# Live Working as an Example of Electrical Installation Maintenance with the Zero Accidents Philosophy

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***Abstract*–Live working can be considered a contribution to safety at work, as it is an example of electrical installation maintenance with the zero accidents philosophy. The purpose of this paper is to promote the concepts of maintenance work without accidents or with "zero accidents". Live working can be identified as an unquestionable foundation of business excellence. This paper introduces the legitimacy of implementing and carrying out live working from the perspective of safety and health at work, critically analyses accidents that happen at work in a de-energized state and arguments the goals of implementing live work as work with "zero injuries". Organisations with an integrated management system have excellent organisational conditions for safe implementation of live work and can therefore achieve the goal "zero defects" or the idea "zero accidents" or "zero injuries" at work due to electrical shock.**

***Index Terms*–Business excellence, integrated management system, LW, live working, PDCA cycle, zero accidents.**

## I. Introduction

LIVE working (LW) can be considered a contribution to safety and quality of electrical installation maintenance procedures on all voltage levels. There have been quite a few attempts around the world to promote the concepts of maintenance work without accidents or with "zero accidents". Organisations with an integrated management system have excellent organisational conditions for safe implementation of live work and can therefore achieve the goal "zero defects" or the idea "zero accidents" or "zero injuries" at work due to electrical shock. Live working as a tool for preventive maintenance corresponds perfectly with the requirements of Total Productive Maintenance (TPM), which is based on preventive or productive maintenance. We can directly connect the maintenance of electrical installations with the live working method to the basic Total Quality Management (TQM) principle, which satisfies customer's requirements and needs for an uninterrupted energy supply. In connection with the TQM principle, live working can be identified as an unquestionable foundation of business excellence. "Zero" therefore actually means that we must preventively work in such a way that an event cannot happen even once. This paper introduces the legitimacy of implementing and carrying out live working from the perspective of safety and health at work, critically analyses accidents that happen at work in de-energized state and arguments the goals of implementing live work as work with "zero injuries". The integrated management system ISO 9001 and OHSAS 18001 is based on the Deming cycle PDCA (Plan-Do-Check-Act) and enables constant improvements of live working as a tool of preventive maintenance that is integrated into different maintenance concepts (e.g. RCM, TPM, TQMain). An integrated management system with a built-in PDCA cycle demands permanent control of live work implementation, the assurance that the linemen are competent and equipped with personal protective equipment (PPE), prescribed tools and equipment according to each live working method. The integrated management system ISO 9001 and OHSAS 18001 enables constant improvements and supports the idea of implementing electrical installation maintenance without accidents. The short survey was carried out in January 2014 amongst the LWA committee members and presents questions and interesting answers which are variable from country to country.

## II. Overview of Accidents During Maintenance of Electrical Installations

With precise research of sources for accidents that occur during maintenance of electrical installation, we get an overview of the scope and types of accidents in individual countries. Unfortunately, these statistics are not unified, therefore a simple comparison of data is not possible. Further research is necessary, but existing data warns us that work accidents amongst electricians do happen and unfortunately, some have a fatal outcome.

From national statistics, it is not possible to figure out how many accidents are the consequences of LW. An expert benchmarking research needs to be carried out in individual countries or existing literature needs to be studied.

A lot of professional literature (studies, manuals, papers and articles) regarding maintenance of electrical installations with LW is available. LW experts actively work on professional literature in eminent circles of institutes (EPRI, EEI, STRI, BME, EIMV, C&G etc.), internationally recognized agencies (OSHA, EU-OSHA, ILO, ISSA etc.), world-known civil electrical associations (CIGRE, IEEE, LWA, CIER etc.), at specialised conferences or congresses (IEEE-ESMO, ICOLIM, CITTES etc.), in specialized institutions or companies (SERECT, EDF, RTE, TERNA, ENEL, E-ON, RWE, ČEZ, CATU, CHANCE, HEP NOC, C&G etc.) or in magazines.

We have reviewed the papers from IEEE-ESMO since 1993, ICOLIM since 1996 and CITTES from 2011 until 2013. The following subjects prevail on LWA and ICOLIM conferences:

- Live maintenance in low-, medium- and high-voltage fields,

- Construction, operation, modernization and maintenance experience on LW in lines and stations,
- New tools, equipment and materials,
- Standards, regulations and legal aspects,
- Working methods, new procedures and techniques in LW,
- Training, selection and qualification of people on LW.

