



## IPE SHE: an Index for Quantifying the Performance for Safety and Health in a Workplace

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Considering as basis the structure of a new model for evaluating performances in health and safety on workplace, the measures are introduced to allow the quantification of the goodness of the system, in order to verify how much the implemented system matches with the workers safeguard as requested by the in force law. Quantification consists in the inclusion of two different types of tools: check-lists and indicators. These tools are based on the tree structure of the model that is constituted by 6 key-elements, each of them formed by several themes (up to an amount of 27 themes).

The quantification of check-lists and indicators allows to assess the importance of themes and key-elements and to lay the foundation of a complete score, that means the index of global performance of the examined company is obtained. In conclusion, once the quantification is obtained, or in other words, once the performance of company management system is estimated, it will be possible to identify, if it is the case, the priority of interventions for improvements, so that the management process becomes more effective and efficient.

### 1. How quantify health and safety features in workplace

In (Saracino et al., 2011) the new system M.I.M.O.SA. (Methodology for the Implementation and Monitoring of Occupational SAFety) has been introduced, a methodology that allows evaluating the performance of a company concerning health and safety in the workplace through specific key elements and themes. The methodology is constituted by a model whose analysis is available for enterprise of any size. The quantification, which will be discussed in the next paragraphs, is carried out by some tools, check-lists and indicators, able to characterize the themes and the key elements of the methodology. It is important to note that this introduction guarantees to satisfy two aims: the objectivity of the analysis and the evaluation of company's performance in safety. In this way it gives a help in directing improvement interventions. Each measure of check-list and indicator is connected to a specific theme, as a consequence the tree structure of the M.I.M.O.SA. methodology is completely defined. Figure 1 represents this tree structure: at the top are the key elements, from each of them many themes result and finally from each theme many checklists and/or indicators derive.

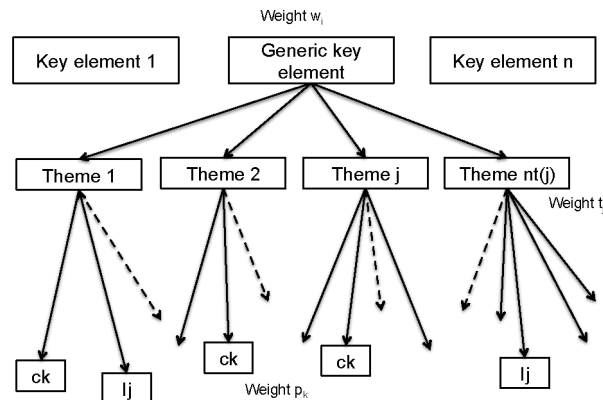


Figure 1: tree structure of M.I.M.O.S.A. methodology

### 1.1 System tools: check-lists and key performance indicators

A check-list is a set of questions; a positive answer to a specific question means acting in compliance with law or highlight presence and solution of criticalities. In a check-list problems are picked out and it is verified whether the solution was planned and implemented or not. In fact the three sets to which check-lists and indicators belong are: -planning safety targets, - implementing safety targets and - checking the obtained results. The third category, that tests the results obtained, consists mainly of key performance indicators. This subdivision highlights that, in order to obtain exhaustive and repeatable results, it is necessary, but not sufficient, to plan actions and to realize them according to schedule provided.

Key performance indicators are frequently used in different fields (environment, safety, economy, energy), because of their reliability, quality and improvement characteristics. The performance of a key indicator can be defined as follow: "an indicator must be representative of the phenomena considered, although featuring only a part of them, and it must be easily measurable". This definition comes from the description of environmental indicators, which are able to characterize a complex phenomenon, not be perceptible in other way, in a condensed and easy value. The indicators of health and safety defined in the M.I.M.O.S.A. methodology must be representative of the complex reality of a company, they must show both the behaviour in time of company performance and the commitments assumed in the field of safety in the workplace. The considered features of the innovative indicators introduced are properties like brevity, statistical significance for small companies, convenience, and calculation facility.

### 1.2 Check-list example: "Safety participation by the workers"

Several researches and meta-analysis in literature have evidenced the importance of the workers participation in workplace safety as fundamental factor in facilitating general safety performance in organizations (Neal and Griffin, 2006). In the most part of cases, safety participation has been considered as discretionary extra-role behaviour, like "helping co-workers, promoting the safety program within the workplace, demonstrating initiative, and putting effort into improving safety in the workplace" (Neal and Griffin, 2000).

