

## PREVENTION OF PROFESSIONAL RISKS FOR "PIPE CLEANING AND REHABILITATION", "HORIZONTAL DRILLING" AND „MICROTUNNELING” WORSTATIONS IN THE S.C. CALA – CENTRE FOR TECHNOLOGIES WITHOUT EXCAVATION S.A.

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**Abstract:** *Construction companies - in general - face an extremely high rate of unwanted events such as work accidents, both in Romania and worldwide. The „no dig” activity area presents very particular challenges and - as a result - this article addresses, researches and provides the detailed results of an extended specific case study for particular work systems operating in this area. The basic purpose of this investigative approach consisted in the development of the prevention and protection plan aimed at minimizing occupational risks in the investigated company, on the one hand, in full agreement with the national provisions currently in force, and - on the other hand - in providing a basis solidly grounded in order to provide all stakeholders with a basic reference on which to initiate pragmatic and realistic actions for real improvement of the state of security, health and well-being in the analysed company.*

**Keywords:** *centre for technologies without excavation, worker's safety, horizontal directed drilling rigs, steering tools, cleaning and rehabilitation of pipes*

### 1. Introduction

Accident prevention is one of the strongest paradigms of safety management. Therefore, understanding how accidents occur is essential in trying to minimize unwanted events. For the optimization of work accident and occupational disease prevention activities in a system, risk assessment is the essential starting point. Whether it is a workplace, a workshop or an enterprise, this analysis allows the classification of risks according to their severity and the efficient distribution of resources for priority measures [1, 2, 3].

This principle is included in European standards and is the basis of various methods applicable in practice. For example, SR EN 292-1/1996, adopted in Romania, specifies in chapter 6 that *"the factors to be taken into account in the risk assessment are the probability of producing an injury or health impairment and the foreseeable maximum severity of the injury or health impairment"* [4].

*"Safety as a process"* includes the perception of the accident production process at the operating level, simultaneously with the organizational conditions that led to the increase in the risk of occupational accidents. The preconditions of the genesis are open factors: deficiencies in the technical / physical environment and in the organization of the workplace; and latent (hidden) factors: insufficient communication and learning, a high level of responsibility combined with a low level of control, conflicting objectives and a severe gap between procedures and practice. These preconditions lead to the acceptance of risks, the abandonment of the voluntary effort to improve safety and the *"normalization"* of risk acceptance [5, 6, 7].

Law no. 319/2006 on safety and health at work provides clear obligations related to risk assessment, including the fact that the employer must *"assess the risks for the safety and health of workers, including the choice of work equipment, substances or chemical preparations used and the arrangement of workplaces work"* (art. 7, paragraph 4, letter a) [8, 9].

According to H.G. no. 1425/2006 for the approval of the Methodological Norms for the application of the provisions of Law no. 319/2006, the first prevention and protection activity carried out within the

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enterprise/unit is *"the identification of hazards and the assessment of risks for each component of the respective work system, work load, means of work/work equipment and the work environment at workplaces of work/jobs"* [10, 11, 12].

This paper aims to highlight in a systematic, rational and scientific manner the measures to reduce occupational risks, based on the correct performance of the risk assessment and to develop a pragmatic, feasible and - especially - implementable prevention and protection plan, at a Romanian company CALA-Centre for No-Excavation Technologies S.A. Râciu. Recognizing the fact that current organizations are socio-technical systems characterized by a high level of complexity, we still consider that the basic levels of work processes are unchanged [13, 14, 15].

As a result, we consider that in developing their own mental model, OSH professionals must know the strengths and limits of various models and be able to critically evaluate the most suitable models for practical application. At the same time, the OSH specialist must have the ability to distinguish between *"what happens"* in the work system and what *"should happen"*, to differentiate the models in relation to the applicable analysis methods based on a model [16, 17, 18].

## 2. General presentation of the company Cala-Centre of Technologies without Excavation S.A.

CALA - Centre for Technologies without Excavation S.A., from the commune Râciu, Mureş county, with a total number of 43 employees, carries out as its main activity drilling and survey works for constructions (CAEN code 4313). In an era of technology and sustainability, the company stands out as a leader in the field of *"no dig"* construction works, offering innovative solutions for urban and industrial infrastructure. With extensive expertise in the fields of directional and non-directional horizontal drilling, as well as trenchless pipe rehabilitation, the company aims for efficiency and sustainability in every project. The company's team consists of specialists with extensive experience in directed and undirected horizontal drilling. Using advanced techniques and state-of-the-art equipment, complex work is carried out, respecting the highest standards of precision and safety. Customized solutions are offered, adapted to the requirements of our customers. From residential projects to industrial infrastructure, each job is approached with professionalism and determination to achieve the desired results, pipe rehabilitation without excavation, using modern technologies such as refurbishment by renewal and repair by pipe cladding being part of the specific portfolio. These minimally invasive methods reduce work time and costs, without affecting traffic and the environment.

In the *"no dig"* construction activity, which includes directed and undirected horizontal drilling, as well as the rehabilitation of pipelines without excavation, various machines, installations, machines and specialized devices are used, briefly described below:

### a. Directed Horizontal Drilling (HDD):

- **Horizontal Directional Drilling Units (HDD rigs):** these units are complex equipment that include powerful motors to drive the drill bit, hydraulic systems to control drilling force and direction, as well as a drilling fluid supply system and a tailings evacuation system. More modern units may include on-board computers that automatically monitor and adjust drilling parameters to ensure accurate job execution (fig. 1).
- **Steering tools:** these tools are mounted in front of the drill and are used to control the direction and angle of drilling. They can include gyroscopes, magnetometers and GPS navigation systems, which provide real-time information about the orientation of the drill and its position underground.
- **Special drills for HDD:** to cope with the different types of soils and geological conditions encountered during drilling, special drills are used, such as twist drills for soft soils or cutter roller drills for hard rock. These drill bits are designed to provide optimal performance depending on the drilling conditions.

### b. Undirected Horizontal Drilling:

- **Unguided horizontal drilling machines** (fig. 2): these machines are robust and versatile equipment that can perform horizontal drilling in a variety of geological conditions. They include a powerful drilling system, a drilling fluid supply system and a cooling system to cope with the high temperatures generated during drilling.
- **Specific drills and tools:** for unguided horizontal drilling, drills and tools adapted to deal with hard soils and rocks are used. These may include diamond cone drill bits for drilling in rock and twist drill bits for soft soils and sand.



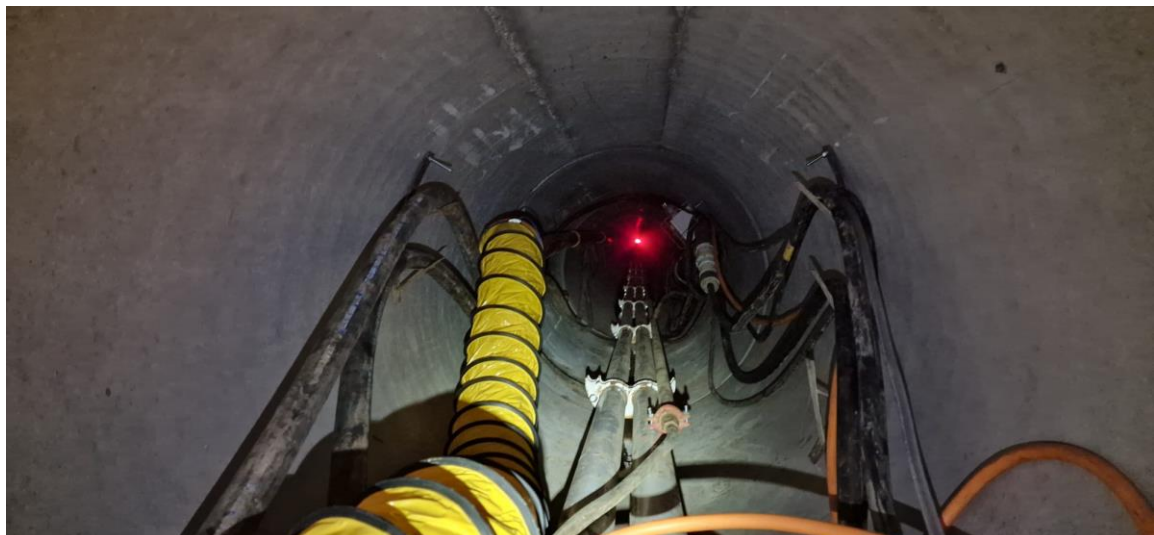
*Fig. 1. Directional horizontal drilling unit (HDD rigs)*



