



## Degree of Integration of Risk Preventive Measures in the Management System of Companies in the Electricity Sector

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Despite the increasingly severe POH (Prevention and Occupational Health) regulation and the mandatory use of more effective protection equipment, workplace accidents and mishaps are still common events worldwide. Moreover, these mishaps include a considerable number of occasional accidents, that is, those that are caused by unsafe working conditions and behaviours, and therefore, could be avoided. Aiming to investigate the causes of such failures, the present study analyses the adoption and application of prevention measures within companies of the electricity (which has one of the highest levels of accidents). In this context, data on the organisation and adoption of prevention measures was collected through a survey with workers and supervisors of companies from Galicia, Spain (n = 220). Results suggest that there is a general deficiency regarding awareness of risk within companies from the sector, which leads to an insufficiency of adequate prevention measures. More specifically, a considerable percentage of both managers and workers have shown not to have enough knowledge on POH. Practical implications to mitigate these problems are addressed in the conclusions.

**Keywords:** Accidents, Electricity industry, Occupational health, Prevention, Training

### Introduction

Data from the Census of Fatal Occupational Injuries (CFOI) and the Survey of Occupational Illnesses and Injuries (SOII)<sup>1</sup> show that between 1992 and 1998, 2287 workers died and 32 807 others had leaves due to electrical discharges or electrical burns in the United States. More recent (2011-2015) data from the Bureau of Labour Statistics (BLS), cited in Gammon *et al.*<sup>2</sup>, indicate that electrical work is not particularly dangerous when compared to other types of work. However, the same document points out that this type of labour has a much higher percentage of fatal accidents, and that the number of non-fatal shocks and burn injuries increased in 2015, indicating a need for more electrical hazard awareness.

As observed by Hinze *et al.*<sup>3</sup> back in the late 1990's, the first step towards improving safety in the workplace is to understand the key-factors leading to accidents. Nevertheless, as pointed out by Khosravi *et al.*<sup>4</sup>, 16 years later, research on causes and factors that lead to unsafe conducts and accidents is still insufficient. Further studies<sup>5</sup> have provided additional contributions to safety in electrical work. However, it is particularly worrying that, as pointed out by Gammon & Jamil<sup>6</sup>,

accident rates in electrical sector remain high despite the advances made in safety measures and requirements in the last twenty years.

Improving workplace safety, avoiding and minimizing accidents is naturally a goal in every industry. The first step towards achieving this goal is to understand the factors that lead to accidents. This includes not just the hazards *per se*, but mainly risk increasing factors, such as risky behaviours or ill-planned procedures. One of the pioneer authors on the topic was Heinrich<sup>7</sup>, who proposed a theory of accident causality, which addresses issues such as man-machine interaction, the gravity and frequency of accidents, the role of management in accident prevention and the costs of accidents. This theory has been considered and improved upon by many subsequent studies. Amongst those, Petersen<sup>8</sup>, introduced the concept of multiple causality, according to which many factors combine randomly to create the cause of an accident. According to Reason<sup>9</sup>, these factors range from latent organisational failures (e.g., poor planning decisions or deficient design) to working conditions that may increase the chances of active failures (errors and infractions in the workplace).

Some industries, such as construction, are inherently riskier than others, due to aggravating factors such as work at height and heavy electrical machinery.

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Therefore, literature on work safety in such industry is more abundant. Regarding the causes of workplace accidents in the construction industry, studies like Tam *et al.*<sup>10</sup> conclude that different factors combine to create the cause of accidents, which is in line with Peterson's<sup>8</sup> concept of multiple accident causality. This idea is also reinforced by the results of a more recent work carried out by Winge *et al.*<sup>11</sup>, which however, does point to one most frequent originating factor: risk management (56%). This is consistent with studies in the UK (84%), Australia (21%), and USA (67%)<sup>(12)</sup>, suggesting that risk management is indeed frequently neglected in construction projects worldwide, which in turn, causes many accidents.

