CHEMICAL ENGINEERING TRANSACTIONS
VOL. 43, 2015

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Chief Editors: Sauro Pierucci, Jiří J. Klemeš

ISBN 978-88-95608-34-1; **ISSN** 2283-9216

DOI: 10.3303/CET1543210

Objectives and Early Results of the Centre for Study on Safety Culture and Prevention

Micaela Demichela*[a], Mario Patrucco[b] , Roberto Luzzi[c]

[a]SAfeR - Dipartimento di Scienza Applicata e Tecnologia, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italia;
[b]Dipartimento di Ingegneria dell'Ambiente, del Territorio e delle Infrastrutture -DIATI-, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129, Torino, Italia;
[c]INAIL CONTARP Direzione Regionale Piemonte – Corso Orbassano 366, 10137, Torino, Italy
micaela.demichela@polito.it

In the present paper the framework of a complex research activity carried out in the field of occupational accidents is described. The activities are here introduced with their early results related to: a) the analysis of large database of occupational accidents, with the aim of identifying, through the clustering of similar events, the more critical features to be used in risk assessment and prevention; b) the in-depth analysis of occupational accidents, that through a combination of Event Tree and Fault Tree Analysis, leads to focus step by step the intermediate and root causes of work-related accidents; c) the collection, classification and analysis of unsafe acts and unsafe conditions as precursors of occupational accidents, in order to identify the measures to be adopted to minimize their recurrence.
The set of procedures, tools and data retrieved are intended to help different end-users to maximize the effectiveness of occupational accident prevention.

1 Introduction

The Centre for Studies on Safety Culture and Prevention is funded by INAIL – Direzione Regionale del Piemonte from 2011 with the aim of developing methods and tools to maximize the effectiveness of the analysis of the data collected by INAIL itself for compensation purposes, in order to allow their use also for prevention purposes.
In fact, the large databases where the occupational accidents are recorded and classified according to ESAW (European Statistics on Accidents at Work) accident taxonomy, are mainly used for statistical analysis; this meaning that the information about the accident dynamic and other relevant data, despite available, often remain unexploited.
Previous cooperation between INAIL and Politecnico di Torino allowed highlighting the information that could be used for prevention purposes within the databases and drafting an initial tool to retrieve these pieces of information and to use them to support the decision making in occupational accident risk reduction. The tool, base on neural networks was named SKM [Demichela & Palamara, 2007; Palamara et al., 2011].
A tool was also developed to perform the quantitative risk assessment related to occupational accident in a work environment, based on fuzzy logic, in order to deal with uncertain and sometimes contradictory data, named FAP (Fuzzy Application Procedure). The methodology is described in Demichela et al. (2006) and Murè & Demichela (2009).
In parallel, another approach – and related tool - was developed, guiding the analysis of occurred occupational accidents: the Computer-aided Cause Consequence for Prevention CCCP evolved by a combination of Event Tree and Fault Tree Analysis, leading to focus step by step the intermediate and root causes of work-related accidents, whose framework is described in Figure 1.
The initial activities described above highlighted some needs for further research and integration.

Please cite this article as: Demichela M., Patrucco M., Luzzi R., 2015, Objectives and early results of the centre for study on safety culture and prevention, Chemical Engineering Transactions, 43, 1255-1260 DOI: 10.3303/CET1543210

In particular, the research needs were related to some methodological shortcomings identified in the SKM method proposed by Palamara et al. (2011).

