THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI.
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N^0. 1 – 2013, ISSN 1453 – 083X

R.N.U.R. METHOD OF RISK ASSESSMENT BASED ON ERGONOMIC CRITERIA. CASE STUDY: CRANE MAINTENANCE ELECTRICIAN

Adrian VASILIU, Marian BORDEI
"Dunărea de Jos" University of Galaţi, 111, Domnească Street, 800201, Galaţi, Romania
email: avasiliu@email.ro

ABSTRACT

This paper presents a case study on the evaluation of a job (electrical maintenance) in AMG plant through a less used method in Romania, respectively Renault method, used especially in France. Means of work are analyzed on the basis of the technological equipment, the work task based on the job description and the work medium based on analyzes of made by occupational medicine. The test results are tabulated and graphically processed and they are taking into account to establish the conclusions and the measures to be imposed at the analyzed work place.

KEYWORD: ergonomics, risk assessment, Renault method, system work, physical environment, reduction efforts, job profile

1. Introduction

Ergonomics refers to the compatibility of people with their job: employee abilities and limits, ensurance of tasks, equipment, information and working environment that fit everyone. In assessing this compatibility it is taken into consideration: the degree of fulfilling the employee obligations, the equipment qualities (size, shape, and how appropriate are for service obligations), the information used during work activities (mode of presentation, access and change). The ergonomic analysis of the workplace has as objectives the optimization of constructive design of jobs by improving occupational safety and improving the physical environment factors, reducing the negative effects because of the work monotony and decrease of physical and mental demands.

To ensure the efficiency man - work means - environment and to minimize error possibilities, while reducing stress, the same time with increasing job satisfaction, it is necessary for organizers and leaders of work processes to use appropriate methods based on possibilities and human requirements during labor process. In these circumstances, the analysis, design and ergonomic redesign of the workplace is of great utility.

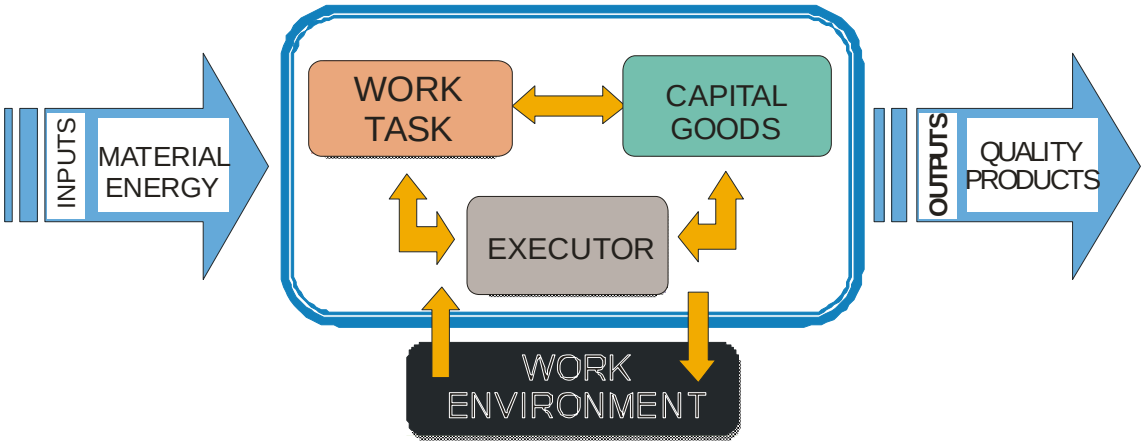

Fig. 1. *The components of the work system*

The work system can be defined as the assembly of inter-relationship components, developing during various activities, in order to transform the system inputs (materials, subassemblies, energy, etc. purchased / supplied) in system outputs (products, services, etc. delivered / sold) to meet the needs in the market.

The components of the work system are: work tasks, worker (executive), inputs, work environment (Figure 1).

2. Theoretical considerations

R.N.U.R. method assessment based on ergonomic criteria aims the analysis and redesign of the existing work systems and has been developed at the National Administration of Renault Plants, France. It is based on the interaction man - machine, which takes place in an environment of mutual dependencies between the components that are being investigated thoroughly, emphasizing possible problems highlighted in these interactions.

The process has as its starting point the analysis of existing working conditions (based on direct observation) or designed to perform in different ways and for each job, depending on the evaluation factors and criteria of influence. In order not to omit important ergonomic issues, the R.N.U.R. method analysis 27 influence criteria (Table 1), divided into 8 evaluation factors (A - H), with 5 fields of research, where the more favorable is level 1 and the worst is level 5, (Table 2).