Studies on the topic have also provided some practical implications to reduce accidents. For instance, authors like Duff *et al.*<sup>13</sup> have developed safety inspection/audition checklists for construction projects, based on the evaluation of unsafe conditions in construction sites. More recently, based on the analysis of 255 electrical fatalities, Chi *et al.*<sup>14</sup> divided such accidents into five patterns, identified the main causes for accidents of each type, and developed a list of preventive measures. Following a similar logic, upon analysing the causes of labour risks in 500 construction projects, Suraji *et al.*<sup>15</sup> proposed an improved approach for construction management.

Studies like Chi *et al.*<sup>16</sup> focus on electricity-related accidents precisely because it is one of the main hazards within the construction industry, as well in other industries. Electricity was placed 6<sup>th</sup> in a ranking of fatal workplace accidents in general (all industries), accounting for 5.2% of occurrences. In the construction industry, specifically, injuries caused by electrical accidents are disproportionately higher than in other sectors.<sup>17,18</sup>

Reducing electrical accidents in the workplace is normally a concern of national governments, which formulate and regulate laws with this specific purpose. However, as demonstrated by a case study in Brazil<sup>19</sup> companies not always follow those rules, especially when external oversight is not particularly effective. Interestingly, even when companies follow all the legal requirements, or even go beyond them, accident rates are rarely decreased significantly.

As the same authors describe, in the early 2000's, many companies did not have structured safety programs or even any written safety procedure, workers had insufficient training and poor equipment, and were expected to work unprotected on (or near)

energised circuits. Currently, safety procedures, training programs and protective equipment are all much more developed, however, this does not lead to a significant decrease in the accident rate. Nevertheless, electrical hazards are well known, and arguably controllable.<sup>20</sup> Therefore, existing measures must be reevaluated in order to reduce frequent occurrences.

Aiming to contribute to minimise occupational risks in electrical work, recent studies analyse this industry in different contexts, and bring about relevant implications for accident prevention. Laal *et al.*<sup>21</sup>, for instance, conclude that Integrated Management Systems (IMS) have a significantly positive effect on health and safety performance indices as they reduce accident rates and improve workers' safety.

An issue that is frequently overlooked when addressing electrical work safety is the set of challenges brought by multi-lingual and multi-cultural work environments, which are increasingly common, as companies frequently have facilities in other countries or receive expatriate workers. This issue is addressed by Kovacic and Cunningham<sup>22</sup>, who conclude that creating an interactive training environment is essential to ensure that all individuals grasp the necessary safety procedures, regardless of which cultural group they belong to or the consequent language barriers. Finally, Gammon *et al.*<sup>23</sup> conclude that investments on electrical work safety are more than justified, considering the economical and human costs of accidents, which further reinforces the necessity of improving accident prevention in this sector.

In this context, building on the extant literature on occupational hazards and electrical work safety, the present study aims to examine how companies of the electricity sector are organised in terms of accident prevention measures. To this end, an exploratory approach is employed and the Autonomous Community of Galicia, in Spain, is adopted as research settings. Through a survey (n = 220) with companies' workers and supervisors, relevant data on preventive measures organization and adoption was collected. Results point to a general deficiency in both workers' and supervisors' risk awareness and knowledge on POH, as well as to additional critical problems. These, in turn, lead to relevant practical contributions, which are addressed in detail within the conclusions.

## Materials and Methods

### Data Collection Analysis

The present study's main objective was to examine how companies of the electricity sector are organised in terms of accident prevention measures. To this end, an exploratory approach is adopted, and primary data was collected through a quantitative survey with workers and supervisors of companies from the Autonomous Community of Galicia, Spain. The survey was divided into three parts:

- The first part aimed to collect general information about the companies, i.e., economic activities, legal framework, number of work centres, number of workers, time in activity, etc.
- The second part aimed to examine the companies' organisation in terms of accident prevention, i.e., adopted prevention model, preventive specialities contracted, specific preventive activities, training, and resources.
- The third part addressed the adoption and application of prevention measures.

In the first two parts, multiple choice questions were employed, while the third part consisted of 22 items measured through a 4-point Likert scale. The research population consisted of 981 companies, which is the total number of companies of the electricity sector in Galicia.<sup>24</sup> Through a random sampling method, 220 workers and supervisors were selected to integrate the study's sample. The companies were subsequently surveyed during the second semester of 2018. Given the finite nature of the population, sampling error is  $\pm 6.6\%$  (for a confidence interval of 95%).

