ANNALS of Faculty Engineering Hunedoara
International Journal of Engineering
ISSN: 1584 - 2665

ACCIDENT LOSSES ELIMINATION BY MEANS OF SAFETY PYRAMID ANALYSIS

Agata RADVANSKA

Technical University of Kosice, Faculty of Manufacturing Technologies,
Department of Manufacturing Management, Kosice, SLOVAKIA

ABSTRACT:
The aim of the paper is to provide a summary of the research works in the field of accident frequencies and seriousness, leading to final assessment of action-oriented pyramid. The emphasis is put on the root-cause analysis, to find the real source of hazards on the workplace. The measures have to be taken to prevent not only the fatal accidents, but also minor accidents or unsafe acts, which can lead to more serious injury under certain changed circumstances.
KEYWORDS:
Accident, occupational safety and health, safety pyramid, accident loss, root-cause analysis

1. INTRODUCTION

An accident is defined as any unplanned event that results in injury or ill-health to people, or equipment, property or materials damages, or an event where there was a risk of harm. This definition clearly focuses attention onto health and safety management. However, events where people are not hurt, but could have been, are considered to be a health and safety issue. A slight change in circumstances may have meant a person being harmed. [6]

Accident costs can be divided into two types:

1. Financial costs - these are additional costs incurred to achieve the desired output. For example:
   - overtime payments;
   - cost of repairs;
   - cost of extra materials; and
   - fines and penalties.
2. Opportunity costs - the costs of labor paid for no production. For example:
   - salary costs of people waiting to work at an idle machine;
   - people at home unable to work through injury; and
   - costs for machinery running idle. [6]

The only possibility how to eliminate the losses caused by minor or major accidents, is to focus on cause root of these undesired events, examine it and implement the measures that are to minimize the frequency and mitigate the accidents consequences.

2. ACCIDENTS FREQUENCY AND SERIOUSNESS

The accident triangle, known also as the accident pyramid or safety pyramid, was defined in 1931 by H.W. Heinrich and detailed in his book, Industrial Accident Prevention: A Scientific Approach. Its theory (Figure 1) had been widely accepted for over 70 years – its main idea is, the accident causation: unsafe acts lead to minor injuries and, over time, to major or even fatal injury. The accident pyramid proposes that for every 300 unsafe acts there are 29 minor injuries and one major injury. [3], [7]

Since unsafe acts are difficult to define and record accurately and Heinrich's theory seems logical, the safety pyramid remained unchallenged for decades. Based on safety pyramid, the occupational safety and health management was aimed at bringing unsafe acts under the control. As the unsafe behavior is controlled then the major injury would not occur. Despite targeting unsafe acts through behavioral systems and a variety of difficult-to-administer programs, the major injury still occurred. [7]. The original Heinrich's theory has been modified several times over the years to create a more accurate and quantifiable image of the accident incidence, as it is shown on Figure 2.

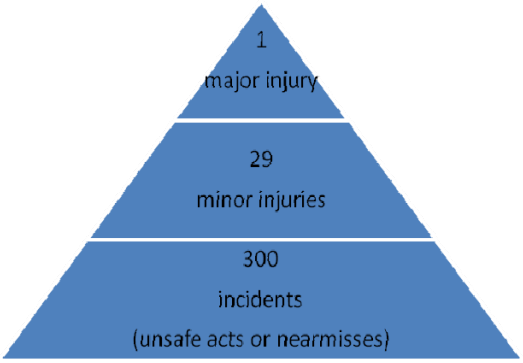

Figure1. Accident pyramid (safety pyramid) as defined by h. W. Heinrich in 1931 [3]

In 1969, a study of industrial accidents was undertaken by Frank E. Bird, Jr., who was interested in the clarification of accident ratio of 1 major injury to 29 minor injuries to 300 no-injury accidents first defined by. H. W. Heinrich (Figure 1). [3] As Heinrich estimated the ratio in the relatively small group of events of the one accident type concerning the one profession, F. Bird tried to find the accident severity ratio in broader group of workers and professions. To date, the Heinrich´s original accident pyramid is considered to be the primary draft of accident types and their frequency. [7]

