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RISK-BASED COMPARATIVE ANALYSIS OF THE ACTIVITIES OF OPERATORS WITHIN A NON-TECHNOLOGIZED POWER STATION IN RELATION TO A RE-TECHNOLOGIZED STATION

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Abstract: The aim of the paper is to perform a comparative analysis of the two power transformation stations (a non-technologized power station and respectively, a re-technologized one), focusing on their description, the main electrical risk factors and the activities of the operational staff**.** The main risk factors were identified, as well as the circumstances favoring the risk occurrence. The final section includes a summary of the main activities carried out by the operational staff within the two typical power stations. The results will serve developing an innovative management system for occupational safety and health with national applicability.

Keywords: National Power System, electrical risk, re-technologized power station, occupational safety and health**.**

1. INTRODUCTION

The National Power System comprises all installations intended for the production, transmission and distribution of electric power. The purpose of the National Power System (Fig. 1) is to ensure all technical, economic and safety conditions for supplying consumers with electric power [1]. Functionally, the National Power System can be found in one of the following conditions (Fig. 2): normal operating state, critical state, exposed state (alarm) and damaged condition.

The National Power System is achieved by interconnecting regional systems that are located in different geographical areas. Conversion, transformation and connection functions can be performed through power stations.

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The operational management of the power stations can be achieved locally and remotely. The functions of the management systems are found on three levels, such as: operational processing, application and data transmission.

Fig.1. The purpose and requirements of the National Power System [1]

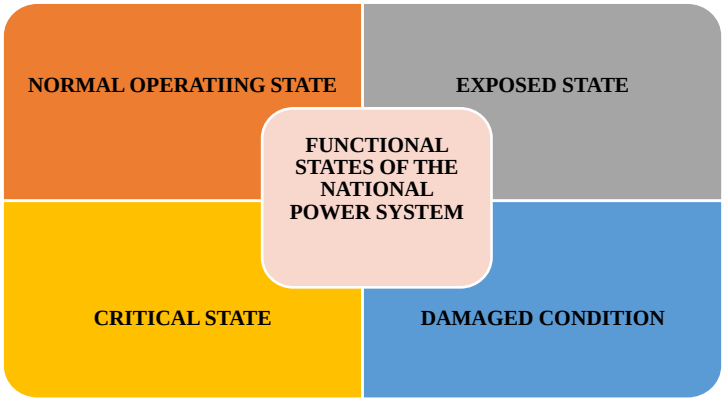

Fig.2. The National Power System – Operating conditions [2]

Fig.3. The main components of an Electric Power System

The importance of a power station is an indicator for highlighting the influence that the power station can have on the hierarchical level within an organization.

2. POWER STATIONS DESCRIPTION: NON-TECHNOLOGIZED AND RE-TECHNOLOGIZED

Within the non-technologized station, the staff that ensures its operation consists of 10 persons. The operative staff has a minimum rest time of 24 hours between shifts. A shift is 12 hours long. Within the re-technologized station, the staff that ensures its operation consists of 6 persons, and the minimum rest time for the operational staff is 24 hours between shifts.

Table 1. **The installations served in non-technologized station, respectively re-technologized station**

220/110/20kV non-technologized station	**220/110/20kV re-technologized station**
• Auxiliary systems with on-site control and tracking;	• Fully controlled and remotely monitored separators;
• Switches with SF6 insulation and 220kV spring mechanisms;	• Partially remote-controlled auxiliary systems;
• 220kV remotely-controlled separators and 110kV selector switch separators;	• Switches with SF6 insulation and 110-220-400kV spring mechanisms;
• Polygonal system in the 220 kV station – 6 knots, 7 coupling cells with switch;	• Secondary numerical equipment;
• Secondary equipment of different types such as: 220kV numerical, electromechanical with nine 110kV cells and numerical with five 110kV cells;	• The connection between the 110kV substation and the 20kV substation is made by two 25MVA transformers;
• The connection between the 220kV substation and the 110kV substation is made by two 200MVA transformers;	• The connection between the 400kV substation and the 110kV substation is made by one 250MVA transformer;
• The connection between the 110kV substation and the 20kV substation is made by one 25MVA transformer;	• The connection between the 400kV substation and the 220kV substation is made by two 400MVA transformers;
• Double bar system in the 20kV substation – 14 cells with switch;	• Simple sectioned bar system in the 20 kV – 14 cells with switch;
• Double bar system in the 110 kV substation – 14 cells with switch;	• Double bar system and 1.5 circuit breakers in the 400kV substation;
• Command/control and supervision system in the classical one;	• Extinguishing coil compensation system for medium voltage network;

• Extinguishing coil compensation system for medium voltage network.	• Remote communication network for protection and command/control equipment.