In summary, the participatory factor is considered as a managerial index of the highest levels of safety culture by companies and plants (Didla, 2009).

In the framework of our operative aspects of M.I.M.O.S.A. methodology, safety participation by workers is measured both by check-lists and quantitative indicators. For example, two items of the planning check-list are: "Are considered systematic programs or practices to collect spontaneous signalling by workers on dangers and potential risks?" and "Is planned the workers involvement in the analyses of near-misses?". Examples of items of realization check-lists are "Over the year, the workers report hazard and risks to the team safety head (or to the safety manager)?" and "Over the year, worker report spontaneously suggestions for the improvement of safety issues in the workplace to their team safety head (or to the safety manager)?".

In both cases, the aim is to consider if the safety management systems (or the organizational model) actually include the active involvement of the workforce in the management of safety issues as a key strategy to face with unpredictable sources of risks on the day-by-day activities and to envision for potential improvement of safety, beside and beyond the formalized procedures of monitoring and control and the efficacy of the whole safety management system.

Some questions of a check list of planning in the theme "Safety climate" are transferred as follow, to clarify the information about check-lists:

- The company has adopted some appropriated instruments (i.e. survey, interviews, focus groups...) to investigate in which the extent their employees perceive the values and the priority given to safety issues in the different firm's activities? (i.e. perceived priority in the definition of goals, timetable and speed of production; perceived priority of safety in the general improvement of the company...)
- The discussion of safety themes and issues (if it is pertaining) is planned as a key-item on the agenda of the management meetings?
- Are planned organizational interventions and initiatives for the promotion and the active caring of safety in the organization? (i.e. guidance actions for new recruits to facilitate their socialization with the safety regulations and procedures; mentoring and/or coaching initiatives by team safety heads and senior workers...).

Concerning check-lists of implementation, for the same theme, the following questions have been found:

- The senior management of the firm is directly and publicly involved in the safety programs, with explicit information of their commitment to the workforce? (i.e. constant attendance at periodical meetings; direct and personal commitment in the risk-assessment procedures; drafting of safety procedures...)
- The safety head in the firm (or the safety manager) is constantly involved in the planning and schedule meetings of the firm direction?
- The considerations and the suggestions of the firm safety head are constantly discussed as key items during the management meetings?

### **1.3 Key performance indicator format and example**

The format drawn up for each indicator is formed by the following seven fields: 1-definition of indicator; 2-target of indicator; 3-belonging to theme and key element; 4-quantification methodology; 5-reference indicator values; 6-laws, rules and other references; 7-type of company.

These fields must be filled in for each proposed indicator.

Points 1, 2, 3, 4 and 6 are easy to understand and they do not require other specific explanations. Points 5 and 7 define respectively which values are considered valid for a positive self-evaluation and for which types of companies (small, medium or big) the concerned indicator can be used. The person in charge of compiling the form has only to calculate the indicator n. 4, that characterizes the company examined.

Figure 2 is an example: it represents an indicator of the theme "emergencies" belonging to the second key element "Orientation to risk reduction and people protection, in compliance with the law". The concerning indicator is defined as a number of identified and implemented "opportunities for improvement" during emergency simulations, on the total number of registered opportunities. "Opportunities for improvement" can include for example: suggestions or proposed changes in the Emergency Plan. This indicator aims the systematic elimination of monitored and recorded criticalities derived from the emergency simulations.

In addition the indicator aims to provide a reference value for the interventions of improvement; it is given as a fraction of the total of opportunities for improvement derived from simulations carried out in the year.

Other examples of key performance indicators of M.I.M.O.S.A. system are:

- Fraction of near misses recordings with corrective actions completed;
- Assessments characterized by "significant risk" for health and by "high risk" for safety, divided by the total number of assessments into risk assessment report;

- Number of recorded controls of DPI (Individual Protection Devices) belonging to the third category, compared to the total number of controls.

