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# Methodology for Assessing the Degree of Occupational Safety Specific to Hydrotechnical Construction Activities, in Order to Increase Their Sustainability

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**Abstract:** The effectiveness of the audit is conditioned by the systematic nature of the analyses and their periodicity. In this respect, the work of internal auditors must be coherent, continuous, and professional. These conditions can be met only if the activity is organized as a permanent system, which has its objectives and has resources (human, material, and financial), as well as adequate tools (audit method) corresponding to the activities carried out within the hydro-construction companies. The methodology for assessing the occupational safety status specific to companies in the field of hydrotechnical constructions was tested at the economic operators within SC HIDROCONSTRUCȚIA SA Bucharest. Thus, from the observation made based on the two calculation formulas' application, it can be appreciated that the weighted amount more clearly and objectively reflects the existence of problems in achieving safety and health at work, thus constituting the result of a cautious approach, as opposed to the arithmetic mean formula, which leads to a result that tends to overestimate the value of the assessment. Additionally, the security risk determination in the field of occupational security at the economic operators was performed, according to the procedure of applying the method, based on the Gumbel probability function associated with insecurity, and the accuracy of various estimates on risk predictors was ensured by using the Kolmogorov–Smirnov statistical verification test in order to determine the confidence interval of the forecast results.

**Keywords:** audit method; hydro-construction; safety and health at work



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## 1. Introduction

The activity of auditing, as it is perceived today, began to take shape at the beginning of the last century. Initially, it was applied to the financial field and meant the accounting certification of quotable companies by specialized independent organizations. The first major change occurred during the economic crisis in the United States, where to save at least partially the audit expenses, many large companies decided to carry out the necessary preparatory work inside—inventory of assets, an inspection of accounts, verification of balances, etc., organizing their audit compartments accordingly. For the actual certification, the external audit companies were still used, and to distinguish between these two categories, the specialists of the external organizations were appointed external auditors, and those of the audited company internal auditors. Even after the economic crisis, the internal audit activity was maintained. Over time, it has been suggested that there is a need for an internal audit function within organizations. The role and need for internal

auditors have grown steadily and have been unanimously accepted. Consequently, in 1941, the Institute of Internal Auditors—IIA, was created in Orlando, Florida, USA, which was internationally recognized. Later, Great Britain joined the new organization, and in 1951, Sweden, Norway, Denmark, and other states joined. Currently, more than 90 national institutes of internal auditors and members from more than 120 countries are affiliated to the IIA, having obtained the quality of CIA—certified internal auditor, granted by the IIA based on specialized professional examinations [1,2].

Regarding the occupational safety and health audit, it was mandatory according to the repealed labor protection legislation, but the prescription was no longer included in the current occupational safety and health law (Law no. 319/2006); there are currently no regulations outlining the reference framework for this area, specifying the particular conditions under which the audit is performed, the methods used, etc.

Starting with the second half of the twentieth century, a new approach to working conditions was imposed. Thus, for complex, objective, and ethical reasons, all developed societies require the individual entrepreneurs to ensure the safety and health protection of workers at work. The objective is supported by mandatory regulatory laws, the application of which requires decisions of a financial–economic nature from the employers. It is therefore in the interest of the latter to have the tools to ensure that the decision is so substantiated that the results of its application ensure compliance with the legislation to minimize losses due to the costs of prevention and even, if possible, profitability [3].

In essence, achieving safety and health at work means that the organization has a degree of control over the risks of accidents and occupational diseases that exist or may occur during work. In this way, the objectives imposed by the legislation are met. Therefore, the effectiveness of the preventive activity and, implicitly, the assessment of its efficiency as a basis for the managerial decision, can be established with the help of internal audit, considered the optimal evaluation method for any type of internal control.

In Romania, the use of occupational safety and health audits as a tool for scientific management of preventive activity is mainly supported by practice. In the case of many companies where the quality of the activity is audited, the preventive activity is also audited.

From the analysis of the specialized literature, it was concluded that on the international level, there are two categories of methods. The first includes those that have been designed for the inspection control of the preventive activity or safety analyzes, but which are also used for the audit of occupational safety and health. The second category includes methods designed specifically for occupational safety and health audits. In both cases, the purpose is the same: the degree of compliance of the audited object with the legal requirements on safety and health at work is assessed and, on this basis, the level of safety is assessed [4–14].

Common methods for inspections, safety analyzses, and occupational safety and health audits include:

- Methods based on the questionnaire technique: They have as a principle the finding of deficiencies concerning the norm, but they differ in the degree of formalization. The minimum tool required to perform the analysis is a questionnaire that records, in a more or less detailed manner, the key points to be observed to a reference system—the legal provisions. Questionnaires are local in character and can rarely be generalized. Among the main methods we can mention: the checklist designed by Thony, France, 1986, and the observation guide developed within the National Plant Management Renault—France.
- DCT method (Diagnostique des conditions du travail): proposed by French researchers Piotet and Mabile in 1984 and involves five steps.
- DST (Diagnosis Safety Form) method: developed in 1974 by a group of American researchers, aiming to identify a set of deficiencies existing in a given activity that determine the safety performance, for analysis and evaluation occupational safety issues common to a set of similar jobs or activities characterized by common risks.

- Nosa method: It is applicable at company level and analyses the absence of preventive measures provided by legal regulations. The working principle is the comparison of the situation in the field with a checklist of key articles, representing the basic elements of any prevention program [15].

Specific occupational safety and health audit methods include:

- WorkWell method: used for external audits and was developed by the Commission on Occupational Safety and Insurance (Workplace Safety & Insurance Board (WSIB)—Canada). By assessing compliance with legal requirements and principles of good practice in the industry, the method allows the evaluation of occupational safety and health management of the organization.
- Alberta method: was developed in 2002 by the authorities of the Canadian province of Alberta, as part of a partnership program with employers to improve occupational safety and health.
- CHASE method (Complete Health and Safety Evaluation Method): was developed by the British company HASTAM and has a modular character. It comprises the following basic modules: CHASE EME, CHASE SMi 18001, CHASE SMS 18001, CHASE SMi HSG65, CHASE SMS HSG65, and DSE Self Assessment.
- OSHA method (Occupational Safety and Health Administration Method): It is an internal audit method, which was developed by the Administration for Safety and Health at Work (OSHA) in the United States of America and small businesses.
- INCDPM method (National Institute for Research and Development of Occupational Safety Method): developed within the National Research and Development Institute for Work Protection in Romania, having as a principle the examination and systematic analysis, independent and documented, of the existing conditions in a company, to determine if and to what extent they comply with the requirements of safety legislation and occupational health in force.

The occupational safety audit system specific to hydro-construction companies must focus on the following theoretical arguments [16,17]:

- The preventive activity must result in the control of the injury risks and occupational diseases specific to the hydrotechnical constructions activities, at such a level as to eliminate the possibility of their action on workers, the most objective guarantee regarding the achievement of this desideratum being offered by the audit of occupational health and safety.
- In order to have permanent information on the control degree of occupational risks in the hydrotechnical field, the most effective and efficient solution is to organize the internal occupational safety audit as a function of the company; in this sense, there are many advantages, namely [18]:
  - The use of external audit is limited by the current financial possibilities of the hydro-construction company that wants to audit and by the auditor's availability;
  - the internal audit has a strong preventive character, performing controls that guarantee the OSH objectives' achievement, respectively, the prevention of the weakness gettting worse, while the external audit finds and monitors, first of all, their existence;
  - internal auditors can more quickly identify non-compliances, due to the knowledge they already have about the hydrotechnical activities of the company they belong to;
  - internal auditors are practically doubly interested in increasing the organization's performance in occupational safety and health, as auditors and employees of the hydro-construction company who must contribute to the implementation of occupational safety and health policy promoted by the top management of this institution.

The effectiveness of the audit is conditioned by the systematic nature of the analyses and their periodicity. In this respect, the work of internal auditors must be coherent,

continuous, and professional. These conditions can be met only if the activity is organized as a permanent system, which has its objectives and has resources (human, material, and financial), as well as adequate tools (audit method) corresponding to the activities carried out within the hydro-construction companies [19].

## 2. Synthesis of the Specialized Method for Assessing the Degree of Occupational Safety Applicable to Hydrotechnical Construction Companies

This specialized method of auditing allows the assessment of the control degree of the achievement of safety and health at work in economic organizations in the field of hydro-construction, i.e., the assessment of the legal regulations in the field for the activities carried out by these enterprises [20,21].

The objectives proposed in the design of the method can be summarized as follows: identification of the "weaknesses" of an activity, process, or work system, respectively, those for which not all preventive measures are adopted to ensure compliance with legal requirements; determining the extent of the deviation from the legal provisions in order to establish priorities in adopting the necessary measures; assessment of the safety and health at work level depending on the compliance degree with the benchmark; and establishing the occupational safety and health measures to be adopted in order to ensure a degree of 100% compliance with the legal provisions [22–25].

The principle of the method consists in identifying the applicable essential requirements, specified in a pre-established reference system, which regulate the achievement of occupational safety and health in the hydro-construction activity. It also consists in evaluating the degree of compliance of the audit object with this system, in order to observe if the legislative requirements are met [26,27].

The developed method involves the following steps, as appropriate: general information on the audit object; checklists application; studying occupational safety and health documentation, field investigation, and completing documents; quantitative indicators calculation to assess conformity (degree of compliance with the whole reference system adopted—overall degree of compliance and degree of compliance with detailed sets of requirements for activities, systems, or risks for which significant non-conformities have been identified—specific degree of compliance); overall assessment of the occupational safety and health level; synthesis of non-conformities; and drafting the audit report.

The method tools are: reference system, general check-list for overall assessment of compliance with the reference system, specific checklists to assess compliance with detailed sets of requirements for achieving safety and health at work, identification and analysis sheet of non-compliance, weighting coefficient stake grid for assessing the overall degree of compliance, assessment sheet of the overall degree of compliance with occupational safety and health requirements, non-conformity summary sheet, and final audit report.

The reference system includes all legal regulations on occupational safety and health or with an impact on the achievement of occupational safety and health in the hydro-construction activity [28,29].

The reference system will be supplemented by other specific occupational safety and health regulations applicable, as appropriate, to the company's activities, as well as its occupational safety and health instructions. Additionally, any other regulations will be added that do not have as object the safety and health at work, but contribute to its realization and have an impact on the company's activities [30].

### *2.1. General Checklist for Occupational Safety and Health Audit*

The general checklist is a document formalized in tabular form, which systematically groups, by categories of problems, the main requirements whose observance guarantees the achievement of safety and health at work, stipulated in Law no. 319/2006 and the regulations derived from it. It also includes the maximum score that can be given for complying with each requirement, as well as two columns that allow the average compliance indices' calculation [17–19].

In order to select the requirements included in the checklist, on the one hand, the generic structure of the work systems was observed, and on the other hand, the logical ordering of the actions to be performed, leading to the operation of a socio-economic objective in safe and healthy conditions for workers. As a number of measures have effects on both the means of production and the working environment, they have been treated as a single category. The distribution of the categories of requirements by the elements of the work system is presented Table 1.

