Continuous Improvement in a Safety Management System: the Case of a Bottling Company

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Abstract: An appropriate approach to manage Occupational Health and Safety (OHS) is to develop management systems, which can integrate safety into the ordinary and overall management of the company. The Safety Management Systems (SMS) represents now the main instrument adopted in medium to large-sized companies, in order to minimize the occurrence of accidents and occupational diseases. The auditing phase allows the feedback necessary to reinforce, maintain and develop the ability to reduce risks and to ensure efficiency and effectiveness of the SMS. In addition, the correct operation of the SMS requires an information flow across the development, implementation and maintenance stages and the auditing/reviewing stage, in order to manage and control safety performances and to highlight any deviation from the safety improvement program. The aim of the research is to assess the capability of the OHS management system adopted in a medium enterprise operating in the industrial sector of soft drinks bottling. The current SMS complies with OHSAS 18001 standard requirements, but its structure is so singular that external auditors repeatedly challenged its effectiveness. The critical aspect is the assignment of priorities to safety interventions that is currently based on corrective factors applied to the medium risk level of each risk category. A multi-criteria decision process based on Analytic Hierarchy Process (AHP) was proposed to the company by using both the traditional AHP method and a hybrid model based on Value-AHP, which is easier to understand and to apply in the company safety management routine. A three levels hierarchy was identified by considering the priority of interventions as the general objective of the assessment, four criteria for the accounting policies and eight macro-alternatives of risk categories. The result is an integrated management system able to track all risk categories, efficiently addressing the safety improvement program.

Keywords: Value AHP, Occupational health and safety, OHSAS 18001, Safety interventions priority

1. Introduction

The most recent statistical reports from ILO registered over three hundred million occupational accidents per year all over the world, with over six thousand of dead people every day (International Labor Organization, 2016). The implementation of an Occupational Health & Safety (OHS) Management System is currently considered the better way to state a company safety policy and to define objectives in order to keep under control safety aspects.

Italian law does not require the implementation of an OHS Management System but it is highly recommended as it represents an opportunity to reduce the probability of occurrence of accidents and occupational diseases. The decision to implement a safety and health management system does not relieve in any way the Employer from the responsibilities assigned to him by law, but it can be very useful to prove the efforts done to ensure workers' safety and health. There are a lot of elements in an OHS Management System which contribute to improve safety and health conditions. The "OHS policy", the identification and assignment of roles, tasks and responsibilities, the boost for continuous improvement through the definition of ever new objectives and of appropriate activities scheduling, the control on achievement of stated objectives, the emphasis on training and communication are the key elements of an OHS Management System (OHSMS).

For Small and Medium Enterprises, which want to implement an OHSMS, the legislation also includes a set of simplified procedures for the adoption and the effective implementation of safety organizational models and management system, compliant with art. 30 of Legislative Decree 81/2008 and subsequent amendments.

OHS Management Standards that indicate essential elements to properly implement a safety system are available since long time: the most widely internationally accepted BS OHSAS 18001 standard and the Guidelines for Health and Safety at Work Management System (better known as Guidelines UNI-INAIL - see ref. INAIL, 2001) are the common references for the OHSMS.

As it is known, the successful implementation of a management system passes through the commitment of all levels and all business functions, from the Employer and the Top Management right up to individual employees and/or their representatives.

Figure 1 schematically shows the sequence of activities useful to realize an OHSMS, according to the typical elements of a Deming cycle (PDCA).

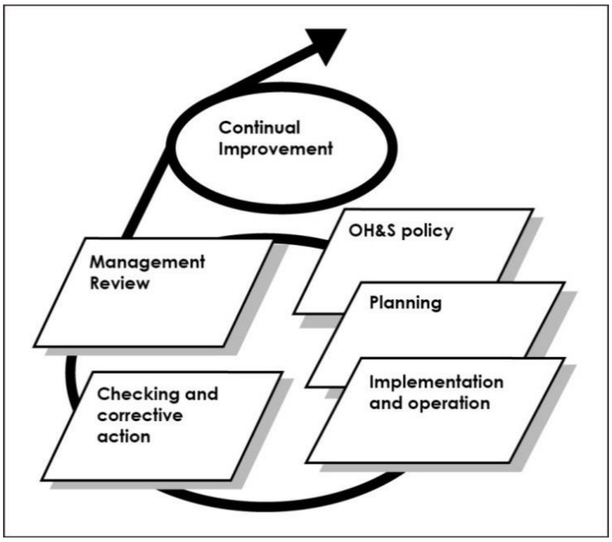

Figure 1: OHSAS 18001 implementation process (British Standards Institution, 2007)

