for the occupational safety and health management systems in the Romanian

Received: 28.07.25; **Similarities**: 01.09.25: **Reviewed**: 28.07./28.07.25: **Accepted**:16.09.25.

organizations. The synthesis of an example of good practice regarding the existing experience in an industrial company, which is part of a large multinational group, in terms of resorting to the complementary use of various tools for analysis and assessment of occupational risks can be a set of effective guidelines, useful to all those involved in risk management processes.

2. GAÏA RISK FRAMEWORK IN THE COMPANY

Several methods and tools are currently used in the units within the company investigated to conduct risk assessments. Units may continue to use them, if they ensure in advance that they comply with the internal standard. The company has developed a module in the MSS Gaïa series for Health and Safety Risk Assessment to assist in conducting Health and Safety risk assessments in accordance with this internal standard [9].

This module allows us to guide the evolution of the different evaluation stages, according to the method described in the company standard, to collect the evaluation results by ensuring the traceability in time and the contribution to the management of the control measures / safety barriers implemented for the identified risks.

Gaïa risks framework consists of five maturity levels classified in 3 stages: (1) immaturity, (2) maturity, (3) excellence, as highlighted in Figure 1. Each GAIA Risks maturity level comprises services having 5 knowledge areas, which are responsible for maintaining the information organized and can be customized according to the needs of each company. Figure 2 shows a graphical representation of the service structure [10].

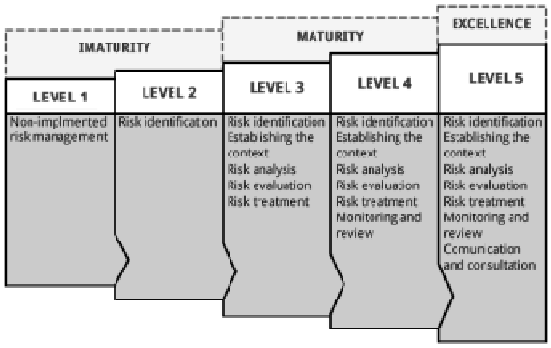

Fig. 1. GAÏA Risks Framework [9]

Fig. 2. GAÏA Risk Service Structure [10]

		Likelihood				
		Very high	High	Average	Low	Very low
		10	8	6	4	1
Very high (Death)	100	1000	800	600	400	100
High (Permanent invalidity)	40	400	320	240	160	40
Medium (Lost Time Injury	21	210	168	126	84	21
Low No absence from work but medical treatment)	8	80	64	48	32	8
Very low (Minor treatment)	2	20	16	12	8	2

Fig. 3. Criticality grid applied in the standard method of the investigated company

In the long run, all Health and Safety risk assessments should be conducted using this new module, with the assessment method described in the company's internal standards. The implementation will be done gradually, under the authority of the Sectors and Activities, in accordance with the objectives of the Group in this field.

Any new risk assessment, especially for newly built units, must be performed directly with the risk assessment method described in this standard and with the Gaïa Health and Safety Risk Assessment Module.

It should be noted that the risks associated with exposure to toxic agents must be assessed in accordance with the company's TAS (Toxic Agents Standard) standard, using the tool in the Gaïa Toxic Risk Assessment module [11]. However, no instrument can replace the risk assessment process in the field, which must first and foremost be a participatory process and include employees, which is coordinated by a guarantor of the method and which covers all work functions. and unit activities [12].