The data collected through the first and second parts of the survey were analysed through descriptive statistics, including relative frequency counts and averages. Regarding the data collected through the third part, the 22 items were reduced to 6 dimensions, which were then subjected to a Pearson correlation analysis (correlation between the covariance and the product of the standard deviation in each variable).

### Sample Characterisation

The electricity sector in the autonomous community of Galicia consists mainly of small companies that provide services of installation and maintenance of electrical and telecommunications systems. The collected data shows that these companies mainly provide services of installation and maintenance of low-tension electrical systems (including industrial machinery, electrical appliances, lighting, and energy

efficiency systems), as well as installation, repair, and assembly of electronic and telecommunications appliances (antennas, video intercom, musical cables, megaphonia, and voice and data cables). The companies typically carry out two activities in parallel, i.e., installation/repair and assembly of electrical systems (21.31% of companies). About 72% companies are legally organised, followed by autonomous entrepreneur (18%), and autonomous entrepreneur without employees (10%). The average time in activity is 23.18 years, while the most common value is 20 years and the maximum is 82 years.

Most companies are small-sized, and the average number of workers is 6. Therefore, most are qualified as Small and Medium-sized Enterprises (SMEs). Regarding gender, there is a noticeable discrepancy: 5 men are employed against each woman. Moreover, women typically carry out administration tasks, rather than technical ones. Most companies (72.26%) have only one work centre, while 27.74% have 2 or 3 centres throughout Spain, under the same business name. Moreover, 80% of the companies with multiple centres have their headquarters in Galicia. Regarding the place where the services are carried out, the most common answer is "In the construction site, in the facilities of a particular client (housing office)" (91.80%).

## Results and Discussion

### Organisation of Preventive Measures in the Company

Only 1.69% representatives of the companies surveyed stated to have a work health and safety system in execution. The same percentages of companies are allegedly in the process of adopting such a system. Meanwhile, 93.22% of companies simply do not have any such system.

The preventive measures vary according to their characteristics. In general, it can be classified into one of five categories, amongst which In House Prevention Service (IHPS) is by far the most frequent (79.77%). The other categories are Personal Assumption by the Employer, Employee Denomination, Third Party Prevention Service (TPPS), and Joint Prevention Service (JPS). Within the companies and work centres that deal with prevention through IHPS, 88% have an employee that acts as an interlocutor with the prevention service and tends to basic demands from other employees. The remaining 22% does not have any interlocutor. Moreover, in 93.48% of companies employing IHPS that have such interlocutor, the person

on this position has the minimum training required on POH (basic level), while in 4.35%, they do not have any training at all (Fig. 1). Accordingly, in 73.91% of companies, the people who act as interlocutors with the IHPS consider that they have enough time to deal with their functions, while in the remaining cases, they do not always do.

Prevention delegates and Health and Safety Committees are present in only 2% of the companies. This is somehow expectable, considering that most companies of the electricity sector in Galicia have less than 20 employees. Within all the sampled companies, preventive resources have the minimum required training in POH. Moreover, in 92.31% of companies, the people responsible have time enough to perform their functions, and in 97.44%, they always have the necessary material means for that.

The Coordination of Business Activities (CBA) is one of the fundamental drivers of Occupational Risk Prevention (ORP) measures in Spanish companies. This is especially true in the context of sectors such as electricity and telecommunications, in which employees frequently work in other companies' facilities, along with those companies' own employees.

The CBA's goal is to control the risks brought about by the simultaneity of activities carried out by different employees of companies, which require planning,

compromise, anticipation, knowledge of the developed activities, and control of working conditions. Therefore, managers must actively participate in companies' preventive measures. However, among the companies surveyed within this study, 23.41% never discuss the state of POH planning in management meetings, or only do it eventually.

**Adoption and Application of Prevention**

Within the present study, 20% of work centres of the companies in the data set have not carried out an occupational risk evaluation within the last twelve months. In turn, 80% of company representatives state to have done such evaluation in the same period. Within the companies that have not undertaken the occupational risk evaluation within the last twelve months, 16% have done it within the same time frame.

