



Plugging the Gap between Safety Documents and Workers Perception, to Prevent Accidents at Seveso Establishments

Patrizia Agnello*, Silvia M. Ansaldi, Paolo A. Bragatto

INAIL- DIPIA exISPESL, Centro Ricerca, Via Fontana Candida, 1, I-00040 Monte Porzio Catone (RM), Italy
p.agnello@inail.it

At “Seveso” establishments, Safety Report SR and Safety Management System SMS have been mandatory for many years. At most small and medium size enterprises, the complex documents underlying SR and SMS are managed by specialists, which are very far from daily operation. The gap between safety documents and real operation may be a major drawback for a successful SMS and must be plugged. The study of near misses may be exploited to revive documents and involve much more workers in plant safety. Here a new method for near misses management is presented, based on the digital representation of the safety documents and tested in the framework of the mandatory inspections, required by the Seveso Legislation.

1. Introduction

According to the European Legislation on Major Accident (Seveso Legislation), Safety Report (SR) and Safety Management System (SMS) have been mandatory for many years. Even though benefits are widely recognized, SMS and SR have dramatically increased the number of documents. A gap between safety documents and real operation is a major drawback for a successful SMS and has to be carefully prevented. At most small and medium size enterprises, SR and SMS with all underlying documents are managed by specialists, which are very far from daily operation. Every day, failures, anomalies, deviations show the weak spots of the system and challenge the credibility of safety documents. Inspections and audits may highlight further defects in safety procedure application. The importance to study near misses to reduce accidents is recognized in all industries, starting from the works of Heirich (1931) and Reason (1997), which are true milestones for the safety research. Despite this, however, there is still disagreement in scholars and practitioners on a few issues, including the exact definition of near miss, the analysis method and the value of near miss information in daily safety management. As far as construction industry, the issue of integrating adequately near misses in daily operation has been discussed in a recent paper by Cambraia et al. (2010). In Seveso sector, the importance of near misses was demonstrated by Jones et al. (1999), but in the common practice the potential of near misses study for safety management is inadequately exploited. The concept of “near misses” should be extended, to include also deviations and failures, which have the potential to give the operator weak signals of something wrong in the system. As discussed by a few authors, including Agnello et al. (2009), Blackstad et al. (2010), Bragatto et al. (2009), in mature industry, such as process industry, most accidents happen because safety knowledge has been ignored, or forgotten, or misunderstood, or badly applied, or mistrusted. For that reason, the study of near misses could be the key to involve workmen in the safety deal and fill the gap existing between “shop floor” and “experts”.

2. Objective

The goal of the present research is to propose a methodology to analyze the near misses and other unexpected events at a Seveso establishment and to improve the documents in the SMS. A software tool has been developed to support the proposed methodology. It is named NOCE (NO n Conforming Events management). An essential requirement for NOCE has been the consistency with the formal structure of the documents defined by European and National Seveso regulations. In particular, it has been developed having in mind the Italian guidelines on mandatory Seveso Inspection (MATTM, 2009), which have a chapter on Near Misses analysis, as well as the code of the Italian standardization body on the audit of the Safety management system (UNI, 2007). As the Seveso inspections are regularly attended by our Institute, there are frequent opportunities to test the method and the software. A sample case is discussed in § 4.

3. Proposed methodology

In accident prevention, the benefits of a planned study of near misses and non-conforming events are well known. The main difficulty is to define and adopt a reference model which should be simple and easy to use by the safety managers in their daily operation in the establishment.

Instead of referring to complex models, the proposed methodology mainly keeps track of the discussion of the event occurred, with respect to all the safety documents related to the establishment.

On the other hand such a method should be time and resource consuming if it would not be a digital-based model.

The proposed methodology follows these steps:

- *Event registration*, each deviation, failure or near miss occurred is promptly detected and recorded by the worker into the unexpected-event register;
- *Precedent retrieval*, the possibility to browse in the register for knowing those events happened in similar contexts;
- *Event analysis and discussion*, a desktop activity developed by the safety manager for locating this event inside the safety documents.

The framework on which this methodology runs needs safety digital model, containing both the establishment digital model and their safety documents, and unexpected-event register, ad hoc organized for capturing all the information necessary to describe the event.

3.1 Safety digital model

A few forerunners of the idea of a “safety digital representation” may be found in the literature. The potential of the knowledge-based methods to capture experience and reuse it in other studies has been demonstrated by Zhao, Bhushan, and Venkatasubramanian (2005). The potential of the digital models coming from computer-aided design system, for supporting hazard analysis has been demonstrated by Venkatasubramanian, Zhao, and Viswanathan (2000). On the other hand, both SR and SMS may be seen as two “digital trees” of a number of documents or parts of them. Both have a well-defined structured format, featuring even four or five nested levels. A multilevel structured format is highly preferable as any single paragraph contains just a little piece of information and may be directly addressed.