The *Plan* phase involves the initial examination, the drafting, adoption and diffusion of the OHS policy, planning and definition of the organizational structure of the OHSMS. The *Do* phase involves the construction and implementation of the planned actions and staff awareness through the involvement and participation of all members of the organization. The *Check* phase provides operational control by measuring, monitoring and internal audits. The *Act* stage involves the definition of corrective and preventive actions, the review by the Management and system changes to obtain continuous improvement.

An OHSMS has to be centred on risk assessment and on its continuous and progressive reduction. To do this, the OHSMS has to be focused on company processes, operational procedures and their relations between them, planning and implementing specific operational controls and a system for monitoring and measurements useful to take under control the adequacy and relevance for the reality of the specific organization. The scope is to obtain effectiveness and efficiency in the prevention performance by using available resources. It is appropriate to attach a process of non-conformances treatment to be resolved through appropriate corrective actions especially for near misses, accidents and injuries.

All information from monitoring, control and internal audits on accidents and injuries eventually occurred, repeated non-conformances and new legal requirements leads to a Management review. The Safety Management System requires a continuous revision of safety interventions priorities which is a typical multi-criteria decision process. The Analytic Hierarchy Process (Saaty, 1980), also known as AHP, is a well-established technique for multi-criteria decision processes that can also support safety analysis and decisions.

The paper provides a general literature review about OHSMSs performance and a specific review of OHS related AHP applications. OHSMSs models often are able to develop highly detailed safety analysis for risk identification, but could have limitations in the objective assignment of values in the risk assessment phase and in correctly prioritize the interventions to define a safety enhancement program. The paper wants also to highlight the criticalities that arise in the application of a theoretical model to a company, often wiping out its effectiveness

A case study is described in order to show the importance, for a medium size company, of having an objective method to define priority of safety intervention in order to comply with legal and voluntary safety requirements and to establish a continuous improvement process. After a synthetic description of the company's current method, an AHP based approach was used in order to obtain a priority list for safety interventions. Moreover a hybrid model was defined to cope with a request for simplification and rapid application, compared with the traditional pairwise comparison typical of traditional AHP. Results are discussed to compare advantages of the three proposed methods and their general validity and scalability to small-medium enterprises.

2. Literature review

OHSMSs are voluntary OHS programs. which incorporates safety assessment and continuous improvement using a proactive approach (Robson et al., 2007). The OHS researchers don't agree on the effectiveness of OHSMSs: some of them (Granerud & Rocha, 2011) found that the OHSAS 18001 adoption has little effects on continuous improvement (Podgorski, 2015), even if the companies with a certified OHSMS have more "auditable" OHS performances and better fulfil legal compliance, satisfying external stakeholder requirements (Hohnen & Hasle, 2011); other researchers found that safety performances are better in companies which adopt SMSs if compared to companies that do not adopt them (Bottani et al., 2009; Fernández-Muñiz et al., 2009; Gopang, 2017) and continuous improvement is favoured when a company implements an OHSMS (Fernández-Muñiz et al., 2012).

According to an EU-OSHA (European Agency for Safety and Health at Work) study (EU-OSHA, 2010), the adoption of a OHSMS can lead to both direct and indirect benefits on health and safety, as shown in Table 1.