*Fig. 2. Unguided horizontal drilling machines*

**c. Pipeline Rehabilitation Without Excavation:**

- **Reconditioning equipment by renewal** (fig. 3): the equipment include renewal by reconditioning systems that apply a protective layer or repair material inside the existing pipes. They may include injection machines and material application equipment to ensure uniform coverage of the entire pipe surface.
- **Pipe lining repair and rehabilitation equipment:** Pipeline rehabilitation uses equipment that applies new pipe or composite materials inside existing pipes. This equipment includes pipe dressing machines and installation equipment that ensure correct pipe positioning and uniform application of materials.



*Fig. 3. Reconditioning equipment by renewal*

**d. Other machinery and equipment:**

- **Underground infrastructure scanning and detection equipment:** this equipment includes radar scanners and metal detection systems that are used to identify and locate underground infrastructure, such as water and sewer pipes, electrical and communications cables, and other underground objects.
- **Video inspection equipment:** this equipment includes video inspection cameras mounted on special vehicles or inserted into pipelines using robots or drones. They are used to examine the inside of pipes and identify problems such as cracks, corrosion or blockages.

Figure 4 shows a typical overview of the construction site organization specific to the analyzed company, and table 1 specifies the job categories for which the occupational injury risk assessment was carried out.



Fig. 4. Overview of the CALA site organization

Table 1. The list of jobs for which the risk assessment was carried out for safety and health at work

| No.   | Job/workstation                         | Number of workers |
|-------|-----------------------------------------|-------------------|
| 1.    | Pipe cleaning and rehabilitation worker | 9                 |
| 2.    | Horizontal drilling worker              | 15                |
| 3.    | Microtunneling worker                   | 12                |
| TOTAL |                                         | 43                |

### 3. Case study: assessment of occupational hazards for the workplace: cleaning and rehabilitation of pipes

**Work process:** workers carry out the work necessary to inspect, clean and rehabilitate sewage pipes/drinking and industrial water networks and gas pipes.

**The components of the evaluated work system:**

**a. Means of production/work equipment:** passenger transport vehicles; vehicle with trailer for moving equipment and machinery; the CCTV self-laboratory; mobile inspection system; self-service pipe cleaning with pressure; truck with seagull type crane (6 tons); high pressure pumps; mobile steam production equipment; pressure liner inverter; shotcrete equipment (pump, shotcrete robot (from DN 800 to 1600), pneumatic shotcrete robots (up to DN 800); helical screw compressors, with a flow rate of 5 - 20 mc/min and a pressure of 5-10 bar; semi-dirty water pumps (bypass), hydraulic pumps (50 kva), traction winches, hoists (material for lining), epoxy, polyester and vinylester resins, polyester and vinylester resin additives (special cements for potable water and heating networks); fuel; special keys, ladders, manual and electric tools, self-contained breathing apparatus, sanitary materials for workers.

**b. Working task:** from the Job Description prepared by the company, the following competences, knowledge, obligations, responsibilities and attributions were retained:

- to have the theoretical and practical training necessary to carry out the procedures on the workstations that frame the team;
- to show up at work physically and mentally fit;
- comply with the duties in the job description;

- to be trained by the head of the workplace, in order to use the equipment correctly;
- to be fit from a physical and mental point of view (medical certificate <fit> for employment and periodic medical examinations, according to the planning of the occupational medicine doctor), aptitude assessed according to the legal provisions and the "occupational risk exposure sheet";
- to acquire the job duties and the training corresponding to the qualification, respectively the work instructions, the own safety and health instructions at work in accordance with the legislation in force;
- compliance with the prevention and security plan;
- handle various materials safely;
- to apply the general rules of risk prevention at the workplace;
- to be informed, or to be informed, about the measures to be taken regarding safety and health at work;
- to use the individual protective equipment, for the purpose for which they were equipped;
- receives the protective equipment on the basis of a handover-acceptance report from the head of the workplace;
- to know how to act in case of accidents, according to work safety instructions, alarm, according to the specific emergency alarm plan;
- execution of the tasks outlined by the workplace manager regarding the organization of the construction site;
- unloading machines, equipment and positioning them in the location provided by the workplace leader;
- compliance with traffic rules in the construction site;
- servicing the machines in safe conditions, in compliance with the work instructions;
- ensuring the widest possible field of vision between team members during the execution of rehabilitation;
- reception of the work-report;
- checking the existence of all machine components, cleaning, loading, moving to the base.

### c. Work environment

The worker cleaning and rehabilitating pipes performs his activity especially in the open air, in visiting dormitories and pipes of water, sewage or gas networks. The work environment is characterized by: natural and artificial lighting; air currents; precipitation (rain or snow depending on the season); noise due to the operation of work equipment; high or low temperature depending on the season; flammable, explosive, toxic gases; work in closed spaces. Table 2 centralizes the results of the risk assessment for the assessed workplace, by applying the established and widely used (in Romania) INCDPM Bucharest method [19, 20]. Employing the tools and the steps of the INCDPM Bucharest method [21, 22], the specific risks were identified, the severity classes and the probability classes related to the identified risks were assigned, and the partial risk levels were determined. The evaluation results were systematized in Table 2.

The notations in table 2 have the following explanations: *WSE* - Work system element; *IR* - identified risk; *RF* – risk factor; *MC* - Maximum consequence; *S* - Severity; *Likelihood*; *RL* - Risk level; *WE* - Working equipment; *OE* - Occupational environment; *WT* - Working task; *HF* - Human factor; *N-negligible*; *LTI 3-45* – Lost Time Injury from 3 to 45 days; *LTI 45-180* – Lost Time Injury from 45 to 180 days; *INV I* – first degree invalidity; *INV II* – second degree invalidity; *INV III* – third degree invalidity; *D* – death.

The global risk level of the workplace is: **3,22**

$$N_{rg} = \frac{\sum_{i=1}^{80} ri Ri}{\sum_{i=1}^{80} ri} = \frac{0(7 \times 7) + 0(6 \times 6) + 0(5 \times 5) + 18(4 \times 4) + 54(3 \times 3) + 8(2 \times 2) + 0(1 \times 1)}{0 \times 7 + 0 \times 6 + 0 \times 5 + 18 \times 4 + 54 \times 3 + 8 \times 2 + 0 \times 1} = \frac{806}{250} = 3,22$$

The risk levels related to the 80 identified and evaluated risk factors are shown in the histogram in figure 5. Following the analysis of the risk factors and the evaluation carried out, the global risk level ( $N_g$ ) calculated according to the method is equal to 3.22, which places it in the category of medium risks (located below the acceptability limit of 3.5). The result is supported by the "Assessment sheet" from which it can be seen that out of the total of 80 identified risk factors, only 18 exceed factors exceed, as a partial level of risk the value 3 falling into the category of medium risk factors.