Forty two percent of companies consider the presence of special or particularly sensitive workers (handicaps, pregnant and breastfeeding women, underage workers, etc.) in their evaluation. However, 12% of companies do not consider those workers specifically. The remaining respondents (46%) stated that the question does not apply, or simply did not respond. A relevant percentage of companies within this sector always carry out preventive activities related to risk evaluation, which is undertaken specifically for each work position (97.96%). Also, in many cases, the companies consider the opinion of workers (75.51%) to periodically revise the evaluation (89.90%), inform workers of the results (71.43%), and adopt the proposed measures (Table 1).

As stated in art. 18 of the ORP Law (Ley 31/1995), the risk evaluation results, including both the identified risks and the consequent preventive measures, must be reported to workers. As seen in Table 2, 75% of companies make sure their employees are informed about the occupational risks to which they are exposed,

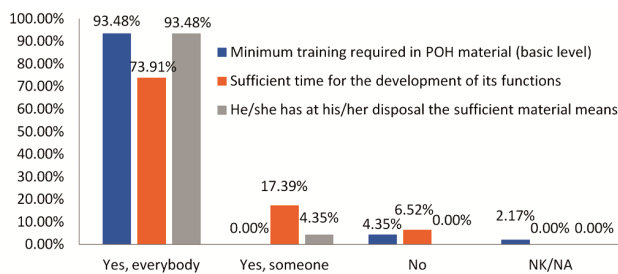


Fig. 1 — Training and resources of the personnel who assume prevention (%)

Table 1 — ORP activities carried out by the company – Risk evaluation

	1	2	3	4	DNK/DNA	Does not apply
1. Risk evaluation specifically contemplates every work position.	0.00%	0.00%	4.08%	93.88%	0.00%	2.04%
2. Risk evaluation considers employees' opinions (if the company has any).	6.12%	12.24%	2.04%	73.47%	0.00%	6.12%
3. Risk evaluation is periodically revised, and significant changes in working conditions are carried out when new risks or inadequate/insufficient actions are identified.	2.04%	2.04%	12.24%	77.55%	0.00%	4.08%
4. Risk evaluation results are reported to workers (if the company has any).	6.12%	14.29%	6.12%	65.31%	0.00%	4.08%
5. Necessary measures, pointed by the risk evaluation results are adopted.	0.00%	4.08%	6.12%	85.71%	0.00%	2.04%

1: Never; 2: Eventually; 3: Almost always; 4: always; DNK/DNA: Does not know or did not answer

including electrical ones, as well as the preventive measures and emergency procedures to be adopted. Most companies also immediately notify workers or their legal representatives (when there is one) in case of exposition to contaminants, as well as the preventive measures to be adopted. Finally, 6.12% of companies either never communicate those results, or do it only eventually.

Regarding work equipment, preventive measures consist of the acquisition of safe equipment, appropriate use and maintenance, risk evaluation, workers' training, and the application of the principles established by art. 15 of the ORP Law. In this context, 93.88% of companies claim to always have CE stamped equipment, which are adequate to the activities in which they are employed, and ensure workers' health and safety in the workplace. The remaining companies did not answer or stated that it does not apply to them.

Almost 94% of companies provide workers with the necessary CE stamped Individual Protection Equipment (IPE) (Table 2). In cases of works at height, almost 88% of companies state to always employ IPE, as well as the adequate preventive measures, while 6.12% state to do it eventually. Moreover, more than half the companies make effective use of IPE regarding the way workers wear them, as well as the choice and reposition of equipment. Meanwhile, 4.08% state to never do it.

Results also show that 69.39% of companies establish safety procedures and instructions, which are known and followed by all workers. On the other hand, around 20% of companies either do not have such procedures, or only employ them sporadically. Almost 80% of companies guarantee that each worker receives adequate theoretical and practical training on prevention focused on his/her work position or activity,

as well as on electricity-related risks. They also carry out adequate control and periodical maintenance of places, facilities, work equipment and protection equipment. However, 30.61% of companies state that adequate safety and health signalling aiming at preventing occupational risks and informing safety measures is never, or only sometimes, present in their facilities.

