

Study on the quality management and health and safety aspects on perceived live working implementation dimensions

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Abstract—The purpose of this paper is to compare the quality management and safety aspects within the Live working (LW) framework. The study draws upon study carried out among the Slovenian electrical distribution and international study which was carried out among Slovenian and foreign LW experts. The results of the first study suggested that health and safety aspects of LW are vital for achieving efficiency and effectiveness of LW. Furthermore, it can be argued that there are no substantial differences among workers and coordinators. Similarly, the results of the international survey showed that health and safety aspects of LW are considered as very important in achieving desired outcomes of LW as expressed by the foreign LW experts. However, the results indicated that Slovenian experts perceived the elements of LW in a similar way as foreign experts.

Keywords—Live working; quality management; health and safety; efficiency; effectiveness

I. INTRODUCTION

Live working (LW) as a tool for preventive maintenance of electrical installations has a hundred year old tradition in the world and more than half a century in Europe [1-3].

In the last decade, LW has been implemented actively at low voltage (LV) in the Slovenian electrical companies for distribution, transmission and generation of electricity as well as in industry and institutions (such as health) [4, 5].

Slovenian electrical distribution began with the introduction of LW at low voltage in 2010. Depending on the complexity of the implementation processes, several special studies were prepared, which defined organizational activities, working documents and prescribed the necessary tools and personal protective equipment. For the purpose of LW at LV, a specific training program was developed as well as the required number of workers and coordinators was defined.

The purpose of this paper is to examine whether

compliance with the requirements for the safety and health, the quality and the effectiveness, and efficiency of maintenance processes with the implementation of LW at low voltage can be achieved.

It is evident from the survey results that safety and health was highlighted as the most important factors/dimensions from the perspective of workers and instructors.

It can be summarized that the results of this study demonstrate that workers and coordinators in all of the surveyed distributions are aware of positive effects of the introduction and implementation of LW at low voltage [4, 5].

Based on the results and discussions, guidelines for the implementation of the LW at low voltage are given in this study. Given the fact that workers and coordinators highlighted safety and health at work, we suggest that regular supervision procedures continue within the implementation of individual work orders, and that possible hazard situations have to be assessed at two year cycles of verifying workers and coordinators competences.

Drawing upon international research, one can conclude that safety as well as reliability and availability were the highest estimated dimensions of LW.

According to the results, performance of LW providers achieved the lowest mean value considering both datasets from Slovenian and foreign countries; however, the dimension still achieved reasonably high scores.

Furthermore, the results of t-test did not reveal any differences between Slovenia and international dataset.

II. LIVE WORKING IN SLOVENIA

Even though LW has a century-old tradition in the world, its implementation in individual countries is a professional and organisational challenge.

The last decade was marked by an active process of implementing and carrying out LW in the Slovenian environment. It started in 2006 with its promotion and the establishment of LW Consortium (with the support of thirty companies that accepted the copyrights of the LW system on low voltage), the translation of system manuals in 2007, the first training in 2008 and the first implementation of the method in 2009 in the Nuclear Power Plant Krško [4, 5].

After LW was successfully implemented and carried out on LV in the industrial environment, the Slovenian distribution companies also joined the process in 2010. The complexity of LW in Slovenian electricity distribution companies manifested itself in the fact that there are five different legal entities and consequently all of them require different approaches and search for individual solutions regarding the contextual (type of work on the network) and organisational issues (inclusion of lineman and coordinators of LW into the organisational structure) [4,5].

The start of LW implementation on LV in 2011 (Fig. 1) progressed with a successful LW implementation on medium voltage (SN) – TS cleaning in 2013 (Fig. 2), i.e. exactly 100 years after an electrician in Ohio, USA, used the LW method for the first time [1-3].



Fig. 1. Carrying out LW on LV in Slovenia



Fig. 2. Carrying out LW on MV in Slovenia

Two years after LW implementation, we carried out an analysis or external audit of the effectiveness and success of the LW implementation on LV in accordance with the directions of the LW scientific study. We also carried out an extensive survey amongst the lineman and coordinators of LW on LV in Slovenian utility companies [11-13].

This survey amongst Slovenian maintenance workers of electrical installations was utilized in order to examine the potential effects of LW on LV in utility companies. The purpose of the study was to gather the opinions of actual LW workers after the first two-year cycle, when the employers are legally required to periodically train and check the skills of their workers [11-13].