Table 1: OHSMSs, benefits for SMEs (EU-OSHA, 2010)

Direct benefits	Indirect benefits
Lower insurance premiums	Reduced absenteeism
Reduction of litigation costs	Reduction of staff costs

Direct benefits	Indirect benefits
Reducing costs for health related absence	Better corporate public image
Improvement of production/productivity rates	Improvement of opportunities to win contracts
Business continuity (a lower number of accidents reduces the duration and consequences of outages)	Improved satisfaction and professional motivation
Reduced damage to products and materials	-
Reduction of costs related to accidents/production delays	-

The current Italian scenario about the driving factors for implementation of OHSAS 18001 and the company safety improvement was the aim of a survey which involved 600 companies with a certified OHSMS (Bevilacqua et al., 2016). A systematic review of literature on OHS practices was carried out by Jilcha & Kitaw (2016).

Even if some authors (Mohammadfam et al., 2016) are sceptical about usefulness of AHP technique to catch the interdependences among the components of OHSMSs and they suggest ANP (Analytic Network Process) as the tool with the right capability for this aim, there are a lot of recent studies in which AHP is applied to safety related matters. Application of AHP allowed the authors to select leading KPI for measuring effectiveness of internal system processes also referred as OHSMS operational performance indicators (Podgorski, 2015); to set priorities in selecting safety equipment for operating machines (Caputo et al., 2013); to define AHP-based methods for safety risk assessment (Gao et al., 2014; Di Bona et al., 2016), and for prioritization of risk factors in small medium enterprises (Fera and Macchiaroli, 2010).

3. Case study

The Company operates in the soft drinks bottling industry. The plant covers a total area of about 6 hectares, of which a half is indoor. The production process is divided into three sub-fundamental processes:

1. preparation of the syrup, which takes place in the appropriate "syrups room";

2. blow moulding of PET bottles, which takes place in a specific department;

3. beverage bottling, which takes place in six lines dedicated to different formats (PET bottles of various capacities, glass bottles, drums and cans), and the subsequent packaging.

The activities described are carried out by 20 different categories of workers, which, according to the duties performed, have been grouped into eight main areas of activity.

As stated in the definition of the Safety Policy Document, the company *is committed in executing its activities implementing any action aimed at ensuring the prevention and protection of workers and public at the workplace. The Management is committed to continuously improve the effectiveness of the implemented Occupational Health Safety Management System, and to respect all the rules and regulations or laws applicable to its production. The Management is committed in identifying the requirements of OHSAS 18001 of rules and laws in order to implement any action to ensure the achievement of the expected requirements. The company shall ensure that the other companies operating on its behalf are acting in compliance with these requirements*.

The Company wants to protect health and safety of workers through the hazard analysis and the risk assessment, the identification of appropriate control measures, and the implementation of a safety program to meet the safety objectives and ensure a continuous reduction of risks related to all company activities, including those outsourced.

The Occupational Health and Safety Management System takes into account the requirements set by the OHSAS 18001:2007 on planning and the best practices for the preparation of complete, comprehensive and comparable risk assessment documents (DVR in Italian language), in order to obtain a global and immediate vision of the workplace risks and to allow the company in defining the necessary control measures.

The risk model adopted by the Company is based on the usual formula to assess the risk level R as the product of frequency (occurrence) and magnitude (severity) of the potential damage:

$$R = F * M$$

In addition, a risk factor reduction coefficient, k (< 1) is considered as the resultant of various initiatives to provide information, training, education, training on equipment, consultation and participation of workers. It sets the residual risk at the value:

$$R' = R * k.$$

The factor reduction coefficients k used by the Company are reported in Table 2 for typical typologies of safety interventions.

Table 2: Safety measures and risk reduction efficacy

k	Safety intervention	k value
k0	Manufacturing process modifications to eliminate the risk	0.05
k1	Modification or replacement of machines, facilities, equipment outdated or dangerous or unsuitable, with other ones updated to the latest technical knowledge	0.35

k	Safety intervention	k value
k2’	Modification and modification of the workplace, to ensure the safety and healthiness in all operating conditions, reducing the occurrence of accident or illness	0.40
k2”	Change and modification of the workplace, to ensure the safety and healthiness in all operating conditions, reducing the magnitude of accident or illness	0.55
k3	Maintenance of equipment, systems or workplace	0.60
k4	Increased level of information and/or training of workers on specific risks	0.70
k5	Construction of facilities or structures for collective protection	0.60
k6	Personal Protective Equipment (PPE) technical upgrade	0.85

The priority of safety intervention is defined using the residual risk R’ calculated for each of 23 risk categories identified in the Company operations and it is the basis for defining the expiration date for the action implementation.