Table 1

Impact of safety barriers on severity and probability

Specification	Equiment/ ECP	Organization/ Behavior	PPE
Severity	X		X
Probability	X	X	

3. THE ACCIDENTS RISK ANALYSIS TOOLS USED

a. Standard method (P x G) - for accidental risk analysis, the standard method (PxG) is based on the criticality grid shown in Figure 3. The score of the probability or severity level should be allocated through discussions with specialists in the field and is based mainly on data such as knowledge of exposure to hazardous situations, health and safety events history for the type of job considered and the means implemented, together with their estimated level of reliability.

b. Kinney - Wiruth method adapted by the company - The adapted Kinney-Wiruth method is also applied for accidental risk analysis (f x P x G). In this method, compared to the P x G method, the probability P is determined by the assumption that the hazardous situation occurs continuously. The severity score G is identical to that of the standard method. The definitions and coefficients of the factors P and G are identical to those of the method P x G. The factor f designates the frequency of exposure of the worker to hazard: ***Rare (f = 0,21):*** from once a year to less than once a month; ***Unusual (f = 0.32)***: from once a month to less than once a week; *Occasional (f = 0.6)*: from once a week to less than once a day; ***Frequent (f = 1)***: at least once a day. Once the risk score has been obtained by multiplying the three coefficients f x P x G, this score is rounded down to the next lower risk level. The corresponding criticality grids are obtained by simply multiplying the values included in the grid of the standard method with value f, of the exposure coefficient.

c. Consideration of security barriers in risk assessment - The definition of the level of probability or severity must be done through discussions with the employees involved. It is based on data such as the qualitative and / or quantitative assessment of exposure to hazardous situations, the history of Health and Safety events for the type of job considered and the means of implementation, together with their estimated level of reliability. In no case can it simply be the result of mathematical calculation of the types of means of control implemented.

Potential severity is inferred from an analysis of the potential consequences of the employee's exposure to hazard, especially based on similar events. ***The probability*** of an accident arises from an analysis of similar events that have taken place in the unit and in comparable units in the business / Group / companies outside the Group, if relevant information is available. This estimate of the probability of events must be systematically supplemented by an analysis of the chain of events / scenarios that may cause an accident / incident. It should be noted that the estimation of potential severity and probability considers the means of control already implemented. It is therefore important to know these means of control and to estimate their known level of reliability, as only additional means of control or an improvement in their reliability will make it possible to reduce the severity and / or probability.

The means of control (safety barriers) are classified according to the following three categories: i) Technical equipment / Collective protection equipment (ECP); ii) Organization / Behavior; iii) Personal Protective Equipment (PPE). Depending on their categories, these means of risk control may have an impact on the probability and/or severity (Table 1).

A level of reliability can be estimated for each category of safety barriers. This estimate shall consider the events that took place, the feedback from the means of control and the results of the inspections and audits of the respective post, workstation or assignment (compliance with existing procedures and wearing of the PPE). Monitoring, surveillance and audits can also be performed to reduce the number of potential damage and deviations and thus increase the level of reliability. Thus, it is extremely rare that level of reliability of the

PPE to be high, as it depends on the level of safety culture, the application of the rules and the wear of the PPE; the allocation of a high level of reliability to the PPE category must be exceptional and requires rigorous enforcement of PPE rules and conduct during inspections and audits. The possible levels of reliability of the three categories of control means are summarized in Table 2.

Table 2

Likely levels of reliability associated with the categories of safety barriers

Probable level of reliability of the barrier category	Equiment ECP	Organization/Behavior	PPE
Low	≈	+	+
Medium	+	+	≈
High	+	≈	-

Legend:
-: Reliability level incompatible with this category of safety barrier
≈: Reliability level unlikely for this category of safety barrier
+: Reliability level incompatible with this category of safety barrier

Table 3

Influence of safety barriers on the risk components

Specification	Initial situation	The new situation of safety barriers	Indicators of the indicative criteria for the new situation
Equipment reliability	Low	High (+2)	Levels -2 for P and G
Reliability of the organization / Behaviors	Low	Average (+1)	Level -1 for P
PPE reliability	Low	Low (+0)	Level -0 for G