Table 1. *Influence factors and evaluation criteria analytical work system*

Areas of investigation	**Factors of influence**		**Criteria of evaluation**	No.
Concept of the work place		A_0	Height - distance	1
			Feed and discharge	2
			Agglomeration – accessibility	3
			Commands - signals	4
Safety Factor		A	Work Security	5
Ergonomic factors	Physic ambience	B	Thermal Ambience	6
			Sound Ambience	7
			Artificial lighting	8
			Vibrations	9
			Hygiene atmospheric	10
			Workplace aspect	11
	Physic load	C	Physical main body	12
			Worst position	13
			Work effort	14
			Work position	15
			Handling effort	16
			Position during handling	17
Psychological and social factors	Mental task	D	Mental operations	18
			The level of attention	19
	Autonomy	E	Individual autonomy	20
			Autonomy in group	21
	Work relationships	F	Independences work relationships	22
			Dependences work relationships	23
	Repetitivity	G	Repetitivity of the work cycle	24
	Work content	H	Work potential	25
			Responsibility	26
			Work interest	27

The determination of ergonomic levels is done taking into account the significance of each criterion, adapted to the concrete situation of work (Table 2).

Assessing the degree of difficulty of each criterion previously met is carried out in order to:

- optimize of workplace;
- ensure security work;
- improve physical environment;
- reduce physical and mental demands;
- establish appropriate psychosocial working conditions
- interpret job profile.

Table 2. *Evaluation grill of method criteria*

Level	Evaluation factor						
	A	B	C - D	E	F	G	H
1	very good		very easy	< 30 min	group+ from outside	< 10 min	high
2	good		easy	15 - 30 min	group	5-10 min	
3	acceptable		normal	5-15 min	easy relationships	3-5 min	medium
4	danger	difficult	solicited	1 - 5 min	direct relationships	1-3 min	
5	very danger	very difficult	very solicited	< 1 min	isolated	< 1 min	low

Workplace concept ($\underline{A_0}$). The specialist attention will turn to the interaction between the work space and the human component of the system. It is checked if the height and distance between the arms and legs zones drive operator both work orthostatic position and sitting, are correlated with anthropometric measurements of the operator (A_{01}).

The possibility of feed and discharge of the pieces (A_{02}) is, also, related to anthropometric dimensions of the worker. At the same time, these activities are investigated based on the moving economy principles; so that the worker can feed and discharge the pieces based on the movements of the lower classes, the less energy consumers. It is preferred to use the solutions which use the law of gravity, reducing both worker effort and time required for these activities.

The agglomeration and accessibility at the workplace (A_{03}) involves a study of the organization of work and the possibility of movement at the workplace. It is useful to have an outline of the section or workshop on which mark the jobs, equipment, material storage items, boxes, tables, etc. In these sketches there will be shown the access roads and routes crossed by the worker to fulfill the task, emphasizing the agglomeration points and unnecessarily long routes.

The commands and signals (A_{04}) may generate problems for the interaction between workspace element and human components: the senses, etc.; consequently, the conception of the machine control actuators (buttons, cranks, levers, wheels, etc.) of the signals (sound, images, etc.), of the measuring apparatus will be verified in terms of the visualisation, the location, the clarity of message.

Work safety (A) is one of the main objectives of ergonomics (safety factor A_5). The conditions of producing accidents and incidents, and their severity are investigated, taking into account the equipment used and the nature of the activities implied.

Physical environment of work (B) is characterized by a set of influence criteria, bringing together both the physical state of air, air hygiene, appearance, and problems related to noise, vibration, lighting etc.

Thermal environment (B_6) assesses whether the workplace air temperature both in warm and cold seasons, coupled with dynamic work load, provides the operator the physiological status, appropriate to carry out work in a normal rhythm.

Sound environment (B_7) is characterized by measuring the sound pressure levels for continuously noises present in the workplace and for intermittent ones. The measurements are made by using precision sonometers with type A filter; the evaluation levels of this criterion are in accordance with ISO standards.

Visual comfort (B_8) involves measuring the levels of lighting with a help of a luxmeter and comparing these values with those recommended for the different activities, depending on the precision of the works. It also taken into account the luminance, both in terms of contrast and brightness of the distribution.

The frequency, amplitude and duration of exposure to vibration (B_9) are determined through their adverse effects on the health of the operator.