In the non-technologized station, the presence of staff inside the installations involves the risk of injury; the latter can be reduced through coordination by the team shift leader. Within the non-technologized station, the equipment has an overdue service life, and the remote control cannot be performed. Preventive actions can be undertaken based on the information provided by the operational staff. Within the re-technologized station, the equipment is modern, efficient and reliable.

3. MAIN RISK FACTORS IDENTIFIED WITHIN THE NON-TECHNOLOGIZED AND RE-TECHNOLOGIZED POWER STATIONS

Electrical risks characterize undesirable events which are specific to the operation of the technical system associated with a potential state of danger. The success of a risk assessment process depends, to a large extent, on the commitment and the involvement of the management, as well as on the allocation of adequate resources [3].

The activity known as risk analysis involves the complete acquisition of the constructive and functional characteristics of the objective or of the protection process, as well as the systematic use of collected data and information with a view to identify the specific threats [4].

This risk analysis is carried out at different levels of risk detail, information, purpose of analysis, available resources and data [4]. An important aspect of any risk analysis is the identification of all risk factors involved in technical and technological systems.

According to SR EN 31000: 2010, risk analysis is a stage of the risk management process. Existing, applied and validated approaches concerning occupational safety and health management focus on management functions, national and international guidelines, quality standards and principles, in order to define, describe and ensure the conditions for implementation of the occupational health and safety management systems within industrial organizations. These approaches may represent a necessary and beneficial step in the overall process of effective management of worker safety and health. However, these approaches may not and are even unlikely to be comprehensive for an adequate address of all the complex aspects associated with occupational risk management in the multifaceted context of current challenges triggered by major changes in the dynamic reality of emerging working environments [5].

Tables 2 and 3 summarize the results of identifying the major risk factors related to the comparative analysis of the two installations.

Electrical risk control covers all the methods, means, analyses, procedures and actions applied throughout the entire life cycle of a system in order to eliminate risks or render them acceptable [4].

There are certain situations in the field of engineering where the elimination of high risks is not possible. In such situations, this is called residual risks, the latter being associated with possible major damages.

Table 2. **Risk factors within the 220/110/20kV non-technologized station**

Risk factors within the 220/110/20kV non-technologized station	Circumstances favoring the occurrence of risk
• Damage to transformation units	• Poor maintenance of installations; • The appearance of defects in the own DC and AC service installations; • Use of equipment with overdue service life; • Improper operation of protection and automation systems;
• Failure of the 220kV overhead power line	• Certain defects in transformer station installations; • Faulty actions of the staff; • Extreme weather conditions;
• Damage to internal DC and AC service installations	• Poor maintenance of installations; • Existence of low reliability installations; • Faulty actions of the staff; • Poor employee training;
• Affecting the safety and the health of the operational staff	• Touching power equipment by employees; • The occurrence of electric arc and pace voltage in the installations; • Failure to provide protective equipment;
• Release of environmentally harmful substances (oil, smoke, etc.)	• The occurrence of fire due to equipment; • Poor maintenance of installations; • Faulty actions of the staff;

Table 3. **Risk factors within the 220/110/20kV re-technologized station**

Risk factors within the 220/110/20kV re-technologized station	Circumstances favoring the occurrence of risk
• Failure of protection and automation systems	• Existence of low reliability installations; • Certain defects encountered in the own DC and AC service installations; • Faulty actions of the staff;
	• Extreme weather conditions; • Existence of low reliability installations;

• Failure of command-control-monitoring systems	• Faulty actions of the staff;
• Inadequate management of human and financial resources	• Using erroneous data; • Failure to achieve the technical and economic indicators established within the investment; • Incorrect estimation of the fiscal result; • Defective financial forecast;
• Damage of communication and telemetering systems of electric power	• The occurrence of defects in the own DC and AC service installations; • Extreme weather conditions; Faulty actions of the staff;