INDICATOR	Number of opportunities for improvement identified and implemented		
Definition of indicator	Number of identified and implemented "opportunities for improvement" during emergency simulations divided by the total number of registered opportunities.		
Target of indicator	Systematic elimination of monitored and recorded criticalities derived from the emergency simulations.		
Belonging to theme and key element	Theme: Emergencies Key element: Orientation to risk reduction and people protection in compliance with the law.		
Quantification methodology	A = total number of implemented opportunities of improvement B = total number of recorded opportunities of improvement		
Reference indicator values	Safety threshold	0.6	$I_{Safety} = \frac{A}{B}$
Low, rules and other references	Art. 18 and Section VI EMERGENCIES MANAGEMENT Chapter I, Legislative Decree 81/08		
Type of company	Big and medium companies		

Figure 2: Indicator form

## 2. IPESHE: Index of Performance for Safety and Health

The value of the company performance is the result of examining a complex set of features. This means giving a score (a weight) to key elements, themes, check-lists and indicators, and then defining rules of validity of obtained results. In particular the final score is obtained by summing the scores of each check-list and each indicator, with different weights, in order to calculate the global index IPESHE or Index of Performance for Safety and Health.

The global assessment is given as follows:

$$IPESHE = \left[ \sum_{N_{ec}} \omega_i \sum_{n_i(i)} t_j \sum_{n_{in-ck}(j)} p_k I_k \right] \times 100 \quad (1)$$

where symbols are:

$N_{ec}$  = number of key elements

$\omega_i$  = weight of i-key element, (the sum of  $\omega_i$  is =1, if all key elements are considered)

$n_i(i)$  = number of themes of the i-key element

$t_j$  = weight of j-theme, (the sum of  $t_j$  is =1, if all themes of one key element are considered)

$n_{in-ck}(j)$  = number of check-lists and indicators of j-theme

$p_k$  = weight of an indicator or a check-list (the sum of  $p_k$  is = 1, if all check list and all indicators of one theme are considered)

$I_k$  = value of indicator or of check list ( $0 < I_k < 1$ )

It is assumed that a check-list of a defined number of questions (i.e. 10) has the same importance of an indicator. The different weights and their numerical values represent the elements on which the definition of the adopted criteria for estimating IPESHE is based.

Note that the global index ranges between 0 and 100, and characterizes the overall performance of a company with reference to health and safety of workers.

### 2.1 Notes on weights

When an indicator or a check-list indicates the lack of compliance with law, a warning must be given, in spite of the value assumed by the Index. Of course the index calculated in this way, whatever its value is, cannot lead to a positive assessment, but its value can provide useful guidelines for the company.

In a detailed assessment, one can define different scale of importance for indicators and check-lists.

For instance, importance of 1/3 can be assigned to a planning checklist, importance of 2/3 to an implementing checklist and importance = 1 to an indicator. Then the values of the weights  $p_k$  are obtained considering that their sum must be = 1 if the number  $n_{in-ck}(j)$  is considered. It is worth remembering that this sum property must be applied to the weights  $\omega_i$  and  $t_j$  too, obviously considering the set of reference (respectively key-elements and themes).

The proposed method must take into account of the actual risks in an enterprise: indicators/checklists or themes that are not useful in a specific case need to be deleted from the calculation and the index must be normalized again, bringing to 100 its maximum value.

### 3. Criteria for weighting

In equation (1) several weights are included and each of them must be determined in order to obtain a global index of performance of the company. The number of the weights can be conveniently reduced if specific criteria are used, in particular two criteria can be indicated as significant: they are named priority-criterion and equality-criterion and represent two opposite ways of evaluation. It is worth noting that other criteria can be identified, and finally a practical choice must be made.

In equal-criterion all indicators and check-lists give the same contribution to IPESHE, and no other information can be independently assigned. The importance of a key-element (and of a theme) is determined by the number of indicators and checklists belonging to the same key element (or theme). Therefore, the global importance of a key element or of a theme is as higher as bigger is number of indicators/check-lists it contains.

The equal-criterion solution requests to assign a factor =  $1/n_{in-ck,total}$  to each  $f_k$  of the following equation:

$$IPESHE_{eq} = \left[ \sum_{n_{i-ck,total}} f_k \times I_k \right] \times 100 \quad (2)$$

This is a simplified form of IPESHE, named  $IPESHE_{eq}$ , in which  $f_k$  is the weight of the  $I_k$ .