Table 4

Residual risk estimation, considering the reliability of safety barriers

Specification	Initial level	Impact of added safety barriers			Final level
		Equipment/ECP	Organization/ Behavior	PPE	
Probability P	**5** Very high (meaning P=10)	-2	-1		**5-2-1 = 2; Low (meaning P=4)**
Severity G	**4** High (meaning G=40)	-2		Unchanged	**4-2 = 2; Low (meaning G=8)**
Risk level	**400**				**32**

d. Indicative guidance on how to take safety barriers into account - The following is an example of an indicative method that allows an estimate of the probability and potential severity obtained after the addition of safety barriers or making them more secure, considering the level (s) of reliability achieved for each barrier category. The principle is to remove from the initial probability and severity of the hazardous situation a level of probability and / or severity for each level of reliability gained for each category of safety barriers, according to the parameters on which they operate. For example, for a hazardous situation initially assessed as having a very high probability and severity, risk control measures have led to an increase in risk control levels (Table 3). The application of these guidelines provides a new risk assessment (according to Table 4). These elements are only suggestions made available to the evaluators and will generally be considered as the maximum possible reduction. They must in no case replace the professional reasoning of the evaluator, which is based on a detailed and participatory analysis. If the assessor considers that the risk reduction obtained by applying this method is exaggerated because of his assessment of the reality of the safety barriers implemented and their observed level of reliability, he may obviously report a lower reduction in severity and / or probability.

4. ERGONOMIC AND CHRONIC RISK ASSESSMENT ALGORITHM DEVELOPMENT IN THE COMPANY

Based on the main international laws, regulations and standards, as well as internal standards and recommendations such as NOS (noise) or PLM (Product Lifecycle Management-ergonomics), the company has established systematized thresholds and criteria for estimating the Main Chronic Risks caused by normal operation of industrial facilities.

The algorithm is inherently non-exhaustive and represents a minimum list of Chronic Risks that are systematically assessed.

For those hazards whose thresholds and criteria are not defined in the company standard, each unit defines its own criteria and thresholds, in accordance with local laws and regulations, allowing the justification of the selected risk levels. The different risk levels and scores that are set are shown in Table 5.

The types of chronic stresses and specific hazards that are considered in the aggregate chronic risk assessment are set out in detail in Tables 6 to 12 and Figures 4, 5 and 6.

4.1. Manual handling of weights

To identify the physical restrictions, present in the unit and to find the main recommendations for reducing these risks, an internal instrument called PLM is accessible on the MSS intranet. However, other instruments may be used and, in this case, a parallel must be drawn up to score the risk levels according to Tables 6, 7 and 8. Figure 4 describes the representations of handling activities of type 1, 2 and 3.

4.2. Postural difficulty, the risk scoring being given in Table 9.

Figure 5 describes the difficult positions of type 1, 2 and 3.

4.3. Repetition of operations performed, risk scoring being given in Tables 10 and 11. Figure 6 represents the painful gestures and positions of type 3.

Table 5

Chronic risk ranking grid in the investigated company

Risk level	Score	Qualitative description
Very critical	**800**	It can cause death due to a serious chronic illness
Critical	**240**	It can cause permanent disability due to a chronic illness
Medium	**84**	Can cause disease that makes it temporarily impossible to return to normal work
Low	**8**	No absence from work, but medical treatment

Table 6

Handling conditions and related risk levels

Criteria	Risk level	Risk score
Activities in which the employee repeatedly adopts one or more type 3 positions during at least half of the work shift each day	Critical	240
Activities in which the employee repeatedly adopts one or more type 3 positions during less than half of the work shift each day OR Activities in which the employee repeatedly adopts one or more type 2 positions during at least half of the work shift each day OR Activities in which the employee repeatedly adopts one or more type 2 and 3 positions during at least half of the work shift each day	Medium	84
Activities that are not subject to critical or medium level risk definitions	Low	8

