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Simplified Procedures and Workers' Involvement: Two Keystones for Improving Safety at Small Seveso Plants

Paolo A. Bragatto, Patrizia Agnello, Silvia Ansaldi, Annalisa Pirone

INAIL Settore Ricerca Certificazione e Verifica
p.bragatto@inail.it

When small enterprises have to face major hazards, tools and procedures developed for major companies, including safety management systems and related procedures could be inadequate. A simplified set of procedures has been developed for the Italian Galvanic Industry, which features many small establishments with major accident hazards. To achieve the workers' involvement in safety management a smart application has been developed, supported by a digital representation of the safety system.

1. Introduction

In Italy many establishments featuring major accident hazard and falling under "Seveso Legislation" are managed by small or medium sized enterprises (SME's). The number of "small" Seveso establishments has increased in recent years, due to the new classification of a few hazardous materials within the Reach Regulation. This is the case for 129 galvanic plants, which are currently under the "Seveso" legislation. Most of them have less than 50 employees and the typical size is some 15 workers. The galvanic industry is the most obvious case but there are many other cases of small enterprises falling under the Seveso Legislation, including chemical and pesticide warehouses, fireworks facilities and a number of chemical process plants. The typical size of Italian enterprises is smaller than in northern Europe and, of course, this is also reflected in the industries affected by the Seveso Directive. The issue of minor enterprises facing major hazards is worthwhile of a deeper discussion.

1.1 SMS for SME's in literature

The organizational model of the galvanic companies is simple, informal and flexible. Direct communication between owner, management and workers overcome formal procedures, if existing. In these establishments, furthermore, the Safety Management System (SMS) is mandatory and subject to periodic inspections by Competent Authorities, as "Seveso" duties do not depend on company size. The SMS models developed for major companies have been downsized for small ones, transferring also procedures and paradigms typical of large organizations. The issue of SMS in different high risk contexts has been discussed in many scientific papers. According to Grote (2012) larger companies are stability oriented and prevent accidents by adopting stricter controls, more detailed rules and behaviour monitoring programs. For SME's it is instead essential to have more flexibility for handling frequent external changes and/or variances and disturbances in work. Thus at SME's, open sharing of information and mutual support are expected to be the best way to improve safety. Reiman & Rollenhagen (2011) say that SMS's tend to be too static. Some approaches to safety management aim at guaranteeing that nothing has changed, and that all the safety measures are still in place. At SME's, instead, people optimize their work practices and make tradeoffs between efficiency and thoroughness in daily tasks (Hollnagel 2012). If everyday work requires too much adaptation and improvisation then the system is unstable and the usual management of change procedures could be inadequate to stabilize it. Kristensen (2011) demonstrated that SMS activities (e.g. audits or near-miss discussion) may stick to bureaucratically ordained tasks that are repetitive and easily ignored; whilst at SME's operators need to deal with constantly changing and competitive situations.

1.2 Practical Experience

INAIL is involved in the enforcement of the Seveso Directive and many colleagues, including the authors, have been acting as inspectors at "Seveso" establishments for a decade and more. The direct experience

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at SME's confirms the misperception of the SMS by the operators. Often procedures are considered useless and time wasting by the operators and compliance is just formal. The SMS is struggling to stay aligned with the continuous changes (personnel, materials, products). The crucial activities to realign the SMS should be the internal audits and the near-miss discussion, but the audits are performed in a bureaucratic way and near-miss understanding is difficult. Thus the negative perception and the real implementation difficulties jeopardize the expected positive effects of SMS at SME's.