The digital trees in the SR and SMS do not sufficiently give a “digital representation” of the safety as they are separate to each other, and even a few weak links must be assured (e.g. between emergency plan and top events). To go from the digital documents to a true digital representation, a backbone is needed in order to connect all the structures together. Plant equipment seems to be a good candidate for this role.

Recently, the authors (Bragatto et al., 2010) have defined a safety digital model, whose core is the plant representation, and its components are mainly described through only the information necessary to risk assessment, without the details required for their design and fabrication. In this model all the items of the safety systems (i.e. documents, procedures, equipment) are connected to each other to form a network. Digital representations of equipment and processes are the basis of all modern tools for computer-aided engineering, but a digital representation of safety is quite new.

The model adopted has a hierarchical representation which better reflects the tree structure commonly used for representing plant and its equipment. On the other hand, safety documents, both SR and SMS, have by definition a hierarchical structure.

The safety model is organised into different levels: establishment and plant, mainly referring to management information (e.g. their position, the owner and safety managers, documents used in risk assessment); logic units, i.e. parts of plant which may be characterized as shared physical entity; process lines, described as sequence of piping and components, and eventually related to some devices. Each component, and similarly each device, is characterized by a function (e.g. storage, transfer, heat exchanger, measure, control) and by a set of adequate parameters (e.g. pressure, flow, temperature, level, capacity). A device can be associated to a component or a pipeline. A few general documents do not refer to any document, but they must include documents which refer to pieces of equipment. On the other hand, all the safety documents, both those referred by SR (e.g. index method, Hazop, incidental scenarios) and those contained into SMS (e.g. procedures, operational instructions, audit and maintenance plans, emergency plans), have a large number of relations with the elements in the digital representation of the establishment.

This safety digital model is a simple structure. It can be built step by step. Firstly, an equipment representation is needed with a few links to the main documents. In the further steps, more and more documents will be linked to equipment, resulting in a more and more robust digital net.

The figure 1 shows how the risk assessment, contained in SR, and the SMS documents, together with the plant model, are related each other in order to compose a complete representation in the safety framework. The overall representation is alive and dynamic through the operative experience management.