Table 7

Weights handled and risk scoring

Criteria	Risk level	Risk score
Manual handling activities during at least half of the work shift each day, during which repetitive transports of loads over 15 kg and / or push-pulls of trolleys weighing more than 200 kg have been identified	Critical	240
Manual handling activities during at least half of the work shift each day, with repetitive transports of loads greater than 5 and less than or equal to 15 kg and / or push-pulls of trolleys with a weight between 100 and 200 kg	Medium	84
Manual handling activities during at least half of the work shift each day, during which repetitive transports of loads less than or equal to 5 kg and / or push-pulls of trolleys weighing less than 100 kg have been identified	Low	8

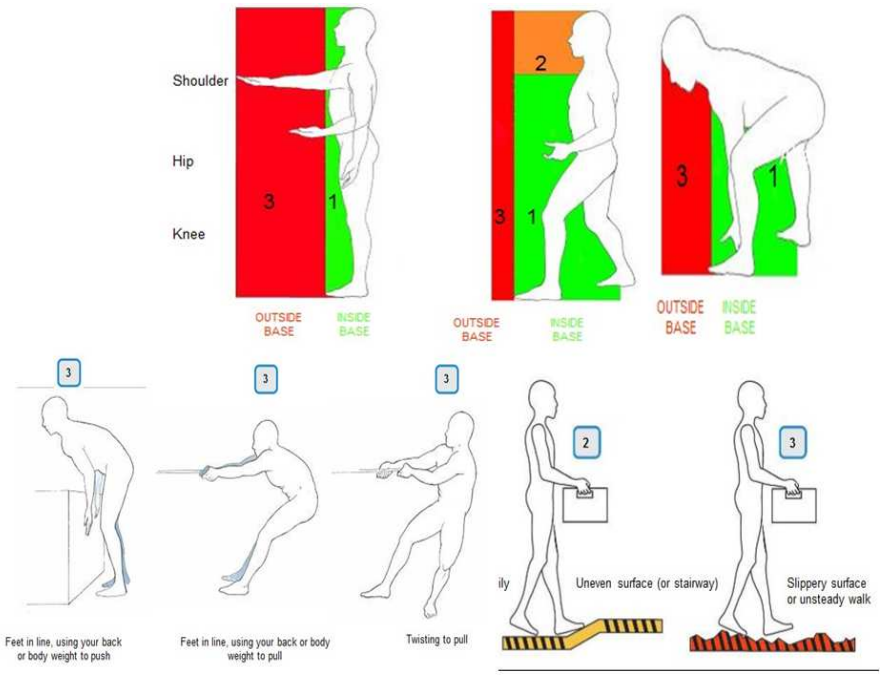

Fig. 4. Representations of manual handling activities type 1, 2 and 3 - selective

Table 8

Risk score based on handled mass

Criteria	Risk level	Risk score
7,5 tons <total mass	Critical	240
3 tons <total mass ≤ 7.5 tons	Medium	84
Total weight ≤ 3 tons	Low	8

Table 9

The degree of difficulty is associated with the posture. Assigning the risk score

Criteria	Risk level	Risk score
Activities in which the employee repeatedly adopts one or more type 3 positions during at least half of the work shift each day	Critical	240
Activities in which the employee repeatedly adopts one or more type 3 positions during less than half of the work shift each day, OR Activities in which the employee repeatedly adopts one or more type 2 positions during at least half of the work shift each day, OR Activities in which the employee repeatedly adopts one or more type 2 and 3 positions during at least half of the work shift each day	Medium	84
Activities that are not subject to critical or medium level risk definitions	Low	8

Table 10

Demanding work rules from the perspective of repetitiveness

Thresholds	Frequency criteria	Risk level	Risk score
Cycles ≤ 30 sec or no. of actions ≥ 40 / min	Repetitively 50% of the work shift every day	Critical	240
Cycles ≤ 30 sec or no. of actions ≥ 40 / min	Repetitively > 3 hours / day	Medium	84
Cycles ≤ 40 sec or nr. of actions ≥ 30/min	Repetitively 50% of the work shift every day	Medium	84
Cycles ≤ 30 sec or no. of actions ≥ 40 / min	Repetitively > 1 hour / day	Low	8
Cycles ≤ 40 sec or nr. of actions ≥ 30/min	Repetitively > 1 hour / day	Low	8