With the second criterion, the priority-criterion, weights can be assumed different for each key elements, but equal weights for each theme of a key element and also equal weights for each indicator/check-list of the theme are considered; their importance is calculated starting from the weights fixed. The global importance of themes derives from weights previously established, because there is a priority defined only for key elements. Summarizing, the contribution of a check-list or an indicator to IPESHE is as smaller as bigger is the number of indicators and check-lists in a theme and as bigger is the number of themes in a key element, since only the contribution of the key element is fixed. It is noticing that this may seem a contradiction if the number of indicators in the themes is considered a measure of the importance of the same theme and its key element.

### 4. How to apply priority and equality criteria for calculating IPESHE

A simple case is considered where three key elements are included and each key element has from two to five themes (note that M.I.M.O.SA system contains 6 key elements and 27 themes). Each theme is evaluated by checklists of planning and implementation and by some result indicators, whose values depend on particular company, which will be examined. These values are not included here, being the example simply devoted to show how define weights and importance of them. Indeed the two criteria are applied in order to calculate and compare importance of key elements, themes and check-lists and indicators. A global picture of all weights and scales of importance of key elements and themes is presented in Figure 3. In this simplified case, check-lists and indicators have the same importance, whatever is the criterion applied.

Equal-criterion - As above said, the  $f_k$  values of checklists and indicators are fixed in order to calculate IPESHE by using the equation (2). A value of 0.024 (= 1/42) is used, as shown in Figure 3, in grey in column n. 9. Starting from this value (the same for all checklists and indicators) the importance of each theme and of each key element is calculated: the obtained values are shown respectively in column five and two (in grey in Figure 3).

Priority-criterion - A scale of importance is fixed for key elements and from this one the weights of key elements inferred: they are shown in column three of Figure 3. As above said, the importance of themes and checklist and indicators are deduced (columns six and ten of Figure 3).

Now values of the importance of key elements, themes and checklists/indicators can be compared: as it can be clearly shown by Figure 3 they greatly differ in the two cases and consequently the IPESHE index may differ in a small or great way once the values of  $I_k$  are known.

Key element	Importance of key element		Theme	Importance of theme		Number of check-lists included	Number of indicators included	$f_k$	Importance of ind-ck
	Equality-c	Priority-c		Equal-c	Priority-c				
1	0.214	0.5	1	0.119	0.250	2	3	0.024	0.050
			2	0.095	0.250	2	2	0.024	0.063
2	0.524	0.33	1	0.143	0.066	2	4	0.024	0.011
			2	0.071	0.066	2	1	0.024	0.022
			3	0.095	0.066	2	2	0.024	0.017
			4	0.071	0.066	2	1	0.024	0.022
			5	0.143	0.066	2	4	0.024	0.011
3	0.262	0.17	1	0.095	0.057	2	2	0.024	0.014
			2	0.095	0.057	2	2	0.024	0.014
			3	0.071	0.057	2	1	0.024	0.019
	sum=1	sum=1		sum=1	sum=1	sum=20	sum=22		

Figure 3: Data and results of the simple case-study

## 5. Final considerations

The IPESHE index is presented, which is able to evaluate the performance of a company in levels of health and safety for workers. It contains several weights but their number can be greatly reduced if some simple but significant criteria are applied. These two criteria are different and extent of their differences is clearly deduced by the simple case presented. Nevertheless, if a sequence of their application is defined, both criteria are useful. For instance a company can use the priority-criterion for a first self-assessment and, only if its results are good, apply the equal-criterion which better manages the compliance with requirements of Italian Health and Safety laws. At present this is the choice included in the M.I.M.O.SA. system. In the future M.I.M.O.SA. will be tested by applying it to some companies in order to evaluate health and safety performances and to establish possible improvements of the methodology.

## References

- Neal A., Griffin M.A., Hart P.M., 2000. The impact of organizational climate on safety climate and individual behavior. *Safety Science*, 34(1-3), 99-109.
- Neal A., Griffin M.A., 2006. A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of Applied Psychology*, 91(4), 946-953.
- Didla S., Mearns K., Flin R., 2009. Safety citizenship behaviour: A proactive approach to risk management. *Journal Of Risk Research*, 12(3-4), 475-483.
- HIS, 2008. Italian Health and Safety laws: Legislative Decree n. 81/2008 and Legislative Decree n. 231/2001.