**Table 1.** Distribution of the requirements categories on the elements of the work system.

| No. | Requirement | The Element of the Work System to Which It Refers |
|---|---|---|
| 10.00 | Personnel selection and control | Worker |
| 11.00 | Occupational safety and health training and information | |
| 12.00 | Personal protective equipment | |
| | Total | |
| 9.00 | Establishing and allocating work tasks | Work task |
| | Total | |
| 1.00 | Buildings and rooms where work processes take place | Means of production and work environment |
| 2.00 | Stairs, steps, level differences, scaffolding, platforms | |
| 3.00 | Location of technical equipment | |
| 4.00 | Protection against mechanical risks | |
| 5.00 | Electrosecurity | |
| 6.00 | Loading, unloading, transport, handling, and storage of materials | |
| 7.00 | Portable equipment and hand tools | |
| 8.00 | Fire prevention and control | |
| | Total | |
| 13.00 | Organization of prevention and protection activity | Work system |
| 14.00 | First aid in case of injury | Worker |
| | Total | |

The establishment of the maximum score required finding a correlation that would allow an objective assessment of the importance of each requirement in achieving occupational safety and health stipulated by the selected regulations. It was considered that the most relevant are the maximum potential consequences that non-compliance with the specified requirements would have.

As a result, three categories of consequences were established, each of which was conventionally assigned a number of points, as shown in Table 2. This reasoning did not apply to the requirements grouped in the last two categories, which have effects on occupational safety and health only indirectly. For them, 100 points were conventionally awarded.

**Table 2.** Maximum score by category of consequences.

| Maximum Possible Consequence to Be Avoided by Complying with the Requirement | Score Awarded |
|---|---|
| Accidents at work and/or occupational diseases resulting in temporary incapacity for work | 40 |
| Accidents at work and/or occupational diseases resulting in disability | 80 |
| Accidents at work and/or fatal occupational diseases | 100 |

### *2.2. Specific Checklists for Occupational Safety and Health Audit*

Specific checklists are formalized documents that are used to assess the degree of compliance with detailed sets of occupational safety and health requirements that correspond to a single activity or to combat a single risk of occupational injury and illness. These questionnaires are elaborated on the basis of the regulations derived from Law no. 319/2006 and its own occupational safety and health instructions included in the adopted reference system.

They include essential requirements selected from these regulations for each activity, as well as the maximum score for each requirement. Based on statistical information on the causes of accidents and occupational diseases specific to the hydro-construction activity in Romania, a number of 19 checklists were developed, respectively: checklist for excavation activities for municipal works and civil and industrial constructions; check-list for concrete preparation activity; checklist for masonry, finishing, and painting in construction; checklist for metalwork; checklist for doors, windows, prefabricated houses, and building panels manufacture activities; checklist for prefabricated assembly works (including sewer pipes); checklist for painting activities and working with toxic and/or hazardous substances; checklist for work at height; checklist for internal transport activities; checklist for handling, non-mechanized transport, and materials storage; checklist for welding works; checklist for blasting (blasting with explosives); checklist for storage of explosives and their transport underground; checklist for roadworks; checklist for underground mining operations; checklist for lifting installations operation; checklist for the use of electrical equipment; checklist for vehicle maintenance and repair operations; and checklist for activities carried out in warehouses and gas stations [31–37].

The last two columns of the checklist are intended for the score assigned to the actual situation identified in the field and for the calculation of the average compliance index. Finally, the degree of compliance with the reference system specific to each questionnaire is calculated. The assignment of the maximum score is made according to the same reasoning as in the case of the general checklist.

The specific checklists presented may be supplemented by other specially designed ones if the auditors assume the possibility of existence or find significant non-conformities in relation to other activities or risks than those initially considered.

### *2.3. Nonconformity Identification and Analysis Sheet*

The nonconformity identification and analysis sheet is a working document in which the negative results of the analysis of the way of fulfilling each requirement in the checklist, particularly the deviations from the reference, found in the field, are registered. A decrease of the score in the case of a requirement is performed depending on the number and severity of non-conformities found.

The form contains all the details regarding the nonconformity, its structure being the following: the facts (description of the non-compliance), cause (description of the origin of the non-compliance), consequence (consequences of non-compliance), and recommendation (proposed action to eliminate non-compliance).

### *2.4. Grid of Weighting Coefficients for Assessing Overall Compliance*

In order to assess the compliance degree, it was assumed that the effects of compliance with occupational safety and health requirements are different. Each measure applied increases the general level of security in a specific way, depending on the capacity of the action, the process, the material element, etc., which refers to endangering the safety and health of employees. At the same time, it was admitted that the four elements of a work system participate equally in achieving the safety and health at work of the employees involved in carrying out that work process.

### *2.5. Assessment Sheet of the Global Degree of Compliance with Occupational Safety and Health Requirements*

The assessment sheet is the summary document of the operations for assessing compliance with the reference system for the audited object. It consists of a table that contains 14 rows, corresponding to the 14 categories in which the requirements of the general checklist have been grouped, as well as six columns, for entering the average compliance indices by category. The last row of the table is intended to calculate the overall degree of compliance with occupational safety and health requirements.

### *2.6. Summary Sheet of Nonconformities*

The summary document, which allows the synthesis of the audit results, includes all negative findings made during the audit, in ascending order of the average compliance index of the requirement in relation to which the non-compliance was identified, as well as the measures taken by the heads of the entities to assess the desired level of security.

### *2.7. Final Audit Report*

The final audit report is an informal document, which must include, in a clear and concise expression, the elements specified in its content.

The conceived method is addressed both to the internal auditors of the hydro-construction companies and to those belonging to some authorized institutions for the following purposes: when adopting the decision to introduce the management of safety and health at work; during the operation of the occupational safety and health management system, as a basis for corrective actions in connection with the control of occupational safety and health; prior to the adoption of decisions on major changes in the technologies used, technical equipment, etc.; and after the introduction of major changes in connection with complex technological processes and technical equipment. The method can also be used at the level of the entire enterprise of an administrative component (section, workshop, or workplace) or for a sub-activity, and can also be used as a tool for diagnostic tests aimed at assessing the level of safety and health at work.

## 3. Procedure for Applying the Specialized Method for Assessing the Degree of Occupational Safety

### *3.1. Information on the Object of the Audit*

If the method is applied by external auditors, the first operation to be performed is the familiarization with the company, for which information is collected, as appropriate, on the object of activity, territorial organization of the enterprise, the size of the company and the characteristics of the staff employed, organizing the activity of achieving safety and health at work, statistics on accidents and occupational diseases, and the results of previous audits.

The next step for all auditors—internal or external—is to inform them about the subject of the audit. Whether it is the degree of compliance for all activities of the company or only for an activity or a system of its own, the audit requires the identification and knowledge of the components of the audible object: processes and work systems.

In the case of the audit of the activities carried out in a single organizational entity—workshop, section, or activity sector—the necessary primary data refer to the activities carried out (products, works, and services), number and structure of staff (trades, qualification, number of workers, etc.), technology or technologies applied (operations, machinery, installations, etc.), functional parameters and characteristics, raw materials and auxiliary materials, special characteristics and physico-chemical properties, movement of people and materials (raw materials, materials), handling and storage in the workplace, access and escape routes, means of transport and lifting, environmental conditions, location of the subsystem, and possible incidents of activities carried out on the same premises or in neighboring areas.

In the conditions of auditing all the activities of the enterprise, it is necessary for the auditors to be informed about the activities through which the activity object is realized; the number and structure of the staff and their distribution by activities; special occupational safety requirements for various categories of employees; technologies and energies used; degree of automation; categories of technical equipment; functional parameters and characteristics; special buildings and constructions: territorial distribution, traffic routes, access, and evacuation; means of transport; warehouses for raw materials, materials, etc.; and environmental conditions and special issues [38–40].

Regardless of the type of audit—internal or external—the audit team performs a preliminary analysis of the occupational safety and health situation for the audited activ-

ity/activities or system. The analysis aims to identify those aspects that must be investigated with certainty, because they arre presumed to represent points: actions that are not performed, work processes where the existence of non-conformities is suspected, etc. The analysis uses statistical data on occupational morbidity, minor accidents, incidents, and breakdowns; control reports issued by labor and health inspectors; previous audits; and any other available information such as analyses performed by the prevention and protection service, the general manager, etc.

### *3.2. Establishing Working Tools*

Depending on the object of the audit and the conclusions of the preliminary analysis of occupational safety and health, the chief auditor determines the applicable reference system and the specific checklists that will be used. The reference system identifies the legislative regulations and occupational safety and health standards, as well as any other regulations with preventive effect, including the company internal ones, applicable to the object of the audit. Depending on the composition of the reference system and the conclusions of the preliminary analysis, the Chief Auditor decides, in principle, whether the specific checklists will be applied and, if so, which of them.

He can choose to: use the entire set of checklists; use only checklists specific to activities in which events such as accidents, incidents, damages were recorded; or supplementation with specially developed checklists.

### *3.3. Checklists Application*

The checklists application aims to complete them based on the analysis of occupational safety and health documentation and field investigations. For each requirement in a checklist, the audit team first analyzes the occupational safety and health documentation (decisions on internal regulations of the company, procedures, registers, reports, analyzes, etc., related to the audited object). Auditors must monitor whether they comply with legal requirements in terms of the issuer, content, updating, control, access, archiving, decommissioning, etc. Field investigation is carried out through two types of actions: direct investigation and interview.

The direct investigation consists of visiting workplaces and following up on how various occupational safety and health measures are applied. Where appropriate, if auditors have the necessary expertise and have metrologically verified equipment, measurements of the level of harmful risk factors may also be made.

The interview is the main source of information for people involved in occupational safety and health (chief engineer, department heads, workshop leaders, foremen, people responsible for carrying out preventive measures in the workplace, and workers and their representatives). In order to conduct the interviews in good conditions, the auditors can prepare helpful questionnaires, which allow them to obtain complete and correct answers on how the requirements entered in the checklist are met, the reasons for their non-compliance, and the measures that should be taken. For each nonconformity with the requirements found in the analysis of the documentation and in the investigation, a Nonconformity Identification and Analysis Sheet shall be completed.

If the results of this step demonstrate that there are non-conformities for which the preliminary analysis did not indicate the need to apply the specific checklist, or if it is considered that certain issues need to be considered in more detail, the Chief Auditor will determine. The score given for each requirement in the checklist is established in compliance with the rules in Table 3, in correlation with the severity of the non-compliance, assessed according to the foreseeable consequences for workers.

