ASSESSMENT OF THE TECHNICAL AND ECONOMIC DIMENSION IMPLICATIONS OF ELECTRICAL WORK ACCIDENTS

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Abstract - This paper presents, identify and analyzes the consequences of electrical work accidents and estimates their implications from the employers' point of view and also from workers' perspective, analyzing also a real case. It proposes a calculation method for evaluation of the cost and losses for companies and the victims that were involved in an accident and is exemplified for a real event

Keywords: work accidents, cost analysis, technical and economical effects, safety, accident losses calculation method.

1. INTRODUCTION

Accidents at work can mean suffering, disability and may affect a worker's life, both inside and outside the workplace. Many workers in Europe continue to perceive that their jobs pose a threat to their health or safety. According to a recent Eurostat study (2010) 3.2% of the workforce in the EU-27 reported an accident at work in the past 12 months (data from 2007).

A considerable loss that has a negative impact on economic is growing and puts a burden on society. Thus preventing occupational accidents and diseases should make economic sense for society as well as being good business practice for companies.

Mossink and De Greef (2002) report that whatever the initial costs associated with the accident, the consequential costs go beyond what may or may not be visible and subject to insurance cover. These include disruption to production, bad publicity, administrative costs, legal costs and lost workdays. Mossink and De Greef (2002) estimated that the EU lost between 1 and 3 % of GNP as a result of accidents and ill health in 1998. They also stated that in 1998 there were approximately 150 million work days lost as a result of accidents and ill health. Mottiar (2004) cites the overall costs of accidents and ill health in the European Union in 2002 as being approximately €20 billion and approximately €171 billion in the U.S.

In Romania the work accidents in the field of Production and supply of electricity, gas, steam and air conditioning represent almost 3% of the total at national level (Table 1), although the main causes of these events are not related to electricity hazards.

Table 1. Work accidents in Romania

Types of work accidents		Years				
		2008	2009	2010	2011	2012
TOTAL	National	4592	3476	3678	3681	3686
	Production and supply of electricity, gas, steam and air conditioning	110	94	87	83	107
Work Accidents with up to 3 days' absence from work	National	4261	3200	3013	3433	3471
	Production and supply of electricity, gas, steam and air conditioning	100	86	79	79	101
Fatal Accidents	National	331	276	272	248	215
	Production and supply of electricity, gas, steam and air conditioning	10	8	8	4	6
Collective Accidents	National	27	22	26	32	22
	Production and supply of electricity, gas, steam and air conditioning	0	0	3	0	4
Collective Accidents Fatalities	National	22	30	23	29	9
	Production and supply of electricity, gas, steam and air conditioning	0	0	1	0	0