The gathered answers to the survey, which included several areas, and the data statistics were described in technical studies on the implementation of LW on LV in Slovenian utility companies. The gathered data served as a basis for us to prepare an in-depth analysis, the presentation of results and a discussion in our study that showed some of the effects of carrying out LW on LV in utility companies [11-13].

Our articles, which were published at ICOLIM 2011 and 2014, described in detail the development of implementing and carrying out LW in Slovenia in the nuclear power plant and in industrial and distribution companies on LV and MV level with the emphasis on the training and the “Zero Accidents” philosophy [14-17].

III. STUDY OF LIVE WORKING EFFECTS IN SLOVENIA

In agreement with the Slovenian electrical distribution companies Elektro Gorenjska (EG), Elektro Ljubljana (EL) and Elektro Maribor (EM), an outsourcing survey was carried out on “the introduction and implementation of LW on LV in distribution companies” [11-13].

The purpose of the study was to examine how workers, coordinators and other participants in the process of

deployment and implementation of the LW at LV in the Slovenian distribution companies evaluate the effectiveness and efficiency of maintenance processes in their working environment.

The survey was conducted among workers and coordinators (EG, EL and EM), who completed the basic training for LW at LV in October 2011 and refresher courses in October 2013 and October 2015 (every two years).

We investigated whether compliance with the requirements for occupational safety and health, the quality and the effectiveness and efficiency of the maintenance process through the establishment of LW at LV was achieved.

The questionnaire of the introduction and implementation of LW on LV in Slovenian distribution companies contained 99 questions divided into six groups [11-13]:

- Part I. "Introductory basic information about respondents" (12 questions),
- Part II. "Competencies for implementation LW at LV (personal, "distribution)" (25 questions),
- Part III. "Safety and health (OSH) of LW at LV" (12 questions),
- Part IV. "Quality management in the implementation of LW at LV" (11 questions),
- Part V. "Efficiency and effectiveness in the implementation of LW at LV" (14 questions),
- Chapter VI. "Appendix" (25 questions).

All in all, the analysis included 55 respondents (26 workers and 29 coordinators), out of which 15 are from the EG, 12 from EL and 28 from EM.

The following section shows the selected results concerning the viewpoint of workers and coordinators regarding the perception of different LW implementation dimensions. The profile of respondents is shown in Table 1.

TABLE I. RESPONDENTS FROM UTILITIES [11-13]

Respondents	EG	EL	EM	TOTAL
Workers	3	7	16	26
Coordinators	12	5	12	29
TOTAL	15	12	28	55

In order to empirically assess whether there are significant differences between means of the two categories of respondents, we applied an independent t-test. The results of the t-tests show that there is significant difference between mean values for the "Competencies for implementation LW on LV" and "Efficiency and effectiveness in the implementation of LW at LV" ($t = 2.631$, $p = 0.011$, $t = 2.396$, $p = 0.026$, respectively). It appears that there are no significant differences regarding the "Safety and health (OSH) of LW at LV" and "Quality management in the implementation of LW at LV" ($p > 0.05$).

TABLE 2. SUMMARY OF THE RESULTS REGARDING THE COMPARISON BETWEEN WORKERS AND COORDINATORS

Dimension	Mc	Mw	t	p
Competencies for LW	4.14	3.83	2.631	0.011
OSH at LW	4.75	4.66	0.851	0.408
Quality management at LW	4.58	4.20	2.006	0.066
Efficiency and effectiveness at LW	4.30	4.02	2.396	0.026

Note. M_c – Mean value for coordinators. M_w – mean value for workers

IV. INTERNATIONAL STUDY OF THE LIVE WORKING EFFECTS

This survey was carried out in 2014 amongst the LWA committee members from Croatia, Czech, France, Germany, Hungary, Ireland, Italy, Poland, Portugal, Romania, and Slovenia and participants of ICOLIM 2014. The survey later also included LW specialists who are active in CIGRE.

The international questionnaire contained 83 questions divided into five groups:

- Part I. "BASIC INFORMATION ON THE RESPONDENTS" (10 questions),
- Part II. "QUALITY MANAGEMENT DURING LW IMPLEMENTATION" (20 questions),
- Part III. "HEALTH AND SAFETY AT WORK DURING LW IMPLEMENTATION" (19 questions),
- Part IV. "EFFICIENCY AND EFFECTIVENESS OF LW IMPLEMENTATION" (15 questions),
- Part VI. "ADDITIONAL SECTION" (19 questions).

