Application of the Pareto principle to accident analysis to improve working environment

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1. Introduction

Occupational accidents are associated with the nature of industrial activities and the conditions under which such activities are conducted. While it appears unrealistic to eliminate all such accidents, it is by all means necessary to reduce their number and severity. To gain the ability to reduce accident rates, one needs to identify their causes and put in place proper working environment improvements which fit the nature of the irregularities discovered. To this end, in the majority of cases, one needs to employ tools which help identify event causes and measures which will effectively reduce accident rates and accident severity (Górny, 2014a).

For the information gathered to be objective, it is vital to analyze issues thoroughly with the use of proper analysis instruments. To that end, it is possible to resort to some of the traditional quality engineering tools. These include the Pareto principle which helps identify the main causes of events whose removal will significantly improve working conditions and minimize worker exposures to working-conditions-related impacts. The tool is of particular use for organizations having to copy with limited working-conditions improvement budgets. The study has helped identify the causes of accidents in Poland between 2010 and 2013 (Accidents at work ... 2011-2014). Accident statistics were derived from the Central Statistical Office as published in its bulletin. The accident cause findings may be applied to improve working conditions and prevent accident recurrence.

2. Descriptions of occupational accidents and their causes (in Poland)

During the period covered by the study, i.e. from 2010 to 2013, accident rates remained fairly constant. More than 94,000 occupational accidents were reported in Poland in 2010 and over 88,000 in 2013. Accidents rates peaked in 2011 exceeding 97,000. For detailed accident rate statistics broken down by cause, see Table 1. The accident causes have been defined as any deficiencies and irregularities which either directly or indirectly contribute to accidents and which can be associated with physical (technical) factors, the company's overall work design, the workstation or the workers themselves. As the majority of occupational accidents are caused by multiple factors, the sum total of such causes is greater than the total number of the reported accidents.

Table 1. Causes of accidents at work in Poland in the years 2010 – 2013 (Accidents at work ... 2011-2014).

Years	**2010**	**2011**	**2012**	**2013**	**Total**	**Total** (in %)	**Total** (in %, ithout [8])
Accidents at work in Poland	94207	97222	91000	88267	390676	-	-
[1] Inappropriate condition of material agent	16620	17042	15651	14589	63902	8,78	19,18
[2] Inappropriate organization of work	9371	9696	8801	8083	35951	4,94	10,79
[3] Inappropriate organization of work post	10139	10289	9735	9048	39211	5,39	11,77
[4] Absence or inappropriate use of material agent	13382	13925	13079	11742	52128	7,16	15,64
[5] Not using protective equipment	2741	2960	2720	2512	10933	1,50	3,28
[6] Inappropriate wilful employee action	12531	12962	12100	11324	48917	6,72	14,68
[7] Inappropriate mental – physical condition of employee	3746	3542	3123	9814	20225	2,78	6,07
[8] Incorrect employee action*)	101494	102393	95608	95002	394497	54,21	-

[9] Other	13853	15958	16180	15975	61966	8,52	18,59

*) Considering the way in which accidents have been broken down into categories and that they have been classified to cover various event types with only rare references made to the causes of improper behavior by workers, such a breakdown has not been reflected in further analysis.

Table 1 shows that the main cause of the accidents which took place between 2010 and 2013 was improper behavior by workers (cause [8]). However, due to the nature of the accident causes and, most importantly, the fact that the classification reflects varying types of worker violations, it was not possible to examine such accident causes in detail. For that reason, such causes were not accounted for in further analysis, the assumption being that the distribution of the reflected causes will be insufficient to identify advisable improvement measures.

Irrespective of cause [8], one can demonstrate that the occupational accidents which took place in Poland between 2010 and 2013 were caused mainly by:

- [1] an improper condition of physical factors: ca. 16,000 accidents per year (19.18%),
- [4] the improper use of physical factors: ca. 13,000 accidents per year (15.64%),
- [6] improper and/or self-willed worker behavior: more than 12,000 accidents per year (14.68%),
- [3] improper workstation design: ok. 10,000 accidents per year (11.77%),
- [2] improper workflow design: ca. 9,000 accidents per year (10.79%),
- [7] worker's psychological condition failing to ensure safe performance of work: more than 5,000 accidents per year (6.07%),
- [5] failure to use the personal protective items issued to worker: ca. 3,000 accidents per year (3.28%),
- [9] other causes: ca. 16,000 accidents per year (18.59%).

The above causes were reflected in the Pareto analysis.