Table 2. Job evaluation sheet

|                                                                |               |                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                         |   |   |    |
|----------------------------------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|---|---|----|
| Company:<br>Cala C.T.F.S.<br>S.A.                              |               | WORKPLACE EVALUATION SHEET                                                                                                                                                                                                                                                                                                                                                        | Number of<br>exposed<br>individuals: 9                                                                                                  |   |   |    |
| Workplace:<br>Pipe cleaning<br>and<br>rehabilitation<br>worker |               |                                                                                                                                                                                                                                                                                                                                                                                   | Assessment<br>team members:<br>Administrator,<br>OSH designated<br>worker,<br>occupational<br>medicine doctor,<br>workplace<br>managers |   |   |    |
| WSE                                                            | IR            | The concrete form of manifestation of risk factors                                                                                                                                                                                                                                                                                                                                | MC                                                                                                                                      | S | L | RL |
| WE                                                             | Mech.<br>RF   | F1. Catching, crushing, hitting by machine bodies (in normal operation) of the work equipment with which it may accidentally come into contact, due to the lack of protective devices and guards or the operator entering the area of their action                                                                                                                                | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F2. Flows/jets of fluids due to accidental cracking or breaking of pipes and hoses through which fluids circulate under pressure or failure to anchor and stiffen these pipes/hoses                                                                                                                                                                                               | D                                                                                                                                       | 7 | 2 | 4  |
|                                                                |               | F3. Grabbing, hitting, crushing by means of transport within the company premises or the perimeter of the pipe network (site), when moving from one workplace to another within the company premises or the perimeter of the pipe network, or on public roads when coming/departing to / from /service, in case of road incident                                                  | D                                                                                                                                       | 7 | 2 | 4  |
|                                                                |               | F4. Contraindicated self-triggering or self-blocking of the functional movements of work equipment or fluids (contradicted starting or the impossibility of stopping some work equipment or component parts of work equipment) due to malfunctions arising due to non-maintenance and/or non-proper repair or non-replacement of AMCs (measurement and control devices) defective | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F5. Free fall under the effect of gravity, of materials, parts or component parts of work equipment and not properly secured against accidental falls or their manual handling and near which the operator may be                                                                                                                                                                 | LTI<br>45-180                                                                                                                           | 3 | 5 | 4  |
|                                                                |               | F6. Rolling, under the effect of gravity, of parts stored near work equipment in operation, repair/overhaul and not secured against uncontrolled movement                                                                                                                                                                                                                         | LTI<br>45-180                                                                                                                           | 3 | 4 | 3  |
|                                                                |               | F7. Wheeling of vehicles being loaded/unloaded and not properly secured against unauthorized movements                                                                                                                                                                                                                                                                            | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F8. Breaking, collapsing of the walls of the visiting dormitories or of the pipelines undergoing rehabilitation resulting in the operator being caught, hit or crushed in that area                                                                                                                                                                                               | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F9. Deviation from the normal trajectory of the means of transport that have access to the premises/site due to damaged roads, the loss of the ability to drive the vehicle by the driver due to the state of health or the failure of the vehicle's steering system                                                                                                              | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F10. Dangerous balance of transported goods (compressors, etc.) with the means of lifting provided by the company                                                                                                                                                                                                                                                                 | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F11. Recoil due to cracking or accidental breakage of pipes and hoses through which fluids under pressure are circulated                                                                                                                                                                                                                                                          | D                                                                                                                                       | 7 | 2 | 4  |
|                                                                |               | F12. Jet of fluids due to cracking or accidental breakage of pipes and hoses through which fluids under pressure are circulated                                                                                                                                                                                                                                                   | D                                                                                                                                       | 7 | 2 | 4  |
|                                                                |               | F13. Accidental direct contact with dangerous, sharp, cutting, slippery, abrasive, adhesive, etc. surfaces or contours. when performing work                                                                                                                                                                                                                                      | LTI<br>3-45                                                                                                                             | 2 | 5 | 3  |
|                                                                |               | F14. Explosions due to improper operation, hidden defects, or other causes of pressure vessels for storing compressed air and fire extinguishers                                                                                                                                                                                                                                  | D                                                                                                                                       | 7 | 1 | 3  |
|                                                                |               | F15. Vibrations - the transmission of vibrations produced by machines during their operation or the use of portable technical equipment                                                                                                                                                                                                                                           | LTI<br>3-45                                                                                                                             | 2 | 4 | 2  |
|                                                                | Thermal<br>RF | F16. Accidental direct contact with very hot surfaces or objects (elements of work equipment) or very cold surfaces and objects (work equipment with very low temperatures)                                                                                                                                                                                                       | LTI<br>3-45                                                                                                                             | 2 | 4 | 2  |

|    |                       |                                                                                                                                                                                                                                                  |            |   |   |   |
|----|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---|---|---|
|    |                       | F17. Fires or explosions due to damage to work equipment or their improper technical condition (use of work equipment or tools without complying with the work safety standards in force)                                                        | D          | 7 | 1 | 3 |
|    | Electric RF           | F18. Electrocution by direct and/or indirect contact (open electrical panels, improvisations when making electrical connections, discontinuous earth sockets)                                                                                    | D          | 7 | 1 | 3 |
|    | Chemical RF           | F19. Accidental direct contact with flammable, explosive substances (petroleum products, etc.) resulting in fires, explosions, chemical burns or death by massive inhalation                                                                     | D          | 7 | 2 | 4 |
|    | Biologic RF           | F20. Direct contact with bacteria, fungi, viruses, etc. when handling the hoses of the machines used to clean the pipes and which can lead to the illness of the operator                                                                        | LTI 45-180 | 3 | 4 | 3 |
| OE | Physical RF           | F21. High or low air temperature, depending on the season when working outdoors                                                                                                                                                                  | LTI 3-45   | 2 | 4 | 2 |
|    |                       | F22. Variable humidity, high or low, depending on the season                                                                                                                                                                                     | LTI 3-45   | 2 | 4 | 2 |
|    |                       | F23. Noise, above the permitted limits, due to the operation of the work equipment (air compressors, pumps, vehicles, etc.)                                                                                                                      | INV. III   | 4 | 2 | 3 |
|    |                       | F24. Direct or reflected glare – high glare from the sun or snow when working outdoors                                                                                                                                                           | LTI 3-45   | 2 | 3 | 2 |
|    |                       | F25. Low artificial lighting level inside visiting dormitories or pipelines when inspected by the operator                                                                                                                                       | LTI 3-45   | 2 | 5 | 3 |
|    |                       | F26. Natural disasters (lightning, wind, falling trees, landslides, earthquakes, etc.)                                                                                                                                                           | D          | 7 | 1 | 3 |
|    | Chemical RF           | F27. Gases, vapours, toxic aerosols (inhalation hazard) in the workplace atmosphere due to sewage residues, chemical, oil spills, etc.                                                                                                           | D          | 7 | 2 | 4 |
|    | Special environment   | F28. Work in the sewage system (underground) and in conditions of high humidity due to waste water transiting through the pipes and deposits of sludge and chemical substances, oil, etc. on the walls of the sewage pipes                       | LTI 45-180 | 3 | 4 | 3 |
|    | Biologic RF           | F29. Accidental direct contact with dangerous animals or insects (community dogs, wasps, bumblebees, spiders, bears, wild boars, etc.) located in or around the mobile/temporary construction site                                               | LTI 45-180 | 3 | 4 | 3 |
|    |                       | F30. The presence of pathogens, bacteria, viruses (corona virus SARS-CoV), fungi in suspension in water or air, in offices and in means of transport.                                                                                            | LTI 3-45   | 2 | 6 | 3 |
|    | Psycho-social RF      | F31. Non-principled relations between the boss and subordinates, relations due to the way and time of the works                                                                                                                                  | LTI 3-45   | 2 | 3 | 2 |
|    |                       | F32. Panic states due to the working environment (underground) and the high risk of explosion and/or fire due to the substances transiting the sewage system and the specifics of the activity.                                                  | LTI 45-180 | 3 | 4 | 3 |
| WT | Inadequate WT content | F33. Wrong operations, rules, procedures – when performing specific work operations or specific work operations or revision and maintenance operations (dismantling and assembling parts, lifting and transporting materials, spare parts, etc.) | D          | 7 | 1 | 3 |
|    |                       | F34. Incorrect sequence of operations or failure to ensure the correlation of work operations carried out within complex works                                                                                                                   | D          | 7 | 1 | 3 |
|    |                       | F35. Inadequate coordination of work operations                                                                                                                                                                                                  | D          | 7 | 1 | 3 |
|    |                       | F36. Admitting the inappropriate assignment of workers to jobs:<br>✓ With inadequate training<br>✓ No training or incomplete training in the field of OSH<br>✓ With psychophysiological incompatibilities with the job requirements              | D          | 7 | 1 | 3 |
|    |                       | F37. Tolerating deviations from technological discipline                                                                                                                                                                                         | D          | 7 | 1 | 3 |
|    |                       | F38. Tolerating deviations from the own OSH instructions                                                                                                                                                                                         | D          | 7 | 1 | 3 |
|    |                       | F39. F39. Allowing work to be carried out with production means that do not meet safety requirements                                                                                                                                             | D          | 7 | 2 | 4 |
|    | Physical overload     | F40. Physical strain when manually handling and positioning heavy parts/subassemblies                                                                                                                                                            | LTI 45-180 | 3 | 4 | 3 |
|    |                       | F41. Forced, vicious working positions when performing work operations in visiting dormitories or in the pipes of the sewage system                                                                                                              | LTI 45-180 | 3 | 5 | 4 |
|    |                       | F42. Static strain, fixed position for long periods of time                                                                                                                                                                                      | LTI 3-45   | 2 | 4 | 2 |
|    | Psychical overload    | F43. Difficult decisions in a short time in case of massive gas leaks, fire, etc. – interventions based on action procedures for special situations                                                                                              | LTI 45-180 | 3 | 4 | 3 |