Lately LW experts on rare occasions also mention the following topics:

- Safety and quality aspects,
- Electromagnetic field,
- Economic aspects and environmental protection,
- Live Working and Energy Market.

### *A. Overview of Dead Working Accidents*

National reports on health and safety at work are available on-line. The reports of the European Agency for Safety and Health at Work (EU-OSHA) are also interesting. EU-OSHA has been using statistical data to educate the public that accidents (also with fatal outcomes) occur in the maintenance sector and that work related professional diseases and medical issues (i.e. asbestosis, cancer, hearing problems, and bone and muscle disorders) are most frequent with workers in the maintenance sector. Maintenance workers are also exposed to accident related risks.

EU-OSHA uses data from Eurostat or European statistics on Accidents at Work (ESAW). According to Eurostat's data from five EU countries, at least 15% to 20% of all accidents and 10% to 15% of fatal accidents in 2006 were related to maintenance activities (Eurostat [3]).

The ESAW project includes data on accidents with more than three calendar days of accident leave. A work related accident is defined as an "individual event that occurs during work and causes physical or mental damage". A fatal accident is defined as an accident that causes the death of the victim within one year of the day the accident occurred. According to Eurostat data for 1998 [4], 4.7 million work related accidents with an accident leave longer than three days occurred to a total of 136.15 million workers, t.i. 0.4% or 4,089 accidents per 100,000 employees. In the same year, fatal work accidents reached a staggering number of 5,476 (if we add 3,100 fatal accidents on the way to work, the total number goes up to 8,600).

The statistics on these events in Eurostat's [3] report for the period 1999–2007 is very diverse. We have chosen the following electricity related data: accidents caused by electricity, explosion or fire (these caused almost 500 deaths in the period 2003–2005 and around 15,000 accident-leaves longer than 3 days in 2005) and accidents caused by voltage, temperature or dangerous substances (these caused around 600 deaths in the period 2003–2005 and around 100,000 accident-leaves longer than 3 days in 2005).

French and Slovenian statistical data was also analysed. The French data [5] is quite informative; in 2006 and 2007 eleven people died due to electric shock, which is around 2% of all work related deaths (the total number of deaths in these two years was 537 or 622). The accidents with electric shock are 2-times more dangerous with regards to permanent invalidity and 13-times more deadly than the average of all work accidents. Fig. 1 and 2 depict accident trends with diagrams. These show that the number of accidents in the last 30 years has greatly reduced. The IRSD's (Labour Inspectorate of the Republic of Slovenia) report shows the statistical data on all fatalities in Slovenia [6], which is between 13 to 29 in the period 2000–2011, but this number has been persistently falling in the last five years (Fig. 3).

We should also mention the European Commission's message to the European Parliament regarding improvement of quality and productivity (Brussels, 21.02.2007, COM (2007) 62). The Commission feels that the general goal for the period 2007–2012 should be a 25% reduction of accidents at work. This reduction will be evaluated in relation to the number of fatal accidents at work in 2007.

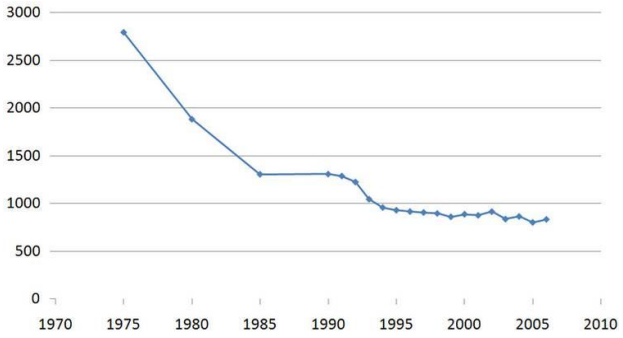


Fig. 1. Number of electricity related accidents at work (with sick leave) (France) [5]