3. Application of the Pareto principle to assessing accident causes

To identify the actual accident causes, it is essential to use such deduction tools as reflect the nature of the available data. Whether or not an assessment is possible depends on the rules of systemic approach and, in particular, on whether decisions and actions have been based on reliable facts and adopted by reliable data analysis methods. By relying on credible information in one's decisions, one will indirectly increase one's capacity to demonstrate the effectiveness of prior decisions (ISO 9004). Analyses based on the systemic approach are helpful in identifying the causes that are most likely to result in accidents (Górny, A. 2015).

In order to select measures that ensure effective improvements, it is critical to identify the causes of irregularities. This is a sine qua non condition for ensuring a safe working environment. Since the approach is systemic, the solutions based on such assessments help effectively prevent occupational accidents and ensure steady improvements in an enterprise's working conditions. Such improvements should be seen as a direct consequence of adopting the principles of systemic management (Górny, 2014a).

The Pareto principle was first applied in the 1940s to eliminate the causes of defects in quality engineering. It was popularized in part by J. Juran who used it to analyze uneven quality loss distributions (Juran, 1970). The principle is based on an empirical relationship in which ca. 20% of the causes generate 80% of the effects (Koch, 2004; Wilkinson, 2006). Hence, once 20% of the most common causes have been identified, it is possible to effectively improve the conditions in which processes take place. An analysis of accident rates and types shows that 20% of the most predominant irregularities contribute to approximately 80 percent of accidents (Butlewski, 2014).

Based on the empirical relationship whereby roughly 20% of the causes generate some 80% of the effects, (Juran, 1970), the Pareto principle proves to be helpful in effectively identifying the causes of the majority of problems. With respect to accidents, one may assume that by diagnosing 20% of accident causes one can eliminate approximately 80% of the effects which elevate accident rates and constitute the key driver of losses suffered by organizations.

The key aim of applying the Pareto principle is to identify the weights of individual accident causes. As a consequence, it is possible to ascribe them to one of three categories classified by the urgency of improvement measures, which in turn depend on the extent of the damage that might be inflicted by accidents and result from failures to ensure proper working conditions (Górny, 2015):

- Category A: key defects exerting a substantial impact on processes, whose elimination is a top priority or whose impact needs to be considerably reduced,
- Category B: less critical defects whose elimination is a secondary priority,
- Category C: highly insignificant defects whose elimination/mitigation is not cost-efficient and makes little

organizational sense.

It enables one to grasp the nature of the problem at hand and link it to the most common injuries (Kuprenas, 1999). Such causes are the predominant driver of financial losses and a critical contributor to damage to business organizations. Therefore, one may conclude that the key factor to effectively improving the working environment and, specifically, ensuring occupational safety, is to identify the key causes of any discovered irregularities. The bulk of the resources mobilized to improve working conditions should therefore be dedicated to improvements in such areas and to eliminating the key drivers of losses (Kuprenas, 2003). Used on the basis of well-tested solutions applied in similar circumstances to optimize task completion (Dell'Olmo, 2005), the Pareto principle will facilitate the identification of key areas for improvement.

The cumulative percentages arrived at by modifying the Pareto chart (Figure 1) suggest that the primary cause of accidents is [1]. This particular cause contributes to ca. 20% of all accidents and, as such, can be associated with 80% of the losses suffered by the economy. The cause falls into Category A (the top priority) of factors requiring the most urgent action. Once this particular cause has been eliminated, accident rates should drop considerably. Other causes whose complete elimination or reduction is well worthy of consideration are causes [9], [4] and [6] which have been placed in Category B (less critical). The remaining causes (Category C, highly insignificant) should be seen is less significant or downright insignificant for the improvement of working conditions.

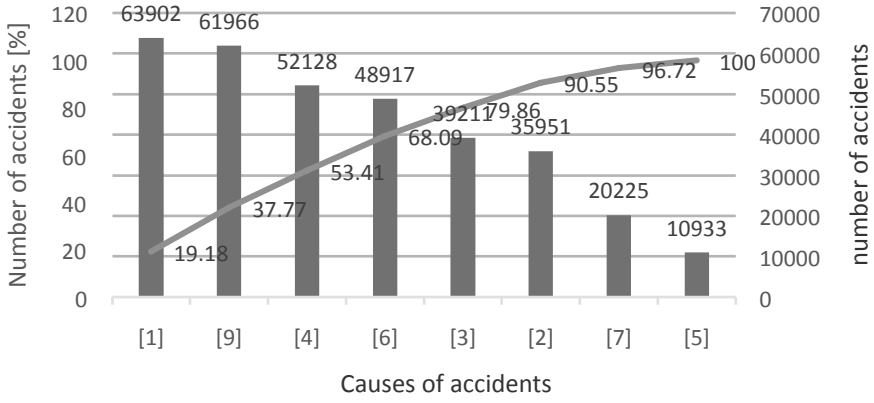

Figure 1. The Pareto chart showing the causes of accidents at work in the years 2010-2013 in Poland.