Table 11

Painful gestures and positions

Criteria	Risk level	Risc score
Activities in which the employee repeatedly adopts one or more type 3 positions during at least half of the work shift each day	Critical	240
Activities in which the employee repeatedly adopts one or more type 2 positions during less than half of the work shift each day, OR Activities in which the employee repeatedly adopts one or more type 3 positions during at least half of the work shift each day, OR Activities in which the employee repeatedly adopts one or more type 2 and 3 positions during at least half of the work shift each day	Medium	84
Activities that are not subject to critical or medium level risk definitions	Low	8

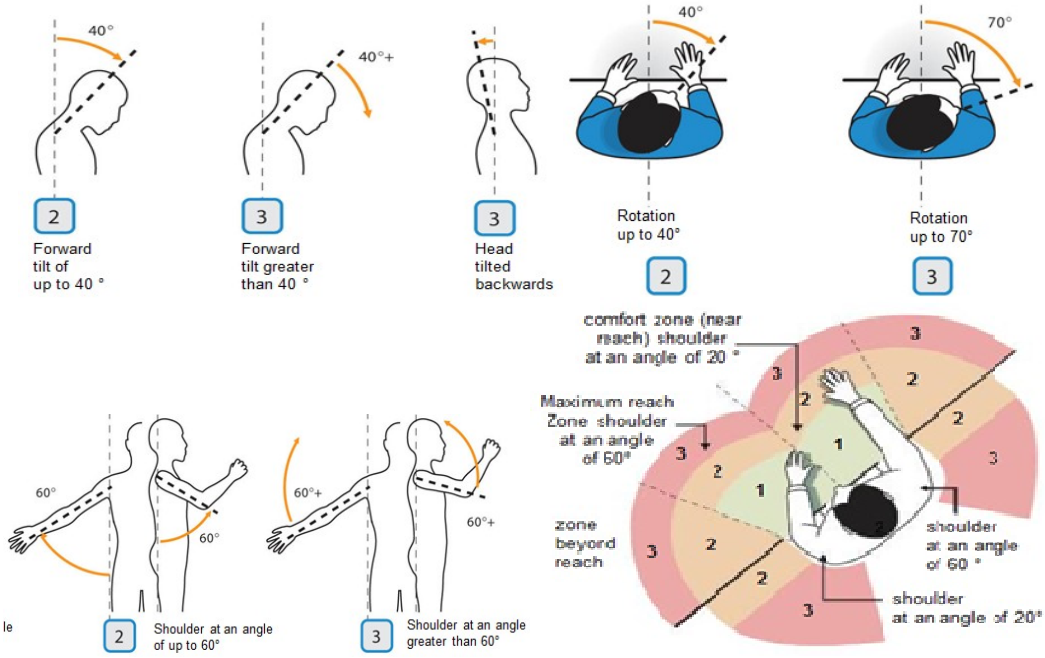

Fig. 5. Illustration of grade 1, 2 and 3 postural difficulty – selective

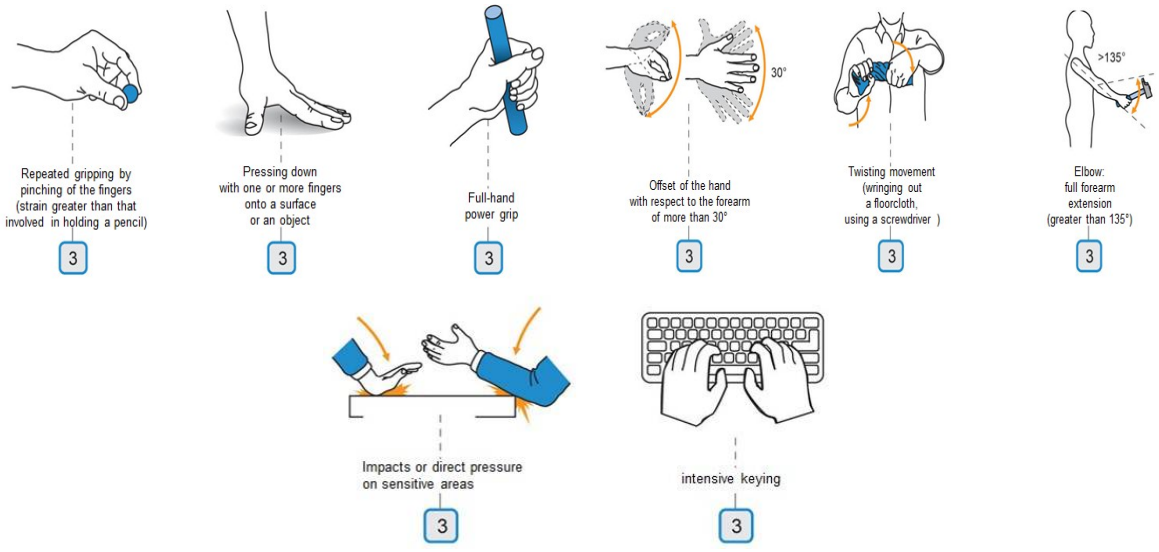

Fig. 6. Painful gestures and positions type 3

4.4. Night work is related to the thresholds between 9.00 p.m. and 6.00 a.m.; Risk level: Critical; Risk score: 240.

4.5. Successive shifts: Thresholds: shift changes between morning, evening, night or day shifts; Risk level: Critical; Risk score: 240.

4.6. Work-related stress related to the risk scoring being given in Table 12.

4.8. Vibrations, the risk scoring being given in Table 13.

