Safety Management Diagnostic Method Regarding Work Cost Accidents from Electrical Power Installations

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Abstract: - This study aims to realize a cost-benefit analysis in order to make available, for all factors involved in the working process, the results of case studies that can be used in the development of occupational safety and health (OSH) management policies and financial resources within the company, to ensure a safe and healthy working environment and to increase the business competitiveness in the market. The necessary indicators for quantifying the accidents at work and occupational diseases will be identified, related to the legal requirement for ensuring the highest possible level of safety at work, taking into account that the Romanian legal framework is different from that one applied in the most U.E. States Member, compared to insurance and compensation. The presented case study aims to make an analysis over the cost of an electrocution accident regarding the live working technology and the cost of applicable safety measures that are required.

Key-Words: - Electrical accidents, accident cost, electrical installation, health and safety, graphical models

1 Introduction
An accident at work is a violent body injury and an occupational acute poisoning that occur during the work process or in time of working duties and causing temporary work incapacity of at least 3 days, disability or death. The accidents at work and the related injuries represent a considerable economic burden for employers, workers and society and can cause suffering and can affect the worker's life, both at work and at home.
The impact that an accident at work has on a company is the immediate purely economic effect: loss of working time, reducing the work productivity, reducing the capital stock, etc. It is well known that one of the important advantages of applying live working technologies is to reduce the number of accidents at work. Respecting the procedures and work instructions is essential in live working installations.
In Romania, after more than 30 years in the live working there hasn’t been recorded a high-voltage accident. Regarding the live working in low voltage installations, there is no statistics recorded for accidents at work. The appearance of NTE 10/11/00 supports employers who performs live working, as well as in support of HG no. 1146/2006.
In figure 1 is presented an analyze developed by the electricians in their work electrical activities and which was carried out in order to establish the level of risk of injury and disease that took place over six years, 2004 ÷ 2010, made under contracts with some of the national companies and energy the evaluation of working conditions in the electrical installations.

Figure 1. Power stations evaluated in the study on assessing the risk of accidents and occupational diseases

The live working method is a commonly used method in the maintenance activities such as corrective and preventive of electrical installations. From an economic perspective, in order to secure continuity of electricity supply to consumers is considered an effective method both for producers, transporters, distributors and electricity suppliers and users. However, in terms of safety and health at work, taking into account the maximum foreseeable consequence in case of injury, using this method
involves a special attention regarding the high level of professionalism of employees, organizational forms of work, the working equipment for live working and the protective measures. A large percentage of employers, particularly in the field of electricity, believes that the prevention and protection is an activity that is without profit, consuming resources, particularly financial resources and should be treated in terms of its efficiency. [1]

Taking into account the loss of profit, the main problem for them is the amount of money to be allocated to prevent accidents and occupational diseases. The accidents at work and occupational diseases occur in the time of working duties by the workers, the effects and severity of them depending on risk factors at work. In this sense, every employer should realize the value of workers and to admit that their safety is justified. An evolution of the incidents number per month during 2004 - 2010 in high-voltage electrical installations is given in figure 2.

The novelty of this paper is to quantify the cost - benefit rate for the company, related to specific national legislation regarding the insurance for accidents at work and occupational diseases under the Law number 346/2002 with subsequent amendments.[3]

In many countries, there were estimated the cost of accidents at work and occupational diseases. In general, the cost estimations must be interpreted carefully, as there are different approaches from one country to another.

2 The cost of accidents at work
The cost of occupational safety (taking into account that its achievement is equivalent to maintaining the anatomical integrity and functional health of employees) is the expression value of the cost of health - essential component of cost of living, which measures individual effort and / or maintaining social health. [2].

The safety cost consists of preventive expenses (the cost of prevention and / or protection) and costs of accidents at work and occupational diseases. To determine the cost of accidents is extremely difficult, if not all implications for accidents are highlighted, since they are varied and may occur on several levels. The determination of the cost of accidents can’t be achieved if their consequences are unknown and therefore, if these effects can’t be measured by quantitative financial or economic indicators.

The companies often do not support the full costs of accidents, work-related diseases, injuries or occupational malady. For example, healthcare costs (due to accidents at work) may not be covered by companies and disability pensions could be borne by collective funds. The accidents cost is the cost of losses at the company level, the victims and victim's family losses cost and financial / economic cost losses for society.