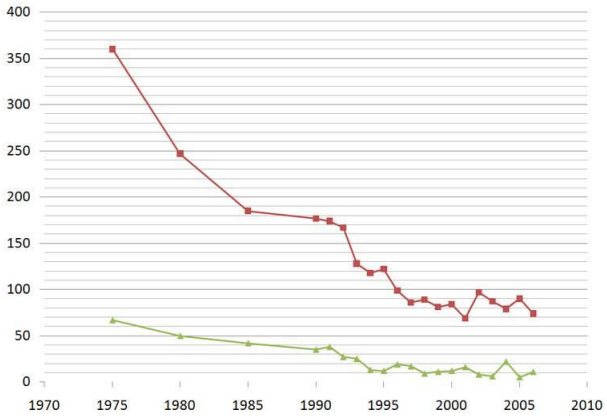


Fig. 2. Number of permanent disabilities and number of deaths (France) [5]

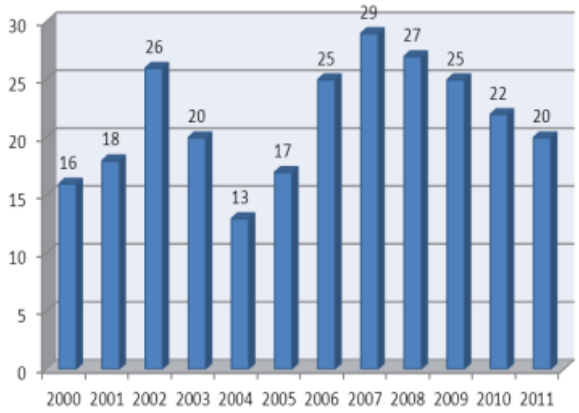


Fig. 3. Number of all deaths (Slovenia) [6]

A special analysis of fatalities was carried out in cooperation with IRSD. This analysis shows the number of accidents and fatalities in Slovenia and Slovenian utility companies due to electrical current. In Slovenia, in the period 2005–2010, the lowest number of electricity related accidents was reported in 2005 (13) and the highest in 2007 (46). In the same period, 14 serious accidents and 11 fatalities occurred (the most, t.i three cases, in both 2008 and 2009). During 1991–2011 Slovenian utility companies reported 134 minor, serious and fatal accidents (42 serious, 6 fatal). The number of events greatly varies amongst the years, with just 1 minor accident in 2006 and 12 accidents in 1995. Fatal accidents occurred in 1992 (1), 1993 (1), 2000 (1) and 2008 (2) [7].

French statistics does not show if any accident is the consequence of LW. All accidents in Slovenia occurred with the dead working method.

### *B. Review of Live Working Accidents*

We carried out an on-line research to gather data regarding safety and quality aspects. We used the following search terms: Live Work (LW), Live Working (LW), Travaux sous tension (TsT) – (French), Lavoro sotto tensione (LsT) – (Italian), Arbeiten unter Spannung (AuS) – (German), Trabajos en tensión (TeT) – (Spanish), Trabalho em tensão (TET) – (Portuguese), Prace pod napięciem (Polish), Práce pod napětím (Czech), Lucru sub Tensiune (LST) – (Romanian), Rad pod naponom (RPN) – (Croatian), Delo pod napetostjo (DPN) – (Slovenian), Работы под напряжением (ПРН) – (Russian) and others.

There is a lot of promotional and professional material (rules, regulations, recommendations, studies, manuals, guidelines, etc.) on general health and safety at work when maintaining electrical installations. The documentation on health and safety at work is available for all methods of maintenance works on electrical installations:

- Dead working,
- Working in the vicinity of live parts,
- Live working.

Not a lot of records on LW accidents exist. We spent a lot of time searching for sources, but only managed to get a few documents [8]–[18] that describe LW accidents.

STRI carried out an international review of LW [8]. Maintenance work is carried out with the LW method almost all over the world; in North and South America, in Japan, China, Korea, in Russia, in most of the countries in Eastern Europe, and in most countries in South and Central Europe i.e. France, Germany, Spain etc. Actually, it is almost only in the Nordic countries that live working is not used at higher voltage levels [8].

A STRI study [8] shows the results of a research carried out in twenty countries on all continents (Argentina, Australia, Bangladesh, Brazil, France, India, Japan, Canada, China, Korea, New Zealand, Poland, Romania, Russia, Spain, United Kingdom, South Africa, Czech Republic, Germany, Ukraine, USA, Venezuela). This research concentrated on "Problems and Accidents" of LW. Accidents are rarely mentioned in the literature. A couple of flashovers are mentioned [9]–[10], but they are the only exceptions. The reason was deemed to be high humidity in combination with hard wind [8].