Atmospheric hygiene of the physical environment (B_{10}) refers to environmental pollution with: dust, fumes, gas, and vapor. The extent to which those pollutants and how they affect the health of the operator and his ability to work are considered.

Aspect of workplace (B_{11}), both in terms of cleanliness, space, chroma, and in terms of natural lighting - appreciated by fitting windows, floor surface, the distance between work and frontage windows.

Physical exertion (C) who is subject the operator is a fatigue generator, frequent cause of decreased of the work capacity. Based on the analysis of the work task and the work method, worker position during their activities are determined.

Postural solicitation gived by the main position once of the operator body (C_{12}), correlated with time-keeping in that position, should be determined not only the most important activity such as processing itself on a machine tool, but for all activities which are carried by the operator to achieve the task, eg training activities and closing operation for the operator make an effort (lift, push, pull, push, grip, etc..) request generated is estimated by the strain time and effort to maintain the position and frequency of efforts.

This evaluation is done for the step of converting the product (C_{14}) and for the step of handling thereof (C_{16}). The position of the worker requests, generated during the effort in both the step

of the product converting (C_{15}) and the step of handling (C_{17}) are examined and evaluated.

Nervous solicitation (D*)* of the operator during the work aimed at overloading the nervous system, resulting in time to exhaustion. In assessing the application date nervous mental operations (DL8), depending on the number of information received and processed in a minute and duration for implementation of these operations without affecting the smooth running of the process. Request nervous due care level (D_{19}) is determined taking into account the care and precision required by the tasks.

Autonomy in the work activity (E) is a factor with which to appreciate enables the operator to leave the workplace in order to consume the time for rest and physiological needs, without disrupting production. Check both individual autonomy (E_{20}), depending on the maximum duration of leaving the job of a performer and group autonomy (E_{21}) by the maximum in which many performers may leave the workplace without affecting the production process, for example to take a break superimposed during machine operation.

Labor relations (F) man-machine system environment in which the work is the use and the organization of work, including social problems. The nature of the task and work organization influences independent labor relations (F_{22}) between operators, seen through the extra-communication during the work, without negatively impacting its deployment.

Investigation dependent relations to work (F_{22}) covers the possibility of communication with the next higher hierarchical organs, control staff, refinish, repair, transport, etc.., In the interest of the service.

Repetitive work cycle (G) tires the operator by monotony. Depends on the number of operations is repeated identical cycle work, the number of different jobs that can rotate performer, and rotation period.

Labor content (H) is a factor that investigates the relationship between the human and tasks. The necessary skills to perform the task, correlated with activity during adaptation are taken into account by potential employment criterion (H_{25}).

Responsibility criteria (H_{26}) focuses the ergonomist attention to the potential for error because of the nature of the task, for the consequences of producing errors and operator's ability to solve the errors and labor problems incurred.

Working interest (H_{27}) is a criterion which addresses the extent to which task work gives satisfaction operator. Check that the operator runs several phases necessary to manufacture a product or has met only one task, if his work is recognized in the product, making the whole product or only parts of the whole, if it can decide and choose the order of technological operations, machinery, tools, appliances, checkers needed.

3. Case study: maintenance electrician risk assessment

This step is done at work which operates under review. It will collect information on the existing technical conditions, for example, equipment, tools, devices, checkers, wear and so on, and on specific issues of work organization.

The work task is studying by the analysis method applied to measure the activities and time for the exercise of these work activities. For the data collected to be realistic and complete, will discuss these issues with the operators involved in working with specialists from the slot.

The work process is aimed at maintaining, repairing, supervision, adjustments and interventions to remedy defects in components of lifting equipment and transport (the cranes, hoist, etc.) of the Furnaces Department.

4. The components of the system of work reviewed

Means of production: lifting equipment (cranes, hoist, jib cranes etc.) with related equipment (electrical, mechanical, etc.); panels and / or internal service switchboards DC and AC.

Gears on the side panels of automation and protection: AMC: meter, ammeters, voltmeters; relays; switchgear; electrical protection; strings of terminals for conductors; medium voltage cables.

Motors, synchronous, asynchronous and current; DC voltage converters; DC generators; Process computer and peripherals; Electricity transmission systems cables MV, LV, control and signaling.