4. Conclusion

The aim of the above accident analysis was to identify the primary causes of accidents. The top priority of the study team was to determine the causes having the most impact on accident rates and, where accident drivers are complex, define links between individual accident causes. This helps one to respond to accident causes (which may be organizational, technical or human-induced), adopt measures having the greatest impact on safety improvements, ensure the company operates efficiently and improve the efficiency and effectiveness of company processes (Mazur and Gołaś, 2014; Mrugalska, 2013; Sławińska and Mrugalska, 2015). Ultimately, such measures are instrumental in reducing the company's operating expenditures.

In order to choose and apply improvement measures that are best suited to a given problem, one needs to assess their potential for producing specific improvement outcomes. This can be achieved by defining the actual options for improving working conditions. By its very nature, the systemic approach is bound to make such improvements more effective. By committing to changing worker behaviors and facilitating task completion, the management as well as all workers across the board will promote a culture of safety in their organization and significantly improve safety levels (Górny, 2014b, 2014c).

References

"Accidents at work in 2010-2013. Statistical Information and Elaborations." 2011-2014. Warsaw: Central Statistical Office.

Dell'Olmo, P., M. Gentili, and A. Scozzari. 2005. "On finding dissimilar Pareto-Optimal paths." European Journal of

Operational, 162(1): 70–82.
Butlewski, M., A. Misztal, and R. Ciulu, 2014. „Non-financial factors of job satisfaction in the development of a safety culture based on examples from Poland and Romania." Digital Human Modeling. Applications in Health, Safety, Ergonomics and Risk Management, Lecture Notes in Computer Science. 8529: 577-587.
Górny, A. 2014a. "Application of quality shaping methods in the work environment improvement. A case of theoretical frames." Management Systems in Production Engineering, 3(15): 106–111.
Górny, A. 2014b. „Influence of corporate social responsibility (CSR) on safety culture." Management, 18(1): 43–57.
Górny, A. 2014c. „Kultura bezpieczeństwa i społeczna odpowiedzialność, jako determinanty rozwoju przedsiębiorstwa." In A., Juźwicka, et al. (eds.) Nowe spojrzenie na kulturę organizacyjną, 19–30, Łódź: Wydawnictwo Politechniki Łódzkiej.
Górny, A. 2015. "Identification of accidents causes by the Pareto principle." In P., Arezes, et al. (eds.) Proceedings of the International Symposium on Occupational Safety and Hygiene (SHO'2015), 143-145, Guimaraes: Portuguese Society of Occupational Safety and Hygiene.
EN ISO 9004. 2009. Managing for the sustained of an organization – A quality management approach. Brussels: European Committee for Standardization.
Juran, J.M. 1970. "Quality Planning and Analysis." New York: McGraw-Hill.
Koch, R. 2004. "Living the 80/20 Way: Work Less, Worry Less, Succeed More, Enjoy More." London: Nicholas Brealey Publishing.
Kuprenas, J.A., and I.A. Minkarah. 2003. "A method to improve worker safety Pareto analysis of construction accidents" In B.O., Uwkweh (ed.) 10th International Symposium on Construction Innovation and Global Competitiveness, Cincinnati, Construction Innovation and Global Competitiveness, vol.: The Organization and Management of Construction: 1029-1104.
Kuprenas, J.A., M.D. Kenney, and E.B. Nasr. 1999. "A Pareto analysis of construction and maintenance operations accidents." In 2nd International Conference of CIB Working Commission W99, Honolulu, Implementation of Safety and Health on Construction Sites: 807-8013.
Mazur, A., and H. Gołaś. 2014. "Providing reliability of human resources in production management process." Management Systems in Production Engineering, 3(15): 94–99.
Mrugalska, B. 2013. "Environmental disturbances in robust machinery design." In P., Arezes, et al. (eds.) Occupational Safety and Hygiene. 9th International Symposium on Occupational Safety and Hygiene (SHO'2013), 229-233, London: Taylor and Francis Group.
Sławińska, M., and B. Mrugalska. 2015. „Information quality for health and safety management systems: A case study." In P. Arezes, ed al (eds.) Occupational Safety and Hygiene III, 29-32, London: Taylor and Francis Group.
Wilkinson, L. 2006. "Revising the Pareto Chart." The American Statistician, 60: 332–334