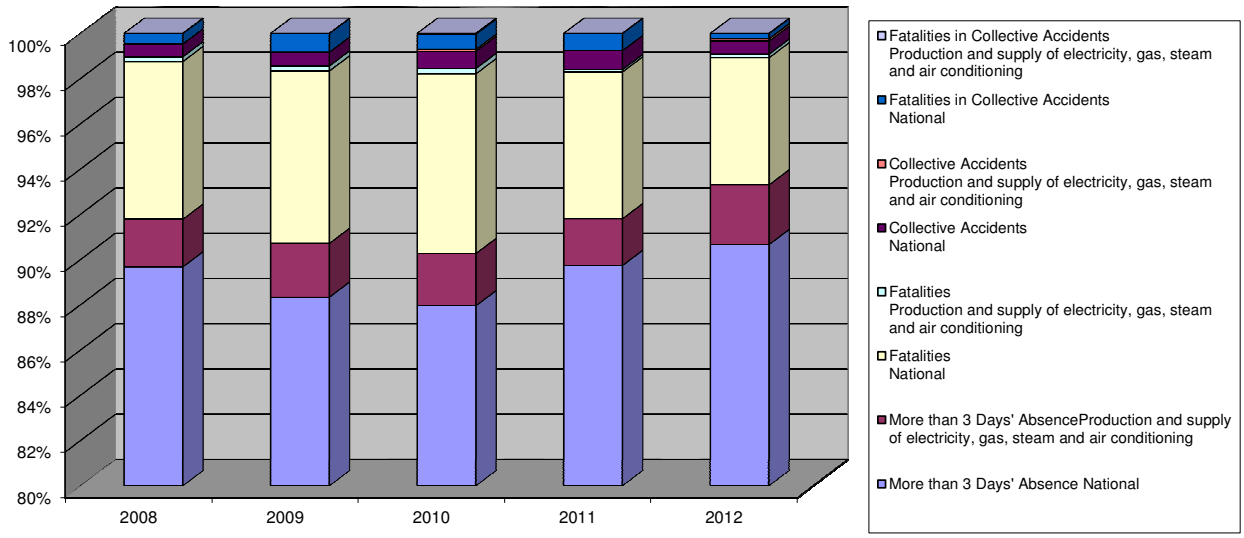

Fig.1.Comparative percentages of work accidents:
National vs. Production and supply of electricity, gas, steam and air conditioning

According to recent statistics of occupational accidents (Table 2), they are falling at the end of 2012 to first semester of 2014; their share in the electro-energy industry is about 2, 8%.

However, their number remains high, the impact of their consequences generate not only physical suffering for the injured and his family but also direct economic consequences for business and society as a whole.

Table 2. Work accidents in Romania

	2012	**2013**	**2014***
Total Work Accident Victims	4176	3627	1500
Work Accidents with up to 3 days' absence from work	3686	3428	1452
Fatal Accidents	308	199	48
Total Route related Accidents	610	401	157
Total Deaths in Route related Accidents	42	9	7
Total Collective Accidents	30	24	7
Total Victims involved in Collective Accidents	158	115	32
Fatalities in Collective Accidents	12	10	3

** First semester of 2014*

Providing companies an insight in the costs and benefits of occupational safety and health can contribute to healthy work but also to a healthy economy. According to the International Labour Organisation (ILO) the total costs of work-related accidents and ill-health amount to approximately 4 per cent of the world's Gross Domestic Product (ILO, 2006).

Employer costs from the accidents included salary costs for replacement staff or overtime payments, production and productivity losses, retraining costs, personal injury claim compensation, repair bills, medical & travel expenses and increased supervision. Salary costs were the largest cost category, being nearly half (45%) of total losses. Resentment towards the employer from the injured employee was also reported. Over one-third of the injured employees reported a 'significant' or 'large' amount of resentment towards the employer after the accident. This was reported to result from the way they were subsequently treated by their employer rather than from the accident itself.

2. THE DIMENSIONS OF WORK ACCIDENTS

Electrical risks are risks of death, electric shock or other injury caused directly or indirectly by electricity.

When analyzing the costs of accidents it has been a common practice to present the mathematical relationship between different types of costs. Heinrich's frequently depicted iceberg model (as quoted by Rikhardsson & Impgaard, 2004) is often used to convey the concept of a relationship between direct costs such as repairs and indirect costs such as lost business opportunities. The ratio between these two types of costs has been found to vary across work sectors (Mottiar, 2004) and cannot be directly compared between studies (Grimaldi & Simonds, 1984; HMSO, 1993; Larsson & Betts, 1996; Monnery, 1998). Hence this iceberg model is a poor predictor of the actual negative cost consequences an organization is likely to face from workplace accidents.

Costs of accidents at work and work-related ill-health need to be analyzed on three levels: the society, the company and the victim. These three levels are affected by the consequences of poor working conditions and bear the costs. The costs are not equally distributed between the three groups. Furthermore, the costs are not perceived in the same way.

The difference in perspective on costs of accidents at work and work-related ill-health has several consequences. First, it means that other assessment methods must be used on all three levels to make realistic cost estimates. Moreover, when using economic

arguments based on these costs, one has to take into account this difference in perspective. The decision-making process of a government is totally different from a decision-making process of a company. This means that other cost arguments will have to be developed.

The consequences of accidents at work and work-related ill health are affecting not only the victim by inflicting pain and suffering and moral and psychological suffering but also to his family and friends. Also the colleagues of the victim are affected by distress, worry or panic.

Last but not least, the companies are directly affected by image deprecation, law fines, insurance premium increases, technical disturbances, etc. and also the society by reduction of the human labor potential, of the quality of life, the decrease of the standard of living, the increase of social security costs, or medical treatment and rehabilitation costs, and early retirement.

For example, it can be estimated ***the calculation of gross income loss*** due to various costs involved in production of a work accident.