**Table 3.** Scoring rules.

| No. | Criteria for Penalizing the Maximum Score | Gravity | Penalizing (%) |
|---|---|---|---|
| 1. | Non-compliance that results in partial non-compliance with the requirement in the checklist, but cannot constitute a cause or a favorable factor for the occurrence of an accident and/or occupational disease. | low | 5 |
| 2. | Non-compliance that results in partial non-compliance and may be a factor in the occurrence of an accident and/or occupational disease | medium | 10 |
| 3. | Non-compliance that results in partial non-compliance with the requirement and may be the cause of occupational injury and/or illness | high | 20 |

### *3.4. Calculation of Quantitative Indicators to Assess Conformity*

#### 3.4.1. Overall Compliance with Occupational Safety and Health Regulations

The first operation consists in calculating, on the basis of the ratios between the score awarded and the maximum entered in the general checklist, the average compliance indices for each occupational safety and health requirement—$\overline{I_i}$ and for each category of requirements—$\overline{I}_{C_j}$:

$$\overline{I_i} = \frac{p_{a_i}}{p_{max_i}} \times 100, \quad (1)$$

where $p_{a_i}$ is the score given for each requirement, $p_{max_i}$—the maximum score that the requirement can receive "$i$", and $i$—current requirement number, $i = 1, \ldots, n$;

$$\overline{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{max_i}} \times 100, \quad (2)$$

where $j$ is the serial number of the requirements category, $j = 1, \ldots, 14$.

Both indices are included in the general checklist, column 4 and 5, respectively.

Next, the overall degree of compliance with occupational safety and health regulations ($G_{CF}$) is calculated as a weighted sum of the average compliance rates by category:

$$G_{CF} = \sum_{j=1}^{14} a_j \overline{I}_{C_j} \times 100, \quad (3)$$

where $a_j$ is the weighting coefficient by category of requirements, established according to the grid in Table 4.

The value calculated for the general degree of compliance is entered in the Assessment Sheet of the overall degree of compliance with occupational safety and health requirements.

In order to establish the coefficients, it was assumed that the four elements of the work system are equal in importance in terms of achieving safety and health at work, so the amounts of the coefficients assigned to the requirements concerning the elements of the work system must be equal. Considering the total sum of the coefficients equal to 1 and assigning in total to the two requirements with indirect impact on security—the organization of the prevention and protection activity and first aid—the value of 0.04, the remaining 0.96 was divided by 4, to each group of categories of requirements corresponding to the four elements of the work system, amounting to 0.24. For the differentiations between the requirements related to the same element, the importance that each has in the realization of the personnel protection was taken into account.

The correctness of the formula choice for the calculation of the global degree was verified by the experimental application for the four possible cases of two variants—weighted sum and arithmetic mean: case 1: all average indices have the value 0%; case 2: all indices have the value 100% (all provisions of the reference system are fully complied with); case 3: all indices have a value of 50% (for each requirement, at least two of the measures competing to meet it are not complied with); case 4: the indices have different values.

**Table 4.** Grid weighting grid for assessing overall compliance.

| No. | Requirement | The Element of the Work System to Which It Refers | Weighting Coefficient |
|---|---|---|---|
| 10.00 | Personnel selection and control | Worker | 0.08 |
| 11.00 | Occupational safety and health training and information | | 0.08 |
| 12.00 | Personal protective equipment | | 0.08 |
| | Total | | 0.24 |
| 9.00 | Establishing and allocating work tasks | Working task | 0.24 |
| | Total | | 0.24 |
| 1.00 | Buildings and rooms where work processes take place | Means of production and working environment | 0.07 |
| 2.00 | Stairs, steps, level differences, scaffolding, platforms | | 0.05 |
| 3.00 | Location of technical equipment | | 0.07 |
| 4.00 | Protection against mechanical risks | | 0.07 |
| 5.00 | Electrosecurity | | 0.07 |
| 6.00 | Loading, unloading, transport, handling and storage of materials | | 0.05 |
| 7.00 | Portable equipment and hand tools | | 0.03 |
| 8.00 | Fire prevention and control | | 0.07 |
| | Total | | 0.48 |
| 13.00 | Organization of prevention and protection activity | Work system | 0.03 |
| 14.00 | First aid in case of injury | Worker | 0.01 |
| | Total | | 1.00 |

In the first case, it is obvious that if all indices are 0, regardless of the type of calculation chosen, the final value will be 0. For the other situations, the data can be found in Table 5. As can be seen, the weighted amount reflects more clearly the existence of problems in achieving occupational safety and health, precisely the objective we pursue through audit. Thus, although the values taken into account are quite good in most situations, we could not say the same about the situation of occupational safety in general. The categories in which the index was 100% are "electrical safety", "selection and medical control of staff", but also "organization of prevention and protection" and "first aid", while they are solved to a very small extent. The requirements of the "location of technical equipment", "protection against mechanical risks", and "prevention and extinguishing of fires" certainly have a much greater impact than if, for example, the problem of organizing preventive work had not been resolved.

**Table 5.** Comparative situation of the use of the arithmetic mean and the weighted amount for the calculation of the overall degree of conformity.

| Category | Weighting Coefficient | Average Indices by Category | | | Weighted Average Indices | | |
|---|---|---|---|---|---|---|---|
| | | Case 2 | Case 3 | Case 4 | Case 2 | Case 3 | Case 4 |
| 1 | 0.07 | 100% | 50% | 50% | 0.07 | 0.035 | 0.035 |
| 2 | 0.05 | 100% | 50% | 30% | 0.05 | 0.025 | 0.015 |
| 3 | 0.07 | 100% | 50% | 20% | 0.07 | 0.035 | 0.014 |
| 4 | 0.07 | 100% | 50% | 10% | 0.07 | 0.035 | 0.007 |
| 5 | 0.07 | 100% | 50% | 100% | 0.07 | 0.035 | 0.07 |
| 6 | 0.05 | 100% | 50% | 20% | 0.05 | 0.025 | 0.01 |
| 7 | 0.03 | 100% | 50% | 40% | 0.03 | 0.015 | 0.012 |
| 8 | 0.07 | 100% | 50% | 30% | 0.07 | 0.035 | 0.021 |
| 9 | 0.24 | 100% | 50% | 60% | 0.24 | 0.12 | 0.144 |
| 10 | 0.08 | 100% | 50% | 100% | 0.08 | 0.04 | 0.08 |
| 11 | 0.08 | 100% | 50% | 70% | 0.08 | 0.04 | 0.056 |
| 12 | 0.08 | 100% | 50% | 80% | 0.08 | 0.04 | 0.064 |
| 13 | 0.03 | 100% | 50% | 100% | 0.03 | 0.015 | 0.03 |
| 14 | 0.01 | 100% | 50% | 100% | 0.01 | 0.005 | 0.071 |
| Global degree of compliance | | | | | Case 2 | Case 3 | Case 4 |
| weighted amount: $G_{CF} = \sum_{j=1}^{14} a_j \bar{I}_{C_j} \times 100$ | | | | | 100% | 50% | 56.8% |
| arithmetic average: $G_{CF} = \frac{\sum_{j=1}^{14} \bar{I}_{C_y}}{14} \times 100$ | | | | | 100% | 50% | 57.86% |

3.4.2. Degree of Compliance with Occupational Safety and Health Regulations for an Activity or a Risk of Occupational Injury and Illness

The degree of compliance with the requirements contained in the specific checklists is calculated in a similar way.

In the first step, the compliance index is determined for each requirement:

$$I_k = \frac{p_{a_k}}{p_{max_k}} \times 100, \quad (4)$$

where: $I_k$ is the compliance index for the requirement "$k$"; $p_{a_k}$—the score given for the requirement "$k$"; $p_{max_k}$—the maximum score given to the requirement "$k$".

Based on the average compliance indices, the degree of compliance $G_{CF}$ with the reference/reference system on the basis of which the checklist was drawn up is calculated:

$$G_{CF} = \frac{\sum_{k=1}^{m} \beta_k \times \overline{I}_k}{\sum_{k=1}^{m} \beta_k} \quad (5)$$

where $\beta_k$ is the weighting coefficient for the requirement "$k$", equal in value to the average conformity index.

*3.5. Overall Assessment of the Level of Safety and Health at Work*

Based on the overall degree of compliance with legal regulations, the level of occupational safety and health for the audited activity/activities or system is assessed. The assessment is based on a conventionally established grid. The overall assessment of the level of occupational safety and health can be made before the application of specific checklists, as a basis for identifying the activities, systems, or risks for which the detailed analysis is required.

*3.6. Synthesis of Non-Conformities and Establishment of Prevention Measures*

For each checklist, a nonconformity summary form is completed, based on the information from the nonconformity identification and analysis sheets. Nonconformities are recorded in descending order of their severity, based on pre-established criteria, according to Table 6.

**Table 6.** Degree of compliance—level of safety and health at work.

| Global Degree of Compliance | Security and Occupational Health Level | |
|---|---|---|
| $G_{CF}$ = 100% | Maximum | 6 |
| 100% > $G_{CF}$ > 80% | Very high | 5 |
| 80% > $G_{CF}$ > 70% | High | 4 |
| 70% > $G_{CF}$ > 60% | Medium | 3 |
| 60% > $G_{CF}$ > 50% | Low | 2 |
| $G_{CF}$ > 50% | Very low | 1 |

*3.7. Preparation of the Audit Report*

The audit report shall be prepared by the Chief Auditor, in accordance with its framework structure.

## 4. Procedure for Applying the Specialized Method for Assessing the Degree of Occupational Safety

Established mission: audit of occupational safety and health at the sites of the economic operator with activity in the field of hydrotechnical constructions.

The significant elements are summarized below.

### *4.1. General Information on the Object of the Audit*

The economic operator has been operating since 1950, having as object of activity the accomplishment of hydrotechnical (mainly) and hydropower works. Representative production processes consist of storage, management, energy recovery, and drainage, through various installation works, water management, riverbed creation and development works, shore protection works and slopes in areas where water flows can to cause the destruction or to affect the stability of the banks, works of recovery and greening of the occupied lands, etc. Additionally, related and collateral works are carried out for hydropower works, particularly civil and industrial constructions, car transport infrastructure and C.F., electricity supply installations, water and municipal, and finishing and landscaping.

Currently, the economic operator, which is fully privatized, has 11 branches in Romania and one in Germany and performs works in 30 counties of the country and in Bucharest, the branches having economic and financial autonomy, but not legal personality.

### *4.2. Establishing Working Tools*

Prior to the audit itself, it was established to apply only the "General checklist for occupational safety and health audit". For this purpose, the associated reference system was completed with: occupational safety and health manual, 2019, edition 2, revision 2; system procedures of the occupational safety and health management system; and own occupational safety and health instructions.

Depending on the problems found, it was later decided to detail certain aspects, using the following questionnaires: checklist for works performed at height and checklist for the use of electrically operated equipment.

### *4.3. Application of Checklists*

After completing the necessary phases—studying occupational safety and health documentation and field investigation—the related documents were completed.

### *4.4. Calculation of Quantitative Indicators to Assess Conformity*

- Global degree of compliance

The first operation consisted in calculating the average compliance indices for each occupational safety and health requirement—$\overline{I_i}$ (column 4) and for each category of requirements—$\overline{I}_{C_j}$, the values obtained by entering in column 5. Next, the overall degree of compliance with occupational safety and health regulations was calculated ($G_{CF}$):

$$G_{CF} = 0.08\ (80 + 93.33 + 86.67) + 0.07\ (89.26 + 86.67 + 84.29 + 98.18 + 100) + 0.24 \times 100 + 0.05\ (85.71 + 82.76) + 0.03\ (97.5 + 90) + 0.01 \times 100 = 91.94$$

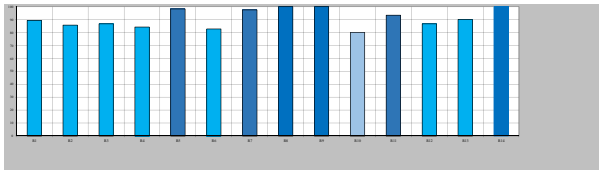
The value obtained was entered in the Assessment Sheet of the global degree of compliance with occupational safety and health requirements—Table 7.