1.3 Research needs

Both scientific literature and practitioners' experience confirm the needs of specific solutions for the minor enterprises facing major hazards. An improved system for major hazard management is essential for SME's falling under Seveso legislation, where the SMS is enforced by law. This system should also meet the needs of small companies dealing with significant amount of hazardous materials, just below the Seveso thresholds. In Italy many incentives, including premium discount and grant funding, have been introduced for the SMEs adopting a SMS. In order to support industries to implement an SMS adequate for protecting workers and complying with law, a number of methods have been developed by Italian researchers, including Saracino & al. (2012). The solutions include a few "Occupational Safety and Health Management" (OSHM) models, which are a set of procedures and forms, customized for a very specific industry. SMS models have been developed on the basis of recognized guidelines and recommended practices, such as BS/OHSAS 18001/2007. A few samples of OSHM models may be found at INAIL website(INAIL). These models aim to support compliance to OSH (Occupational Safety & Health) legislation and do not deal with major accident hazards but may be considered as a good basis to elaborate integrated SMS for small plants subject to Seveso Legislation. The involvement of workers in the SMS is the major challenge to achieve the control of both major accident and occupational hazard at SME's.

2. Objectives

The goal of the present research is to provide the Italian Galvanic Industry with a practical solution to facilitate the implementation of the integrated SMS, which has to be simple as much as possible, to fit the flexible organizational model. A number of small companies participate in the project and they will use the developed prototype in advance. As discussed by Manca et al. (2012), shared understanding, among workers, of instructions and procedures increases the safety of the operations and may even improve its efficiency. The study of near-misses and the internal audits could be the key to involving workers in understanding the safety issues and fill the gap existing between "shop floor" and "experts", as discussed by Agnello & al. (2012). The corner stone of the proposed solution is the bow-tie representation, widely used both in OSH and in Seveso field. It is suitable to support both audits and near-miss discussion. As discussed by Bragatto et al. (2014) in the bow-tie approach the focus is on the barriers that reduce the main risks, instead of looking for abstract categories; thus it is easier to make concrete recommendations for improvement.

3. Methods

The two pillars of the proposed solution are 1) an integrated model for SMS, aimed to prevent both major accident and occupational safety, 2) a mobile application, which has been developed to support the SMS implementation. The standardized procedures are briefly discussed, as well as the model underlying the developed application.

3.1 Outline of the "standardized procedure"

In this paper a model for the management of OSH risks at workplace harmonized with aspects connected to the control of major accident hazards is proposed. The model is composed of simplified procedures and forms developed for galvanic establishments and suitable to be modified in other small Seveso plants according to specific occupational risks assessment. The basis for this model has been provided by a standard OSHM model developed for companies below 30 employees by the Local Health Agency (ASL/FO). The model has been extended gradually; the first step has been the study of documentations and operative instructions elaborated for electroplating activities subjected to Seveso legislation and collected by INAIL's researchers involved in SMS inspections, accordingly to the article 18 of Seveso II Directive. Specific procedures (P) and relative forms (F) have been elaborated. Four new procedures have been implemented, including most typical "Seveso" duties not present at all or very poor in standard OSH procedures. The new procedures are related to the management of incidents and near-misses, management of changes, internal/external emergency planning and audit processes. In order to include the management of major hazards, existing occupational procedures have been modified and a few new

forms have been added to the model. It is the case of procedure P3 “Instrumental Resources” in which the text of procedure has been integrated with all aspects of the safe operation and maintenance, specific forms about critical items and permits to work have been prepared. The permit to work, containing information about contractors, type of work, person in charge, equipment, specific risks and personal protection equipment, is mandatory for Seveso plants. A major commitment has been the harmonization of new procedures with existing standardized OSH procedures. The extensions to the OSHM model, made to include the control of major hazards, are shown in Table 1. By the extended OSHM model even a company with a poor background can achieve an adequate level in safety documentation.

Table 1: The new procedure developed for controlling major accident hazard, harmonized with existing OSHM model.