For the purposes of identifying the priorities of safety intervention for the same level of risk, the Company consider a further index defined "Risk Priority" (Rp). It is obtained by multiplying the "Medium risk" index (Rm), calculated for each risk category, for the percentage number of workers exposed to that risk and for an "Importance index" (Iimp), which numerically estimates the importance of the specific risk among all company hazard taking into account the history of accidents occurred and of the possibility of occupational disease. The analysis of the Risk Priority (Rp) is used by the Company as a means to plan the action for safety improvements.

As the reader can guess, there is a certain arbitrariness in the allocation of the k value as well as of the Iimp, and subsequently in the assessment of the risk priority index Rp, which is based on them as described above. Moreover sometimes the Company doesn’t meet the requirements of the safety system because the priority assignment is somewhat arbitrary. This is why a different approach was proposed.

4. AHP-based risk priority definition

In order to obtain a consistent result about the Safety Action Priority (equivalent to Risk Priority), without changing the safety process measurement, an AHP based method was proposed to the Company.

The first analysis was carried out by a traditional AHP based on experts’ judgment with a three-level hierarchy, as shown in Figure 2 and described below:

- Level 1 – General aim = Priority of Safety Actions
- Level 2 – Four Assessment criteria where defined, i.e.:
    - Rmax, actual risk value which derives from the risk assessment process;
    - N, Number of Exposed to risk;
    - Time available for safety action implementation, also called Urgency (U);
    - Implementation request: this is referred to the motivation for a safety action that could be a legal compliance, a request from internal safety review (e.g. due to an accident), a request from safety auditor, a request from workers in order to obtain better quality in workplace conditions.
- Level 3 – Alternatives of evaluation

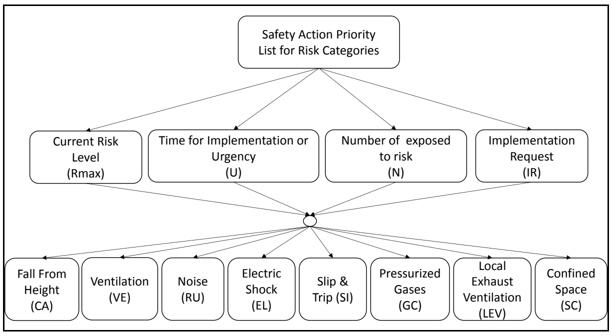

Figure 2: AHP hierarchy

Rather than the mean value Rm, for the Actual Risk Value criterion, the maximum risk value (Rmax) was chosen, associated with each risk category. This approach has the advantage of comparing the most critical situations for each type of risk by making it clear which category requires more attention but not completely neglecting the other ones. Moreover, by solving the most critical matter for each risk category, the medium risk level such as the overall risk level in the company will be reduced.

Figure 3 shows the local weight of criteria, obtained realizing the pairwise comparison matrix by the support of experts.

The pairwise comparison of alternatives, according to each criterion, was done by using the software application Super Decisions© as shown in Figure 4.

Two main issues araised from this procedure: it is considered too long and too complex by the company’s experts and it doesn’t take into account the advantage of having three quantitative criteria that could be directly compared on a numerical basis.