- The specific degree of compliance was calculated for work performed at height and the use of electrically operated equipment.

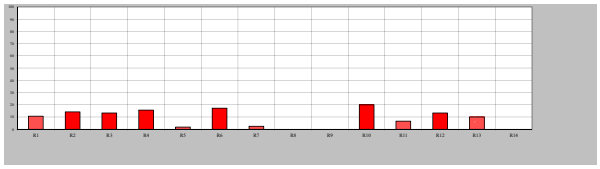
**Table 7.** Assessment sheet of the global degree of compliance with occupational safety and health requirements.

| | Categories of Requirements | Average Compliance Index by Category of Requirements (%):—$\bar{I}_{C_j}$ | | | | | |
|---|---|---|---|---|---|---|---|
| | | <50 | 51–60 | 61–70 | 71–80 | 81–90 | 91–100 |
| | | Unsatisfactory | Low | Medium | Good | Very Good | Excelent |
| 1.00 | Buildings and rooms where work processes take place | | | | | 89.26 | |
| 2.00 | Stairs, steps, level differences, scaffolding | | | | | 85.71 | |
| 3.00 | Location of machinery, machines, and installations | | | | | 86.67 | |
| 4.00 | Protection against mechanical risks | | | | | 84.29 | |
| 5.00 | electro | | | | | | 98.18 |
| 6.00 | Loading, unloading, transport, handling, and storage of materials | | | | | 82.76 | |
| 7.00 | Portable equipment and hand tools | | | | | | 97.50 |
| 8.00 | Prevention and firefighting | | | | | | 100 |
| 9.00 | Establishing and allocating work tasks | | | | | | 100 |
| 10.00 | Medical selection and control | | | | 80 | | |
| 11.00 | Occupational safety and health training and information | | | | | | 93.33 |
| 12.00 | Personal protective equipment | | | | | 86.67 | |
| 13.00 | Organization of prevention and protection activity | | | | | 90 | |
| 14.00 | First aid in case of injury | | | | | | 100 |

$$G_{CF} = \sum_{j=1}^{14} \alpha_j \bar{I}_{C_j} = 91.94\%$$



Histogram of the average values of the global/specific degree of conformity



Histogram of the average values of the global/specific degree of non-conformity

### *4.5. Overall Assessment of the Level of Safety and Health at Work*

Based on the overall degree of compliance with the calculated legal regulations, the level of occupational safety and health for the audited systems was assessed.

Applying the grid from Table 6, it was appreciated that the economic operator with activity in the field of hydrotechnical constructions has a very high level of security (level 5: 100% > $G_{CF}$ > 80%).

### *4.6. Synthesis of Nonconformities*

Synthesis of nonconformities was undertaken for each non-compliance found, on the basis of which the requirements and categories of problems were scored in a specific standardized document.

The safety risk was then determined on the basis of the Gumbel probability function associated with insecurity, and the accuracy of the various estimates of risk predictors was ensured by the use of the Kolmogorov–Smirnov statistical verification test, determining the confidence interval of the forecast results.

In order to determine the safety risk in the field of occupational safety and health, the probability law was adjusted to the sample of representative/maximum values (values associated with insecurity states) obtained from the 21 checklists used to audit the objectives analyzed within the economic operator and activity in the field of hydrotechnical constructions, according to Gumbel's theoretical law of probability (Table 8).

$$i = \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \\ 9 \\ 10 \\ 11 \\ 12 \\ 13 \\ 14 \\ 15 \\ 16 \\ 17 \\ 18 \\ 19 \\ 20 \\ 21 \end{bmatrix} \quad j = \begin{bmatrix} 1 \div 14 \\ 1 \div 20 \\ 1 \div 21 \\ 1 \div 7 \\ 1 \div 21 \\ 1 \div 16 \\ 1 \div 21 \\ 1 \div 22 \\ 1 \div 34 \\ 1 \div 27 \\ 1 \div 40 \\ 1 \div 18 \\ 1 \div 42 \\ 1 \div 39 \\ 1 \div 22 \\ 1 \div 16 \\ 1 \div 43 \\ 1 \div 34 \\ 1 \div 12 \\ 1 \div 12 \\ 1 \div 20 \end{bmatrix} \quad \mu_i = \begin{bmatrix} 8.9735 \\ 15.7500 \\ 18.8095 \\ 25.0000 \\ 29.2857 \\ 19.6875 \\ 25.7142 \\ 13.8636 \\ 28.3823 \\ 23.8235 \\ 25.2500 \\ 10.5000 \\ 15.4761 \\ 15.4700 \\ 15.4761 \\ 24.0625 \\ 15.4761 \\ 12.3529 \\ 11.6666 \\ 24.1666 \\ 18.5000 \end{bmatrix} \quad \sigma_i = \begin{bmatrix} 7.0473 \\ 22.6600 \\ 21.2664 \\ 25.0000 \\ 20.8138 \\ 21.1714 \\ 22.2084 \\ 15.9561 \\ 21.0238 \\ 21.6617 \\ 21.2419 \\ 21.1437 \\ 17.5932 \\ 17.5900 \\ 17.5932 \\ 19.0804 \\ 17.5932 \\ 13.0404 \\ 14.6680 \\ 23.5326 \\ 16.3111 \end{bmatrix} \quad x_{0i} = \begin{bmatrix} 5.8017 \\ 5.5477 \\ 9.2381 \\ 13.7482 \\ 19.918 \\ 10.1588 \\ 15.7189 \\ 6.68223 \\ 18.920 \\ 14.074 \\ 15.6896 \\ 0.9838 \\ 7.55796 \\ 7.55796 \\ 7.55796 \\ 15.47495 \\ 7.55796 \\ 6.48381 \\ 5.06501 \\ 13.57529 \\ 11.15884 \end{bmatrix} \quad a_i = \begin{bmatrix} 5.4950 \\ 17.675 \\ 16.352 \\ 19.4931 \\ 16.229 \\ 16.5079 \\ 17.3165 \\ 12.44146 \\ 16.392 \\ 16.890 \\ 16.5629 \\ 16.4863 \\ 13.71795 \\ 13.71795 \\ 13.71795 \\ 14.87752 \\ 13.71795 \\ 10.16799 \\ 11.71406 \\ 18.34907 \\ 12.71821 \end{bmatrix}$$

where $i = 1 \div 21$ represents the serial number of the checklist; $j$ represents the number of requirements contained in each of the 21 checklists; $x_{0i}$ represents the "module" corresponding to the synthetic sample of representative/maximum values related to checklist $i$; $a_i$ represents the "form parameter" corresponding to the synthetic sample of representative/maximum values related to the checklist $i$; $x_i^j$ represents the probability density function variable $f_i\left(x_i^j\right)$/distribution function $F_i\left(x_i^j\right)$, whose range of values is characterized by the representative/maximum values related to checklist $i$ and requirement $j$; $\mu$ represents the statistical average value corresponding to checklist $i$; and $\sigma$ represents the value of the standard deviation corresponding to checklist $i$.

**Table 8.** Value situation of the global specific degree of conformity/non-compliance.

| No | General And Specific Checklists For Verifying Occupational Safety And Health Requirements | Average Values of the Global Degree/Specific Compliance * (%) | Average Values of The Global/Specific Degree of Non-Compliance (%) |
|---|---|---|---|
| **0.** | **1.** | **2.** | **3.** |
| 1. | Checklist of Compliance With The Requirements of the Occupational Safety and Health Management System ($Cj$ = 14 Requirements Categories) | $G_{CF_1} = \sum_{j=1}^{14} \alpha_j \bar{I}_{Cj}$ 77.34 | $G_{NCF_1} = 100 - \sum_{j=1}^{14} \alpha_j \bar{I}_{Cj}$ 22.66 |
| 2. | General Checklist For Occupational Safety and Health Audit Specific to the Work System and Its Components ($Cj$ = 20 Categories Of Requirements) | $G_{CF_2} = \sum_{j=1}^{20} \alpha_j \bar{I}_{Cj}$ 91.93 | $G_{NCF_2} = 100 - \sum_{j=1}^{20} \alpha_j \bar{I}_{Cj}$ 8.07 |
| 3. | Checklist For Excavation Activities For Urban Works and Civil Constructions ($j$ = 21 Requirements) | $G_{CF_3} = \frac{\sum_{j=1}^{21} \beta_j \times \bar{I}_j}{\sum_{j=1}^{21} \beta_j}$ 86.49 | $G_{NCF_3} = 100 - \frac{\sum_{j=1}^{21} \beta_j \times \bar{I}_j}{\sum_{j=1}^{m} \beta_j}$ 13.51 |