All occupational accidents involve a number of direct costs strictly financial, reflected in the accounting records of the company, such as:

a). sick pay to the victim (on site or in specialized institutions, to the extent that the payment is not for the company's policyholder);

b). payment of various benefits for the victim or his heirs;

c). pay money experts employed during the accident investigation;

d). payment of training courses and / or qualifications of the persons injured or replacements thereof;

e). telephone payment generated by various actions to be taken after the event (personal commitment, communication, accident investigation, discussion with clients, lawyers, etc.);

f). pay of the court costs;

g). pay compensation to partners established by final judgment.

Summing of all these charges lead to a value that represents the loss of gross income of the company, which can be reduced only by the amounts recovered legally from people found guilty of causing the accident.

The calculation formula is:

$$\Delta L_{g_i} = \sum C_f \cdot N - C_r \quad (1)$$

where:

ΔL_{gi} - loss of gross income from various financial losses;

C_f - costs financial direct;

N - number of types of financial expenses;

C_r - recovery from persons declared guilty;

At the worker level, we can say that it is very difficult to estimate the impact of the consequences of accidents or, where appropriate, on his family because it's a human life or suffering in human terms can not be economically fundamental value.

The calculation formulas for determining the final loss of personal income are:

a). Loss of personal income from incapacity for work (including temporary disability third degree completed return to activity):

$$\Delta L_{pi_a} = [S_{am} - I_d (P_{inv})] \cdot \beta \cdot T_{dd} + C_{bp} \cdot \cdot N_1 - \sum A_1 \cdot N_a \quad (2)$$

b). In case of accidents that resulted in disablement victim, the relationship for calculating personal income loss due to permanent loss of working capacity is:

$$\Delta L_{pi_b} = (S_{am} \cdot N_{ms} - P_{inv} \cdot 12) \cdot N_p + (C_{bp} \cdot N_1 - N_a \sum A_1) \cdot N_{al} \cdot \varphi + (P_{ela} - P_{inv}) \cdot 12 \cdot D_{al} \cdot \varphi \quad (3)$$

c). Loss of personal income due to the victim death can be determined following:

$$\Delta L_{pi_a} = [(PS_{am} - PS) \cdot 12 \cdot \varphi \cdot N_A] - (\sum A_{ai}) \cdot 12 \cdot N_A \cdot \varphi \quad (4)$$

where:

S_{am} - average monthly salary before accident;

I_d - indemnity disease;

P_{inv} - invalidity pension;

β - transformation coefficient monthly income daily income;

T_{dd} - temporary disability duration in days;

C_{bp} - monthly expenses cost in personal budget;

N_1 - number of months that records the expense of personal income;

ΣA_1 - monthly amount of aid received by the victim and / or survivors of the state budget, local budgets, companies other institutions and corporate;

N_a - number of months in which the victim receives aid;

N_{ms} - average number of months with salary in a year;

N_p - projected number of years receiving survivor's pension;

N_{al} - number of years from the date of the accident until the average length of life;

φ - the discount rate amounts dependent on the rate of inflation, growth, etc., projected for the calculation period;

P_{ela} - expected pension age limit (if the accident would not have produced);

D_{al} - number of years from retirement age for age limit to death.

PSam – part (cuantum) of average monthly salary;

P_S – survivors pension.

If the injured person died after a certain interval after the accident, the range in which the victim was incapable temporal work, or has been declared invalid, personal income loss includes besides losses of the descendants and the lost income during the time from the victim accident until the death.

3. PRACTICAL CASE ANALYSIS

It is analyzed the case of an employee working on the test bench of equipments that has got burns to his face because of an arc flash.

An equipment has been tested for heating for about 3 and half hours and the operation was almost finalized.

Before the equipment has been stopped, the employee went near the terminal box and started to make preparation operations for the next measurements (stator's ohmic resistance measurements); he wanted to take off the insulated mat that covered the terminal box and cables. He pulled the rope that was securing the insulation mat and in this moment a flame occurred.

His colleague was preparing to stop the equipment when he heard a load noise; he turned to see what happened and saw the injured person with his hands at his face and a flame in the terminal box.

The ambulance was called and the employee was immediately sent to the hospital. He had superficial skin burns on the face. The medical checks shown that the eyes were not affected. The expectation is that he will recover well, possible without any scars. He was kept in hospital for few days to ensure that the skin did not become infected.