New forms in existing procedures	**New procedures and related forms**
P1 – Starting and Review	
P1-F12 Seveso Information Form	**P9 – Miss and Near-miss**
P2 – Risk Assessment	*P9-F1 Operational Experience analysis*
P2-F11 Galvanic plant: phase process, health&safety risks and protection measures”	1. *P9-F2 Form for injury – accident or near injury investigation*
P2-F12 Risk analysis (bow-tie)	**P10 – Management of Changes**
P3 – Instrumental Resources	*P10 – F1 Move for change*
P3-F3 Instruction for dangerous equipment (II PART)	*P10 – F2 Assessment and Acceptance of change*
P3-F5 Critical item Registry	
P3-F6 Form for Permit to Work	**P11 – Management of Emergency**
P4 – Personal Protective Equipment	*Emergency plan*
SP4-F5 PPE for galvanic activities	**P12 – Audit**
P5 – Information and Training – Regular meeting	*P12 – F1 Performance indicators*
SP5-F5 Check list Information and Training	*P12 – F2 Internal audit/inspections*
P6 – Health Surveillance	
P6-F3 Specific rules to galvanic plant	

3.2 Outline of the “safety digital model”

The backbone of the developed application is the safety digital model, which has been presented a couple of years ago by the authors (Bragatto et al. 2010). The advantage of this model is that equipment, devices, operative instructions, procedures, and modules are linked to each other in a “net”, where all logical connections are present. The very core of this logical model is the bow-tie representation, as shown in Figure 1. In bow-tie, for each event (major accident or occupational accident), there are the links to the technical and organizational systems for prevention or mitigation. In such a way material and immaterial barriers are linked each other. The standardized SMS and the operative instructions, specific for each establishment, already provides the appropriate procedures, with the empty forms to be filled in by the operators. Each instruction is directly linked to one or more items of equipment in the establishment. Both procedures and operating instructions should be linked to the bow ties, as critical for preventing or protecting accident events. In this way the new integrated SMS, developed for galvanic industry, has been represented adapting the existing framework of “safety digital model”, based on bow-tie representation.

3.3 Bow-ties and near-misses

In order to achieve the objectives, the near-miss analysis has been included into the improved safety digital model. The method suggests a sort of path along which the near-miss is processed, starting from the equipment or device involved and moving back inside the safety model, visiting both technical and organizational items, in order to find out which item (equipment, instruction or procedure) failed. That is equivalent to look for a “*bug”* in the SMS. The analysis starts by checking if the component involved is critical, that is contained into a bow-tie, in order to direct the interest of examination toward the pertinent devices and documents. The discussion, focused on contextualized subsets of items, is carried out by

checking the operative instructions and the procedures which may be found in the virtual net, close to the directly involved piece of equipment. Finally, it is important to arrive at a solution (fix the bug), indicating if the document requires further improvement, modification or learning, or simply a "*revival*" is needed. In a similar way the audit may also be performed starting from a top event represented in a bow-tie of the digital model and going back looking for related instructions and procedures. Adopting such a method, each worker may be directly involved to improve procedures and instructions in the SMS. This method may help to reduce the gap between the field and the organization management, and increase the perception that procedures and instructions, even though intangible, are a real and effective barrier against accidents. This aspect guarantees a major workers' involvement and optimize their work. The choice to develop a mobile application (app) instead of classical desktop software is aimed to stress the personnel involvement as in smart environments (e.g. android) where the interaction is much easier and quicker. The app, named AGILE-G, has been required to be adaptive to the screen size, in order to be optimized both for smart-phones and tablet.