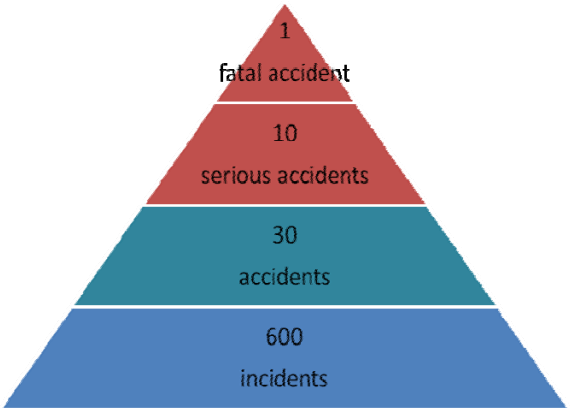

Figure 2. Accident pyramid as defined by Frank E. Bird [1]

In his study Bird analyzed 1 753 498 of accidents reported by 297 cooperating companies. These companies represented 21 different industrial groups, employing 1,750,000 employees who worked over 3 billion hours during the exposure period analyzed. [1]

The study revealed the following ratios in the reported accidents depending on their severity:

- For every reported major injury (resulting in fatality, disability, lost time or medical treatment), there were 9.8 reported minor injuries (requiring only first aid). For the 95 companies that further analyzed major injuries in their reporting, the ratio of lost time injury to medical treatment injuries was 1:15.
- Approximately 20% of the companies indicated that they investigated all property damage accidents and 80% stated that they investigated major property damage accidents. The final analysis indicated that 30.2 property damage accidents were reported for each major injury.
- Part of the study (involving 4 000 hours of interviews) was aimed at the clarifying of the occurrence of incidents that under slightly different circumstances could have resulted in injury or property damage. Analysis of these interviews indicated a ratio of approximately 600 incidents for every reported major injury. [1], [7]

Figure 2 details the accident pyramid as defined by F. E. Bird, referring to the 1:10:30:600 ratios. It should be accentuated that this represents accidents reported and incidents discussed with the interviewers and not the total number of accidents or incidents that actually occurred. [1]

In accordance with Bird's pyramid, 30 property damage accidents were reported for each serious or disabling injury. Property damage incidents cost billions of Euros annually and yet they are frequently misnamed and referred to as "near-accidents". Ironically, the fact is that each property damage situation could probably have resulted in personal injury under the slight change in conditions or circumstances.

The 1:10:30:600 relationships in the ratio indicate clearly how improper it is to direct the major effort only at the relatively few events resulting in serious or disabling injury when there are so many significant opportunities that provide a much larger basis for more effective control of total accident losses. [1]

It is worth emphasizing that the study of accidents ratio was carried on a certain large group of organizations at a given point in time. It does not necessarily follow that the ratio will be identical for any particular occupational group or organization. That is not its intent. The significant point is that major injuries are rare events and that many opportunities are afforded by the more frequent, less serious events to take actions to prevent the major losses from occurring. These actions are most effective when directed at incidents and minor accidents with a high loss potential. There is always a large variation between the most serious and no claim incident, as shown in both pyramids. [1], [2]

In 2003, in the ConocoPhillips Company a similar study was conducted demonstrating a large difference in the ratio of serious accidents and near misses. The study found that for every single fatality there are at least 300,000 at-risk behaviors, defined as activities that are not consistent with safety programs, training and components on machinery. These behaviors may include bypassing

safety components on machinery or eliminating a safety step in the production process that slows down the operator. With effective machine safeguarding and training, at-risk behaviors and near misses can be diminished. This also reduces the chance of the fatality occurring, since there is a lower frequency of at-risk behaviors. The variation can be explained by distance or time – for example, the injury was missed by one second or by one centimeter. [1], [7]