Specific tools, accessories and devices: locksmith T.S.L. kit; electrician kit; voltage detector; measuring devices (multimeters, oscilloscopes, signal generators, testers, etc.); field equipment (limiters, proximity detectors, pressure transducers, flow, displacement, position); flashlight; portable scale; shorted; voltage detectors (test);

Workshop engines: universal drilling machine; fixed electric grinder; vice; various kits for verification; solders; wire brushes; pick; shovel; pickaxe; shovel; fire extinguishers; electrical heating unit; workbenches; transformer oil; painted gun; paint thinner, alcohol technical brushes; installation of fluorescent and mercury vapor.

Inputs to the electrician performing work or in contact during work: DC motors; AC motors; ventilation systems; controls; control cable, power and low voltage; bridge, well, basement, electrical cable tunnel; drilling machine; car stopped; tipping

trough; oxygen distribution facilities; installation of methane gas distribution and gas protection; compressed air systems; electrical installations; automation systems; other specific work activities occurring within the department furnaces.

Working tasks

According to the documentation provided by the department, the burden of work is shown mainly by the following documents:

- work and safety instructions for the maintenance and repair of cranes;
- ISCIR technical requirements;
- safe work practices for working at heights;
- workplace description for the position maintenance electrician platform.

Besides the work tasks of the documents listed above, maintenance electrician has the following job responsibilities:

- have to come to work in full capacity to perform work tasks smoothly incumbent;
- is obliged to strictly observe the rules laid down by the laws and regulations of the interior order;
- must be committed to work, presenting before starting the program without delays or interruptions;
- has an obligation to perform quality work and meet the technical standards of maintenance and repair;
- performs the binding of pregnancy (pregnancy related authorized);
- does not leave work without the driver or without good reason;
- works only with specific equipment sector approved, verified and approved by the responsible factors;
- is required to make and maintain cleanliness in the workplace;
- responsible for compliance with OHS and general and sector-specific SU activity;
- responsible for compliance with RI, CCM and occupational standards.

In this assessment were checked electricians job descriptions of CM (no brand 86xxx), MG (no brand 69xxx).

Work environment

Electrician work is conducted on the premises which houses the production areas and outside the Department furnaces (stoves raw sewage / fine dosing skip drive, chargers, etc.). From the analysis report no. 88 - 100 of 12/08/2013, are found to be exceeding the allowable values for the following pollutants in the work environment: noise and dust. In addition we can remark during unloading iron, air temperature, and (within legal allowable) the presence of particulates, carbon monoxide, silicon oxide, air currents and IR radiation emission.

Work system analysis method based on specific criteria

Work system analysis method was used RNUR This method is typical of industrial usability. Analyzing employment situation - taking into account the factors of influence - has the advantage of allowing an overview of all aspects that define the work system interacting not only assign a single decisive factor, which would be easily visible and easier Mitigation.

As each factor is defined by values and characteristics, compliance levels ergonomic factors under evaluation grid is done with precision, without interpretation.

This means analyzing and evaluating ergonomic ensure, through systemic vision that has on labor activity, the fact that improvements in one area does not entail negative effects in other areas of influence.

Evaluation Criteria

The evaluation criteria are the number of 27 organized so as not to omit any issue that would be important in terms of ergonomics the system work and hence the health and safety of workers operating in job analysis.

The evaluation criteria are divided into eight evaluation factors and are valued using valuation scale from 1-5, where level 1 is the most favorable, and level 5 the worst.

As a result of analysis of the working of the system, each component of the working part, and the evaluation levels are obtained for evaluation criteria summarized in Table 3.

Table 3. *Evaluation criteria*

Factors of influences	**Evaluation criteria**	**Level evaluatedt**
A_0 1	Fall on same level as the imbalance by sliding the drive, by tripping, etc. and falls from height: by stepping into the void, the balance is lost, the drive, sliding etc., falls from height due to inadequate spontaneous reactions in case of danger.	2
A_0 2	Slipping, rolling of parts, materials, assemblies, subassemblies, etc. stored without stability.	3