|           |               |                                                                                                                                                                                                                                                                                                             |            |   |   |   |
|-----------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---|---|---|
|           |               | F44. Interventions based on acquired reflexes (greater effort when working in difficult weather conditions – fog, rain, snow)                                                                                                                                                                               | LTI 3-45   | 2 | 4 | 2 |
|           |               | F45. Increased mental effort in the case of taking decisions with deep implications, responsible for the performance of work duties                                                                                                                                                                         | LTI 45-180 | 3 | 4 | 3 |
|           |               | F46. High work rate, repetitive short-cycle operations - permanent demand for attention in carrying out work tasks (nervous system)                                                                                                                                                                         | LTI 3-45   | 2 | 5 | 3 |
| <b>HF</b> | Wrong actions | F47. The wrong location, in the perimeter of the sewage system, of the pipe cleaning trucks and the route of the supply and discharge pipes, a fact that can lead to the occurrence of human or technical accidents                                                                                         | D          | 7 | 1 | 3 |
|           |               | F48. F48. Wrong commands given to the operator or the driver of the special vehicles used in the rehabilitation of the sewage system (drainage and AMEX installation)                                                                                                                                       | D          | 7 | 1 | 3 |
|           |               | F49. Wrong commands sent to co-workers (eg: starting or stopping work equipment before carrying out all the operations provided for in the work procedures, the operating manual, etc.) when carrying out the rehabilitation works of the sewage system                                                     | D          | 7 | 1 | 3 |
|           |               | F50. Improper fixings of pipe cleaning and rehabilitation plant elements (flexible connecting hoses, etc.) that can come loose and lead to operator injury, product leakage and environmental pollution                                                                                                     | D          | 7 | 1 | 3 |
|           |               | F51. Failure to check the level of gases (oxygen, hydrogen sulphide, explosive gases, carbon monoxide, etc.) inside the dormitories for visiting the sewage system, before entering the dormitories, as well as during the entire period of the presence of workers inside pipelines                        | D          | 7 | 2 | 4 |
|           |               | F52. Failure to use protective masks with air adduction or self-contained ones to prevent workers from being poisoned by dangerous gases or vapors resulting from substances passing through the sewage system at all times when working in the visiting closed spaces or in the pipes of the sewage system | D          | 7 | 2 | 4 |
|           |               | F53. Failure to use the safety rope to remove the worker in case of danger or untie it before exiting the sewer system                                                                                                                                                                                      | D          | 7 | 2 | 4 |
|           |               | F54. Failure to use portable explosive gas detectors when performing work in the sewage system that may result in explosions and injury                                                                                                                                                                     | D          | 7 | 2 | 4 |
|           |               | F55. The use of metal tools, producing sparks in areas with possible gas accumulations when carrying out sewerage system rehabilitation works                                                                                                                                                               | D          | 7 | 1 | 3 |
|           |               | F56. The use of clothing made of synthetic fibers, producing by friction static electricity                                                                                                                                                                                                                 | D          | 7 | 1 | 3 |
|           |               | F57. Wrong commands sent to workers to adjust work parameters or allow functional parameters to be exceeded in operating work equipment, regime parameters resulting in breakdowns, fires or explosions                                                                                                     | D          | 7 | 1 | 3 |
|           |               | F58. Failure to carry out checks, according to work procedures, of the physical condition of the measuring and control equipment and warning of dangerous conditions within the work equipment, resulting in the occurrence of breakdowns, fires or explosions                                              | D          | 7 | 1 | 3 |
|           |               | F59. Failure to complete or incorrect or incomplete completion of record forms (work permits) of the work operations to be performed                                                                                                                                                                        | LTI 45-180 | 3 | 4 | 3 |
|           |               | F60. Allowing work equipment to operate, without it being equipped with all the control and protection devices provided in the technical books and without being connected to the earthing belt                                                                                                             | D          | 7 | 2 | 4 |
|           |               | F61. Carrying out overhaul and repairs during the operation of equipment                                                                                                                                                                                                                                    | D          | 7 | 1 | 3 |
|           |               | F62. Carrying out work with an open flame without the existence of the Permit to work with fire                                                                                                                                                                                                             | D          | 7 | 1 | 3 |
|           |               | F63. Arbitrary starting or stopping of technical equipment                                                                                                                                                                                                                                                  | D          | 7 | 1 | 3 |
|           |               | F64. F64. Arbitrarily turning on or off the power supply to work equipment                                                                                                                                                                                                                                  | D          | 7 | 1 | 3 |
|           |               | F65. Falling to the same level while moving from one job to another by slipping, unbalancing or tripping                                                                                                                                                                                                    | D          | 7 | 1 | 3 |
|           |               | F66. Falling from a height by slipping, tripping or unbalancing when working at height                                                                                                                                                                                                                      | D          | 7 | 1 | 3 |
|           |               | F67. Parking or driving in dangerous, prohibited areas                                                                                                                                                                                                                                                      | D          | 7 | 1 | 3 |
|           |               | F68. Non-compliance with the rules of access and circulation within the premises of the company / construction site                                                                                                                                                                                         | D          | 7 | 1 | 3 |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |               |   |   |   |
|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|---|---|---|
|  | F69. Defective performance of operations:<br>✓ leaving the machine during its operation and getting on it under the same conditions<br>✓ leaving tools or other metal objects on the battery<br>✓ starting or braking suddenly with a heavy load - to prevent the load from falling or the machine tipping over<br>✓ engaging in discussions while operating the machine<br>✓ handling the machine - with the risk of hitting parts of nearby buildings, trees, rocks or overhead power lines<br>✓ non-verification after loading of the uniform distribution of the load, compliance with its tonnage and dimensions. | D             | 7 | 1 | 3 |
|  | F70. Failure to use the full range of personal protective equipment (PPE), depending on the risk factors for occupational injury and/or illness identified at workplaces, during the performance of work obligations by workers, or failure to comply with the manufacturer's indications regarding the protective qualities of PPE or maintenance and lifetime of PPE                                                                                                                                                                                                                                                 | D             | 7 | 2 | 4 |
|  | F71. Failure to perform medical examinations in accordance with legal provisions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | LTI<br>45-180 | 3 | 4 | 3 |
|  | F72. Showing up at work in an inadequate physical condition                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | D             | 7 | 1 | 3 |
|  | F73. Consumption of alcoholic beverages while on duty                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | D             | 7 | 1 | 3 |
|  | F74. Smoking in non-permitted places - risk of fire                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | D             | 7 | 2 | 4 |
|  | F75. Non-compliance with personal hygiene rules                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | LTI<br>45-180 | 3 | 4 | 3 |
|  | F76. The impossibility of using first-aid extinguishers in the event of a fire due to failure to check the validity period (expired validity period) or lack of knowledge of how to use them                                                                                                                                                                                                                                                                                                                                                                                                                           | D             | 7 | 1 | 3 |
|  | F77. Impossibility of using the medical first aid kit in the event of an accident due to failure to check the expiration date (expired expiration date) or lack of knowledge of how to use it                                                                                                                                                                                                                                                                                                                                                                                                                          | D             | 7 | 1 | 3 |
|  | F78. Non-compliance with work procedures, own safety and health at work instructions developed within the company, the rules of operation, maintenance and repair mentioned in the technical books of the technical equipment serviced                                                                                                                                                                                                                                                                                                                                                                                 | D             | 7 | 2 | 4 |
|  | F79. Wrong actions, by workers, of the commands of work equipment due to the lack of their symbolism, or the non-translation into Romanian of the meanings of the commands, or the non-translation into Romanian of the operating instructions from the technical books of the machines, or the lack of technical books, operations which may lead to the occurrence of human accidents and/or material damage                                                                                                                                                                                                         | D             | 7 | 1 | 3 |