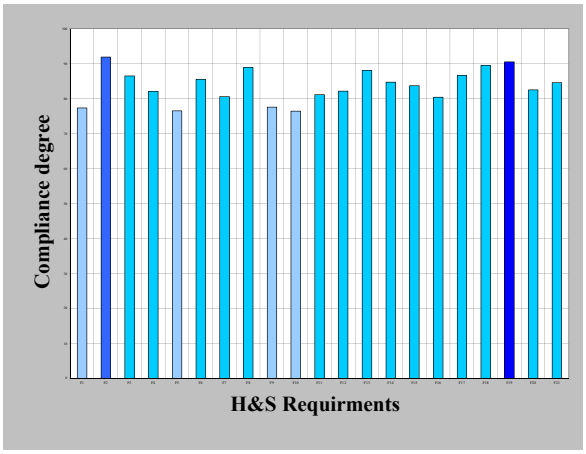
**Table 8.** *Cont.*

| No | General And Specific Checklists For Verifying Occupational Safety And Health Requirements | Average Values of the Global Degree/Specific Compliance * (%) | Average Values of The Global/Specific Degree of Non-Compliance (%) |
|---|---|---|---|
| **0.** | **1.** | **2.** | **3.** |
| 4. | Checklist For Concrete Preparation Activity ($j$ = 7 Requirements) | $G_{CF_4} = \frac{\sum_{j=1}^{7} \beta_j \times \bar{I}_j}{\sum_{j=1}^{7} \beta_j}$ 82.14 | $G_{NCF_4} = 100 - \frac{\sum_{j=1}^{7} \beta_j \times \bar{I}_j}{\sum_{j=1}^{7} \beta_j}$ 17.86 |
| 5. | Checklist For Masonry, Finishing, Painting and Painting In Construction ($j$ = 21 Requirements) | $G_{CF_5} = \frac{\sum_{j=1}^{21} \beta_j \times \bar{I}_j}{\sum_{j=1}^{21} \beta_j}$ 76.54 | $G_{NCF_5} = 100 - \frac{\sum_{j=1}^{21} \beta_j \times \bar{I}_j}{\sum_{j=1}^{21} \beta_j}$ 23.46 |
| 6. | Checklist For Metalwork ($j$ = 16 Requirements) | $G_{CF_6} = \frac{\sum_{j=1}^{16} \beta_j \times \bar{I}_j}{\sum_{j=1}^{16} \beta_j}$ 85.54 | $G_{NCF_6} = 100 - \frac{\sum_{j=1}^{16} \beta_j \times \bar{I}_j}{\sum_{j=1}^{16} \beta_j}$ 14.46 |
| 7. | Checklist For The Manufacture Of Doors, Windows, Prefabricated Houses, and Building Panels ($j$ = 21 Requirements) | $G_{CF_7} = \frac{\sum_{j=1}^{21} \beta_j \times \bar{I}_j}{\sum_{j=1}^{21} \beta_j}$ 80.60 | $G_{NCF_7} = 100 - \frac{\sum_{j=1}^{21} \beta_j \times \bar{I}_j}{\sum_{j=1}^{21} \beta_j}$ 19.40 |
| 8. | Checklist For Prefabricated Installation Works, Including Sewer Pipes ($j$ = 22 Requirements) | $G_{CF_8} = \frac{\sum_{j=1}^{22} \beta_j \times \bar{I}_j}{\sum_{j=1}^{22} \beta_j}$ 88.95 | $G_{NCF_8} = 100 - \frac{\sum_{j=1}^{22} \beta_j \times \bar{I}_j}{\sum_{j=1}^{22} \beta_j}$ 11.05 |
| 9. | Checklist For Painting Activities and Working With Toxic And/Or Hazardous Substances ($j$ = 34 Requirements) | $G_{CF_9} = \frac{\sum_{j=1}^{34} \beta_j \times \bar{I}_j}{\sum_{j=1}^{34} \beta_j}$ 77.60 | $G_{NCF_9} = 100 - \frac{\sum_{j=1}^{34} \beta_j \times \bar{I}_j}{\sum_{j=1}^{34} \beta_j}$ 22.40 |
| 10. | Checklist For Work Performed At Height ($j$ = 27 Requirements) | $G_{CF_{10}} = \frac{\sum_{j=1}^{27} \beta_j \times \bar{I}_j}{\sum_{j=1}^{27} \beta_j}$ 76.45 | $G_{NCF_{10}} = 100 - \frac{\sum_{j=1}^{27} \beta_j \times \bar{I}_j}{\sum_{j=1}^{27} \beta_j}$ 23.55 |
| 11. | Checklist For Internal Transport Activities ($j$ = 40 Requirements) | $G_{CF_{11}} = \frac{\sum_{j=1}^{40} \beta_j \times \bar{I}_j}{\sum_{j=1}^{40} \beta_j}$ 81.16 | $G_{NCF_{11}} = 100 - \frac{\sum_{j=1}^{40} \beta_j \times \bar{I}_j}{\sum_{j=1}^{40} \beta_j}$ 18.84 |
| 12. | Checklist For Handling, Carrying By Transport, and With Non-Mechanized Means and Storage of Materials ($j$ = 18 Requirements) | $G_{CF_{12}} = \frac{\sum_{j=1}^{18} \beta_j \times \bar{I}_j}{\sum_{j=1}^{18} \beta_j}$ 82.17 | $G_{NCF_{12}} = 100 - \frac{\sum_{j=1}^{18} \beta_j \times \bar{I}_j}{\sum_{j=1}^{18} \beta_j}$ 17.83 |
| 13. | Checklist For Welding Work ($j$ = 42 Requirements) | $G_{CF_{13}} = \frac{\sum_{j=1}^{42} \beta_j \times \bar{I}_j}{\sum_{j=1}^{42} \beta_j}$ 88.09 | $G_{NCF_{13}} = 100 - \frac{\sum_{j=1}^{42} \beta_j \times \bar{I}_j}{\sum_{j=1}^{42} \beta_j}$ 11.91 |
| 14. | Checklist For Explosive Shooting/Demolition Work ($j$ = 39 Requirements) | $G_{CF_{14}} = \frac{\sum_{j=1}^{39} \beta_j \times \bar{I}_j}{\sum_{j=1}^{39} \beta_j}$ 84.74 | $G_{NCF_{14}} = 100 - \frac{\sum_{j=1}^{39} \beta_j \times \bar{I}_j}{\sum_{j=1}^{39} \beta_j}$ 15.26 |
| 15. | Checklist For Storage Of Explosives and Their Transport Underground ($j$ = 22 Requirements) | $G_{CF_{15}} = \frac{\sum_{j=1}^{22} \beta_j \times \bar{I}_j}{\sum_{j=1}^{22} \beta_j}$ 83.73 | $G_{NCF_{15}} = 100 - \frac{\sum_{j=1}^{22} \beta_j \times \bar{I}_j}{\sum_{j=1}^{22} \beta_j}$ 16.27 |

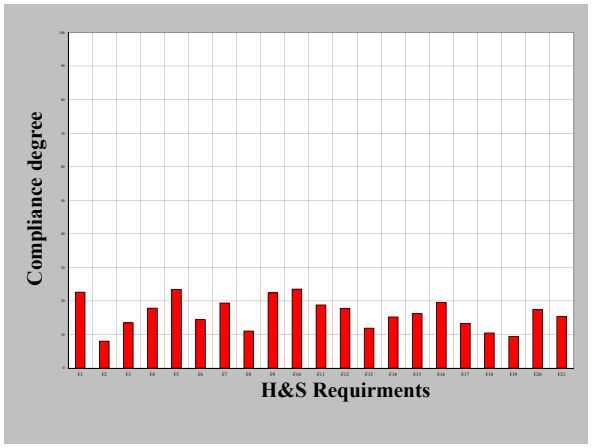
**Table 8.** *Cont.*

| No | General And Specific Checklists For Verifying Occupational Safety And Health Requirements | Average Values of the Global Degree/Specific Compliance * (%) | Average Values of The Global/Specific Degree of Non-Compliance (%) |
|---|---|---|---|
| 0. | 1. | 2. | 3. |
| 16. | Checklist For Road Works ($j$ = 16 Requirements) | $G_{CF_{16}} = \frac{\sum_{j=1}^{16} \beta_j \times \bar{I}_j}{\sum_{j=1}^{16} \beta_j}$ 80.43 | $G_{NCF_{16}} = 100 - \frac{\sum_{j=1}^{16} \beta_j \times \bar{I}_j}{\sum_{j=1}^{16} \beta_j}$ 19.57 |
| 17. | Checklist For Underground Mining ($j$ = 43 Requirements) | $G_{CF_{17}} = \frac{\sum_{j=1}^{43} \beta_j \times \bar{I}_j}{\sum_{j=1}^{43} \beta_j}$ 86.64 | $G_{NCF_{17}} = 100 - \frac{\sum_{j=1}^{43} \beta_j \times \bar{I}_j}{\sum_{j=1}^{43} \beta_j}$ 13.36 |
| 18. | Checklist For Operation Of Lifting Installations ($j$ = 34 Requirements) | $G_{CF_{18}} = \frac{\sum_{j=1}^{34} \beta_j \times \bar{I}_j}{\sum_{j=1}^{34} \beta_j}$ 89.53 | $G_{NCF_{18}} = 100 - \frac{\sum_{j=1}^{34} \beta_j \times \bar{I}_j}{\sum_{j=1}^{34} \beta_j}$ 10.47 |
| 19. | Checklist For the Use of Electrically Operated Equipment ($j$ = 12 Requirements) | $G_{CF_{19}} = \frac{\sum_{j=1}^{12} \beta_j \times \bar{I}_j}{\sum_{j=1}^{12} \beta_j}$ 90.56 | $G_{NCF_{19}} = 100 - \frac{\sum_{j=1}^{12} \beta_j \times \bar{I}_j}{\sum_{j=1}^{12} \beta_j}$ 9.44 |
| 20. | Vehicle Maintenance and Repair Checklist ($j$ = 12 Requirements) | $G_{CF_{20}} = \frac{\sum_{j=1}^{12} \beta_j \times \bar{I}_j}{\sum_{j=1}^{12} \beta_j}$ 82.52 | $G_{NCF_{20}} = 100 - \frac{\sum_{j=1}^{12} \beta_j \times \bar{I}_j}{\sum_{j=1}^{12} \beta_j}$ 17.48 |
| 21. | Checklist For Activities Carried Out In PECO Warehouses And Stations ($j$ = 20 Requirements) | $G_{CF_{21}} = \frac{\sum_{j=1}^{20} \beta_j \times \bar{I}_j}{\sum_{j=1}^{20} \beta_j}$ 84.60 | $G_{NCF_{21}} = 100 - \frac{\sum_{j=1}^{20} \beta_j \times \bar{I}_j}{\sum_{j=1}^{20} \beta_j}$ 15.40 |

* $\alpha_j$ represents the weighting coefficient of the $Cj$ requirements category; $I_{cj}$ represents the compliance index of the $Cj$ requirements category; $\beta_j$ represents the weighting coefficient of the $j$ requirement; $I_j$- represents the compliance index of the $j$ requirement




Histogram of the Average Values of the Global/Specific Degree of Conformity




Histogram of the Average Values of the Global/Specific Degree of Non-Conformity

The adjustment of the synthetic sample was made based on the calculation of the mean statistical parameters ($\mu$) and the standard deviation ($\sigma$) starting from the synthetic sample of representative/maximum values, in order to determine the statistical values associated with the mode $x_0$ and the shape parameter "$a$" that characterizes Gumbel's law of theoretical probability.

Next, we proceeded to evaluate the determination of the synthetic sample used for adjustment was performed, for each of the 21 checklists, in the following four steps. (a) Fixing the time unit: this time unit T served as a basis for defining the characteristic of the undesirable event (establishing the periodicity of the audit's occupational safety and health monthly, quarterly, half-yearly, or annually). (b) Distribution of the initial sample: the initial sample was segmented into t periods of T time units (two periods of six months); (c) in each of the two periods, the values of the observed characteristic were determined; (d) the representative/maximum values (values associated with insecurity states) were selected and regrouped in the form of a synthetic sample. The uncertainty of the results obtained by using the Kolmogorov–Smirnov statistical adequacy test to validate the quality of the adjustment of the synthetic sample of representative/maximum values to the Gumbel theoretical distribution law for a risk threshold $\alpha = 0.05$. Considering the 21 samples of size $j$ corresponding to the 21 checklists, each arranged in ascending order, for which $Fi = 1 \div 21$ ($j$) represents the empirical frequency regarding the data quantifying the non-compliance with the requirements $j$, and $F(xj)$ the frequency with which these data were not exceeded, calculated on the basis of the theoretical law, the following difference was calculated for each sample:

$$\Delta j = |F(xj) - F_{i=1\div 21}(j)|$$
$$k = \underset{j}{max}\Delta_j$$

Depending on the results of parameter $K$, the following assessments can be made:

1. If $K = 0$, then there is a perfect fit, which is not recommended to be given full confidence, because in theory it is unlikely.
2. If $K > 0$, then the two distributions are different. The $K$ value is then compared with the Kolmogorov function quantile, and the following is concluded: if $K < K_a(j)$, variations between distributions are due to chance and the assumption of adequacy is not to be rejected at the risk threshold, so the adjustment is accepted; if $K > K_a(j)$, the hypothesis of good adequacy between the sample and the theoretical law must be rejected.