A_0 3	Visits and stationary in hazardous areas - ex. on the access roads and rail cars under suspended load lifting hook, right next to the furnace platform work equipment that is in working order (ie in the vicinity of the discharge chute, cast iron machine gauge stopped or drilling, etc.) adjacent mounting holes, bearing the guard rails provided in areas where there is the possibility of falling from height, crossing gutters clay through undeveloped places, travel out work tasks in the vicinity of installations etc. energized.	3
A_0 4	Making electrical drives by identifying erroneous cells and / or items of electrical equipment. Means not checking electrical protection (electrical poles, voltage indicator, etc.) and individual protection means. Run memory electrical connections. Using makeshift control lamps. Running the wrong power cable connections from the connection terminals of electric motors. Putting accidental electrical voltage of a cell that has not been removed or CLP scurtcircuitorul coupled. The power supply of an electric cell located in pregnancy (running) by operating (opening) separator line or bar etc. The drive switching devices without protective cover. Use fuse handle M.P.R. defective without ferrules etc. Remove fuses M.P.R. high voltage without de-energize the associated circuit before performing this activity.	2
A 5	Unexpected activities performing work activities (outside work tasks) do work for which no qualifications and / or authorization required. Making operations, activities, work, etc. in a different manner than those of working instructions, instructions for safety, work procedures and manufacturing requirements for safety and health at work, etc. ISCIR prescriptions.	3
B 6	High air temperature in some work areas, especially near the iron and slag troughs, etc. Low air temperature in cool season in some areas of work.	3
B 7	High noise level - as attached determinations ballot - more than the maximum allowable.	2
B 8	Low light in some areas of it.	3
B 9	No vibration.	1
B 10	Accumulation of toxic gases - carbon monoxide presence in some areas of work (as ballot measures linked to below the maximum allowable), the occurrence of toxic gases from certain insulation piercing (epoxy resins, PVC, etc..) Current transformers and / or electric motors, complex gases from burning insulation of electrical conductors, etc..	2
B 11	High contrast between the iron and clay, and general background incandescent lighting of the hall, a visual overload. Ionizing radiation (IR) from the flow of liquid iron gutters, etc.	3
C 12	Postures mixed forced vicious	3
C 13	Forced postures, vicious - ex. interventions to be carried out at height, in confined spaces, etc..	3
C 14	Dynamic effort than intervention route.	3
C 15	Complete of major routes for interventions	3
C 16	Dynamic effort handling tasks.	3
C 17	Lumbar spine disorders handling large electric motors	3
D 18	Difficult decisions to be taken in short time to remedy situations of "incident" or "failure".	2
D 19	Mental stress related to risk of injury	2
E 20	There are individual autonomy depending on the time of leaving the workplace	2
E 21	There is autonomy grouped by time of leaving job	2
F 22	There are interdependent relationships in the band working without affecting the work.	2
F 23	Communication with hierarchical structures and other operators in the work stations, radio stations directly or through	2
G 24	Operations repetitive short cycle time repair shop engine	2
H 25	High work pace on some days of service (scheduled repairs or damage).	2
H 26	Performing operations with high degree of responsibility	2
H 27	Solving multiple and diverse work tasks	2

Evaluation grid (method criteria)

The evaluation grid is evaluated for the 8 levels of evaluation factors, labeled A to H. The level of each factor is calculated as average of criteria related influence. After analyzing the work system under evaluation in terms of ergonomics, we obtained values of levels of assessment factors entered in Table 4.

Table 4. *Levels of assessment factors*

Evaluation factors	A	B	C	D	E	F	G	H
Evaluated level	2.6	2.3	3	2	2	2	2	2

The workplace profile interpretation

Levels ergonomic listed in Table 3 translates to a graphic in the assessment levels are noted at equal distances on the abscissa and the ordinate are ranked the 27 influential factors, in order of their current numbers.

After analyzing the work system using the R.N.U.R. method each criterion investigated revealed interactions between different blocks of the system and was rated with the evaluation grid. These results can be plotted to highlight areas of poor system design.

Analytical profile of the work system consists of a graphical representation of all levels of evaluation criteria influence. The analysis shows the normal operation of the system work, but may be searched for ways to improve the performance of the whole system work and not just one of its components. Influence criteria considered are those listed in Table 1.

Overall picture of the system work gives an overview of the system, the level of each factor yielding the arithmetic mean of the respective criteria of highlighting the weight factor and the difficulty accordingly. As shown in Figure 3, the physical load limit reaches normal levels remaining evaluation factors ranging between good and very good.