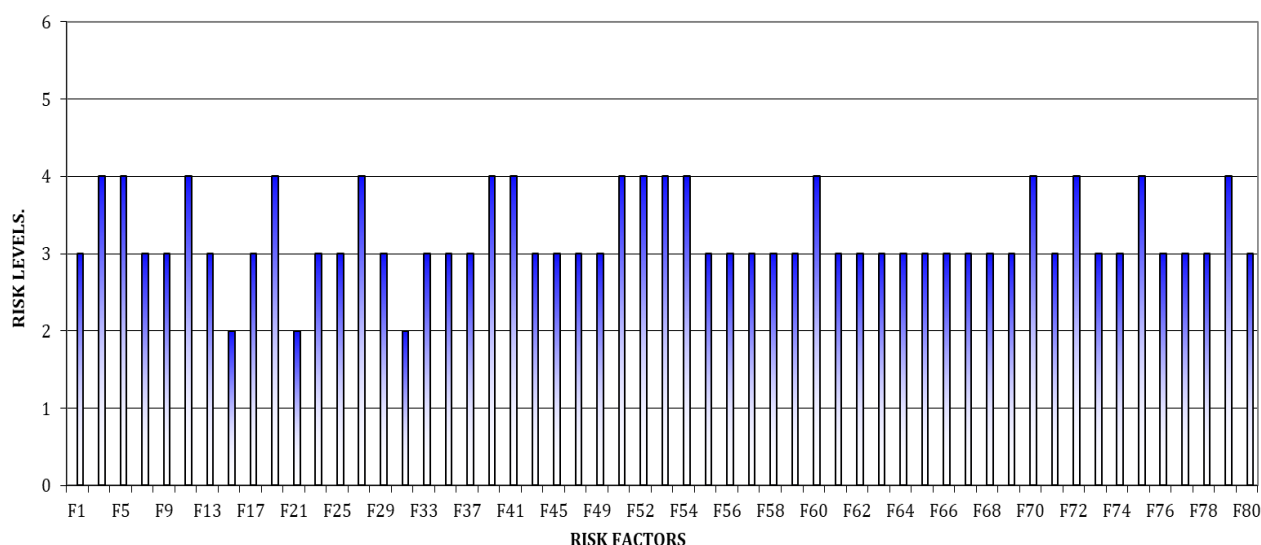


Fig. 5. Partial risk levels by risk factors - Job no. 1: "Pipeline cleaning and rehabilitation worker"

To reduce or eliminate the effects of the 18 risk factors placed in the field of unacceptability, the measures presented generically in the "Prevention and Protection Plan (Table 3) are necessary. From the point of view of the distribution on generating sources, the situation is presented graphically in figure 6:

- 25.00% factors specific to the working equipment
- 15.00% factors specific to the work environment
- 17.50% factors specific to the work load
- 42.5% own factors of the human factor.

From the analysis of the risk factors, it is observed that 68.75% of them cause irreversible consequences on the human body (death or disability). In a similar way, the risk assessment was carried out for the job "Horizontal drilling worker" and "Microtunneling worker", the prevention-protection measures proposed on this basis also being centralized in table 3.

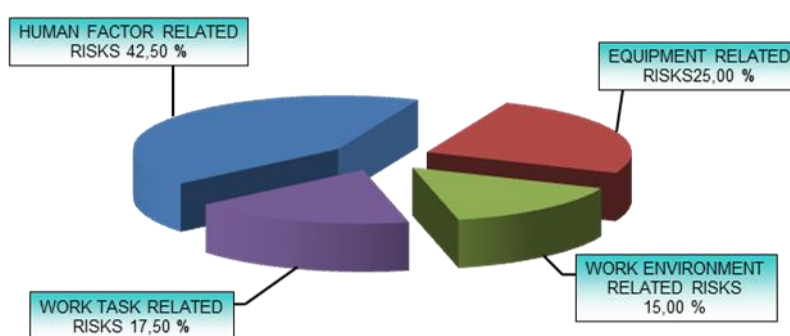


Fig. 6. The share of risk factors identified by the elements of the work system.  
Job "Pipeline cleaning and rehabilitation worker"

#### 4. Prevention and protection plan development for workplaces within the analysed company

In accordance with the applicable national legislation and on the basis of the previously presented justification, the prevention and protection plan was developed, aimed at minimizing the identified occupational risks, evaluated by quantification and ranked in order to quickly establish the priority measures. The results are centralized in Table 3.

Table 3. Prevention and Protection Plan

| Workplace / job            | Assessed risks                                                                                                                                                                                                         | Technical measures                                                                                                                            | Organizational measures                                                                                                                                                                                                                                        | Actions for achieving the measure                                                                                                                                                                                                 | Implementation deadline                                                    | Responsible person                                        |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------------------------------------|
| Horizontal drilling worker | Movements of means of transport on and off site<br>Risk of injury to circulation in the premises and/or outside.<br>Manoeuvres with earthmoving equipment.<br>Car parks.                                               | Establishing and marking paths/routes/access passages, vehicle loading/unloading platforms, parking/stationing places for means of transport. | The training of workers regarding the importance of complying with the road traffic code and the legal restrictions for railway traffic areas from the Regulation for the application of O.U.G 195/2002, from H.G. 1391/2006; H. G. 1146/2006; H. G. 971/2006. | Equipping with means of safety signals according to H.G. 971/2006. Periodic (annual) psychological testing                                                                                                                        | Permanently and at each site location<br>Monthly at the thematic trainings | Workplace managers<br>Designated OHS workers              |
|                            | Functional movements of technical equipment – machine parts in motion:<br>-block crane-hook<br>-pneumatic winches<br>- intermediate transmission axles<br>- thermal/electric motors<br>- compressors<br>-mud agitators | Functional maintenance of measurement and control equipment, repair and installation of all protective devices                                | Prohibition of removing protective devices, checking the physical condition of the active elements of technical equipment before starting work, Training workers in the "OHS's own instructions." on                                                           | The rhythmic supply of spare parts, the performance of adjustments/calibrations/checks of technical equipment, practical assembly / disassembly exercises of mechanisms and sub-assemblies where risks of hitting may occur, etc. | Permanently and at each site location<br>Monthly at the thematic trainings | The managers of the workplaces and the workers themselves |