In calculating the costs of accidents incurred by a company should be considered: cost of insurance premiums, the repayment of a number of basic family wage, if death, according to law. All these losses are leading to a lower gross profit of company-level effects and the gross national income. [4]

The reducing of personal income for the victim and his dependents is due:
- Temporary or permanent loss of working capacity;
- The costs for services and care and rehabilitation to the extent not covered entirely by insurance
- Changes in social and professional status
- And in the event of death:
- Loss of personal income due to death of the victim;
- Funeral expenses;
- Other expenses;

The following cannot be quantified in costs:
The effects of biological and physical conditions such as:
- Anatomical and functional integrity impaired;
- Reduction / loss of vital and working capacity;
- Pain, suffering;
- Death.
The effects of psychiatric disorders such as:
- Decreasing the confidence in their abilities for working duties;
• Fear of producing another similar accident;
• Social uselessness for permanent incapacity to work;
• Humiliation degraded physical condition and dependency for other close persons;
• Pain, compassion, etc. felt by those close to victim;
• Fear not to suffer an similar accident for those from similar working places;
• The image of accident;

Or the decrease, partly or complete, of the creative and emotional potential (especially for permanent incapacity to work) for companies, and disability pensions could be borne by collective funds. [5] The costs for health and safety at work for companies and individual workers are very much influenced by national social safety system. Also, national healthcare system can have effects on costs.

3 The cost of accidents at work

Electrocution accident resulted in the death of the electrician, working in a low voltage live installation switchboard.

3.1 Income losses for the victim (including the family) (ΔVp)

The accident is made in low voltage installation and the preliminary data concerns a fatal electrocution accident: The victim is an electrician, 48 years old, taking care of his mother, 65 years old.

\[ ΔV_p = (P \bar{S}_v - P \bar{S}_e) \cdot D_v \cdot N_u \cdot φ + (P \bar{S}_v - P \bar{S}_e) \cdot N_p \cdot N_u \cdot φ + φ(A_p \cdot L_p + A_B \cdot L_B + A_F \cdot L_F + A_C \cdot L_C + A_{NG} \cdot L_{NG} + A_{PF} \cdot L_{PF} + \sum A_i \cdot N_{Ai}) \]

The cause of accident was the use of not periodically checked personal protective equipment (insulated gloves) and the lack of protection of live parts of the installation in the working area. Loss of income of the victim / family varies depending on the nature and consequences of accidents and the recovery time of the victim.

The financial data for the victim are in Table 1, the last three columns represent: Notation, Measurement and the accident type case of immediate death.

<table>
<thead>
<tr>
<th>No</th>
<th>Preliminary data</th>
<th>Not.</th>
<th>M.U.</th>
<th>A.C.</th>
<th>I.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Financial support from CNPAS to the victim and / or survivors</td>
<td>A_{BS}</td>
<td>RON</td>
<td>8108</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Number of months with financial support from state budget</td>
<td>L_{bs}</td>
<td>months</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

In figure 3 it is observed that the ΔVp for the analyzed work accident obtained is 30920RON. To perform this analysis should launch the LabVIEW

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Table 1
A graphical program designed using the analytical equation presented above.

![Graphical interface of the income losses for the victim calculation (ΔVp)](image)

The graphical interface shown in figure 4 is a software simulation designed, by pressing the "Simulate" each variable can be varied between an imposed minimum or maximum value.

![Graphical interface of simulated situations for the income losses (ΔVp)](image)

In this case, the consequences of the accident is death, the dependent wife will bear the loss of income, besides burial costs, and the difference between the wage and the survivor's pension fee for the rest of lifetime.

3.1 Income losses for the company

The loss for the company is equal with the cost of the accident.

Income losses due to waste of working time ($\Delta V_{\text{expl}}$)

Operating loss of income due to loss of work time varies depending on the nature and consequences of the work accident and the recovery time of the victim. If the victim was unable to work, the company would have savings because the National House of Pensions and Other Social Insurance Rights - CNPAS would be paid compensation for temporary disability throughout recovery. The loss for the company in a deadly accident is given by a new employee after a vacancy of the working place.