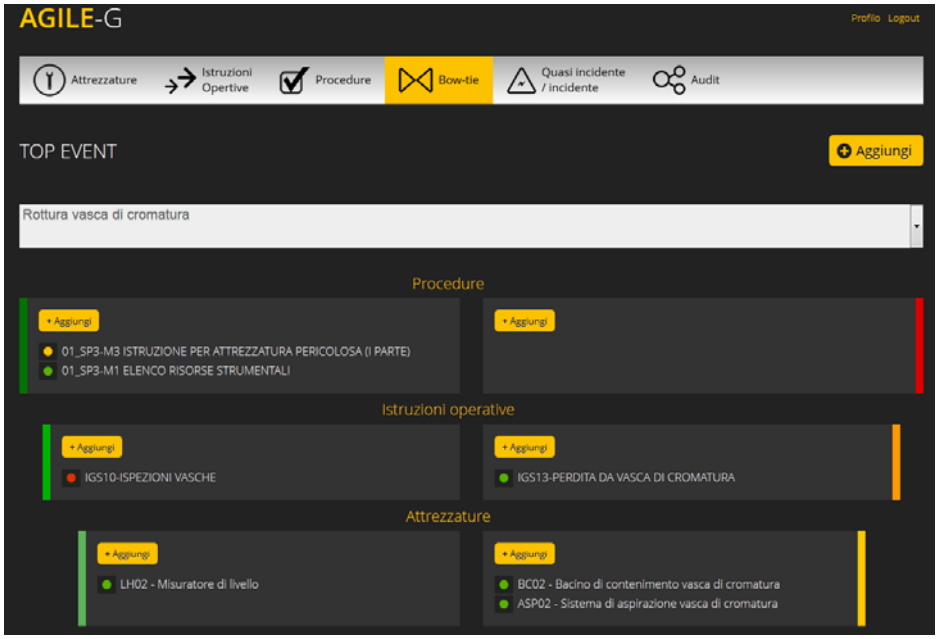

Fig 1: bow-tie representation collects procedures, operative instructions and devices (top-down view), organized into preventive and protective measures (left-right view)

4. Results

The method described above has been tested in a sample of three galvanic establishments, featuring plants both for nickel and for chrome plating. In order to demonstrate the applicability and adequateness of the software, three experimental tests have been organized by the research team, with the active cooperation of three safety inspectors. To perform the test, the information gathered by the inspectors on the field has been used. It includes basically a filled form for each top-event, as analyzed in the risk assessment phase, where preventive and protective, technical and organizational measures are described and, for each near-miss, a form where essential details are recorded. A total of nine top events are present in the plants, including overflow of material, loss of containment and warehouse fire. A total of 24 recorded near-misses have been analyzed, including initial ruptures of the protective covers, failures of devices such as valves or level detectors, incidents with forklifts and formation of toxic vapours. The objectives of the experiments were to test the adequateness both for on-site operation and for off-site analysis.

4.1 Testing of the software

For each plant, the test process has been performed as follows: the safety model compilation, the bow-ties description, the near-misses registration and analysis. The first step corresponds to the system *start-up*, in which a digital representation of the plant, in terms of equipment and devices, has been imported; standard forms for the procedures have been opportunely filled in and organized into the SMS; a few

operative instructions are linked to the equipment. In the second phase, the bow-ties have been registered by taking the information contained into technical systems documents.

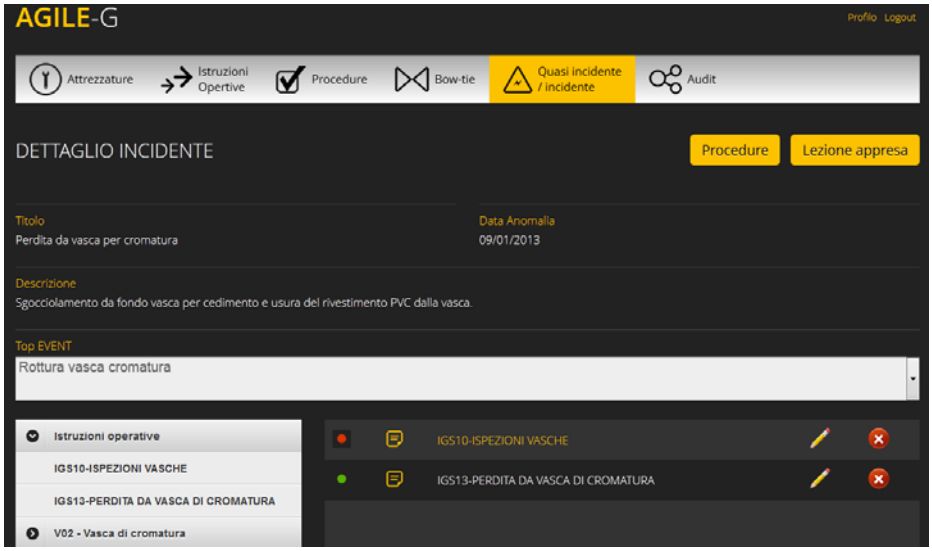

Fig 2: a snapshot showing a partial result of near-miss ("Loss from the pool") analysis: its relation with a Top Event ("Rupture of chrome pool") and the Operative Instructions involved. The red light means that the document needs some modifications.