A total of 171 respondents from 36 countries participated in the survey. Most of the respondents were from Slovenia (44 or 25.7%) and Croatia (27 or 15.8%). The respondents from abroad were in average represented with a sample size of 1 to 5. The above-average response of LW experts was seen in Hungary (10), Canada (9), Germany (8) and Poland (6).

Prior to further statistical analysis, we first investigated the descriptive statistics for study variables. Observing the four dimensions ("Quality management at LW" - QM, "Health and safety at LW" - HS, "Reliability and Availability of LW" - R&A and "Performance of LW providers" - Providers Perf), we can see that the highest mean value of Slovenian dataset corresponds to the "Reliability and Availability of LW" ($M = 4.52$), while the lowest value corresponds to the "Performance of LW providers" ($M = 4.05$). Given the international dataset our results showed that the highest mean value corresponds to the "Health and safety at LW" ($M = 4.61$), while the lowest value corresponds to the "Performance of LW providers" ($M = 4.17$). Furthermore, t-test (Table 3) was used to examine whether there are significant differences between international and Slovenian dataset concerning the aforementioned LW dimensions.

TABLE 3. T-TEST FOR EQUALITY OF MEANS BETWEEN INTERNATIONAL AND SLOVENIAN DATASET

Dimension	t	p	MD	95% CI	
				Lower	Upper
QM	-1.235	0.219	-0.162	-0.421	0.097
HS	1.653	0.103	0.175	-0.037	0.388
R&A	0.428	0.669	0.047	-0.171	0.266
Providers Perf	0.769	0.443	0.118	-0.185	0.420

Note. MD - Mean Difference. CI - Confidence Interval. QM - Quality management during LW implementation. HS - Health and safety at work during LW implementation. R&A - Reliability and availability. PP - Performance of providers.

According to the results of the t-test, there are no significant differences between two groups of respondents, namely international and Slovenian LW experts. Several regression tests were performed in order to analyse the effects of deploying the quality management as well as health and safety practices on efficiency and effectiveness of LW implementation. It can be argued that both quality management and health and safety positively influence reliability and availability ($\beta = 0.487$, $p = 0.000$, $\beta = 0.710$, $p = 0.000$, respectively) as well as performance of LW providers ($\beta = 0.339$, $p = 0.000$, $\beta = 0.617$, $p = 0.000$, respectively).

V. CONCLUSIONS

The purpose of the research was to examine the perception of LW experts on LW from the Slovenian and international perspective. The study provides empirical evidence suggesting that there is no substantial discrepancy between Slovenian and international perspectives regarding the LW implementation factors and LW outcomes. The key comparison between Slovenian and international dataset is shown in Figure 3.

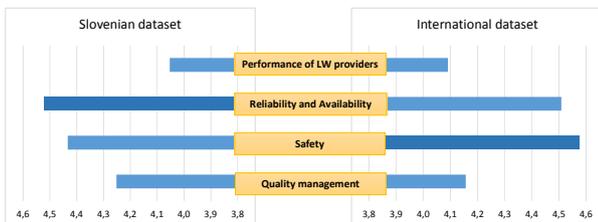


Fig. 3 The results of Slovenian and international survey

Overall, the findings underpin previous assertions [5] that emphasise the importance of LW in achieving the desired performance in different settings such as distribution, transmission and generation of electricity.

The results of the regression analysis have confirmed the premise that quality management as well as health and safety at work can be beneficial in terms of reliability, flexibility and availability of electric installations and performance of LW workers.

Results from both empirical studies emphasise the importance for LW providers to recognize safety aspects, the importance of providing periodical training in the field of LW as well as the need to be aligned with the requirements

concerning the safety equipment.

Furthermore, it should be noted that standardized management systems, such as ISO 9001 and OHSAS 18001, can provide systematic approach towards integrating the quality management and safety aspects into the LW procedures and processes.

It is of great importance that research is continued as it should give answers to the following questions:

- Does carrying out of maintenance of electrical installations by the live working method have an impact on meeting the requirements of customers for electricity and higher level of quality of electricity?
- Does carrying out of maintenance of electrical installations by the live working method reduce the number of accidents at work with electricity?
- Does carrying out of maintenance of electrical installations by the live working method contribute to better effectiveness and efficiency when carrying out preventive maintenance of electrical installations?

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