4.7. Exposure to toxic agents - The assessment of the risks related to exposure to toxic agents must be carried out in accordance with the TAS standard, using the Gaïa Toxic Risk Assessment module. The maximum limit recommendations not to be exceeded are 5 m/s² for vibrations transmitted to the hands and arms and 1.15 m/s² for those transmitted to the whole body [13].

4.9. Noise exposure - Maximum limits not to be exceeded are 87 dB (A) for Lexd (8 hours) attenuated by PPE, or 140 dB (i.e. 200 Pa) in Lpk, according to the NOS standard methodology and criteria (Table 14).

4.10. Extreme temperatures - Where relevant, methods such as Heat Index and Wet Bulb Globe Temperature (EN 27243) can be used to characterize risk levels as low, medium, critical and very critical (Table 15).

Table 12

Workplace stress rating

Thresholds	Risk level	Risk score
To be defined	Very critical	800
To be defined	Critical	240
To be defined	Medium	84
To be defined	Low	8

Table 13

Risk score ranges associated with vibration exposure

Thresholds: vibrations allowed		Risk level	Risk score
Hands and arms- 8h ref. period	Whole body - 8h ref. period		
2.5 m/s² <	0.5 m/s² <	Critical	240
1.25 m/s² < … ≤ 2.5 m/s²	0.25 m/s² < … ≤ 0.5 m/s²	Medium	84
≤ 1.25 m/s²	≤ 0.25 m/s²	Low	8

Table 14

Areas of variation in noise level

Thresholds	Frequency criteria	Risk level	Risk score
85 dB(A) ≤ Lexd (8h), OR 137 dB ≤ Lpk	According to the NOS methodology and criteria	Critical	240
80 dB(A) ≤ Lexd (8h) < 85 dB(A), OR 135 dB ≤ Lpk < 137 dB	According to the NOS methodology and criteria	Medium	84
Lexd (8h) < 80 dB(A) OR Lpk < 135 dB	According to the NOS methodology and criteria	Low	8