The third step of the experimentation is related to the near-misses management, that is: registration, analysis and discussion, eventual improvement of the safety model. Each near-miss is registered using an appropriate form for catching primary information (e.g. description, component involved, current working activity, actions done) and linking it into the safety model. The analysis of each near-miss has the objective to better understand the causes and to find out the solutions. The discussion is developed with respect to the safety model following a sequence of steps:

- checking if the near-miss may be located into a chain bringing toward a top event;
- looking at contextualized safety documents, firstly the operative instructions (see Figure 2) and then the procedures, for finding possible failure, e.g. misleading, poor training, or something missing;
- tagging those documents with opportune comments and updating requirements;
- getting the lesson learnt, the outcome that summarizes the operations done, as illustrated in Figure 3.

All phases are performed by taking advantages of the safety digital model, and are always contextualized, thus a few candidates are proposed to the analyst, and the set of pertinent documents is drastically reduced.

5. Conclusions

The results demonstrate the applicability of the software in the galvanic plants under Seveso legislation; in the continuation, in order to gather valuable improvement suggestions, a wider test cycle with the other partners of projects is planned, including a local agency in charge of safety & health controls at workplaces and a local entrepreneurs' association, with many galvanic companies. The wider use of the software by the small companies participating in the project will provide the opportunity to have more feedback by the workers and the duty holders.

The implementation of SEVESO III EU Directive in National Legislation, due by mid 2015, could slightly change the number of SMS falling under Seveso obligation, but the scenarios of small companies facing major hazards will be not affected. The demand for this application is supposed to increase in the near future, as many SMEs will adopt an SMS, even not mandatory, for many reasons, including incentives and soft laws, ethical commitment, internal and external image promotion.

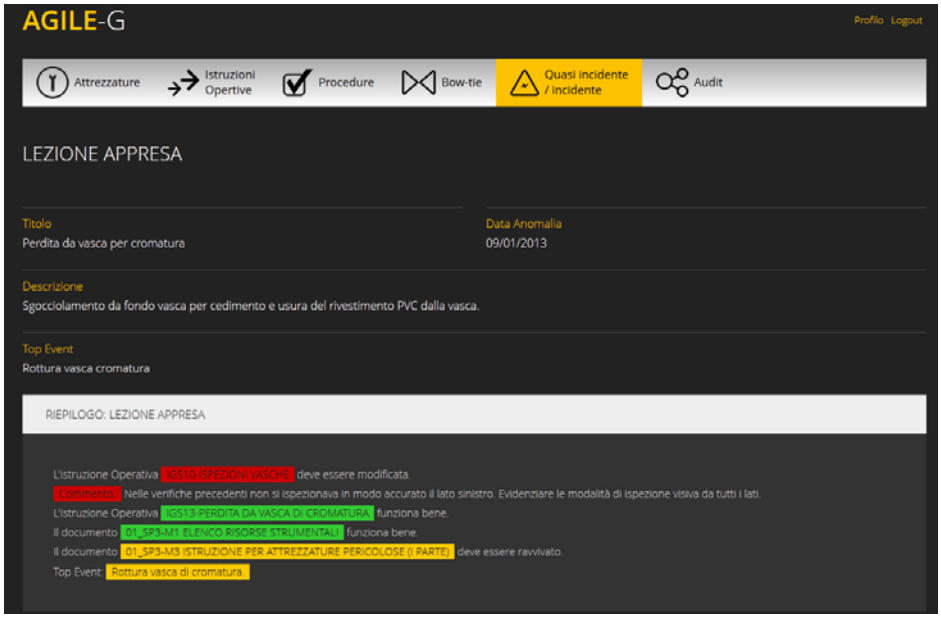

Fig 3: an example of lesson learnt as a summary of the analysis done: an instruction needs to be modified (red highlight) according to the comment, a module needs more training for the operators (yellow)

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