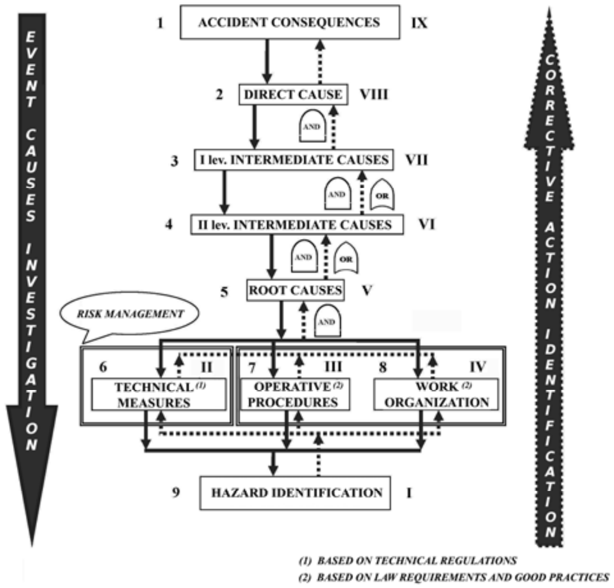

Figure 1 – Logic flow chart of CCCP tool

Furthermore, the attention was shifted towards the precursors of occupational accidents, the unsafe acts and unsafe conditions, whose control in the work environment could bring to the reduction in number and or in the impact of occupational accidents.
The need for integration of the different devised tools descends from the optimization of the use of information coming from different sources, in order to maximize the effectiveness of the occupational accidents prevention. The baseline for the integration is shown in Figure 2, where the available techniques are linked.

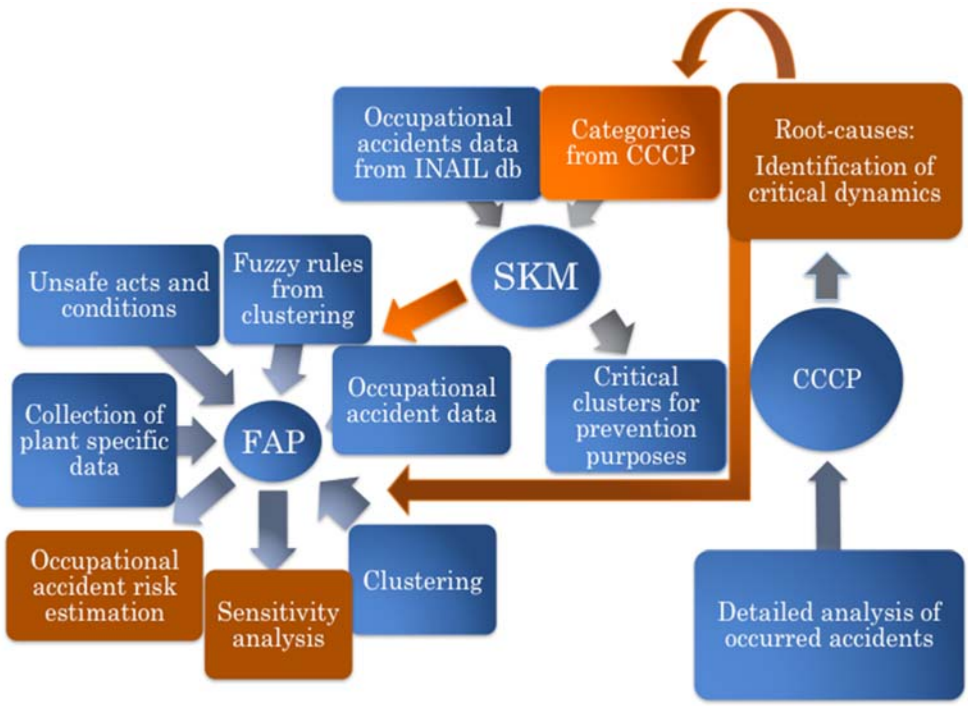

Figure 2 – Integrated tools for occupational accident risk management

The complete suite of tools, that can be used by different end-users, but in particular by the health and safety managers of the companies - of any dimension - to enhance the safety in the work environment and by the control authorities during the audit in the companies themselves and in case of accident investigation, in order to gather the relevant information and lessons learnt from previously occurred accidents.

2 Running projects and early results

2.1 SKM

The SKM methodology, based on the clustering algorithms SOM and K-means, was applied to the large accidents databases of INAIL to identify, within an activity domain (e.g. wood industry) or within an industrial operation (e.g. maintenance) in order to group the events characterized by similar parameters, as those related to accident dynamic discussed above.

The clustering returns maps as the one in Figure 3, where each dark area groups the accident already occurred similar for dynamic. To each group a index of risk can be assigned in order to have a prioritization criteria allowing the decision making in terms of prevention and protection to be supported.