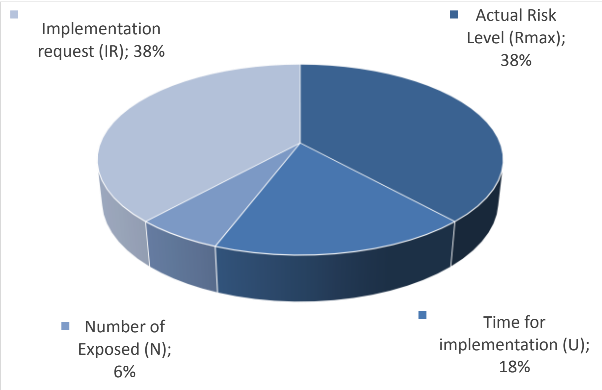

Figure 3: Local weight of criteria

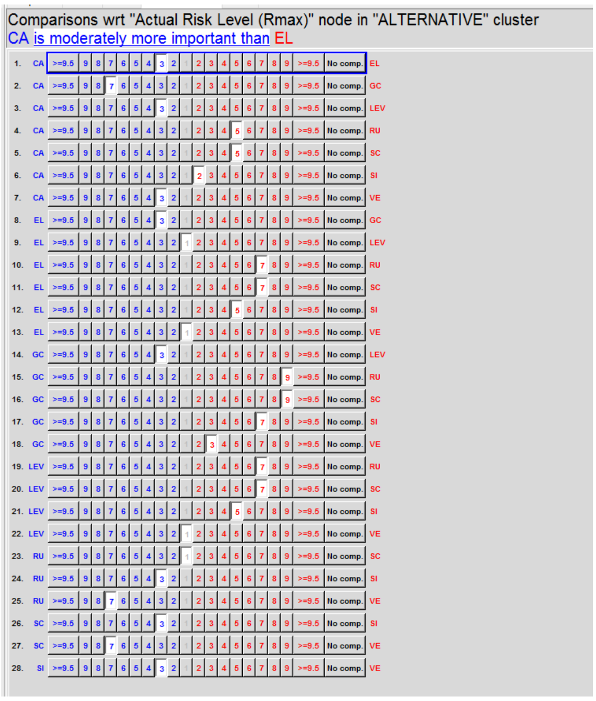

Figure 4: Pairwise comparison in AHP method

For this reason, a hybrid model was proposed to the Company. This is based on a Value-AHP (Compagno et al., 2013) approach for quantitative criteria and a traditional AHP, based on pairwise comparison, limited to compare the qualitative criteria (also supported by a general criterion as described below).

Then, the Value AHP uses:

- N, Number of Exposed to risk; the local weights for this criterion are reported in Table 3;
- Rmax, current risk value which derives from the risk assessment process, local weight for this criteria are reported in Table 4;
- U, the time available for the safety action implementation; it is taken into account through the Urgency Factor (U) that was defined with the aim of generate an higher priority for planned safety actions with an approaching due date but not still implemented. This factor was definied as:

$$U = 1 + (CD\text{-}DA)/(ED\text{-}DA)$$

Where

DA = Date of Analysis; it is the date of Safety Action Definition;

CD = Current Date; it is the Current Date;

ED = Expiring Date; it is the due date for the implementation of Safety Action;

Table 3: Number of Exposed (N) Local Weights

ID Risk Categories	Number of Exposed (N)	Local Weights for N
CA	44.00	24%
VE	26.00	14%
RU	7.00	4%
EL	18.00	10%
SI	60.00	33%
GC	7.00	4%
LE	6.00	3%
SC	16.00	9%

Table 4: Current Risk Level (Rmax) Local Weights

Risk Categories	**ID Risk Categories**	**Current Risk Level (Rmax)**	**Local Weight for Rmax**
Fall from Height	CA	8.00	13%
Ventilation	VE	6.00	10%
Noise	RU	12.00	19%
Electric Shock	EL	6.00	10%
Slip & trip	SI	9.00	14%
Pressurized Gases	GC	4.00	6%
Local Exhaust Ventilation	LE	6.00	10%
Confined Space	SC	12.00	19%

So, (ED-DA) represents the total time available to implement the required safety action; (DA-CD) represents the time consumed without implementing the safety action.

If the current date is the date of safety action definition, i.e. the safety date was just defined and scheduled, DA is equal to CD and U is set to 1. If the CD is equal to ED, U is equal to 2; if the expiring date (ED) is surpassed without implementation, the factor IF is higher and higher so higlighting the urgency of implementation. Local weights for this criterion are reported in Table 5.