The financial data for material damage are in the Table 2 [2].

$$
\Delta V_{\text{expl}} = \sum t_i + \sum S_{hi} + T_{AI} + \frac{\eta_q \cdot S_T}{\eta_p} + \sum N + \\
\sum N \cdot H = 31936 \text{ RON}
$$

<table>
<thead>
<tr>
<th>No</th>
<th>Preliminary data</th>
<th>Not.</th>
<th>M.U.</th>
<th>A.C. I.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Net wage in the accident time</td>
<td>$S_0$</td>
<td>RON/month</td>
<td>1521</td>
</tr>
<tr>
<td>2</td>
<td>Financial support for illness</td>
<td>$I_B$</td>
<td>RON/month</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Monthly wage for the person temporarily or permanent employed on the victim's working place</td>
<td>$S_t$</td>
<td>RON/month</td>
<td>1665</td>
</tr>
<tr>
<td>4</td>
<td>Duration of the vacancy of working place (only if is different from disability period)</td>
<td>$D_n$</td>
<td>month</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>Transformation coefficient from monthly income in daily income</td>
<td>$\beta$</td>
<td>days/month</td>
<td>76.05</td>
</tr>
<tr>
<td>6</td>
<td>Supplementary payment for the persons who take the working tasks of the victim</td>
<td>$S_h$</td>
<td>RON/hour</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>The remaining average number of years for occupation of the same working place</td>
<td>$A_L$</td>
<td>years</td>
<td>17</td>
</tr>
<tr>
<td>8</td>
<td>Updated rate</td>
<td>$\varphi$</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Hourly production whack programmed at the old working place, respectively on a new working place</td>
<td>$\eta_{p0} \cdot \eta_{p1}$</td>
<td>Products per time unit</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Hourly production made by the victim at old working place or new working place after coming back, respectively by the makeshift</td>
<td>$q_v \cdot q_i$</td>
<td>Products per time unit</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Price per production unit</td>
<td>$p$</td>
<td>RON/product</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Duration of adaptation after coming back to work (at old working place or new working place) by the victim or by the makeshift</td>
<td>$T_{AV}$</td>
<td>hours</td>
<td>-</td>
</tr>
<tr>
<td>13</td>
<td>Number of effective working hours per month</td>
<td>$\mathcal{N}_{\text{wk}}$</td>
<td>hours/month</td>
<td>170</td>
</tr>
<tr>
<td>14</td>
<td>The number of persons involved in actions and activities regarding the accident (without production)</td>
<td>$\Sigma \mathcal{N}$</td>
<td>person</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>The wasting time of the persons from point 14</td>
<td>$\Sigma t_i$</td>
<td>hours</td>
<td>40</td>
</tr>
<tr>
<td>16</td>
<td>The monthly net average wage of the employees from</td>
<td>$\sum S_{hi}$</td>
<td>RON/month</td>
<td>12.9</td>
</tr>
</tbody>
</table>
3.2 Loss of permanent capital ($ΔV_{\text{expl-CF}}$)

In the analyzed situation, the working equipment (electrical installation) are fully damaged and replaced.

$$ΔV_{\text{expl-CF}} = V_r + R_{ho} \cdot T_{\text{ind}} + (a_{ia} - a_{io}) \cdot 12 \cdot n_a \cdot \varphi = 20193.2 \text{ RON}$$

The following are giving few data applicable at national level: Capital losses resulting from destruction of electrical board and of an electrical cable are $ΔV_{\text{expl-E1}} = 20052,6\text{RON}$ and $ΔV_{\text{expl-E2}} = 140,62\text{RON}$, loss of floating capital (office costs, first aid equipment, cleaning materials) $ΔV_{\text{expl-CC}}$ and the penalties $ΔV_{1-P}$.