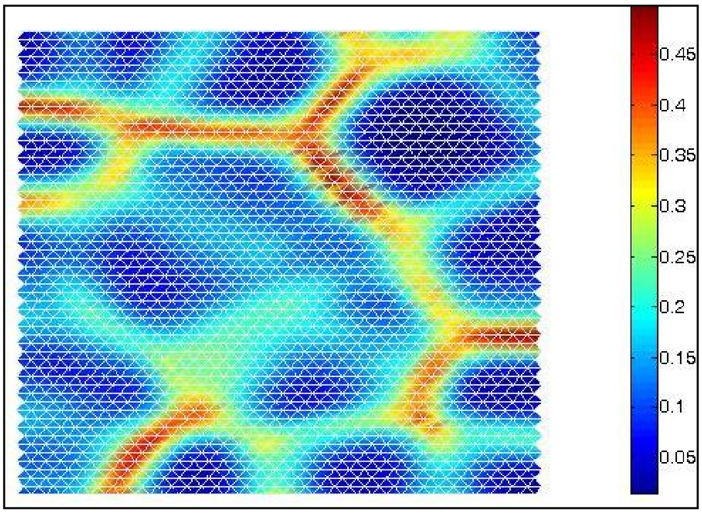

Figure 2: SOM map elaborated at the end of the clustering

Figure 3 shows e.g. the more critical dynamics within the wood industry as acquired by the analysis of the accidents occurred in Piedmont over the years 2007-2010. It's worth to notice the predominance of the "no data" sequence, that highlights a low quality in the preliminary classification of the data recorded, since they are not characterized through the fields describing the accident dynamics. This problem could be overcome enhancing the reporting culture, as described in Douglas *et al.* (2014), in the companies where the accident occurred in order to have better quality data sent to the INAIL.

	Activity.	Activity material.	Deviation.	Deviation material.	Contact.	Contact material	Risk index
1	No data.	No data.	No data.	No data.	No data.	No data.	6.0
2	Driving.	Transportation .	Loss of control.	Transportation .	Impact with something in motion.	Transportation .	2.1
3	Working with tool.	Tools.	Loss of control.	Tools.	Contact with sharp, pointed or abrasive material.	Tools.	1.2
4	Movement.	Surface.	Fall.	Surface.	Falls, stumbling.	Surface.	1.2
5	Working with machinery.	Machinery.	Loss of control.	Machinery.	Getting stuck.	Machinery.	0.7

Figure 3: Critical occupational accident dynamics occurred in the wood industry in Piedmont over the years 2007-2010

As discussed in Comberti et al. (2015), the SKM method has been revised in order to overcome some methodological shortcomings highlighted during its application to the INAIL databases. The method has been updated and validated. The running work is now the application of the revised model to the new set of occupational accidents data, and namely:

1. maintenance activities;
2. minimal handling of loads;
3. more recent data on the wood and metallurgical industry, to which the method was previously applied.

The results obtained will be published in open reports, in order to make available to interested figures the knowledge acquired for sake of prevention.

2.2 CCCP

The tool was developed starting from the acknowledgment that the limited knowledge of accident root causes, slapdash remedies, and occasional inspections are inadequate to highlight and control the criticalities of complex activities, thus the need for a system for an unbiased analysis of the causal chain of events that led to the accident was highlighted.

An original technique was then developed, according to the framework already shown in Figure 1, and the data contained in have been enriched: the Computer-aided Cause Consequence for Prevention CCCP evolved by a combination of Event Tree and Fault Tree Analysis, leading to focus step by step the intermediate and root causes of work-related accidents, reducing the possibility of errors due to subjective judgment or hasty evaluation, and the too easily reached conclusion of incorrect behavior of the victim.

The computer assisted approach, discussed in detail in Patrucco et al. (2015) allows the user to:

a) identify the input data useful for the analysis,
b) realize the accident sequence of the causes,
c) identify the design and risk assessment flaws, the non-compliances vs. regulations, and the lack of prevention measures.