Two Canadian sources [10]–[11] talk about problems with carrying out LW at a safe distance on 500kV overhead lines. Two events were mentioned; in 1997 and 2002 workers from Manitoba Hydro (Winnipeg, Canada) were carrying out LW at a safe distance (exchanging an insulator), when an electrical arc flashover between the conductor and the lineman occurred via the insulation rod. The burns of the lineman's hands triggered a thorough analysis of the events to define corrective measures by improving LW procedures (periodical voltage strength testing of insulator rods, inflammable materials for work clothes).

East Germany's experiences in the period 1970–2000 [12] are depicted in the central statistics of LW extent in East Germany's utility companies and the number of accidents, which are the following:

- on HV level above 100kV 8,000 insulators were exchanged on 102 OHLs (no accidents),
- on 1 to 100kV 11,826 installation works were carried out (no accidents),
- on LV level up to 1000V 537,000 working hours were reported (10 accidents reported, two due to poor equipment condition, eight due to insufficient quality of safety technical devices, no fatalities)

UNIPEDE survey analysis for the period 1978–1979 [13] is also interesting. UNIPEDE had many difficulties getting answers to questions about LW accidents. The analysis states that at that time 50,000 electricians in Europe worked with the LW method and anonymous answers to the survey determined 171 accidents and 5 fatalities due to LW (unfortunately we do not have this survey, we are merely quoting the data about the first LW implementations in Europe).

Croatian instructors [14]-[15] that attended the LW training in EDF SERECT (today RTE SERECT) were acquainted with LW safety procedures and were told that since LW activities during maintenance increased, the total number of accidents amongst electricians in France has reduced. This data is shown in Fig. 4 [16]. The French also have an interesting philosophy that "It is better to know that you are working live than believing that you are working dead!" [14].

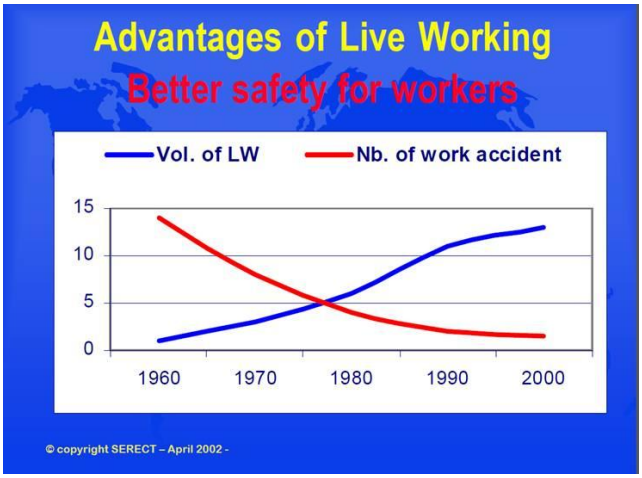


Fig. 4. Advantages of LW, Better Safety for workers [16]

A badly-informed expert for health and safety at work might conclude that accidents of LW electricians are deliberately not being registered. However, it is quite the opposite; meeting notes [17]–[18] of eminent LW experts (CIGRE, LWA) repeatedly mention that they do not know of any LW related accidents. That is why we carried out a short survey in January 2014 amongst the members of the LWA committees (see Chapter V).

## III. Zero Accidents philosophy

LW is rarely considered as an interdisciplinary or complex activity in documents and sources of specialised conferences (IEEE ESMO and ICOLIM). These documents are valuable because they depict new viewpoints; most people see LW through the development of technology and LW methods or the development of tools and personal protective equipment (PPE) and professional LW training.

Papers [19]-[20] open up a discussion on other LW aspects. Papers discus a new marketing image and the necessity to communicate inside and outside of the company that implements LW. Papers also warn that implementing LW is not enough and that its economic, social (external and internal) and environmental benefits need to be clearly presented.

The values of most public companies [20] are incorporated in the corporate culture and are based on the principles of business excellence, which creates new business practices. LW surely builds business excellence; therefore it is the duty of LW managers in the company to promote LW, in combination with maintenance, reconstruction and even construction of new transmission and distribution facilities, as an example of excellent work. LW is thus an example of excellent management of transmission and distribution networks, when sustainable development is strived for.