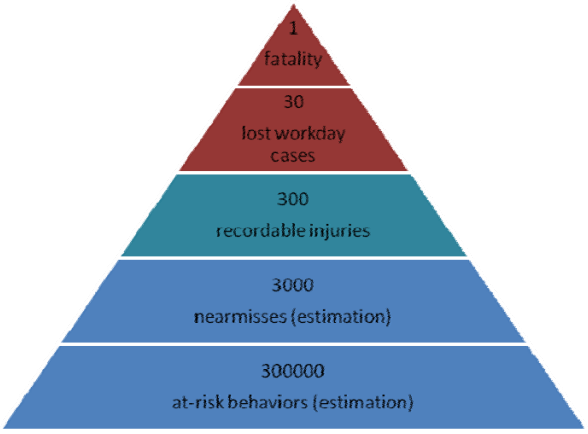

Figure 3. Accident pyramid defined in 2003 based on the study in Conoco-Philips

Over time, a greater accumulation of accident data suggested that the pyramid is not an equilateral triangle at all; depending on a company's safety culture, it may take any one of a variety of shapes, as identified in Figure 3. For example, companies that attribute blame to employees for incidents tend to have fewer minor and more major injuries.

In some cases, the diagrams are not shaped into pyramid, but began to look more like inverted pyramids or even squares. Based on this fact, numerous articles designated as the Heinrich's theory was just a real theory, as the hypothesis of the accident triangle was apparently never tested. Although the logic of his theory seems indisputable, Heinrich did not cite studies or provide supporting data. [6], [7]

In 2003, safety consultant Fred Manuele indicated, that the safety management should be focused on preventing fatal accidents as well as the unsafe act. As written by F. Manuele, „Many accidents that result in severe injury are unique and singularly occurring events in which a series of breakdowns occur in a cascading effect." [4]

The problem of ignoring the causes of fatal accidents is compounded when management becomes obsessed with such accident record, where workers lost-time occurred. Often, the unexpected incidents are omitted and the attention is focused on fatal injury prevention. This means, that efforts are focusing on Heinrich's incident pyramid from the top down rather than the bottom up.

Professor Dan Petersen wrote in his book on Safety Management: "If we study any mass data, we can readily see that the types of accidents resulting in temporary total disabilities are different from the types of accidents resulting in permanent partial disabilities or in permanent total disabilities or fatalities. The causes are different." [5]

Whenever an employee is observed not using a safety procedure, the oversight should be addressed immediately. At examination, it is necessary take into account the fact, if an employee is not forced by stringent production demands perceived as required by management. Action-oriented pyramid could be developed emphasizing the measure priority as indicated in Figure 4. [2], [6]

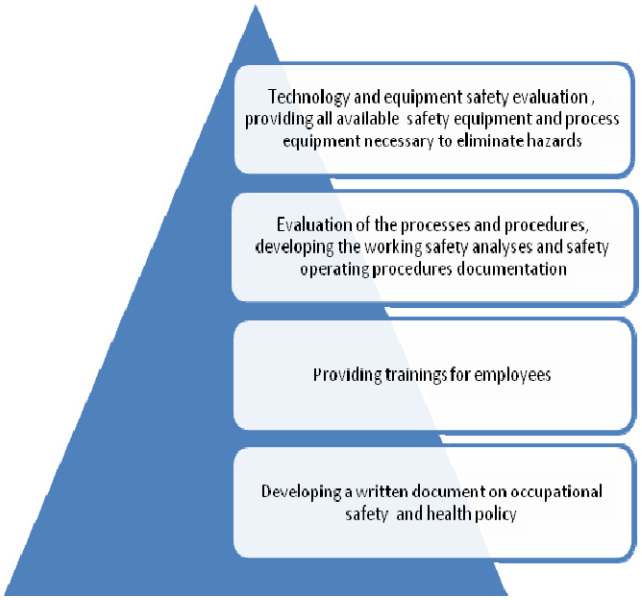

Figure 4. Identification of importance level in preventing fatal injuries

Another of Heinrich's theories is the theory of multiple causation i.e., all accidents occur as a result of many factors or multiple causes. Based on this theory is the Root Cause Analysis (RCA) used in incident investigations whereby the obvious physical circumstance of the incident is investigated to determine its cause, and what led to that, and so forth, until no further upstream or lateral factors can be identified. [2], [3]