Effective and suitable technological and organizational prevention measures can then be introduced for similar cases or industrial situations.

2.3 Unsafe acts and unsafe conditions

In cooperation with FCA group, a procedure for the collection, classification and analyses of unsafe acts and unsafe conditions has been developed and tested in one of the Italian plant of the group. Collection and classification have been based on the HFACS (Human Factors Analysis and Classification System) tools first introduced by Wiegmann & Shappell (2001), discussed in Darabnia & Demichela (2015) and run in parallel with the method already used within the group. Figure 4 shows the taxonomy used for the data classification.

At the moment the activity is dealing with the definition of the procedure able to define the measures to be implemented to deal with the unsafe acts and unsafe conditions on the base not of the single record but on the wider view (in terms of time and phenomenology) of the recorded events.

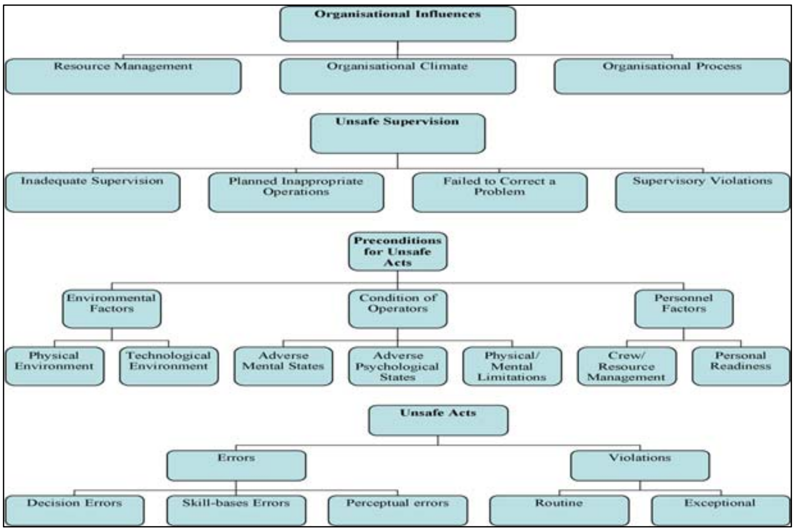

Figure 4. HFACS taxonomy.

As an example, Figure 5 shows the classification related to the well-known problem of the missing use of PPE of the plant operators. The solution, instead of a single recall to the operator itself, sometimes should require a more structural intervention (as the change of PPEs themselves or the re-allocation of personnel), but this could be only highlighted by a more detailed analysis of the events.