Determination of $k_a^i(j)$ was performed by direct calculation using the approximate formula deduced from Kolmogorov's function:

$$k_a^i(j) = \sqrt{\frac{\ln(2,\alpha)}{2(j+1)}} \quad (6)$$

For the determination of the confidence intervals, the results regarding the estimation of the confidence interval limits at 70% and 95% proposed by *j.* Bernier were used based on the statistics that measure the deviation between the quantile of a certain order and its estimation starting from a sample size date.

Below are summarized the results regarding the state of safety and health at work, obtained at the analyzed objectives within the economic operator with activity in the field of hydrotechnical constructions.

The adjustment of the samples of values (associated with the states of insecurity) corresponding to the 21 checklists specific to the OSH audit to the Gumbel theoretical distribution law was considered acceptable for the risk threshold. $\alpha = 0.05$, as long as the condition is met.$K_{\mathrm{MAX}i} < K_{0.05}^i(j)$.

$$K_{MAXi} = \begin{bmatrix} 0.1715 \\ 0.3681 \\ 0.2792 \\ 0.2328 \\ 0.2610 \\ 0.1904 \\ 0.2308 \\ 0.1630 \\ 0.1716 \\ 0.2610 \\ 0.1642 \\ 0.3071 \\ 0.1702 \\ 0.1823 \\ 0.1830 \\ 0.1320 \\ 0.1702 \\ 0.1670 \\ 0.1683 \\ 0.2506 \\ 0.1400 \end{bmatrix} \quad K^i_{0.05}(j) = \begin{bmatrix} 0.2895 \\ 0.2890 \\ 0.3290 \\ 0.2895 \\ 0.2831 \\ 0.0556 \\ 0.2890 \\ 0.2120 \\ 0.3115 \\ 0.2071 \\ 0.2071 \\ 0.2071 \\ 0.3293 \\ 0.2071 \\ 0.2295 \\ 0.3766 \\ 0.3766 \\ 0.2963 \\ 0.3766 \\ 0.3766 \\ 0.2963 \end{bmatrix}$$

where $K_{MAXi}$ represents the maximum value of the discriminant determined as the difference in absolute value between the frequency of not exceeding the data that quantifies in value the non-compliance with the requirements $j$ of the checklist $i$ and the empirical frequency related to these data, respectively $K_{MAXi} = \max_j \Delta_j$, $\Delta j = |F(xj) - F_{i=1\div21}(j)|$; $K^i_{0.05}(j)$ represents the value of the discriminant deduced from the approximate formula of the Kolmogorov function.

1. Based on the results obtained from the occupational safety and health audit, the following aspects found at the level of the analyzed entities can be highlighted: implementation and maintenance of an occupational safety and health management system; management's concern for the functioning and improvement of the occupational safety and health management system; the existence of a complete system of documents and records adequate to the legal and internal requirements regarding the achievement of safety and health at work; improving occupational hygiene conditions; training of first aid workers; and concern for health monitoring; equipping workers with personal protective equipment, purchased only from accredited companies. There are also shortcomings at the level of the entities analyzed in terms of red low knowledge of workers on appropriate behavior in terms of occupational health insurance:
2. Empirical determination of generalized probability density, $f_i\left(x_i^j\right)$ and the generalized distribution function, $F_i\left(x_i^j\right)$:

$$f\left(x_i^j\right) = \frac{1}{a_i} e \frac{x_i^j - x_{0i}}{a_i} e^{-e^{\frac{x_i^j - x_{0i}}{ai}}} \tag{7}$$

$$F_i\left(x_i^j\right) = e \frac{x_i^j - x_{0i}}{a_i} \tag{8}$$

3. Determining the objective medium security risk, $\overline{R}_i\left(x_i^j\right)$:

$$\overline{R}_i\left(x_i^j\right) = \int x_i^j e^{-e^{\frac{-x_i^j - x_{0i}}{a_i}}} dx_i^j \tag{9}$$

$$\overline{R}_i\left(x_i^j\right) = \Sigma x_i^j e^{-e^{\frac{-x_i^j - x_{0i}}{a_i}}} \tag{10}$$

4. Determining the objective average vulnerability, $\overline{R}_i\left(x_i^j\right)$:

$$\overline{G}_i\left(x_i^j\right) = \frac{1}{a_i}\int x_i^j e^{\frac{-x_i^j - x_{0i}}{a_i}} e^{-e^{\frac{-x_i^j - x_{0i}}{a_i}}} dx_i^j \text{ or } \overline{G}_i\left(x_i^j\right) = \frac{1}{a_i}\Sigma x_i^j e^{\frac{-x_i^j - x_{0i}}{a_i}} e^{-e^{\frac{-x_i^j - x_{0i}}{a_i}}} \tag{11}$$

Selecting the values of the parameters for $i$ = 1, 10, and 19 related to the checklists taken into analysis (general checklist, checklist for work performed at height and checklist for the use of electrically operated equipment) we obtain:

The following results were obtained for the three checklists studied:

$$i = \begin{bmatrix} 1 \\ 10 \\ 19 \end{bmatrix};\ j = \begin{bmatrix} 1 \div 14 \\ 1 \div 27 \\ 1 \div 12 \end{bmatrix};\ \mu_{i=} \begin{bmatrix} 8.9735 \\ 23.8235 \\ 11.6666 \end{bmatrix};\ \sigma_i = \begin{bmatrix} 7.0430 \\ 21.6617 \\ 14.6680 \end{bmatrix};\ x_{0i} = \begin{bmatrix} 5.8017 \\ 14.0740 \\ 15.06501 \end{bmatrix};\ a_i = \begin{bmatrix} 5.49500 \\ 16.8900 \\ 11.71406 \end{bmatrix}$$

where: $i$ = 1, 10, and 19 represents the serial number of the checklist; $j$ represents the number of requirements contained in each of the three checklists; $x_{0i}$ represents the "module" corresponding to the synthetic sample of representative/maximum values related to checklist $i$; $a_i$ represents the "shape parameter" corresponding to the synthetic sample of representative/maximum values related to checklist $i$, $x_i^j$:represents the variable of the probability density function $f_i\left(x_i^j\right)$: /distribution function $F_i\left(x_i^j\right)$, whose range of values is characterized by the representative/maximum values related to the checklist $i$ and the requirement $j$; $\mu$ represents the statistical average value corresponding to checklist $i$, and represents the value of the standard deviation corresponding to the checklist $i$.

5. Assessing the uncertainty of the results obtained using the Kolmogorov–Smirnov statistical adequacy test:

The adjustment of the samples of values (associated with insecurity states) corresponding to the 21 checklists specific to the OSH audit to the Gumbel theoretical distribution law was considered acceptable for the risk threshold $\alpha$ = 0.05, as long as the condition $K_{maxi} < K_{0.05}^i(j)$ was met.

Selecting the maximum values of the discriminant for $i$ = 1, 10, and 19 obtains:

$$K_{maxi} = \begin{bmatrix} 0.1715 \\ 0.2610 \\ 0.1683 \end{bmatrix};\ K_{0.05}^i(j) = \begin{bmatrix} 0.2895 \\ 0.2071 \\ 0.3766 \end{bmatrix}$$

where $K_{maxi}$ represents the maximum value of the discriminant determined as the difference in absolute value between the frequency of non-exceedance of the data, which quantifies in value the non-compliance with the requirements $j$ of the checklist $i$, and the empirical frequency related to these data, respectively $K_{maxi} = \underset{y}{max}\Delta_j$, $\Delta j = |F(xj) - F_{i=1\div21}(j)|$, and $K_{0.05}^i(j)$ represents the value of the discriminant deduced from the approximate formula of the Kolmogorov function (Table 9).

**Table 9.** Matrix for estimating and assessing the security risk.

| | |
|---|---|
| **Risk assessment grid** | 0.00 ÷ 0.33 (High)<br>0.33 ÷ 0.66 (Medium)<br>0.66 ÷ 1.00 (Low) |

6. Various estimates:

- Determining the value of exceeding a state of insecurity to which a probability of a certain order corresponds (ex. $P = 10^{-1}$):$x_p = 10.0614–7.1673 \times \ln(–\ln(1–10^{-1})) = 26.19$ $P(x > 26.19) = 1–F(26.19) = 0.11$ (a probability of the order $10^{-1}$)
- Determination of the 95% confidence interval, according to J. Bernier. Ex. For p = 0.1; n = 21; $\alpha = 0.05$; $x_p = 26.19$; $T2(0.1;21;0.05) = -0.75$; $T_1 x\sigma = -6.8940$; $T1(0.1;21;0.05) = 1.03$; $T_2 x\sigma = 9.4678$; $i_{0.95} = [19.29;35.65]$;
- Determining the probability of exceeding a value associated with a state of insecurity: $P(x > 16.27) = 1–F(16.27) = 1–0.6566 = 0.3433$ (Medium level security risk, according to the risk assessment grid).

### *4.7. Audit Report*

The audit report is shown in Table 10.

**Table 10.** Synthesis of data and information specific to the audit report.

| **Economic Operator with Activity in the Field of Hydrotechnical Constructions** | **Audit Report—Extras** |
|---|---|
| Date: September 1, 2019 | Chief Auditor: dr.habil.eng. Gabriel Vasilescu |
| 1. Context and Objectives of the Mission | Background: The mission was established in the context of the audit process of the economic operator with activity in the field of hydro-constructions. |
| | The main objective of the mission: to audit occupational safety and health for the economic operator operating in the field of hydro-construction.<br>During the audit, the objective was to assess compliance with the applicable occupational safety and health regulations for two activities—work performed at height and the use of electrically operated equipment—in which the application of the general checklist led to the assumption that there may be significant non-compliances. |
| | Mission requirement:<br>The validity of the applied method requires the verification of several elements:<br>- whether the checklists are sufficiently concrete and, at the same time, exhaustive to cover all aspects relevant to the effectiveness of occupational safety and health;<br>- if the calculation method of the quantitative indicators leads to a value that reflects as much as possible the reality.<br>The existence of a previous audit of the economic operator operating in the field of hydro-construction provides an objective basis for comparison to answer these questions.<br>Mission area: the entire activity carried out in the construction sites related to the economic operator.<br>The audit team consisted of one person—dr.habil.eng. Gabriel Vasilescu, as chief auditor. During the mission, site managers were consulted, as well as workers from various jobs. |