To avoid litigation of following the cause upstream, many companies simply identify the cause of most incidents as employee error or failure to follow safety rules. This simple and somewhat dishonest defense is brutal to employees and their families and may generate long-term attitude problems among other employees. A practice that sorely damages a safety effort is blaming all injuries on the employee. [2]

3. CONCLUSION

It is obvious, that employer's duty to "identify the dangers and hazards, assess the risks and develop a written document on risk assessment at all the operations performed by employees" implicit from Slovak legislation [8] is necessary to comply in detail and individually for each organization, adjusted the parameters to particular technologies, tools, personal and qualification prerequisites. Based on such risk analysis, it is necessary to address measures to risks elimination and supervise the compliance with safety rules. Every intervention aimed at occupational safety and health enhancement is financially intensive, but never of higher value as the employees' lives and health, respectively damages or loss due to accidents on workplace.

REFERENCES / BIBLIOGRAPHY

[1.] BIRD, F. E., JR., GERMAIN, G. L.: Practical Loss Control Leadership, The Conservation of People, Property, Process and Profits, 1996, Det Norske Veritas (U.S.A.), 452 p., ISBN 0880610549

[2.] ECKHARDT, B: REEVALUATING THE INCIDENT PYRAMID [online] Concrete products, [2003-05-01], Accessed at: http://concreteproducts.com/mag/concrete_reevaluating_incident_pyramid/

[3.] HEINRICH, H.W., GRANNISS, E.R.: Industrial accident prevention: A scientific approach, 1959, 4th edition, McGraw-Hill, 480 p.

[4.] MANUELE, F. A.: Severe Injury Potential, Journal of Professional Safety, February 2003

[5.] PETERSEN, D.: Safety Management: A Human Approach, American Society of Safety Engineers, 2nd edition, 380 p., ISBN 188558119X

[6.] Revitalising Health and Safety [online] HSE, Accessed at: http://www.hse.gov.uk/costs/costs_of_injury/costs_of_injury.asp

[7.] The Accident Pyramid [online] Safety Culture Plus, [2008-22-07], Accessed at: http://emeetingplace.com/safetyblog/?p=275

[8.] Slovak Act No. 124/2006 on occupational safety and health

ANNALS OF FACULTY ENGINEERING HUNEDOARA
– INTERNATIONAL JOURNAL OF ENGINEERING

Ã· Elimination/substitution safety measures. Workplace hazards in the form of exposure sources or other harmful factors may be eliminated or mitigated by substitution (e.g., a less harmful chemical may replace a toxic chemical in a process).Â Organizational safety measures, also known as administrative controls, include separating persons from harmful factors either by means of special working methods or by separation in time or space. Examples of these controls include, but are not limited to, reduced exposure time, preventive maintenance programmes, encapsulating the individual workers with personal protective equipment, and expedient organization of work. Controlling Human Conduct. It is often not possible to isolate all hazards using the above control measures. The â€œaccident pyramidâ€, as depicted by H. Heinrich in the second edition of his book Industrial Accident Prevention: A Scientific Approach, page 27. Note the last sentence: â€œMoral â€” prevent the accidents and the injuries will take care of themselvesâ€. F. Birdâ€™s later work revealed the following ratios in the accidents reported to the insurance companyÂ There has been much confusion about the original ratio in industrial accident prevention. It does not mean, as we have too often interpreted it to mean, that the causes of frequency are the same as the causes of severe injury. National figures show that different things cause severe injuries than the things that cause minor injuries. @inproceedings{Radvansk2010AccidentLE, title={Accident Losses Elimination by Means of Safety Pyramid Analysis}, author={A. Radvansk{\'a}}, year={2010} }. A. RadvanskÃ¡. Published 2010. Computer Science. The aim of the paper is to provide a summary of the research works in the field of accident frequencies and seriousness, leading to final assessment of action-oriented pyramid. The emphasis is put on the root-cause analysis, to find the real source of hazards on the workplace. The measures have to be taken to prevent not only the fatal accidents, but also minor accidents or unsafe acts, which can lead to more serious injury under certain changed circumstances. annals.fih.upt.ro.