In cases in which a company's employees' work together with another company's, around 55% always adopt preventive adequate measures within the coordination of activities (preventive information interchange, periodic meetings, establishment of joint safety measures and instructions, etc.). Approximately 6% of companies never, or only sometimes, adopt such measures. The remaining respondents state that it does not apply to their companies (Table 3).

Within the prevention activities related to emergency measures, the most frequently adopted by companies are: having the necessary and adequate firefighting teams and establishing emergency measures. However, as observed in Table 3, a considerable portion of companies do not establish emergency measures, or only do it sometimes. Accordingly, an equally considerable percentage of companies do not have the adequate fire fighting equipment. They do not inform the workers of the emergency plan, and do not carry out evacuation simulations.

Another worrying data is related to monitoring, registering and documentation. In this regard, 46% of companies do not have properly trained and adequately equipped personnel for executing emergency procedures. Companies must also carry out other ORP activities, such as health monitoring, registry of occupational accidents and of any damage to workers' health, and legally required documentation

Table 2 — ORP activities carried out in the company – Risk information and IPE

	1	2	3	4	DNK/DN A	Does not apply
6. Workers are informed about the occupational risks to which they are exposed, including electricity-related risks, as well as the preventive measures and emergency procedures.	0.00%	4.08%	10.20%	75.51%	0.00%	6.12%
7. Workers and their legal representatives (when there are any) are immediately notified about exposure to contaminants (chemical, physical or biological), as well as the preventive measures to be adopted.	2.04%	4.08%	4.08%	71.43%	0.00%	16.33%
8. The company makes effective use of IPE on what concerns to the way workers wear them, as well as the choice and reposition of equipment.	4.08%	0.00%	0.00%	51.02%	0.00%	36.73%
9. The company establishes emergency procedures.	18.37%	0.00%	2.04%	67.35%	0.00%	8.16%
10. The company has the adequate and necessary firefighting equipment.	6.12%	6.12%	8.16%	71.43%	0.00%	4.08%

1: Never; 2: Eventually; 3: Almost always; 4: always; DNK/DNA: Does not know or did not answer

management. Regarding health monitoring, companies are legally required to provide workers with periodical health examination, due to the risks that are inherent to their work. Almost 90% of companies state to always provide such monitoring to their workers. However, it must be observed, that there are autonomous workers in the electricity sector as well.

Most companies (61.22%) register occupational accidents and damages to workers' health, and a considerable number of respondents (28.57%) stated that it does not apply to their companies, as no accident have taken place in the company. The remaining companies either do not register accidents or only do it eventually. Finally, only a small percentage of companies do not keep the ORP documentation required by occupational authorities or only do it occasionally (4.08%) as shown in Table 4.

The 22 analysed items were grouped in six dimensions: Risk Evaluation; Risk Information; IPE; Other ORP Activities; Emergency Plan; Monitoring, Registering and

Documentation (Table 5). Amongst those dimensions, D1 and D6 showed to be the most important and the most frequently preventive measure adopted/carried out by companies.

To analyse possible correlations amongst these dimensions, as well as to uncover which aspects are emphasised the most by companies, a Pearson correlation analysis has been carried out. The Pearson correlation coefficient expresses the magnitude of the correlation between two dimensions, whereas 1 expresses maximum positive correlation.

As shown in Table 6, D1 – Risk Evaluation – is highly correlated with D2 – Risk Information – and D6 – Monitoring, Registering and Documentation. It means that the companies that evaluate risks considering workers' opinions, also inform the results and register accidents. D2 also reveals to be correlated with D4 – Other ORP Activities – and D6. Other dimensions are also related to both risk of Information and Monitoring, Registering and Documentation,

Table 3 — ORP activities carried out by the company – Other ORP activities

	1	2	3	4	DNK/ DNA	Does not apply
11. The company establishes work procedures and safety instructions, which are known and followed by all workers (when they have any), considering assigned ORP responsibilities.	2.04%	18.37%	0.00%	69.39%	2.04%	6.12%
12. The company guarantees that workers (when they have any) receive adequate theoretical and practical training on prevention, focused on their work positions or activities, namely on electricity-related risks.	4.08%	0.00%	6.12%	79.59%	2.04%	6.12%
13. The company carries out adequate control and periodic maintenance of places, facilities, work equipment, and protection equipment.	2.04%	6.12%	8.16%	79.59%	2.04%	0.00%
14. There is adequate safety and health signalling in the work centre, when necessary, aiming at preventing and alerting about occupational risks, as well as informing about safety measures.	24.49%	6.12%	10.20%	42.86%	0.00%	12.24%
15. In cases in which employees share the workplace with those of another company, preventive measures and adequate activity coordination (preventive information interchange, periodic meetings, establishment of joint safety measures, etc.) are adopted.	4.08%	2.04%	2.04%	53.06%	0.00%	32.65%