Maintenance of electrical installations with the LW method can be indirectly connected with the basic principle of Total Quality Management (TQM), with customer satisfaction or the fulfilment of customer's demands and needs for an uninterrupted power supply (ISO 9001), and the managerial support of health and safety at work (OHSAS 18001).

LW implementation demands permanent competency ratification of the procedure, staff and LW equipment [21]. In CIGRE's technical brochure, permanent examination of LW implementation in the following areas is required: checking costs and advantages of LW in comparison to dead work, periodical quality assessments (PDCA), examination and analysis of past LW activities, monitoring international standards and recommendations, monitoring regulations and incentives for future changes.

### *A. Idea of Zero Accidents Philosophy*

When we think about successful and safe LW, the implementation of the "Zero accidents" philosophy during maintenance of electrical installations is a must. Fact is that there are no accidents with LW, especially none with fatal consequences. This idea should therefore also be developed for dead working and the five golden rules should be consistently put into force.

Zero Defects [22] was a management led program to eliminate defects in industrial production that enjoyed brief popularity in American industry in the late 1960's and early 1970's. It enjoyed a renaissance in the American automobile industry as a performance goal more than as a programme in the 1990's. It can be applied in any type of enterprise. The response to the quality crisis was the principle of "doing it right the first time" (DIRFT). It included four major principles [22]:

- the definition of quality is conformance to requirements (requirements meaning both the product and the customer requirements),
- the system of quality is prevention,
- the performance standard is zero defects (relative to requirements),
- the measurement of quality is the price of non-conformance.

In the past the terms "Zero accidents" and "Zero injuries" have been used a great deal by construction companies espousing their commitment to safety.

The paper [23] carried out an interesting study in this field. It shows that many construction companies, especially those in the industrial sector, have enjoyed significant improvements in their safety performances. These performance statistics have been considerably better than those of the overall construction industry and provide clear testimony of the effectiveness of efforts to improve safety. Although safety performances have been impressive amongst many of these companies, a study was conducted to see if additional improvements could be made. The study was conducted with a selected group of large, primarily industrial, companies to determine if any changes had been made since the Construction Industry Institute (CII) publicized its findings on effective means to improve safety performance. Results show that many of these companies have made additional changes and that the benefits were realized. Safety performances have improved since these additional safety practices have been implemented. The implication is that companies with good safety records can still make improvements by implementing specific safety practices.

USA promotes the concept of maintenance works without accidents or "zero accidents". A campaign and project "Zero Accidents Techniques", which was developed for several years (1989–1993) and then launched in 1993, leads towards a "zero injury" goal [23].

In the LW field there are some examples of promoting the idea "zero accidents" and "zero injuries" [24]–[26]. Italian Enel promotes the ideas "zero accidents" and "SAFETY FOR EVERYONE" [24]. Safety is the main value that distinguishes every person from Enel all around the world. It is an essential condition for workers who work in the company every day. All employees, without exception, must commit to achieve the "zero accidents" goal. Wherever they are – in the office, in the yard, on the street – they must always have in mind to return home safe and sound. Safety is everyone's responsibility. SAFETY FOR EVERYONE (all for safety) represents a new era and a renewed commitment on the part of each employee, at all levels, starting from a strong signal from the top management. The objective of Enel for safety is to eliminate

injuries, both for their employees and for the employees of contractors and suppliers [24].

Slovenian promotion of the "Zero accidents" idea is connected to the amendments in the Rules on industrial safety with regard to electric current hazards [25]. These are addressed to the electricians that work with the dead working method, since we have some ten serious accidents and at least one fatality caused by electrical current each year. Using "The five golden rules" with the dead working method is encouraged, since not following just one out of the five rules can lead to fatal accidents.

A short survey was carried out in January 2014 amongst the LWA committee members (see Chapter V). Only a few answers mention accidents. We received answers from experts in Germany that they know of accidents in the past ten years on MV and LV, but there are no records of these accidents (1 respondent knows of 1 accident on LV without fatal consequences and 2 respondents know of accidents on MV and LV), and from experts in Czech, where one respondent knows of one accident in the last ten years (in 2006 during the connecting of a 22kV mobile substation to an overhead line) and from experts in France that know of accidents on all levels of voltage (HV, MV, LV).