|                                                            |                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                             |                                                                                                                             |                                                                                       |                                                                                                                                                                        |
|------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                            | <ul style="list-style-type: none"> <li>-hydrocyclones-denisers / looseners</li> <li>-vibrating sites</li> <li>- mud pumps</li> <li>- winch axles</li> <li>- hydraulic torque converters</li> <li>- the action of the pressure group</li> <li>- electric current generator groups</li> <li>- centrifugal pump drives</li> </ul>                                                        |                                                                                                                                                                                                                                                                                                          | functions and jobs" and checking how safety rules are respected                                                                                                                                                                                                             |                                                                                                                             |                                                                                       |                                                                                                                                                                        |
| Functional movements of technical equipment – fluid flows: | <ul style="list-style-type: none"> <li>-pull-push/drain ("barren") pipelines, mud pumps</li> <li>- pressure valves (armatures) on the hydraulic routes of the working fluids</li> <li>- storm</li> <li>-vibrating storm</li> </ul>                                                                                                                                                    | Functional maintenance of measuring and control equipment, marking with OHS signaling, of all areas with fluid flow hazards                                                                                                                                                                              | Training of workers from "OHS.'s own instructions on functions and jobs" regarding the consequences of non-compliance with safety restrictions, non-use or incomplete use of PPE.                                                                                           | The rhythmic supply of spare parts, performing adjustments/ calibrations/ checks of technical equipment                     | <p>Permanently and at each site location</p> <p>Monthly at the thematic trainings</p> | The managers of the workplaces and the workers themselves                                                                                                              |
| Self-triggering / self-locking of technical equipment:     | <ul style="list-style-type: none"> <li>-Rotary table</li> <li>- mud pumps</li> <li>- scumbag</li> <li>- winch</li> <li>- hydraulic torque converters</li> <li>-hydraulic head</li> <li>- control desk operator-chief</li> </ul>                                                                                                                                                       | The functional maintenance of the "breakdown stop" commands, the execution of technical revisions at the deadlines established by the law in force and by the other internal rules (provisions of technical books)                                                                                       | Immediate reporting of all malfunctions or even suspicions about the functioning of mechanisms and systems of technical equipment                                                                                                                                           | Checking the operation of these controls at the beginning of each work shift and during revisions before special operations | Permanently and at each site location                                                 | The managers of the workplaces and the workers themselves                                                                                                              |
| Movements under the effect of gravity (slips):             | <ul style="list-style-type: none"> <li>-uninsured mechanical components / assemblies</li> <li>-falling of tools/tubular material from elevators/dropping of the crane-hook</li> <li>block/separation of subassemblies from the site mast</li> <li>-detachment of sub-assemblies after cutting by welding due to their failure to secure them against uncontrolled movement</li> </ul> | Securing mechanical components/assemblies against uncontrolled movements (by anchoring, shoring, stacking, etc., according to non-hazardous procedures, maintaining safe working conditions of tools, assembly elements, etc.                                                                            | Training of workers from "Instructions own them of OHS on functions and trades", with an emphasis on the correct way of handling and stacking parts, subassemblies, etc.                                                                                                    | The rhythmic supply of spare parts, new, appropriate tools, etc.                                                            | <p>Permanently</p> <p>Monthly at the thematic trainings</p>                           | The managers of the workplaces and the workers themselves                                                                                                              |
| Movements under the effect of propulsion:                  | <ul style="list-style-type: none"> <li>- design of bodies or particles:</li> <li>-components of mud pumps, compressors, engines, intermediate transmissions or any other type of transmission</li> <li>- breaks in pipes / fittings</li> <li>gas / steam</li> <li>- deviations from the trajectory:</li> <li>- tubular material</li> </ul>                                            | <p>Checking the physical condition of the bodies before putting the technical equipment into operation and/or maintaining the technical equipment in safe working conditions.</p> <p>Marking of access ways and action lanes of technical equipment</p> <p>Checking all routes with energetic fluids</p> | <p>Training on the need to use safety glasses and a dust masks</p> <p>The appropriate signaling and warning by OHS, the correct positioning of the executors or in relation to the handled load</p> <p>Training of workers regarding the consequences of non-compliance</p> | The rhythmic supply of spare parts, spare technical equipment                                                               | <p>Permanently and at each site location</p> <p>Monthly at the thematic trainings</p> | <p>The managers of the workplaces and the workers themselves</p> <p>Designated OHS workers</p> <p>Occupational medicine doctors</p> <p>Laboratories specialized in</p> |

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                         |                                 |                                                                                                                                                                                         |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <ul style="list-style-type: none"> <li>- balance:</li> <li>-hydraulic head</li> <li>-hose</li> <li>- jet, eruption</li> <li>-storm -vibrating storm</li> <li>-compressor</li> <li>intake/discharge paths,</li> <li>mud pumps</li> <li>- safety valves</li> <li>- gas / steam supply pipes</li> </ul>                                                                                                                                                                  | and immediately remedying the problems that have arisen, fencing off as much as possible the areas where there is a possibility of the appearance of jets, eruptions                                                                                                                                                   | with security restrictions (intrusion into neighboring areas), non-use or incomplete use of PPE.                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                         |                                 | noxious determinations                                                                                                                                                                  |
|  | Accidental direct contact with flammable substances: explosion during the execution of the throwing of war hand grenades, destruction works or ammunition scrapping due to the inappropriate quality of the explosive material (batches with quality deficiencies, expired materials, frozen materials that become sensitive to manipulations) or due to external factors (circuit contact with an electrical source, electrical discharges in the atmosphere, etc.). | Use of personal protective equipment                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Verification of explosives identification data;</li> <li>- ensuring that the ammunition that will be destroyed does not show advanced signs of degradation;</li> <li>- handling explosives and ammunition with particular care in low temperature conditions;</li> <li>- knowledge and compliance with safety operations and rules during shooting and destruction sessions;</li> <li>- knowledge of the characteristics and way of working with explosive substances</li> </ul> |                                                         | Whenever necessary              | Shotfirer                                                                                                                                                                               |
|  | Pressure vessels:<br>-air cylinders (from the air preparation group)<br>-oxygen cylinders, acetylene, hydrogen, nitrogen, etc.                                                                                                                                                                                                                                                                                                                                        | Functional maintenance of measuring and control equipment, provision of these containers with safety components / subassemblies                                                                                                                                                                                        | Periodic training from "Instructions own by OHS on functions and jobs", from the legislation on P.S.I., insurance with means of P.S.I. adequate and within the validity period, risk signalling                                                                                                                                                                                                                                                                                                                         | Protection during transport, handling, storage and work | Permanently and whenever needed | The managers of the workplaces and the workers themselves                                                                                                                               |
|  | Flames (ignition of combustible materials), eruptions of various fluids followed by fires                                                                                                                                                                                                                                                                                                                                                                             | Provision of equipment and materials for the control and liquidation of the consequences of such events                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>Establishing the work area taking into account the possibility of accidental flames, flames in the vicinity or at the point of intervention</li> <li>Staff training on how to use PPE</li> </ul>                                                                                                                                                                                                                                                                                 |                                                         | Permanently and whenever needed | The managers of the workplaces and the workers themselves                                                                                                                               |
|  | <ul style="list-style-type: none"> <li>Electric current - direct touch:</li> <li>-S.D.A.C.R., D.E.C.A.F., electric motors, non-insulated, twisted, pierced electric cable routes</li> <li>Electric current - touch indirect:</li> <li>- corroded connections to the earthing installation, no socket</li> </ul>                                                                                                                                                       | <ul style="list-style-type: none"> <li>Identification of the installations to be worked on, Visual verification of the integrity of the earthing of the casings</li> <li>technical equipment, the provision of means to ensure the collective/individual protection of workers (helmets, protective visors,</li> </ul> | <ul style="list-style-type: none"> <li>Training and authorization according to the provisions of OHS legal and in force as well as the periodic testing of technical and OHS knowledge. of authorized electricians</li> </ul>                                                                                                                                                                                                                                                                                           | The rhythmic supply of personal protective equipment    | Permanently and whenever needed | <ul style="list-style-type: none"> <li>The authorized energy manager for the Company</li> <li>Designated OHS workers</li> <li>The managers of the workplaces and the workers</li> </ul> |