**Table 10.** *Cont.*

| Economic Operator with Activity in the Field of Hydrotechnical Constructions | Audit Report—Extras |
| --- | --- |
| 2. Audited Organizational Entities | The sites related to the audited economic operator are representative for the hydro-construction activities carried out. |
| 3. Audit Synthesis | Overall, the economic operator with activity in the field of hydro-construction has a very good situation of safety and health at work, the overall degree of compliance calculated being 91.94%.<br>The following positive aspects are highlighted:<br>- implementing and maintaining an occupational safety and health management system;<br>- management's concern for the functioning and improvement of the occupational safety and health management system;<br>- the existence of a complete system of documents and records and adequate to the legal and internal requirements regarding the achievement of safety and health at work;<br>- general improvement of working conditions;<br>- improving occupational hygiene conditions by restoring toilets and sanitizing living rooms;<br>- training of workers for first aid;<br>- concern for health monitoring; and<br>- equipping workers with personal protective equipment, purchased only from accredited companies.<br>There are also some negative aspects, among which the most significant are:<br>- the absence of clear responsibilities for workers responsible for safety and health at work in connection with the maintenance of work equipment;<br>- insufficient training of workers on issues specific to working at height;<br>- low knowledge of workers on appropriate behavior in terms of health insurance at work;<br>- inadequate organization of the registration and periodic verification of electrically operated mobile equipment;<br>- insufficient security measures in relation to workers of other organizations carrying out various activities within the economic operator. |
| 4. Performance of the Mission | Tools: The proposed method of auditing occupational safety and health in the hydro-construction activity was used to carry out the mission. Both types of questionnaires were applied—the general checklist and two specific checklists, as well as the interview method and field visits (Tables 11 and 12).<br>Interviewed positions: director for production quality, occupational safety and health inspector, site managers, and heads of functional departments (mechanization office, supply service). |
| 5. Findings and Recommendations | During the mission, a number of 12 non-conformities were identified; for each one, a recommendation was formulated. |

**Table 11.** The general checklist with the quantitative results of the occupational safety and health audit.

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 1.00 | BUILDINGS AND ROOMS | 2560 | 2285 [1] | x [2] | 89.26 |
| 1.01 | The buildings are not damaged or otherwise repaired. | 40 | 35 | 87.50 | x |
| 1.02 | Adequate drinking water supply is ensured. | 100 | 80 | 80 | x |
| 1.03 | Sewerage systems for the collection and transport of industrial wastewater with toxicity characteristics shall be provided with installations to prevent the ingress of gas and aerosol emissions into the premises of the enterprise or in neighboring public spaces. | 100 | 90 | 90 | x |
| 1.04 | There are used wastewater detoxification facilities that can generate toxic, flammable, or explosive gases. | 100 | 100 | 100 | x |
| 1.05 | The dimensions of the work rooms, the volume, and the work area of a worker are appropriate. | 80 | 70 | 87.50 | x |
| 1.06 | The surfaces of the work rooms allow the storage of materials to be processed, auxiliary, etc., and processed materials, without affecting the movement of personnel and means of transport. | 80 | 70 | 87.50 | x |
| 1.07 | The maximum permissible floor load is known, displayed, and observed, as well as the resistance to dynamic stresses and vibrations. | 100 | 90 | 90 | x |
| 1.08 | The floors are suitable for the technological process.<br>Flat, smooth, non-slip surface.<br>Wear-resistant material and mechanical stress.<br>Non-combustible and non-sparking material in rooms where there is a risk of explosion.<br>Material resistant to the action of chemical agents, water repellent, poor heat conductor, sound insulation, and vibro-insulation, depending on the risk factors specific to the work processes in the rooms.<br>The floors are kept clean and well maintained. | 300<br>40<br>40<br>100<br>80<br>40 | 260 | 86.67 | x |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 1.09 | Moving and parking indoors is safe. | 300 | 240 | 80 | x |
| | The number and size of access and escape routes, as well as the arrangement of workspaces, allow the safe movement of staff, as well as the rapid evacuation in case of danger. | 100 | | | |
| | The emergency evacuation and intervention plan is drawn up, displayed, and known. | 100 | | | |
| | The access, escape, and storage areas are properly marked. | 100 | | | |
| 1.10 | Proper lighting is provided. | 200 | 200 | 100 | x |
| | Natural lighting is completed with artificial lighting systems. | 100 | | | |
| | There is emergency and safety lighting. | 100 | | | |
| 1.11 | The microclimate conditions are appropriate; ventilation and natural and artificial ventilation are provided. | 80 | 80 | 100 | x |
| 1.12 | The workplace atmosphere does not present chemical / explosion hazards. | 600 | 600 | 100 | x |
| | The average concentrations of toxic substances and dust in the workplace atmosphere are within limits. | | | | |
| | There is the necessary equipment and installations for the detection, measurement, and signaling of explosive gas concentrations. | 100 | | | |
| | There are dust collection facilities at workplaces. | 100 | | | |
| | Processes for filtering, capturing, or depositing dust particles resulting from the technological process are used. | 100 | | | |
| | Installations, pipes, vessels, etc., through which substances producing harmful, explosive or explosive vapors, gases, or dusts are circulated or transported are appropriately marked. | 100 | | | |
| | All installations which ensure that the level of concentration of toxic substances and dusts is maintained within the permitted limits are properly maintained and operated | 100 | | | |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 1.13 | Noise exposure requirements are met. | 240 | 180 | 75 | x |
| | The level of exposure to noise at work is within the maximum allowed limit. | 80 | | | |
| | Sources that generate noise above the maximum permissible limit are housed and soundproofed. | 80 | | | |
| | The means of collective noise protection are in place and maintained in good condition. | 80 | | | |
| 1.14 | Requirements for vibration exposure are met. | 160 | 120 | 75 | x |
| | The vibration level is maintained at the workplace below the maximum permitted limits. | 80 | | | |
| | Sources which generate vibrations above the maximum permissible limits are fitted with sound-insulating housings and other means of collective protection, maintained in a suitable condition. | 80 | | | |
| 1.15 | Conditions for occupational hygiene are ensured. | 80 | 70 | 87,50 | x |
| | There are appropriate arrangements for ensuring individual hygiene (locker rooms, social groups, etc.). | 40 | | | |
| | The aim is to comply with the rules of individual hygiene. | 40 | | | |
| 2.00 | STAIRS, STEPS, LEVEL DIFFERENCES, Scaffolding, PLATFORMS | 280 | 240 | x | 85.71 |
| 2.01 | Stairs and level differences are provided with handrails. | 100 | 80 | 80 | x |
| 2.02 | Fixed and escalators are checked periodically. | 80 | 80 | 100 | x |
| 2.03 | Pits, canals, platforms, or openings in the wall or floors are provided with guards to prevent people and vehicles from falling and are properly signposted. | 100 | 80 | 80 | x |
| 3.00 | LOCATION OF TECHNICAL EQUIPMENT | 300 | 260 | x | 86.67 |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 3.01 | The technical equipment is located in such a way as to allow the normal movement of personnel and internal means of transport. | 100 | 100 | 100 | x |
| 3.02 | Hazardous areas of technical equipment are properly isolated and signaled. | 100 | 80 | 80 | x |
| 3.03 | Equipment which has elements placed at height, to which staff must have access, shall be provided with access stairs and platforms with sturdy railings. | 100 | 80 | 80 | x |
| 4.00 | PROTECTION AGAINST MECHANICAL RISKS | 700 | 590 | x | 84.29 |
| 4.01 | All moving machine parts in the work area are completely covered and fenced or are provided with guards. | 100 | 80 | 80 | x |
| 4.02 | All installations, equipment, machinery, and means of transport are fitted with locking/locking systems or other means of protection, which are in good working order. | 100 | 60 | 60 | x |
| 4.03 | There are and are written procedures for the operation of technical equipment under normal conditions and for interventions in case of danger. | 100 | 90 | 90 | x |
| 4.04 | The pressure equipment complies with the regulations and is properly operated and maintained. | 100 | 80 | 80 | x |
| 4.05 | The circulation of internal means of transport is regulated by traffic indicators; hazardous areas are properly signposted. | 100 | 100 | 100 | x |
| 4.06 | The means of transport are equipped with functional braking, safety, and signaling devices. | 100 | 80 | 80 | x |
| 4.07 | The means of transport and lifting are provided with stroke and load limiters and are operated in accordance with the regulations. | 100 | 100 | 100 | x |
| 5.00 | ELECTROSECURITY | 1100 | 1080 | x | 98.18 |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 5.01 | Working stresses, accidental contact, and step stresses have values that are within the legal limits. | 100 | 100 | 100 | x |
| 5.02 | All current conductors, which are part of the working current circuits, are inaccessible to a direct accidental touch. | 100 | 80 | 80 | x |
| 5.03 | Additional insulation protection against direct contact is provided, as well as insulation of workplaces. | 100 | 100 | 100 | x |
| 5.04 | Installations or places where electrical equipment exists or is operated are equipped with electrical insulating means and are adequately signaled. | 100 | 100 | 100 | x |
| 5.05 | Personnel used for the execution, operation, maintenance, and repair of electrical equipment are authorized. | 100 | 100 | 100 | x |
| 5.06 | At high voltage installations, there are and are in operation mechanical or electrical locks, which do not allow the opening of the housings and the removal of the protective fences only after the de-energization. | 100 | 100 | 100 | x |
| 5.07 | Protection against overload and fault currents is ensured. | 100 | 100 | 100 | x |
| 5.08 | Checks on installations and means of protection against the danger of electric shock, as well as on insulation resistances, are carried out periodically. | 100 | 100 | 100 | x |
| 5.09 | Works where there is a risk of electric shock are performed under the supervision of an authorized driver. | 100 | 100 | 100 | x |
| 5.10 | Measures to protect against indirect damage are applied. | 100 | 100 | 100 | x |
| 5.11 | Explosion protection is provided. | 100 | 100 | 100 | x |
| 6.00 | LOADING, UNLOADING, TRANSPORTATION, HANDLING, AND STORAGE MATERIALS | 580 | 480 | x | 82.76 |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 6.01 | Physical effort requirements are met for manual transport. | 80 | 60 | 75 | x |
| 6.02 | Loads on means of transport are insured against uncontrolled movement, overturning, or falling. | 100 | 80 | 80 | x |
| 6.03 | The tilting platforms of the means of transport are equipped with fastening devices in good working order. | 100 | 80 | 80 | x |
| 6.04 | When loading, unloading, transporting and storing flammable, toxic, caustic, corrosive products, etc. the legal requirements are observed. | 100 | 100 | 100 | x |
| 6.05 | Materials stacked in warehouses and workplaces do not exceed the maximum permissible floor load and the stacks are stable. | 100 | 100 | 100 | x |
| 6.06 | Areas permanently intended for loading—unloading and storage operations are properly arranged and maintained. | 100 | 60 | 60 | x |
| 7.00 | PORTABLE EQUIPMENT AND HAND TOOLS | 200 | 195 | x | 97.50 |
| 7.01 | Portable equipment and electrically or pneumatically operated hand tools are equipped with devices for fixing the tool, to prevent uncontrolled operation, with guards against direct contact of the active elements, with devices for measuring and regulating the flow pressure. | 100 | 100 | 100 | x |
| 7.02 | Portable equipment and hand tools are checked. | 100 | 95 | 95 | x |
| 8.00 | PREVENTION AND FIREFIGHTING | 300 | 300 | x | 100 |
| 8.01 | There is a plan of action on how to act in case of fire, and the personnel designated to implement it are trained and trained. | 100 | 100 | 100 | x |
| 8.02 | There is adequate equipment, machinery, materials, and protective equipment necessary for extinguishing fires. | 100 | 100 | 100 | x |
| 8.03 | There are alarm systems in case of fires. | 100 | 100 | 100 | x |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 9.00 | DETERMINATION AND DISTRIBUTION OF WORK LOADS | 300 | 300 | x | 100 |
| 9.01 | The staff is assigned to jobs in relation to the results of the medical examination at employment and the regular ones. | 100 | 100 | 100 | x |
| 9.02 | Professional requirements correspond to the physical, physiological, and psychological abilities of employees. | 100 | 100 | 100 | x |
| 9.03 | The personnel used is authorized according to the law. | 100 | 100 | 100 | x |
| 10.00 | PERSONNEL SELECTION AND CONTROL | 300 | 240 | x | 80 |
| 10.01 | Medical examination of the staff is ensured. | 100 | 80 | 80 | x |
| 10.02 | There is the necessary equipment for first aid. | 100 | 100 | 100 | x |
| 10.03 | The health status of workers is constantly monitored. | 100 | 60 | 60 | x |
| 11.00 | TRAINING AND INFORMATION | 300 | 280 | x | 93.33 |
| 11.01 | Occupational safety and health training is provided. | 100 | 80 | 80 | x |
| 11.02 | The training and improvement of the personnel with attributions regarding safety and health at work is carried out. | 100 | 100 | 100 | x |
| 11.03 | Workers are kept informed of all occupational safety and health situations and changes. | 100 | 100 | 100 | x |
| 12.00 | PERSONAL PROTECTIVE EQUIPMENT | 300 | 260 | x | 86.67 |
| 12.01 | There is an internal list of equipment with personal protective equipment. | 100 | 100 | 100 | x |
| 12.02 | Personal protective equipment is granted and is of the quality and quantity corresponding to the risk factors existing in the work processes. | 100 | 80 | 100 | x |
| 12.03 | The equipment is checked, maintained, and cleaned (detoxified). | 100 | 80 | 95 | x |