Table 15

Estimation of the risk associated with thermal discomfort

Thresholds	Frequency criteria	Risk level	Risk score
Direct exposure to a radiant heat source above 300 ° C less than 4 meters away	> 2 hours / day, on a regular basis	Critical	240
Direct exposure to a radiant heat source above 200 ° C less than 4 meters away	≤ 2 hours / day, on a regular basis	Low	3

Table 16

Estimation of the risk associated with exposure to ionizing radiation

Thresholds: Radiation	Risk level	Risk score
> 10 mS/year	Very critical	800
5 mSv /year ≤ … < 10mSv /year	Critical	240
1 mSv /year ≤ … < 5mSv /year	Medium	84
< 1 mSv /year	Low	8

Table 17

Estimation of the risk associated with exposure to electromagnetic radiation

Thresholds	Risk level	Risk score
SAR* ≥ 1 W/kg	Critical	240
0.5 W/kg ≤ SAR* < 1 W/kg	Medium	84
SAR* < 0.5 W/kg	Low	8

4.11. Exposure to ionizing radiation, the risk scoring being given in Table 17.

4.12. Exposure to radio frequencies by using a mobile phone / smartphone - SAR (Specific Absorption Rate) is the radiation rate of mobile phones. Following the chronic risk assessment, a centralized risk diagram will be obtained indicating the weaknesses (requirements that exceed the allowable levels) [14]. The development of the Health and Safety Management System, until reaching the point where we have a safety culture implemented, is followed by the 20-step audit, an audit organized by the company every four years, its results showing at what point of development the organization was at the time of the audit [15, 16].

5. CONCLUSION

Situations may arise in which it is necessary to compare several variants of equipment, methods, technologies or systems, with mandatory consideration of the "risk" criterion. The objective is to obtain information to identify the risks associated with each option and to facilitate the comparison of options. The realistic assessment of variants implies, if the ranking of risks is the only option, the use of quantitative methods of analysis, a structured comparison context with much discernment, as well as the application of statistical methods to clearly demonstrate the differences between variants. Risk awareness in relation to daily work tasks aims to create and develop a state of awareness of potential risks for employees who do not have a correct perception of the hazards associated with changes in the work system in which they work. In this regard, the company under investigation adopted "mental models" to persuade employees to consider the risks in a systematic manner. The risk assessment is led by top management, who will consult and / or directly involve all stakeholders: employer, top management, workers and their representatives.

Workers are best acquainted with the workload itself, the possibilities for its improvement, both from a technological point of view and from the point of view of work safety. For this reason, it is mandatory for the employer to require the person in charge of the risk assessment to consult the staff and the service providers.

Workers, even if not consulted, can and should draw attention to certain categories of hazards which, by their very nature, are difficult to identify. Workers can appreciate that the way work is formulated and communicated can, under certain conditions, lead to malfunctions.

The complementarity of the risk assessment tools applied systematically and in structured manner in the investigated company represent premises of stable success and of continuous development [13-16].

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Evaluarea riscurilor accidentale, ergonomice şi cronice într-o companie de producţie multinaţională: instrumente aplicate în cadrul GAÏA de management al riscurilor

Rezumat: *Utilizarea cvasi-generalizată în România a unei singure metode indigene a redus mult eficacitatea abordării de evaluare a riscurilor, nepermiţând particularizarea tehnicilor utilizate la varietatea de situaţii şi condiţii concrete întâlnite în organizaţii. Această limitare instrumentală generează în cascadă multiple dezavantaje. Lucrarea de faţă rezumă rezultatele cercetărilor care ilustrează experienţa existentă într-o companie industrială multinaţională privind aplicarea complementară a mai multor metode de evaluare a riscurilor pentru atingerea nivelului de excelenţă al dezvoltării culturii siguranţei. Rezultatele obţinute sunt repere pentru îndrumarea eficientă a practicienilor, experţilor, evaluatorilor de risc şi managerilor SSM, în planificarea, organizarea, desfăşurarea şi valorificarea procesului de evaluare a riscurilor profesionale.*

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