|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                        |                                                                                                                                                                                     |                                                                                        |                                                                                                                   |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
|                                                | lugs, accidentally pierced insulations, detachments of flexible cables feeding consumers, integrity of the outer sheaths of the cables affected                                                                                                                                                                                                                                                                                                                     | gloves, electrically insulating boots, carpets and/or electrically insulating tools), the assurance by the members of the work team that there are no nearby (safety distances) unfenced live parts |                                                                                                                                                                                                                                                                        |                                                                                                                                                                                     |                                                                                        | themselves                                                                                                        |
|                                                | Failure to use protective equipment                                                                                                                                                                                                                                                                                                                                                                                                                                 | The purchase of E.I.P. corresponding to the activities to be carried out according to the OHS. regulations, in force (risk assessment and internal regulations for granting PPE)                    | Training workers on the consequences of not complying with safety restrictions, non-use or incomplete and/or incorrect use of PPE                                                                                                                                      | Making the workers themselves aware of the necessity and obligation to wear their individual means of protection;                                                                   | Permanently, periodically and whenever needed<br><br>Monthly at the thematic trainings | The managers of the workplaces and the workers themselves<br>Designated workers<br>The managers of the workplaces |
| <b>Pipe rehabilitation and cleaning worker</b> | Movements of means of transport on and off site:<br>- truck cranes<br>- self-emptying<br>- special transport vehicles<br>- forklifts<br>- bulldozers<br>- passenger transport vehicles<br>- other vehicles<br>Risk of injury to circulation in the premises and/or outside.<br>Manoeuvres with earthmoving equipment.                                                                                                                                               | Establishing and marking paths/routes/access passages, vehicle loading/unloading platforms, parking/stationing places for means of transport.                                                       | The training of workers regarding the importance of complying with the road traffic code and the legal restrictions for railway traffic areas from the Regulation for the application of O.U.G 195/2002, from H.G. 1391/2006; H. G. 1146/2006; H. G. 971/2006.         | Equipping with means of safety signals according to H.G. 971/2006. Periodic (annual) psychological testing                                                                          | Permanently and at each location of site<br>Monthly at trainings by themes             | The managers of the workplaces and the workers themselves                                                         |
|                                                | Functional movements of technical equipment – machine parts in motion:<br>-block crane-hook<br>-pneumatic winches<br>- intermediate transmission axles<br>- thermal/electric motors<br>- compressors<br>-mud agitators<br>-hydrocyclones-<br>denisifiers / looseners<br>-vibrating sites<br>- mud pumps<br>- winch axles<br>- hydraulic torque converters<br>- the action of the pressure group<br>- electric current generator groups<br>- centrifugal pump drives | Functional maintenance of measurement and control equipment, repair and installation of all protective devices                                                                                      | Prohibition of removing protective devices, checking the physical condition of the active elements of technical equipment before starting work, Training workers in the "OHS's own instructions." on functions and jobs" and checking how security rules are respected | Performing adjustments/calibrations/checks of technical equipment, practical assembly/disassembly exercises of mechanisms and sub-assemblies where risks of hitting may occur, etc. | Permanent and at each site location<br><br>Monthly at the thematic trainings           | The managers of the workplaces and the workers themselves                                                         |
|                                                | Functional movements of technical equipment – fluid flows:<br>-pull-push/drain ("barren") pipelines, mud pumps                                                                                                                                                                                                                                                                                                                                                      | Functional maintenance of measuring and control equipment, marking with OHS signaling, of all                                                                                                       | Training of workers from "OHS's own instructions on functions and jobs" regarding the                                                                                                                                                                                  | The rhythmic supply of spare parts, the adjustment/calibration/checking of technical equipment                                                                                      | Permanent and at each site location<br>Monthly at the thematic                         | The managers of the workplaces and the workers themselves                                                         |
|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                        |                                                                                                                                                                                     |                                                                                        |                                                                                                                   |

|                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                         |                                                |                                                                                                                                                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| - pressure valves (armatures) on the hydraulic routes of the working fluids<br>- storm<br>-vibrating storm                                                                                                                                                                                                                                                                               | areas with fluid flow hazards                                                                                                                                                                                                                                                                                                                                                                                                                                  | consequences of non-compliance with security restrictions, non-use or incomplete use of PPE                                                                                                                                                                                                                                                                  |                                                                                                                                         | trainings                                      |                                                                                                                                                                       |
| Self-triggering / self-locking of technical equipment:<br>-Rotary table<br>- mud pumps<br>- sissy<br>-winch<br>- hydraulic torque converters<br>-hydraulic head<br>- control desk operator-chief                                                                                                                                                                                         | The functional maintenance of the "breakdown stop" commands, the execution of technical revisions at the deadlines established by the law in force and by the other internal rules (provisions of technical books)                                                                                                                                                                                                                                             | Immediate reporting of all reported malfunctions or even suspicions about the functioning of mechanisms and systems of technical equipment                                                                                                                                                                                                                   | Checking the operation of these controls at the beginning of each work shift and on the occasion of revisions before special operations | Permanent and at each site location            | The managers of the workplaces and the workers themselves                                                                                                             |
| Movements under the effect of gravity (slips):<br>-uninsured mechanical components/assemblies<br>-falling of tools/tubular material from elevators/falling of the crane-hook<br>block/separation of subassemblies from the site mast<br>-detachment of sub-assemblies after cutting by welding due to their failure to secure them against uncontrolled movement                         | Securing mechanical components/assemblies against uncontrolled movements (by anchoring, shoring, stacking, etc., according to non-hazardous procedures, maintaining safe working conditions of tools, assembly elements, etc.                                                                                                                                                                                                                                  | Training of workers from "Instructions own them of OHS on functions and trades", with an emphasis on the correct way of handling and stacking parts, subassemblies, etc.                                                                                                                                                                                     | The rhythmic supply of spare parts, new, appropriate tools, etc.                                                                        | Permanent<br>Monthly at the thematic trainings | The managers of the workplaces and the workers themselves                                                                                                             |
| Movements under the effect of propulsion:<br>- design of bodies or particles:<br>-components of mud pumps, compressors, engines, intermediate transmissions or any other type of transmission<br>- breaks in pipes / fittings<br>gas / steam<br>- deviations from the trajectory:<br>- tubular material<br>- balance:<br>-hydraulic head<br>-hose<br>- jet, eruption<br>-vibrating hoses | Checking the physical condition of the bodies before putting the technical equipment into operation and/or maintaining the technical equipment in safe working conditions.<br>Marking of access ways and action lanes of technical equipment<br>Checking all routes with energetic fluids and immediately remedying the problems that have arisen, fencing off as much as possible the areas where there is a possibility of the appearance of jets, eruptions | Training on the need to use safety glasses and a dust masks<br>The appropriate signaling and warning by OHS, the correct positioning of the executors or in relation to the handled load<br>Training of workers regarding the consequences of non-compliance with security restrictions (intrusion into neighboring areas), non-use or incomplete use of PPE | The rhythmic supply of spare parts, spare technical equipment                                                                           | Permanent<br>Monthly at the thematic trainings | The managers of the workplaces and the workers themselves<br>Designated workers<br>Occupational medicine doctors<br>Laboratories specialized in noxious determination |
| Pressure vessels:<br>-air cylinders (from the air preparation group)<br>-oxygen cylinders, acetylene, hydrogen, nitrogen, etc.                                                                                                                                                                                                                                                           | Functional maintenance of measuring and control equipment, provision of these containers with safety components / subassemblies                                                                                                                                                                                                                                                                                                                                | Periodic training from "Instructions own by OHS on functions and jobs", from the legislation on P.S.I., insurance with means of P.S.I. adequate and within the validity period, risk signalling                                                                                                                                                              | Protection during transport, handling, storage and work                                                                                 | Permanent and whenever needed                  | The managers of the workplaces and the workers themselves                                                                                                             |