4. ACTIVITIES CARRIED OUT BY OPERATIONAL STAFF OF A NON-TECHNOLOGIZED STATION COMPARED TO A RE-TECHNOLOGIZED ONE

4.1 Main tasks of the operational staff within a non-technologized station

a) Supervisory and operational activity: through this activity, a gathering of data regarding the status of the equipment is carried out. The data will be statistically processed for a proper operational routine with a view to failure and solution analysis, maintenance scheduling and performance assessment. Another important aspect of this activity refers to a evaluation of the installations through aural, visual and olfactory methods in order to identify possible incipient defects. Another important factor to consider is the high risk of injury of the operating staff during its access within the installations or when collecting the functional parameters of the equipment.

b) Operational activity and handling: is performed from the synoptic panel in the control room and it is carried out according to certain handling sheets. In this activity, handling involves the risk of extending the damages, when not all the technical data are known; in this case, the presence of the operating staff is necessary. There is a high risk for the operating staff in the proximity of the electrical installations carrying out the commands, switching devices, as during operation the latter may fail to function properly.

c) Operation and reception of works: taking into account the national standards and the internal regulations of the company, through this activity, the acceptance and the taking over of the works, respectively the access or the withdrawal of the assigned staff is achieved. The forms of acceptance of the work are carried out according to the provisions of Law 319/2006 (on safety and health at work) and operational procedures.

This activity bears a high risk for the operational staff when taking organizational measures or controlling the work area.

d) Administrative organizational activity: consists in carrying out maintenance works of technological spaces and auxiliary equipment, and of periodic inspections in conformity with operational procedures. This activity aims to ensure the proper functioning of the power supply equipment, of the remote protection equipment and of the command-control equipment.

4.2 Main tasks of the operational staff within a re-technologized station

a) Supervisory and operational activity: a collection of the data on the status of the equipment is carried out which will be statistically processed for technical assessment with a view to failure and solution analysis, maintenance scheduling and performance analysis. These data are collected from both the SCADA system and the monitoring system. The purpose of this activity is to track parameters in the MicroSCADA system. A major aspect to be considered is the high risk of injury of the operating staff during access within the installations or when collecting the functional parameters of the equipment.

b) Operational activity and handling: is performed in conformity with certain handling sheets from the SCADA system and from the installations. In this activity, handling involves the risk of extending the damages, when not all the technical data are known; in this situation, the presence of the operating staff within the station is necessary. There is a high risk for the operating staff in the proximity of the electrical installations carrying out the commands, switching devices, as during operation the latter may fail to function properly.

c) Operation and reception of works: taking into account the national standards and the internal regulations of the company, this activity results in the acceptance and the taking over of the works, respectively it ensures the access or the withdrawal of the assigned staff. The preparation of the works within the installations is carried out by the operating staff of the local branch including the operative staff. The forms of acceptance of the work are carried out in keeping with the provisions of Law 319/2006 (on safety and health at work) and the operational procedures. This activity bears a high risk for the operating staff when taking organizational measures or controlling the work area.

d) Administrative organizational activity: aims to ensure the proper functioning of the power supply equipment, of the remote protection equipment and of the command-control equipment. A major risk of this activity is the occurrence of mechanical accidents, infections/poisoning or intense physical effort. For the

supervision and performance of the handling, the presence of the operating staff within the station is required.

5. CONCLUSIONS

The activities carried out by the operating staff in the two types of electrical power stations are quite similar, and depend on the existing electrical equipment. In the case of non-technologized station, the existing electrical gear is outdated in terms of technical performance (low operational reliability, inadequate technical condition of the switching equipment and autotransformers). Within the re-technologized station, there is efficient and reliable electrical equipment with high electrical and mechanical reliability that allows: reduction of the probability of damage, low maintenance costs, protection of the operating and the maintenance staff. Within the re-technologized station there is a decrease in the types of risks: accepted residual risks and eliminated risks. In both power stations, the presence of operating staff is necessary for handling, supervision and coordination of the station staff itself. It seems that it is increasingly need to identify, develop and implement a new pragmatic approach, realistic and adapted to the existing conditions. However, the approaches need to be at the same time systemic in terms of occupational safety and health management. A systemic approach is to be adopted in order to develop a systemic model of occupational safety and health management, a model which will address the "*environmental*" factors explicitly and in detail; moreover it will also include the development of the concept of recursion, with an application of the model within electrical industrial companies in order to illustrate its characteristics.

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