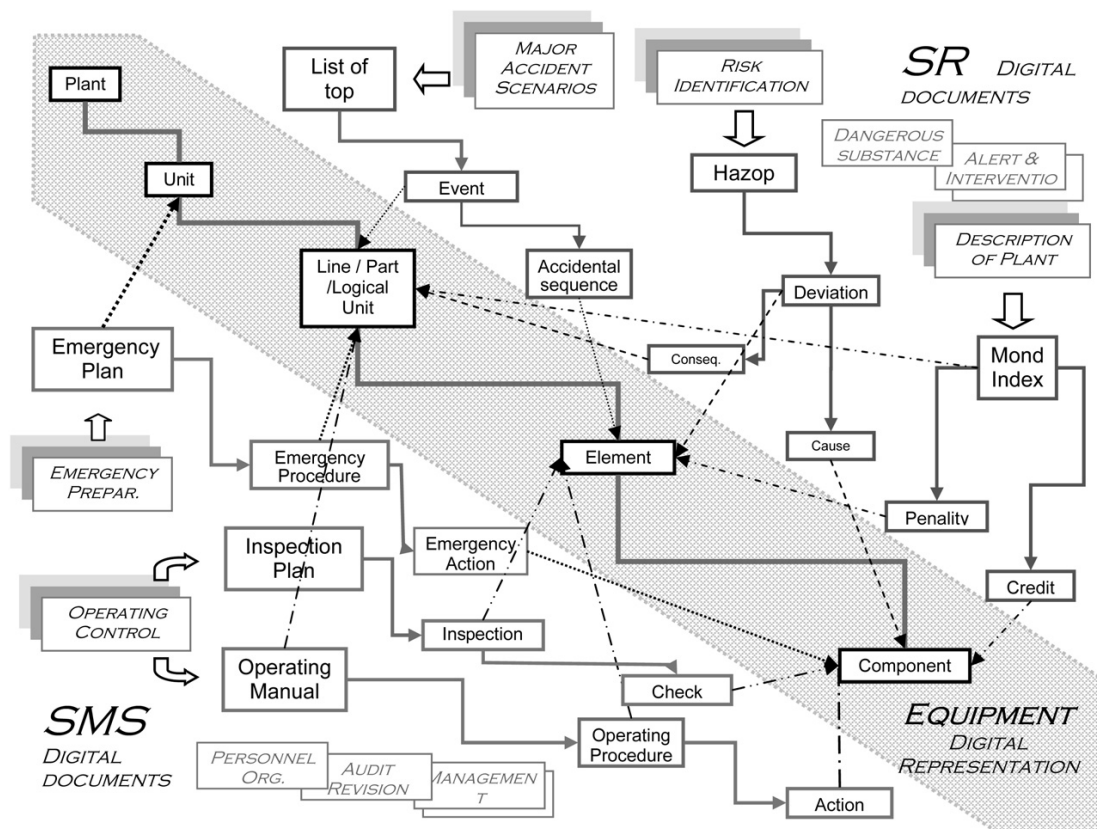


Figure 1: The safety digital representation: in the middle the equipment representation, that is the backbone of the model. Just essential underlying documents are shown.

3.2 Register of unexpected-events

At major hazard installations, it is recognized that near misses may warn the operator before the accidents happen. Therefore, by addressing these precursors effectively, major accidents may be prevented and consequential fatalities, severe injuries, asset damages and production losses may be avoided. For a well-tuned SMS, all anomalies have the potential to give the operator weak signals of something wrong in the system, and the concept of near misses has been extended to also include deviations and failures. The “near misses” should not be seen as a problem, but as a chance to improve the SMS.

Usually unexpected events are recorded only in the case of loss of hazardous materials or damage of equipment, on the contrary every little anomaly, defect, deviation or minor failure should be taken into account, as even a trivial event could be the very first precursor or a potential concurrent to an accident. The workers should be encouraged to record every unexpected event by means of simple forms, adequately managed by the SMS. Those forms vary by organizations, but should answer to the well known “four w’s”: *when* (occurrence time); *where* (unit); *what* (people, equipment, substance, operation procedure); *why* (direct and indirect causes, if known).

3.3 Workflow

The workflow outlined for this methodology is developed into different phases, each one with some basic objectives: to record the event, to look similar events up in the plant history, to find all safety documents which may be related with the event occurred.

The reporting activity is the first step and should be done directly on the field by the worker, in charge of filling a report form in. The technologies adopted may vary by firms, but the use of tools for digital reporting, e.g. a palmtop, could offer advantages to promptly record into the unexpected event register, and eventually to link the information directly to equipment data.

The possibility to retrieve and look at the precedents, occurred in similar context and circumstances, can provide useful information on the measures and actions which have been adopted at that time, but it should also be a warning for understanding why that *lesson* has not been completely *learnt*.

After a preliminary classification of the event occurred, the methodology proposes to understand whether something about the reported event may be found in the knowledge which is stored in safety related documents. This phase is the follow up of the event and it is supposed managed by the safety staff. The analysis phase has the objective to locate the event inside the safety documentation and put some bookmarks in order to keep track of the discussion. The event positioning consists of a backward path, from the single event (failure, near miss, or unexpected event) to a related item in the safety system, and this is supported by the complete digital representation of equipment and safety documents. When a near miss is reported, it is connected to a piece of equipment, present in the plant digital representation, so that the analysis starts from this and moves along the paths up to find the location in safety documents. A few components could be found without a direct link to safety documents; in this case the parent assembly or unit will be considered. Different methods can be adopted to mark the event location in a document. The bookmark may be a simple underline to point out that the event was already foreseen, for instance in the risk analysis done, or may suggest the improvement of the document for making its content clearer and usable. In more complex cases, some remarkable changes could be recommended and taken into account when document will be updated.

In the analysis phase, the first step is to verify the SMS manual. It reflects the action required by the Seveso legislation for updating the documents. That is to identify the paragraph in the SMS manual for introducing the link with the event that occurred, and eventually selecting the procedures or the operational instruction involved. In this phase both general safety procedures and operational procedures have to be checked.

The following steps are the reviewing of the SR and its related documents. In the safety report, the point related to the failed components, or to the affected plant unit should be analyzed. In many cases it will be sufficient to understand the risk documents better, in a few cases a review could be required.

In the case of failure, the inspection plan may be reviewed in order to intensify active monitoring and prevent equipment deterioration.

4. NoCE: an example of practical solution

In order to demonstrate the feasibility of the proposed methodology, NOCE (NON-conforming Event analysis), a software prototype, has been developed. "Client-server" architecture has been adopted, in order to have a palmtop computer usable on the field, connected to unexpected event register and to the digital safety representation on the central server.