### *B. Integrated Management Support of Live Working*

Live work gained a new impulse with the liberalization of the electricity market, since opening up new market leads to falling of old monopolies. With clear economic requirements grows pressure on distribution system operators how to achieve higher quality standards of electricity, which one of the major criteria is reliable and continuity of its supply.

We can directly connect the maintenance of electrical installations with the live working method to the basic Total Quality Management (TQM) principle, which satisfies the customer's requirements and needs for an uninterrupted energy supply. In connection with the TQM principle, live working can be identified as an unquestionable foundation of business excellence.

TQM uses the term "constant improvement", with an emphasis on the constant problem solving process, with two components: systematic improvements and repetition of improvements. Improvement repetition is actually the repetition of Deming's PDCA cycle, which consists of: PDCA (Plan-Do-Check-Act).

An integrated management system with a built-in PDCA cycle demands permanent control of LW implementation, the assurance that the linemen are competent and equipped with personal protective equipment (PPE), prescribed tools and equipment according to each LW method. The integrated management system ISO 9001 and OHSAS 18001 enables constant improvements and supports the idea of implementing electrical installation maintenance without accidents.

Integrated management system ISO 9001 and OHSAS 18001 is based on the Deming cycle PDCA and enables constant improvements of live working as a tool of preventive maintenance that is integrated into different maintenance concepts (e.g. RCM, TPM, TQMain).

Organisations usually implement the quality management system in accordance with ISO 9001. This system serves as the basis for other management standards or systems. Which standard besides ISO 9001 (ISO 14001, OHSAS 18001, ISO 27001) an organisation will use, depends on its activities.

When we talk about management system integration, the foundation of this integration is justifiably the quality management system (ISO9001). The process model of the quality management system follows the constant improvement philosophy (the PDCA cycle) in its structure and content. Even though other standards cover other areas (i.e. environmental management, ensuring health and safety at work), the way they do it is similar to all standards or management systems. That is why the PDCA cycle is the foundation for integrating different management systems.

Not a lot of documents mention incorporating LW into the integrated management systems (ISO 9001, ISO 14001, OHSAS 18001). The reason for this could be that it is not standard practice to certify distribution and utility companies abroad. It is interesting that the Slovenian utility company Elektro Primorska d.d. is the first in Europe to obtain the ISO 9001 Certificate [27]. We did find some such documents in Slovenia in Italy [27]-[29].

The introduction of live work in Slovenian utility companies, with expert's support in health and safety at work, ensures continuous improvement of process and product quality, increased productivity and reduced costs.

Utility company Elektro Ljubljana (EL) [27] implements this method of maintenance practically at the 100-year anniversary of live work. Legislation, system manuals and internal organization of work were carefully examined during the LW implementation. This eventually led to the upgrading of quality management system ISO 9001:2008 with the requirements for performing LW. With the aim to establish a controlled system of planning and execution of LW, instructions for issuing LW documents that ensure safe implementation were adopted.

In Slovenia, the most organizations integrated a management system (OHSAS 18001) in the field of electrical distribution and energetics. A research in 23 Slovenian utility companies showed a very high usage of individual standards: ISO 9001 (78.7%), ISO 14001 (78.7%) and OHSAS 18001 (72.1%) [27].

The research [27] showed that experts and consultants of all 13 Slovenian companies that carry out LW have focused on fulfilling legal obligations, adapting the safety statement with risk assessment and choosing a LW system and working procedures that must be defined and verified in advance. Only four Slovenian companies completed the LW implementation process by upgrading the quality management system ISO 9001. The other 8 of the 9 companies that have been carrying out LW for a short period (1 to 3 years), already have an integrated quality management system and we expect that they will upgrade their ISO 9001 documentation in the next stage of LW implementation.

EL [27] upgraded its integrated management system (ISO 9001, ISO 14001, OHSAS 18001, ISO 27001) by conforming the safety documentation for LW. The guidelines for issuing and reasonable use of documents for safe LW on LV want to insure safe LW with the goal to implement a controlled system for planning and carrying out LW.

EL [27] built its own integrated management system, which is based on the following standards:

- SIST EN ISO 9001:2008, Quality management systems – Requirements (ISO 9001:2008),
- SIST-TS BS OHSAS 18001:2012, Occupational health and safety management systems – Requirements,
- SIST EN 14001:2005, Environmental management systems – Requirements with guidance for use (ISO 14001:2004).