**Table 11.** *Cont.*

| No. | Category<br>Occupational Safety and Health Requirement | Maximum Score ($p_{\max_i}$) | Score Awarded ($p_{a_i}$) | Average Compliance Index (%) | |
|---|---|---|---|---|---|
| | | | | For "*I*" Requirement $\bar{I}_i = \frac{p_{a_i}}{p_{\max_i}} \times 100$ | For the "*J*" Category $\bar{I}_{C_j} = \frac{\sum_{i=1}^{n} p_{a_i}}{\sum_{i=1}^{n} p_{\max_i}} \times 100$ |
| 0 | 1 | 2 | 3 | 4 | 5 |
| 13.00 | ORGANIZATION OF PREVENTION AND PROTECTION ACTIVITY | 100 | 90 | x | 90 |
| 13.01 | There is an occupational safety and health department. | 20 | 20 | 100 | x |
| 13.02 | Tasks on occupational safety and health are set out in the job description. | 20 | 15 | 75 | x |
| 13.03 | The risks of occupational injury and illness were assessed. | 20 | 15 | 20 | x |
| 13.04 | There is an annual work safety program, and it is being implemented. | 20 | 20 | 20 | x |
| 13.05 | The registration, communication, research, and record of work accidents and occupational diseases are organized and carried out. | 10 | 10 | 10 | x |
| 13.06 | An occupational safety and health committee is organized; staff are trained and consulted on specific issues. | 10 | 10 | 10 | x |
| 14.00 | FIRST AID IN CASE OF INJURY | 100 | 100 | x | 100 |
| 14.01 | There are post and first aid kits, properly equipped. | 30 | 30 | 100 | x |
| 14.02 | There are written provisions for first aiders; people are properly trained. | 30 | 30 | 100 | x |
| 14.03 | All workers are trained in specific first aid measures. | 10 | 10 | 100 | x |
| 14.04 | There is a station/rescue team, adequately equipped; the related staff is well trained and trained. | 30 | 30 | 100 | x |

[1] (In the case of questions irrelevant to the audited activities, the maximum score is automatically awarded.). [2] x-not applicable.

**Table 12.** Checklist with quantitative audit results specific to works performed at height.

| No. | Requirement | Maximum Score $p_{\max_K}$ | Score Awarded $p_{a_K}$ | Average Compliance Index (%) $\bar{I}_k = \frac{p_{\max_k}}{p_{a_k}} \times 100$ |
|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 |
| 1 | Access to and from workplaces located at height are ensured against the fall of workers | 100 | 80 | 80 |
| 2 | Execution of work at height is carried out under the direct supervision of the work point manager or the work manager | 100 | 100 | 100 |
| 3 | Check that all necessary safety measures have been ensured to prevent accidents before starting work at height. | 100 | 60 | 80 |
| 4 | The places located at height and the access roads to and from these jobs are marked and signalized | 100 | 40 | 40 |
| 5 | The floors are made of wood corresponding to the execution project; the metal ones are covered with expanded or ribbed sheet | 100 | 95 | 95 |
| 6 | Slip-resistant slats are fixed on the surface of sloping or curved floors at a distance of 300–400 mm | 100 | 80 | 80 |
| 7 | Workers are equipped with personal protective equipment appropriate to the actual conditions of the workplace | 100 | 100 | 100 |
| 8 | Workers use the personal protective equipment provided at work, as well as access to and from the workplace located at height. | 100 | 100 | 100 |
| 9 | The instructions issued by the manufacturer must be observed when using personal protective equipment | 100 | 100 | 100 |
| 10 | The maximum length of the unfolded safety ropes is 2 m | 100 | 100 | 100 |
| 11 | The fastening of the seat belt is made of rigid construction elements | 100 | 100 | 100 |
| 12 | The mechanism of the fall arrest system operates so that the worker does not fall more than 0.5 m | 100 | 100 | 100 |
| 13 | All persons involved in work at height wear a helmet | 100 | 100 | 100 |
| 14 | Before starting work, the headphones are checked by the workers | 100 | 80 | 80 |
| 15 | At the end of the program, workers hand the seat belts to the workplace manager | 100 | 100 | 100 |
| 16 | There is a safety rope that prevents the worker from entering the danger area throughout the work | 100 | 100 | 100 |
| 17 | At the beginning of the work, the component parts of the belts are checked in detail | 100 | 80 | 80 |
| 18 | The seat belts shall be stored in accordance with the manufacturer's instructions | 100 | 100 | 100 |
| 19 | There is evidence of training of workers on the use of collective and individual means of protection, installations, devices, and tools used for working at height | 100 | 95 | 95 |
| 20 | The workplace manager daily checks the integrity and operating condition of the installations, devices, and tools used for working at height | 100 | 100 | 100 |
| 21 | Wooden stairs are used by one person only | 80 | 80 | 100 |
| 22 | The maximum length of 5 m of a wooden staircase is observed | 80 | 80 | 100 |
| 23 | Tools used at height are kept in special pockets or sheaths fastened to the seat belt | 100 | 100 | 100 |
| 24 | Work platforms are provided with railings | 100 | 80 | 80 |
| 25 | Stairs inclined above 60°–80° are fixed, and those inclined above 80° are provided with cage guards and interruptions for rest at a maximum of 4 m | 100 | 100 | 100 |
| 26 | Fixed and portable wooden stairs have steps embedded in the longitudinal frames with a threshold of at least 2 cm | 80 | 80 | 80 |
| 27 | Access ramps are 1 m wide in one direction and 1.5 m in both directions | 100 | 100 | 100 |

Specific degree of compliance: $G_S = \frac{\sum_{k=1}^{27} \beta_k \times \bar{I}_k}{\sum_{k=1}^{27} \beta_k} = \frac{234,450}{2490} = 94.16\%$.

**Table 12.** *Cont.*

| No. | Requirement | Maximum Score $p_{\max_K}$ | Score Awarded $p_{a_K}$ | Average Compliance Index (%) $\bar{I}_k = \frac{p_{\max_k}}{p_{a_k}} \times 100$ |
|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 |
| | Check-List for Using Electric Power equipment Checklist Referencing: Own safety and health instructions of the economic operator with activity in the field of hydrotechnical constructions: | | | |
| 1 | The register of electrical appliances exists and is updated | 100 | 40 | 40 |
| 2 | All tools and electrical equipment are registered, marked and tested (CS or CE marked) | 100 | 40 | 40 |
| 3 | The tools are inspected and maintained daily | 100 | 60 | 60 |
| 4 | Staff are trained to provide first aid in the event of an electric shock | 100 | 100 | 100 |
| 5 | There are identification plates containing data related to the electrical part | 100 | 100 | 100 |
| 6 | All necessary earthworks are in place and are periodically checked | 100 | 100 | 100 |
| 7 | The power cords are protected or laid in pipes | 100 | 100 | 100 |
| 8 | The switches are suitable for the tripping current | 100 | 100 | 100 |
| 9 | Personal protective equipment has been provided and is worn | 100 | 100 | 100 |
| 10 | The cables are laid in such a way that there is no risk of disconnection | 100 | 100 | 100 |
| 11 | All staff are trained to use electrical equipment | 100 | 100 | 100 |
| 12 | All cables, plugs, and switches are in proper condition | 100 | 95 | 95 |
| | Specific degree of compliance: $G_S = \frac{\sum_{k=1}^{12} \beta_k \times \bar{I}_k}{\sum_{k=1}^{12} \beta_k} = \frac{95,825}{1035} = 92.58\%$. | | | |

## 5. Conclusions

Based on the documentation from the literature, the objective analysis, and the detection of theoretical arguments, a method of auditing occupational safety and health for hydro-construction companies was developed, which addresses both internal auditors and those belonging to competent institutions. The purpose of applying this specialized method is to provide the top managers of the hydro-construction company with a systematic and independent assessment of the consistent and effective implementation of measures to prevent accidents and occupational diseases and Additionally to ensure that potential/existing imperfections in achieving safety and occupational health are eliminated due to the effectiveness of the action to monitor the implementation of appropriate measures.

From a methodological point of view, the correctness of the choice of the calculation formula, regarding the conformity global degree, was verified by the experimental application for the four possible cases of two variants—weighted sum and arithmetic mean: Case 1: all average indices have the 0% value; Case 2: all indices have a value of 100% (all stipulations of the reference system are fully complied with); Case 3: all indices have a value of 50% (for each requirement, at least two measures among those which contribute to achieving them, are not complied); and Case 4: indices have different values.

Thus, from the observation made based on the two calculation formulas application, it can be appreciated that the weighted amount more clearly and objectively reflects the existence of problems in achieving safety and health at work, thus constituting the result of a cautious approach, as opposed to the arithmetic mean formula, which leads to a result that tends to overestimate the value of the assessment.

Additionally, the security risk determination in the field of occupational security at the economic operators in field of hydrotechnical constructions was performed, according to the procedure of applying the method, based on the Gumbel probability function associated with insecurity, and the accuracy of various estimates on risk predictors was ensured by using the Kolmogorov–Smirnov statistical verification test, in order to determine the confidence interval of the forecast results.

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