|                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                            |                                      |                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Electric current – direct contact:<br/>-S.D.A.C.R.,<br/>D.E.C.A.F.,<br/>electric motors, non-insulated, twisted, pierced electric cable routes</p> <p>Electric current – indirect contact:<br/>- corroded connections to the earthing installation, no socket lugs, accidentally pierced insulations, detachments of flexible cables feeding the consumers, integrity of the outer sheaths of the cables affected</p> | <p>Identification of the installations to be worked on, Visual verification of the integrity of the earthing of the casings technical equipment, the provision of means to ensure the collective/individual protection of workers (helmets, protective visors, gloves, electrically insulating boots, carpets and/or electrically insulating tools), ensuring by the members of the work team that there are no nearby (safety distances) unfenced live parts</p> | <p>Training and authorization according to the provisions of OHS legal and in force as well as the periodic testing of technical and OHS knowledge of authorized electricians</p>                                                                                                                         | <p>The rhythmic supply of personal protective equipment</p>                                                                                                                                | <p>Permanent and whenever needed</p> | <p>The authorized energy manager for the Company</p> <p>Designated workers</p> <p>The managers of the workplaces and the workers themselves</p>              |
| <p>Noise – engines, compressors, rotary table, winch, mud pumps</p>                                                                                                                                                                                                                                                                                                                                                      | <p>Refurbishment of work equipment and technological installations on site, so that in comparable technological conditions priority will be given to those that produce the least noise.</p>                                                                                                                                                                                                                                                                      | <p>The alternation of work times in the noise with periods of rest, as far as the technological process allows. Marking and security signage of areas with noise exposure above the maximum allowed limit, Worker access will be limited as much as possible, Training workers on how to use earplugs</p> | <p>The purchase of more efficient technical equipment and the rhythmic supply of antiphones; Carrying out periodic determinations of the noise level in installations and on locations</p> | <p>Permanent and whenever needed</p> | <p>The managers of the workplaces and the workers themselves</p> <p>Occupational medicine doctor</p> <p>Laboratories specialized in noises determination</p> |
| <p>Wrong commands and signals:<br/>- in the treatment of well situations (eruptive manifestation, instrumentation, pipe-cement, other special operations)<br/>- in the handling of certain technical equipment (tools, machines, materials)</p>                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>Retraining through education of workers, done within the Company or by training centers</p> <p>ability from the country or abroad</p>                                                                                                                                                                  |                                                                                                                                                                                            |                                      | <p>Directors of the Company</p> <p>Human Resources department</p>                                                                                            |
| <p>Wrong / faulty adjustments to:<br/>- safety valves from the pumps, from the compressed air cylinders within the air preparation group, etc.<br/>-steam boiler burner (with flame return)<br/>- functional parameters of electric / thermal engines<br/>- closing / opening of pressure valves, adjustable nozzles, etc.<br/>- the braking system of the drum<br/>maneuver from the winch</p>                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>Training employees regarding the consequences of non-compliance with security restrictions; Non-use or incomplete and/or incorrect use of E.I.P.</p> <p>Carrying out operations that are not entered in the job description and/or non-compliance with technological discipline</p>                    |                                                                                                                                                                                            | <p>Permanent and whenever needed</p> | <p>The managers of workplaces and the workers themselves</p> <p>R.S.T.V.I.</p> <p>The authorized energy manager for the Company</p>                          |

## 5. Conclusions

Recourse to new information and communication technologies, as well as to new production technologies, is a current aspect of professional activities. These socio-economic changes occur against the background of ever more open markets and increasingly fierce competition, forcing companies to constantly seek to improve their competitiveness. The internal changes that result from the adoption by economic organizations of strategies oriented mainly towards the economic result, lead to the translation of responsibilities in the enterprise and demand a certain degree of polyvalence from the workers. Existing trades and professions are changing, in parallel with the emergence of completely new ones. Accident prevention is one of the strongest paradigms of safety management. Therefore, understanding how accidents occur is essential in trying to minimize unwanted events.

One of the necessary conditions for understanding and mastering a phenomenon is knowing the intimate mechanism of its appearance and unfolding over time. The threshold of the transition from empiricism to science in any field of knowledge is marked by the moment when the question arises of the nature, origin and genesis of the phenomena that constitute the object of study. This work concerned the development of the prevention and protection plan for CALA – Centre for Technologies without Excavation S.A., in accordance with the provisions of art. 7, para. 4, lit. b, art. 12, para. 1, lit. and art. 13 of Law no. 319/2006 and art. 15, para. 1, points 1 and 2 of H.G. no. 1425/2006. From the multitude of methods used on a global and national level for risk assessment, in this work it was decided to use the method developed by I.N.C.D.P.M. Bucharest.

The list of evaluated workplaces/jobs (is shown in Table 4).

Table 4. Centralizer of the ranking of the assessed risk levels

| No. | Code | Workplace/job                           | Overall risk level |
|-----|------|-----------------------------------------|--------------------|
| 1   | F01  | Pipe cleaning and rehabilitation worker | 3,22               |
| 2   | F02  | Horizontal drilling worker              | 3,09               |
| 3   | F03  | Microtunneling worker                   | 2,94               |

The aggregate global risk level for the 3 workstations/jobs is:

$$N_{gs} = \frac{\sum_{i=1}^3 r_i \cdot N_{gi}}{\sum_{i=1}^3 r_i} = 2,89$$

According to the ranking, it is found that all workplaces have a global risk level below the allowed limit (3.5), they fall into the category of those with a low to medium risk level. The value of the aggregate global risk level per company  $N_{gs} = 2.89$ , determines its inclusion in the category of those with a low to medium risk level. A significant period has already passed since the recourse to the method developed by I.N.C.D.P.M. Bucharest and, on a European and global level, to other methods of the same nature, self-named "quantification" of risks, is carried out on a large scale in the field of safety and health at work, for ranking the risks specific to a trade, profession or workplace. Currently, more and more experts in the field criticize the limitations and disadvantages of this category of methods, considering them incomplete, unreliable, with a too pronounced subjective character. Other specialists nuance their opinions, proposing that such methods be applied only as complementary or informative tools. In practice, it has been observed that the ranking of jobs, depending on the value of the global level of risk, does not always correspond to the human perception of their dangerousness. Thus, a workplace less exposed to risks may have a higher global level of risk than another workplace more exposed to risks. Even if the argument can be invoked that this perception is based on "common sense" being, as a result, potentially subjective, it should not be neglected that it generally corresponds to objective reality, except for situations where gross errors occurred in application of the I.N.C.D.P.M. Bucharest method.

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