A requirement of Italian regulations is also interesting; based on the ordinance from 2011 [28], all companies that want to construct training centres for LW on MV and HV, must among others (documentation, LW methods and procedures, LW technology, training programmes, personnel) also comply with the condition that they implement the standards UNI EN ISO 9001:2008 and BS - OHSAS 18001:2007. ENEL adopted these requirements when it certified the training centre [29].

Organizations with an implemented management system have excellent organizational conditions for safely implementing and carrying out LW and can therefore pursue the goals of "Zero accidents" (or "Zero injuries") at work due to electrical hazards. A regular and consistent implementation of the PDCA cycle as a part of the standards ISO 9001 and OHSAS 18001 ensures systematic control of LW technology, procedures, quality of equipment and tools and PPE. PDCA enables timely corrective measures in the area of safe work and prevents error repetition.

## IV. SURVEY

As we already pointed out in the introductory part (Chapters II and II. B), we cannot be satisfied with the information regarding the descriptions and statistical data on LW related accidents.

Are there really no LW accidents? Or do they happen, but experts simply do not want to talk, write or discuss them?

We have been studying online professional sources and especially programmes and articles from specialized conferences (IEEE ESMO, 1993, 1995, 1997, 2000, 2003, 2006 and 2011; ICOLIM, 1996, 1998, 2002, 2004, 2006, 2008 and 2011) for months and unfortunately, we cannot find any written records on LW related working accidents.

A few records that we did find [8-16] encouraged us to carry out a simple survey with YES/NO answers to questions about LW related accidents.

Our goal was to get a simple indication from our colleagues, LWA committee members, if they personally know of any LW related accidents.

The questions were formed for all three voltage levels (LV, MV and HV). With this short survey, we basically wanted to get answers to the first two questions, if our colleagues personally know of any LW related accidents.

This survey was carried out in January 2014 amongst the LWA committee members from Croatia, Czech, France, Germany, Hungary, Ireland, Italy, Poland, Portugal, Romania, Slovenia and Spain. The survey on LW competences included the following questions (Table I):

1. Do you personally know of any LW related accident at work in your country anytime in the past?
2. Do you personally know of any LW related accident at work in your country in the past ten years?
3. Do you personally have any record about a LW accident in your country in the past ten years?

Based on the available data on member countries and committee members (http://www.icolim2014.org/committees), we sent our survey to twenty addresses.

We got a reply from all member countries. As we found out, some committee members are no longer active (wrong addresses, different employment or even retired).

We got three replies from Germany and at a later stage a reply from Spain (colleague from JWG-27 (LW), CIGRE). We managed to get answers from all LWA members (and associate member, Slovenia).

TABLE I
SURVEY ANSWERS

| Country | Voltage level | Accidents in the past | Accidents in the past 10 years | Records about accidents |
|---|---|---|---|---|
| Croatia | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | NO | NO | NO |
| Czech | HV | NO | NO | NO |
| | MV | NO | YES | YES |
| | LV | NO | NO | NO |
| France | HV | YES | YES | YES |
| | MV | YES | YES | YES |
| | LV | YES | YES | YES |
| Germany | HV | NO | NO | NO |
| | MV | YES | YES | NO |
| | LV | YES | YES | NO |
| Hungary | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | NO | NO | NO |
| Ireland | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | NO | NO | NO |
| Italy | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | YES | YES | NO |
| Poland | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | NO | NO | NO |
| Portugal | HV | YES | n/a | n/a |
| | MV | YES | n/a | n/a |
| | LV | YES | n/a | n/a |
| Romania | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | NO | NO | NO |
| Slovenia | HV | NO | NO | NO |
| | MV | NO | NO | NO |
| | LV | NO | NO | NO |
| Spain | HV | NO | NO | NO |
| | MV | YES | YES | n/a |
| | LV | n/a | n/a | n/a |

Before continuing with the analysis, we should mention that the answers were anonymous. It is undisputable that the

survey was filled out by experts with professional knowledge about the LW state in their environment (company, country).