Table 5: Urgency Factor (U) Local Weights

ID Risk Categories	Urgency Factor (U)	Local Weight for U
CA	0.89	2%
VE	2.57	6%
RU	20.54	45%
EL	5.99	13%
SI	1.20	3%
GC	7.42	16%
LE	2.00	4%
SC	5.06	11%

The pairwise comparison is limited only to qualitative criteria but using a general criterion to support the comparison as reported in Table 6. The general criteria were defined also taking into account the analysis on decisional, success, failure and enterprise improvement factors reported in literature as drivers to company safety improvement (Bevilacqua et al., 2016).

Table 6: General Pairwise comparison for the Implementation request criterion

i/j	LC	ISR	ESA	SMS	WR
Legal Compliance (LC)	1	3	3	5	7
Internal Safety Review (ISR)	1/3	1	1	3	5
External Safety Audit (ESA)	1/3	1	1	3	5
SMS audit (SMS)	1/5	1/3	1/3	1	3
Workers' Request (WR)	1/7	1/5	1/5	1/3	1

As shown in Table 6, the Company is primarily interested in satisfying Legal Compliance, than Internal and Safety Rewiev/Audit, SMS Audit and finally Request for working condition improvement (not included in the previous categories) received by workers.

The Consistency Ratio (CR) of the Hybrid AHP applied to case the study is equal to 0,0572 (less than the threshold level of 10% necessary to consider the assessment to be consistent).

The general results of the study using the hybrid AHP method are shown in Figure 5 in comparison to the other two methods (the Company's method and the Traditional AHP).

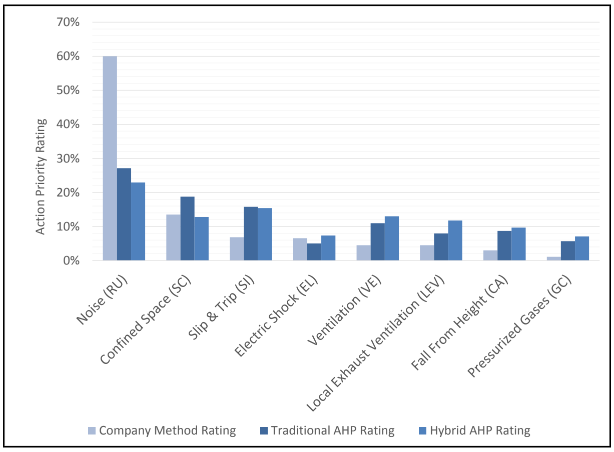

Figure 5: Global weight of alternatives and ranking

5. Discussion and conclusions

The hybrid AHP method proposed in the paper shows results sufficiently coherent with both traditional AHP and the Company's method. This is more evident analysing the ranking shown in Table 7.

Table 7: Ranking comparison

Hybrid AHP	Traditional AHP	Company's Method
Noise	Noise	Noise
Slip & trip	Confined space	Confined space
Ventilation	Slip & trip	Slip & trip
Confined space	Ventilation	Electric shock
Local exhaust ventilation	Fall from height	Ventilation
Fall from height	Local exhaust ventilation	Local exhaust ventilation
Electric shock	Pressurized gases	Fall from height
Pressurized gases	Electric shock	Pressurized gases

The Company's method overestimates the global weight of risk categories with higher medium risk level (Rm) and underestimates the other ones. That is why the Confined space and Electric shock are higher in the ranking when they are analysed through the Company method. Ranking obtained through Traditional AHP are more coherent with the one resulted by the Company method adoption. By the way, Electric shock resulted in a lower position because actions related to this categories derive from a request of workers in order to better manage information on general electric panel but it is more related to operations management than to safety management.

By the way, the Company is satisfied of the results obtained through the Hybrid method because this is extremely more efficient and fast in prioritizing safety actions, allowing to repeat analysis each time that a safety action is implemented, so maintaining a continuous control on required safety actions. Moreover, the Company appreciated the priority list of safety actions obtained through the Hybrid AHP method, because it shows in higher position safety interventions on Slip & Trip and Ventilation that were delayed for some time considering them less important than others.

The proposed method has a general validity and it is potentially applicable in every company, also belonging to different industry sectors. In fact, it is based on information that each company must determine to adequately develop the risk assessment for workers in presence or in absence of an occupational health and safety management system.

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