The plant digital representation adopted is the reference model developed in previous research projects for supporting the development of some risk assessment techniques, e.g. Mond and Dow indices, Hazop method (Bragatto et al., 2007). In NOCE, the safety document archive may be appropriately linked with parts of the plant digital representation, e.g. procedures may refer to units, operational instructions to types of component or device. The formal structures, defined by European and National Seveso regulations respect to SR and SMS, have been adopted as reference indexes to access the documentation of the establishment.

Near miss data recording is done by selecting the component or device in the plant digital representation, and providing all the necessary information through a guided form, such as a brief title, a detailed description, the immediate causes and the consequences noted, the actions performed on field, some possible suggestions for further activities.

The discussion reflects the methodology described in section 3. In order to give a taste of NOCE user interface, a screenshot of the prototype is depicted in Figure 2, it represents a discussion with an event without consequences in a gas depot, in particular the preliminary phase of looking at the precedents occurred. The equipment digital representation is in the tree-window on the right side (1), and the arrow indicates the component involved. The event has been registered and described in form (2). The window (3) shows the information related to a precedent already discussed, highlighting the lessons learnt and the comments introduced. In the example, an SGS chapter (4) and a procedure (5) have been tagged and commented (6).

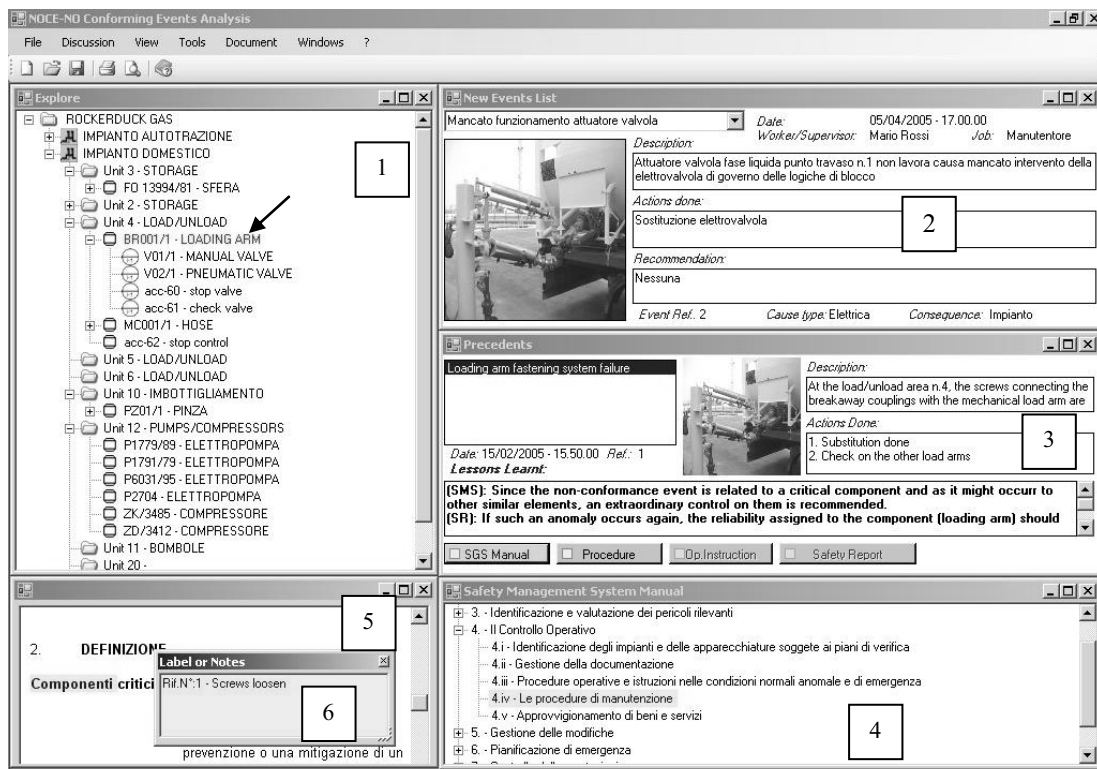


Figure 2: The study of a near miss in NOCE and a looking to the precedents already discussed

5. Conclusions

By using *NOCE* the safety documents may be continuously improved. Even though the safety documents, in the initial version, were from “real world”; they become more and more close to the actual plant operations, as the system, day by day, reacts to the external inputs (near misses). In such a way the experiences of the operators may be captured and included within the revised documents. As a side benefit, workers start to perceive the safety documents as their own, because they participated actively the updating job. It has to be stressed that *NOCE* is suitable just for Seveso establishments, because it requires a set of structured documents, organized according to the Seveso legislation and the common practice in Seveso industries.

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