It has come to our attention that we can expect to get different answers to the same questions in future similar researches, where several experts from the same country are participating. Foremost, this can be expected in bigger countries, where experts are from different or even competing companies. The exchange of such official information is probably insufficient. There is even the possibility that this information is just a consequence of personal experience or informally gathered data.

LW experts are very reserved when discussing this topic, therefore similar surveys should be done anonymously.

Important information that we got from the survey was, that six countries answered "YES" to the question if they know of any work related accidents that occurred while carrying out LW.

We received the French answer from the national LW committee, so we can assume that there is a body that carefully analyses all LW related accidents. Based on the French answers we can assume that the French committee has records about such accidents, but it is a challenge for the researchers to get information on these.

Czech Republic was the only country that sent us a complete record of the only LW accident on MV.

The survey has exceeded all expectations, since all LWA members answered the questions.

The answers indicate that research in the field of LW related accidents should be continued.

The information we got proves that accidents do happen. Unfortunately there are no quantitative data that would, based on official results, show if these are rare events (i.e. one event in Czech) or minor accidents [8-16]?

Informal discussions mention that accidents did happen at the beginning of the LW implementation, but nowadays there are practically no accidents.

For future research it would be interesting to get historical records, such as "UNIPEDE survey analysis for the period 1978–1979 [13]".

Professional organisations (LWA, CIGRE, IEEE, CIER), should be encouraged to include the topic of accidents due to electrical shock and arc flashovers for both dead-work and LW method in their conferences.

It is an undisputed fact that only by exchanging experiences will we warn lineman about possible LW errors and raise the safety of LW to an even higher level.

We must encourage companies, state committees or LW associations and individual experts to start a professional discussion about this sensitive but extremely important topic.

Considering that the ICOLIM 2014 conference will include the topic "Safety and quality aspects", this aspect of LW will need to be openly discussed.

## V. Conclusion

LW is an example of excellent practice and due to the integral development approach (research on working methods, development of technology and tools, PPE development, quality training, periodical knowledge renewal, attentive work of workers when carrying out LW) and constant practical analysis, it surely supports the "Zero accidents" or "Zero injuries" philosophy.

Integrated management system ISO 9001 and OHSAS 18001, in combination with consistent PDCA cycle implementation, support the fulfilment of the "Zero accidents" or "Zero injuries" goal, as they prevent accidents with regular control and corrective measures.

In comparison to dead working, LW is winning the race of "Zero accidents" or "Zero injuries" mainly due to workers, who know how to carry out live work and do not assume they are working in no-voltage conditions (otherwise we cannot understand why they are not obeying the five golden rules during dead working).

LW experts need to be encouraged to promote LW as an example of excellence in all perspectives (professional, organizational and economical) and emphasise that there are no accident when carrying out LW. In case an accident still occurs, the issue would need to be professionally examined and reported to the public to prevent similar accidents in the future. Writing about this topic should not be a problem.

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## VII. Biographies

**Viktor Lovrenčić** graduated at the University of Ljubljana, Faculty of Electrical science and achieved a Master's degree in Power supply. He has more than 25 years of experience in Electro-engineering field and has worked as a junior researcher and assistant at Faculty of Electrical Sciences, design manager at Energoinvest Transformer Company Ljubljana, than as a Commercial and Technical Manager at the same company and is now the Technical Manager at C&G d.o.o. Ljubljana.

He has been a consulter for live working for Slovenian utility companies and industry since 2006. He was a member of JWG 27 CIGRE "Live Work – A Management Perspective". HE is a pioneer and holder of LW activities in Slovenia. He is a member of CIGRE Paris, Slovenian and Croatian CIGRE and CIRED, a member of LWA Technical committee and is fluid in Slovenian, Croatian and English language.

**Boštjan Gomišček** is the associate professor at the Faculty of Organizational Sciences, University of Maribor, Slovenia.

After he finished electro-engineering studies, he worked as a young scientist at the University of Ljubljana (Faculty of Chemical Engineering) and at the University of Vienna at the Institute of Analytical Chemistry, where he obtained his PhD. Before he was appointed a professor at the University of Maribor in 2003, he was a researcher at the Austrian Academy of Sciences for four years.

As head of the Laboratory for Quality Management, he is engaged in the following research and teaching fields: quality management, environmental protection and maintenance management. He published several research papers in international journals and presented his research work at national and international conferences.