![Figure 5. Total loss for the company representation](image)

At the total business losses do not add the costs in case of death, which is supported by the family of the victim or the work accident investigation, these expenses being incurred by CNPAS, but company records penalties applied by the competent bodies (Labor Inspection) due to failure to comply with legal and technical safety and health regulations. Total loss for the company is presented in figure 5:

$$ΔV_{\text{expl-total}} = ΔV_{\text{expl-T}} + ΔV_{\text{expl-CF}} + ΔV_{\text{expl-CC}} + ΔV_{1-P} = 62297,72\text{ RON}$$

3.3. Loss for society

Costs incurred by the company vary depending on national legislation. In accordance with national legislation on insurance for work accidents and occupational diseases, the company records charges related to help pay for death and survivor assistance.[9]

Also public budget records losses for investigating the causes of work accident and for the victim. Considering the definition of national economy (all economic activities which have been constituted in sector of activities, industries, sub-branches, etc., at a country level, that establish links between each other, on which shall be rendered movement of goods and services, is ensure economic operation and economic development of companies) [7], to determine socio-economic cost was applied the following relation:

$$C_S = \Delta V_{Ref} + \Delta V_{\text{expl-T}} + \Delta V_{\text{expl-CF}} + \Delta V_{\text{expl-CC}} + \Delta V_{1-P} + \Delta V_{ca} = 93217.68\text{ RON}$$

The cost for national economy is equal with the loss recorded by the firm after the accident:

$$C_{PNB} = ΔV_{\text{expl-total}} = 62297.72\text{ RON}$$

Final calculation for the cost of fatal accident

After a deadly working accident, even by electrocution, the company, victim’s family and Romanian state institutions (General Directorate of Local Taxes and Fees, National House of Pensions and Other Social Insurance Rights) record major loses (tens of thousands RON). [10]

![Figure 6. Statistical weight of accident cost for victim/family, company and the public budget](image)

4 Calculation of prevention and/or safety measures in case of electrocution accident

The cost of prevention and/or safety measures is the cost of all expenses and investments costs for safety and health assurance of workers in the working process.

*Periodic check of the protective equipment (insulated gloves)*

The approximate costs for testing protective equipment by a company: 20 RON. At these costs are added other expenses made by the firm (wage expenses of Safety and Health representative or other person which is authorized to participate at safety tests – 2 days x 8,2 RON /day, office expenses – 5 RON, transportation of protective equipment – 15 RON). Total expenses for testing the protective equipment = 46,4 RON.

*Buying a new insulated protective equipment*

The cost of personal protective equipment (insulated gloves) – 133,92 RON, to which is added other expenses made by the firm – 26,4 RON. Total expenses for buying a new protective equipment = 160,32 RON. The cost of the devices for protection against direct touch of fuses type HRC (protective sleeves) – 16,67 RON / pcs x 6 pcs = 100,44 RON,
to which is added other expenses made by the firm – 26,4 RON. Total expenses for buying a new protective equipment = 126,84 RON. Training and authorization in terms of safety at work and authorization for live work according to HG no. 1146/2006 and NTE 10/11/00. The cost of the training and authorization in terms of safety at work and authorization for live work = 400 RON, to which is added other expenses made by the firm – 26,4 RON. Total expenses for training and authorization = 426,4 RON. Making a comparison between prevention and / or safety measures costs and the cost of an electrocution accident, it turns out that:

- the prevention measures cost for periodic testing of protective equipment is 0,075 % from the cost of accident;
- the prevention measures cost for buying a new protective equipment (insulated gloves) is 0,26% from the cost of accident;
- the prevention measures cost for buying a new protective equipment (devices for protection against direct touch of fuses type HRC (protective sleeves)) is 0,21 % from the cost of accident;
- the prevention measures cost for training and authorization is 0,67 % from the cost of accident.

4 Conclusion

The giving case study makes a concrete comparison between the costs that are borne by the all 3 factors involved (victim, employer, company) due to a work accident by non-safety, and the cost of safety work or preventive expenditures for protective measures to reduce the risk of injury. A graphical program using LABVIEW environment was developed in order to calculate the income losses for the victim in case of an electrical work accident. After a deadly working accident, even by electrocution, the firm, victim’s family and Romanian state institutions (General Directorate of Local Taxes and Fees, National House of Pensions and Other Social Insurance Rights) record major loses (tens of thousands RON).

The calculation of the accident does not take into account the psychology effect caused by the loss of a human life over the family, friends or colleagues and damage over firm’s image, and does not quantify the investment of the company and the public budget in training and specialization of victims.

In conclusion, it can be said that identifying the consequences and the cost of accidents can be a tool for improving quality of life of whole populations (not only the active ones, if we consider that by reducing the losses caused by accidents, it can be a redistribution of resources to other sectors of society - health, social protection, education etc.)

References: