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SHORT COMMUNICATION

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PERFORMANCE INDICATORS FOR MONITORING SAFETY MANAGEMENT SYSTEMS IN CHEMICAL INDUSTRY

The development of the Safety Management System (SMS) in chemical industry appears as one of the important requirements introduced by the EU "Seveso II" Directive on the control of major-accident hazards. This paper aims to provide a contribution regarding the SMS structure and the definition of the tools for assessing the effectiveness of this system by means of safety performance indicators. The performance indicators are linked to a reference values or policy targets, illustrating how far the SMS is from the desired level. We developed a system of performance indicators for SMS in chemical industry by using the concept of environmental performance indicators defined in standard ISO 14031. A set of three types of safety system performance indicators was proposed: management performance indicators, operational performance indicators and safety status indicators. These indicators represent the most important factors in the linkage between a possible cause of an accident and its effects.

Key words: safety management; Seveso II; performance indicators.

A number of initiatives taken in Europe and elsewhere over the past years resulted in the development of improved regulations on major accident hazard control. The requirements for the major accident prevention policy and a safety management system are newly introduced in "Seveso II" Directive on the control of major-accident hazards for industrial installations involving hazardous substances (96/82/EC), due to the recognition that approximately 85 % of over 300 accidents reported under "Seveso I" Directive (88/610/EEC) have shown some deficiencies in the management system. It has become clear that it is necessary to concentrate on both "hardware" and "software" requirements [1]. A Safety Management System (SMS) is defined in "Seveso II" Directive as including "the organizational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the major-accident prevention policy". The analysis of the SMS requirements highlights the need to define methods for the performance control and for checking the effectiveness of technical and organizational measures. The need to

evaluate the effectiveness of the SMS on-site is well established in the process industry. However, it is insufficient to judge the success of the process safety part of a SMS by counting the number of major accidents, and also some more pro-active performance indicators are needed. The attempts have been made to identify the key performance indicators based on a pro-active approach involving the identification of weaknesses and malfunctioning of SMS, accident causation factors, preventive actions which control the risks, emergency plans, and other issues [2-5].

This paper aims to provide a contribution regarding the structure of the safety management system in the chemical industry and to develop a system of safety performance indicators for SMS in chemical industry by using concept of environmental performance indicators defined in the standard ISO 14031 [6]. A set of three types of the safety system performance indicators was proposed: management performance indicators, operational performance indicators and safety status indicators.

SAFETY MANAGEMENT SYSTEM STRUCTURE

The introduction of the obligation for operators of certain establishments to put into effect a formal SMS has taken account of the development of new managerial and organizational methods in general and, in particular, of the significant changes in indus-

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trial practice relating to the risk management. Management systems are complementary to the need for technical and other specific requirements. The structure of the management system is based on the idea of a "management loop", which involves agreeing on the objective, defining a plan to achieve that objective, formulating the detailed work required to implement the plan, carrying out the work, checking the outcome against the plan, and planning and taking the appropriate corrective action. This means that the organizational structure must tend towards a more clear definition of roles and safety-related competencies, to be integrated into the production process. An improvement of safety can thus be obtained by:

- the systematic use of risk analysis during a design stage,
- the definition of an organizational structure which can improve safety,
- the definition of procedures and drawing up of the rules for their implementation,
- the use of safety performance indicators for the evaluation of the company SMS and
- audit and review of the system efficiency.

Companies handling hazardous substances must establish a written policy setting out overall goals and principles with respect to the prevention and control of major accidents, and ensuring a high level of protection of humans and the environment by appropriate means. They also should establish the adequate on-site and off-site emergency planning. Industry and competent authorities should periodically audit/review and report on the performance of safety management systems. The information on safety issues should be available to the public. This written information is intended to give an overview of how the operator ensures that committed safety policy will be implemented. In principle, the document should take into account the next topics: the organization and personnel, the identification and evaluation of major hazards, the operational control, the management of change, planning for emergencies, monitoring performance and audit and review.

The principal tasks of the chemical safety management system should be:

- reduction of the access to hazardous facilities,
- reduction of chemical risks at hazardous installations,
- reduction of the impact zone of chemical accidents,
- reduction of injuries and fatalities from chemical accidents,

- reduction of environmental impacts from chemical accidents,
- reduction of property damage from chemical accidents,
- improvement in the emergency response to chemical accidents and
- building up the collaboration of public authorities and local communities.

THE PURPOSE OF SAFETY PERFORMANCE INDICATORS

The purpose of indicators is to become tools, to be used as input values in the context of the safety management system. Because of the complex nature of the safety, which involves external as well as internal both intangible factors and measurable parameters, there are many aspects which cannot be expressed through objective, easily measurable indicators. Performance indicators are linked to a reference values or policy targets, illustrating how far the SMS is from the desired level. Safety performance indicators are used in all phases of the management loop for further purposes:

- to supply the information on safety problems in order to enable policy-makers to value their seriousness,
- to support the policy development and priority setting, by identifying key factors that cause(s) risk,
- to develop action plans and means for implementation and
- to monitor the effects of policy responses.

To make the indicators an effective instrument supporting decision-making in the area of the safety improvement of, a process must be established leading from the definition of the indicators themselves. The term "indicators" is used to mean observable measures that should meet the following criteria:

- to be easy to understand and policy-relevant,
- to be normative (possibility to compare to a baseline situation),
- to be scientifically sound and statistically valid,
- to be responsive to change in time and space,
- to be technically feasible and cost-efficient in terms of data collection,
- to be useable for scenarios for future projections,
- to allow the comparison between the organizations, communities and states and
- to be user-driven.

From the perspective of industry, safety performance indicators can be used to assess whether they are implementing the appropriate chemical safety programs and policies, and to help determine the extent to which such programs and policies are making a difference. In addition, performance indicators can identify whether there is an appropriate emphasis on different aspects of the safety management and help set priorities for future investment of resources. Safety performance indicators can even provide an "early warning" of potential safety problems.

THE DEVELOPMENT OF SAFETY PERFORMANCE INDICATORS

There are various systems of safety performance indicators intended for use in the safety stakeholder's triangle, *e.g.* industry, public authorities and communities at local and national levels [2-5]. Types and number of indicators vary from case to case, ranging from ten(th) to several hundreds. The huge number of indicators cannot be effectively used for the safety system performance evaluation, and each company needs to develop its own indicator system using some relevant framework. In that respect, we used the approach to the environmental performance evaluation recommended by the international standard ISO 14031 [6], which enables the development of the well-structured performance indicators for the description of overall performance of the safety management system. This standard describes two general categories of indicators: (1) environmental performance indicators (EPIs), and (2) environmental condition (status) indicators (ECIs). There are, also, two types of EPIs: management performance indicators (MPIs) and operational performance indicators (OPIs).

If we transpose this concept to the safety management system evaluation we can define, by analogy, tree types of indicators:

- **Management performance indicators (MPIs)** - provide the information about the management efforts to improve the organization('s) safety performance,
- **Operational performance indicators (OPIs)** - provide the information about the safety performance of the organization technical operations and
- **Safety status indicators (SSIs)** - provide the information about accidents, incidents and near-misses, as well as about their consequences.

Management performance indicators should provide the information on the organization capability and efforts in managing matters such as legal requirements, resource allocation, the cost of safety mana-

gement, the development of safety procedures, documentation, training, *etc.*

For example, headline MPIs of company and its installations can include:

- number of accident and near-misses notifications/reports,
- number of programs and projects on preventive actions,
- number of safety inspections and verifications (internal/external),
- number of safety meetings, trainings and audits (internal/external),
- number of emergency preparedness programs,
- trends in public information, awareness and trust,
- communication system development-telephonic, computer and radio hardware,
- measures for the protection of possible endangered people (warning, sheltering, evacuation, personal protective equipment, decontamination, medical treatment) and
- addressing the information needs of the public and the news media.

Operational performance indicators can include:

- number of components malfunctions and damages,
- number of hazardous substances accidental leakages,
- quantity of spilled/burned substances,
- maintenance hours / operation hour,
- number of delays on maintenance of critical components and
- number of non-authorized access to facilities and sabotages.

Safety status indicators (notified or assessed) can include the following information:

- number of deaths,
- number of poisoned/number of hospitalized,
- number of evacuated persons,
- killed animals (t),
- contaminated land (ha) and
- economic losses (mil. Euro).

CONCLUSIONS

The development of the Safety Management Systems in the chemical industry is a powerful tool for the prevention of and the effective response to chemical accidents. The key element is that the top management of the company knows what the status of

chemical risk management system is. The status of a SMS can be described by a set of safety performance indicators. In this paper we proposed the use of tree types of safety indicators:

- safety management performance indicators,
- operational performance indicators and
- safety status indicators.

On the basis of these types of indicators it is possible to develop the system of performance indicators on hierarchical basis, by branching off headline indicators in respect to particular topics, subtopics and categories.

Recent study has shown that the enforcement of safety regulations on major chemical accidents control in Serbia have not been satisfactory, mainly due to lack of awareness and weak management in the industry [7]. The proposed system and framework for safety performance indicators can support the efforts to improve the safety management in chemical Industry, particularly in respect of the current process of transposing of the "Seveso II" Directive in Serbian legislation.

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