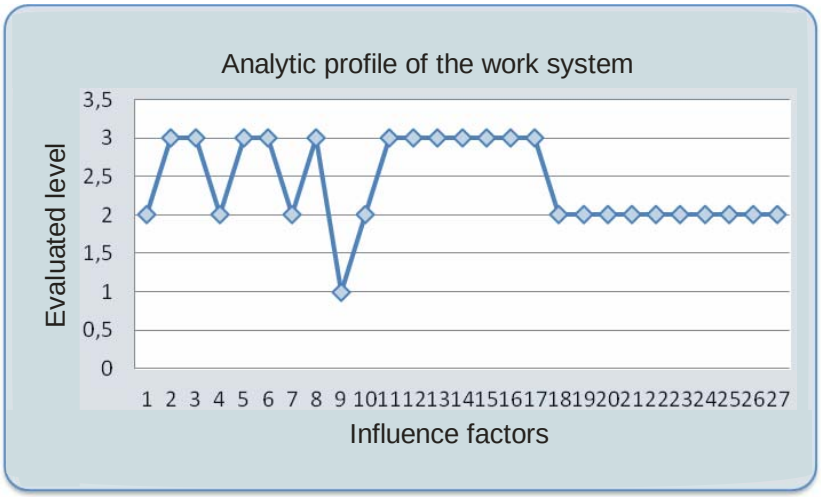

Fig. 2. *Graphic representation of the analytical profile of the work system*

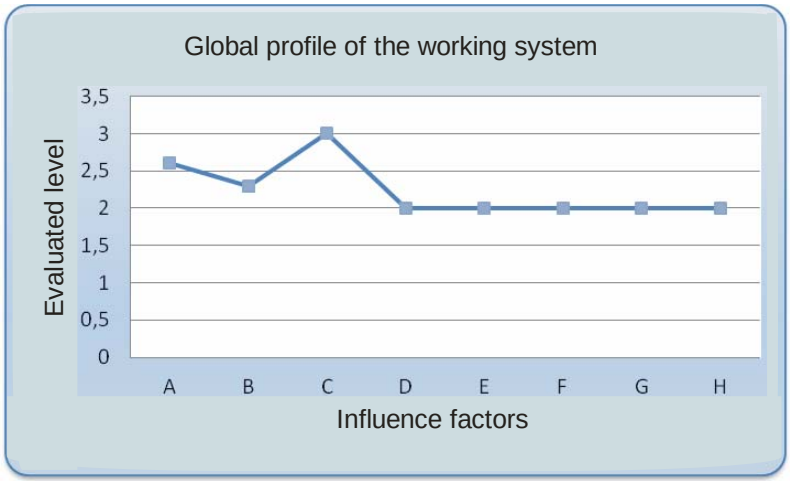

Fig. 3. *Graphical representation of the overall profile of the work system*

Assessment factors analyzed are: (legend): A concept of employment and security B-physical environment, physical exertion C-, D-load nervous, E-autonomy F-relations work; G-repetitive H-labor content.

5. Conclusions

R.N.U.R. method assured the opportunity to analyze the interactions between the worker and the other system components, linking possibilities morphological, functional, psychological, etc. with its technical, economic, organizational, social system works, for which all determinants of the method can be considered ergonomic.

The analysis work performed on *electrical maintenance and repair bridges* in the section of the Mechanical repairs furnaces Department, we can draw the following conclusions:

- overall picture of the work system has values between 1 and 3 These values are within normal limits, demonstrating the existence of a safe workplace, no major influence, in terms of worker health and safety ergonomics.

-higher values are observed in the workplace, physical environment and physical exertion;

-analyzing the graph profile analytical work system see detailed criteria influence the values close to the danger zone. If the global situation is normal, the criteria of influence should be studied and treated individually, according to the assessment made for corrective action to improve the performance of the whole system and not just one of its components.

Measures

We recommend certain technical and organizational measures which can translate into practice the following:

- proper storage of parts and devices to ensure stability;
- marking of access roads and security with guard rail mounting holes;
- training and verification of compliance with work instructions and ISCIR technical requirements;
- work load will be distributed during periods of high thermal discomfort on a larger number of employees by a system of rotation and breaks;
- the arrangement of locations in which workers to regulate body temperature;
- providing the facilities department to ensure microclimate;
- leveling platform furnace to eliminate bumps;
- providing intervention to prevent vehicles traveling on long routes;
- after performing operations requiring the worker to work in orthostatic position for long periods will necessarily perform some gentle exercise warming-up of the body;
- use of mechanical devices for lifting handling and transport operations by response personnel.

References

[1]. Burloiu, P. - *Managementul resurselor umane.* Bucureşti: Lumina Lex, (1997), p. 1272.
[2]. *** - *Les profils de postes*. Paris:Ed. Masson, (1976), p. 20-40
[3]. Grandjean, E. - *Principiile ergonomiei*. Bucureşti: Editura Ştiinţifică, (1972).
[4]. Vasiliu A - *Asigurarea mediului de muncă* – uz intern Galaţi (2013).
[5]. *** - SR EN ISO 6385:2004 – Principii ergonomice de proiectare a sistemelor de muncă.