After the root cause analysis were proposed several corrective actions for short term and mid to long term.

The main causes identified that led to this event where mainly the lack of work instructions which should have contained references to all stages and materials used in this process, the inadequate coordination of the activity in the test area that granted access for worker near the tested equipment during testing process. Another cause was the use of uninsulated cables or with poor insulation for connecting the equipment to energy source, and the cable was positioned at a small or insufficient distance from the metal frame of the terminal box.

Short term corrective actions that were proposed:

- Stopping the operations in the test area until the investigation was finalized, actions identified and short term actions for safe operations implemented;
- Incident and safety communication to all employees;
- Checks of all electrical cables used for testing and restoring the damaged insulation;
- Reviewing all the applicable work and safety instructions for this area, and training the operators.
- Using additional insulation if the distance is less than the standard distance between active parts of the machine to metal mass housing.
- Using torque wrench for connecting the wires to the terminal box.
- Using fireproof covers for terminal box.

Medium and Long Term Corrective/Preventive Actions:

- Implementation of an interlock system at the control rooms that will cut the power in case several parameters are exceeded.
- Protection fence with interlocking and controlled access in the test area.
- System that detects person inside test area.
- Visual and acoustic warning system for test in progress.
- Fault current protection system to be implemented
- Extending the video surveillance system to cover the final test area. Video camera functionality checks and recording mode.

The worker was hospitalized for 21 days, and he received full wage compensation for this period – 2150 lei (475 Euros), according to Romanian law, being affected only at physical and psychological level. His family has spent around 110 Euros for transportation, regular visits to the hospital during the victim was in and other fortuitous expenses.

The effects of this event on the company level where severe, because of the generated costs.

The direct costs of the company were related to the downtime of the test bench that leaded to delays in deliveries and the damage of the tested equipment and test bench wires. These costs where around 5350 euros mainly consisting of:

- 300 euros for the repairing of the damaged equipment
- Delivery penalties for 15 days downtime of the test bench during the investigation and implementation were around 3800 euros for the equipments scheduled for delivery in this period.
- Indirect costs related to the event where around 250 euros.
- Fine from the authorities was the equivalent of 1000 euros.

The loss of gross income from various financial losses of the company was around $\mathbf{\Delta L_{gi}= 5350\ euro}$ because the number of types of financial expenses was singular and there where no amounts recovered from persons that were declared guilty.

All the preventive measures proposed to be implemented cost around 9000 euros for the fencing and interlock system and additional 3000 euros for the current protection system, resulting a total cost of 12000 euros.

4. CONCLUSIONS

The amounts calculated above demonstrate that if the company invests in preventive measures, important costs generated by work accidents can be saved. The presented case is a fortunate one, because the victim recovered well and returned to work, respectively the damages to the equipment were light. In the case of a casualty or invalidity the company reputation could've been affected dramatically and the costs significantly higher due to the possible sue, fines, and longer downtimes.

To support occupational safety and health practitioners in making economic assessments, there is also a need for simple, easy to use tools that are accessible for practitioners.

These tools would support the cost and benefit calculations as well as the process of economic assessments. If these data could be stored in a central database on national or even European level, they could offer interesting benchmarks for companies and institutions willing to perform economic assessments of health and safety measures.

From the analysis of situations previously presented in the paper it can be seen that accidents at work means significant costs to be explored systematically low.

Analysis of occupational accidents and work data presented justify the conclusion (the idea) that the market economy health and safety must be viewed in terms of cost-benefit.

Occupational safety and health practitioners have the need to be more acquainted with techniques such as cost-benefit analysis. Often they lack proper training in the process of making economic assessments.

Training is also needed on communication strategies. In the end, the economic assessment has to be in support of a strategy to convince management to invest in safer and healthier workplaces.

By conducting a cost-benefit analysis, in which all costs are balanced against future benefits, an economic assessment of the health and safety investment can be made. The majority of the case studies have clearly demonstrated that health and safety interventions lead to positive economic indicators.

By doing so, the cost-benefit analysis technique is useful to provide evidence for the profitability of a specific measure within the context of a specific company.

It is a robust approach in support of OSH practitioners when making their case for management.

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