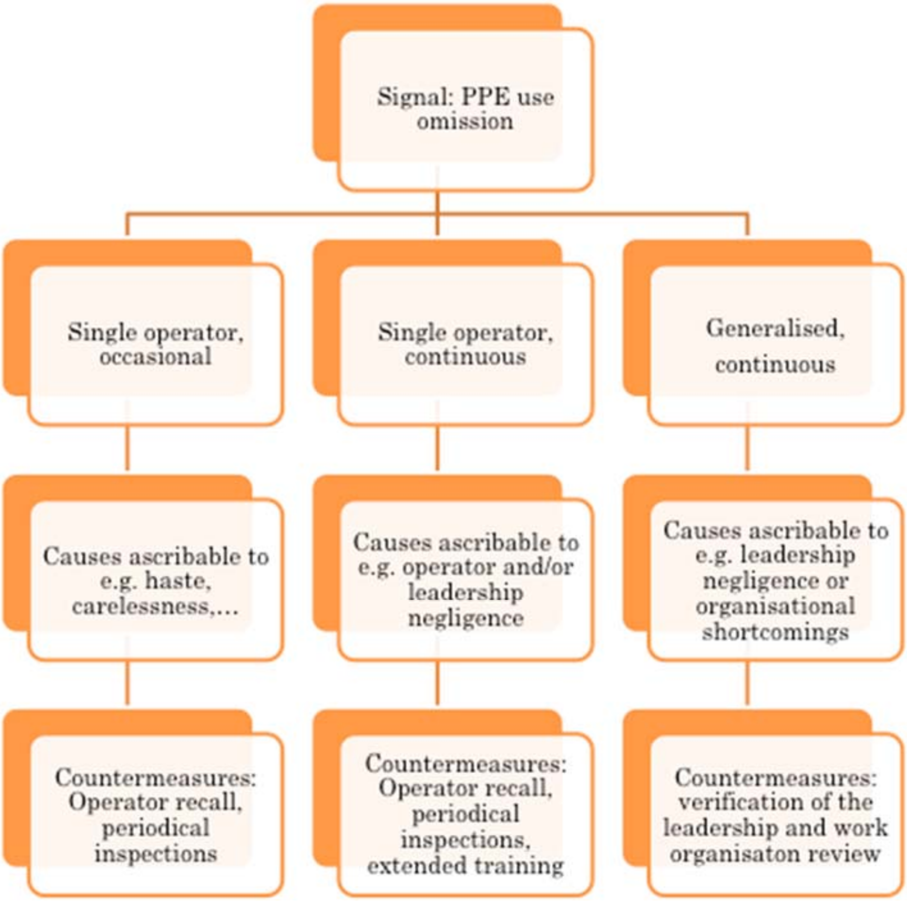

Figure 5. Classification and related countermeasures example

The information gathered from the analysis, included in the risk register of the company (as for Balfe *et al.*, 2014) should improve the safety management in the company itself.

3. Conclusions

The present paper has described the framework of a complex research activity carried on in the field of occupational accidents.
The running activities have been introduced, with their early results, dealing with:

1. the analysis of large database of occupational accidents, with the aim of identifying, through the clustering of similar events, the more critical features to be used in risk assessment and prevention;
2. the in-depth analysis of occupational accidents;
3. the collection, classification and analysis of unsafe acts and unsafe conditions as precursors of occupational accidents, in order to identify the measures to be adopted to minimize their recurrence.

The set of procedures, tools and data retrieved will help different end-users to maximize the effectiveness of occupational accident prevention. The Centre itself will remain as a point of reference and documentation of the analysis and interpretation of the workplace accident phenomenology.

Aknowledgements

The research work was possible thanks to the support of the Italian compensation authority for work-related injuries INAIL (Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro) – Direzione Regionale del Piemonte.

References

Balfe N., Leva M.C., McAleer B., Rocke M. 2014. Safety risk registers: Challenges and guidance. Chemical Engineering Transactions, 36, 571-576.

Comberti, L., Baldissone, G., Demichela, M. (2015) Workplace Accidents Analysis with a Coupled Clustering Methods: S.O.M. and K-means Algorithms. Chemical Engineering Transaction, 43, *in press*.

Darabnia, B., Demichela, M. (2015) Analysis and classification of occupational data: a practical comparison. Chemical Engineering Transaction, 43, *in press*.

Demichela M., Murè S., Piccinini N. (2006) Assessment of the risk of occupational accidents using a FUZZY approach, Cognition Technology & Work, vol. 8, pp. 103–112,

Demichela M., Palamara F. (2007) Occupational accidents risk analysis using clustering algorithms, ESREL 2007, Proc. of the European Safety and Reliability Conference 2007,

Douglas E., Cromie S., Leva M.C., Balfe N. 2014. Modelling the reporting culture within a modern organisation. Chemical Engineering Transactions, 36, 589-594.

Luzzi, R., Passannanti, S., Patrucco, M. (2015) Advanced technique for the in-depth analysis of occupational accidents. Chemical Engineering Transaction, 43, *in press*.

Murè, S., Demichela, M. (2009) Fuzzy Application Procedure (FAP) for the risk assessment of occupational accidents Journal of Loss Prevention in the Process Industries, 22 (5), pp. 593-599.

Palamara, F., Piglione, F., & Piccinini, N. (2011). Self-Organizing Map and clustering algorithms for the analysis of occupational accident databases. Safety Science, 49, 1215-1230.

Wiegmann D.A., Shappell S.A., 2001, Human error analysis of commercial aviation accidents: application of the human factors analysis and classification system (HFACS). Aviation Space and Environmental Medicine, 72(11), 1006-1016.