1: Never; 2: Eventually; 3: Almost always; 4: always; DNK/DNA: Does not know or did not answer

Table 4 — ORP activities carried out in the companies – Emergency plans

	1	2	3	4	DNK/ DNA	Does not apply
16. The company establishes emergency procedures.	18.37%	0.00%	2.04%	67.35%	0.00%	8.16%
17. The company has the necessary and adequate firefighting equipment.	6.12%	6.12%	8.16%	71.43%	0.00%	4.08%
18. The company ensures that the emergency plan is known by all workers, including outsourced ones.	34.69%	6.12%	2.04%	34.69%	0.00%	14.29%
19. The company carries out evacuation simulations.	67.35%	0.00%	0.00%	4.08%	0.00%	0.00%
20. The company provides workers with initial and periodic health examination due to the risks associated with the job.	2.04%	0.00%	0.00%	89.80%	0.00%	4.08%
21. The company registers occupational accidents and damages to workers' health.	2.04%	4.08%	2.04%	61.22%	0.00%	28.57%
22. The company keeps all the ORP documentation legally required by occupational authorities.	2.04%	2.04%	0.00%	85.71%	0.00%	4.08%

1: Never; 2: Eventually; 3: Almost always; 4: always; DNK/DNA: Does not know or did not answer

Table 5 — Occupational risk prevention dimensions

	1	2	3	4	DNK/DNA	Does not apply
D1. RiskEvaluation	2.86%	6.53%	6.12%	79.18%	0.00%	3.67%
D2. RiskInformation	1.02%	4.08%	7.14%	73.47%	0.00%	11.23%
D3. IPE	9.52%	2.04%	3.40%	63.27%	0.00%	16.32%
D4. Other ORP Activities	7.35%	6.53%	5.30%	64.90%	1.22%	11.43%
D5. Emergency Plan	31.63%	3.06%	3.06%	44.39%	0.00%	6.63%
D6. Monitoring, Registering and Documentation	2.04%	2.04%	0.68%	78.91%	0.00%	12.24%

1: Never; 2: Eventually; 3: Almost always; 4: always; DNK/DNA: Does not know or did not answer

Table 6 — Correlation analysis of the six ORP dimensions

	D1	D2	D3	D4	D5	D6
D1	1.00	0.99	0.97	0.99	0.77	0.99
D2	0.99	1.00	0.98	1.00	0.75	1.00
D3	0.97	0.98	1.00	0.99	0.82	0.99
D4	0.99	1.00	0.99	1.00	0.80	1.00
D5	0.77	0.75	0.82	0.80	1.00	0.77
D6	0.99	1.00	0.99	1.00	0.77	1.00

including workers’ OPR training and the control and maintenance of places, facilities and work equipment. Moreover, D4 – Other ORP Activities – and D6 – Monitoring, Registering and Documentation – are also highly correlated.

**Conclusions**

A portion of workplace accidents can indeed be attributed to chance, and therefore, can hardly be avoided. However, accidents caused by unsafe conditions and behaviours also happen frequently. The latter can indeed be prevented and must receive special attention by managers. The findings of the present study pin points to a set of suggestions to increase workplace safety within the electricity industry namely: raising awareness about the need for ORP management, and promoting preventive measures amongst managers and workers. It does include ORP measures within the coordinating activities: when workers of two or more companies share a workplace; increasing and improving ORP training-and including and informing workers on ORP planning and emergency protocols.

The conclusions presented here are based exclusively on a survey carried out in 2018, with companies from the Galician community. To contribute to the exploration of this issue, further studies should analyse more recent data from companies in other countries and regions.

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