QUANTITATIVE DECISION-MAKING BASED ON SAFETY INFORMATION MANAGEMENT SYSTEM IN CHEMICAL PLANTS

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Abstract

Various valuable information scattered all over CPI (Chemical Process Industry) needs to be integrated and retrieved efficiently to manage technique, facility and personnel. This paper focuses on a new decision-making methodology of safety-related investment and management of main causes for accidents and failures. The methodology integrates safety technology, process data and business information in a chemical industry. This methodology suggests a quantitative investment procedure to reduce safety accidents and plant failure cases within limited budget efficiently. Major factors are considered as accident history, human error, facility, service, operation, maintenance, emergency plan, priority of investment, effectiveness of improvement, environmental concerns, loss control and cost. We propose the implementation of a safety information system as ySIMS (Yonsei Safety Information System) to integrate process data and business information in industry. Opposed to conventional AIChE practice that suggests guidelines of safety standards and composes database of historical incident, this methodology proposes a quantitative investment decision-making procedure to reduce safety accidents and plant failures on the budget. We analyze 55 hundreds real accident data and reduce real accidents more than 60% for one and a half year from a petrochemical industry.

Keywords

Decision-making methodology, Quantitative investment procedure, Safety information System, ySIMS.

Introduction

A chemical plant have to keep safety management methods that ensure risk of fire, explosion and toxic material release which is very important in saving life and property. The right decision-making for improving safety in chemical plants requires more quantitative and systematic methods of analyzing previous accident records, process data and business information. This quantitative method needs to be extended to the whole decision-making procedure to prevent major accidents and to reduce the risk of a plant.

The initial design effort includes the prediction of potential hazards. Numerous types of hazard analysis methods have been proposed and used. Hazard analysis methods are classified by qualitatively and quantitatively. The qualitative methods include Checklist, What-If Analysis, FMEA (Failure Modes and Effects Analysis), PHA (Preliminary Hazards Analysis), and HAZOP (Hazard and Operability) Study. The quantitative methods include ETA (Event Tree Analysis), FTA (Fault Tree Analysis), Fire and Explosion Analysis, CA (Consequence Analysis) and SMV (Symbolic Model Verification) [Yoon, Lee and Moon (2000)].

Various computer technologies that have a major impact on chemical and process plant risk assessment are expert systems combined with computerized plant databases. The expert systems are assisting plant operational and safety personnel with situation diagnosis, spill evaluation, safety management, risk assessment and other related functions [CCPS (1994)]. Advanced computer applications are being considered by using incident database concepts. Many database systems on process incidents have been established for use as a process safety management tool. A basic principle of incident database systems in chemical plants is to learn by analyzing mistakes. To achieve this requires the reporting of incidents and the sharing of information.

These methods are systematic approaches for determining whether failures or changes in the process equipment or procedures result in undesirable process events such as fatalities, injuries and environmental damage [Greenberg and Cramer (1991)]. But these hazard analysis and management methods consider each information on safety, technology and plant, but they do not integrate all of them. Besides, most hazard analysis methods cannot suggest counterplan by considering budget, process and business interruption. The safety management method can identify the potential hazard, analyze the human error, suggest the priority of investment, manage the enterprise information and supply the counterplan to safety managers within limited budget systematically [Grimaldi and Somonds (1984), Petersen (1998)].

This paper describes a new decision-making methodology of safety management to classify structured and unstructured data of all information, and integrates all safety information for reducing risk in chemical plants economically and systematically [Yoon, Lee and Moon (2000)]. This work illustrates a new quantitative methodology of supporting decision-making while investing facility and service with human knowledge, safety history, process and business information [Yoon, Oh and Moon (2001)]. The methodology suggests the priority of investment relevant to safety within limited budget, so most possible hazards can be removed or the company may not invest money for the acceptable hazards depending on the budget. The new methodology is performed to reduce risk significantly.

Computer-Based Management System for Safety

Various computer technologies that have a major impact on chemical and process plant risk assessment are expert systems combined with computerized plant databases. The expert systems are assisting plant operational and safety personnel with situation diagnosis, spill evaluation, crisis management risk assessment and other related functions by Center for Chemical Process Safety (1994). The benefits of these expert systems include wider distribution of expertise within the organization, improved decision-making, and enhanced performance of personnel and equipment.

Risk assessment and crisis management are fertile fields for the application of expert systems. Expert systems are well suited for providing knowledge to operators of process and chemical plants. The knowledge of the expert is thus made available to many individuals at many locations, at any time positions. Expert systems are used to evaluate intangible or qualitative factors that are used in quantitative risk assessment programs such as probabilistic risk assessment. Risk assessment methods also identify the points at which human failure could be most serious and thus identify areas in which expert systems should be developed and applied.

Advanced computer applications are being considered by using incident database concepts. Many database systems on process incidents have been established for use as a process safety management tool. But most of the database systems have been developed by regulatory agencies or by national laboratories. To achieve this requires the reporting of incidents and the sharing of information. Keltz (1998) can compile incident data and information to determine the trend in safety performance as below.

- Incident reporting
- Incident investigation
- Incident data
- Incident case histories

Most of the incident database systems address major events of failures such as leak of toxic materials, major fire or explosion. They also address incidents causing fatalities or serious injuries. The historical incident data sources address major events or failures such as:

- Leaks or toxic materials
- Major fires or explosions
- Pipeline leaks and ruptures
- Transportation accidents
- Accidents causing fatalities or serious injuries
- Near misses with potential for serious consequence

Safety Decision-Making Procedure

A framework for viewing management information systems is essential if an organization is to plan effectively and make sensible allocation of resources to information systems tasks [Gorry and Morton (1971)]. A framework is needed to provide a more efficient allocation of resource in safety information. This study describes two types of information of enterprise as structured and nonstructured by safety, process and business information as shown in Fig. 1. This study suggests the procedure, development and information management of safety decision-making methodology in two different information areas [Yoon, Min and Moon (2001)]. A framework is suggested for decision-making by using model structure and implementation procedure which differs sharply between the structured and nonstructured information area.

	Safety	Process	Business
Structured	MSDS Regulation Policy	P&ID PFD SOP	Department Personal Facility Ware house
Nonstructured	Accidents Measure Risk Accident History Causes Analysis	Technical Reports MOC History Recipe	Cost Strategy Planning Investment Priority

Figure 1. Framework of safety information management system.

CCPS (Center for Chemical Process Safety) (1998) in AIChE presents effective taxonomy of safety data for reliability analysis as shown in Fig. 2.

The basic building blocks for the reliability analysis fall into two main classes. One is the data regarding specific events occurring in a piece of equipment. The other is the data describing the sample space of equipment. Event data in the first class is used as a numerator in the reliability calculation and inventory data in the latter class is used as the denominator.

Classification of safety accident is important while collecting safety information, so we classified it as accident results, direct and indirect causes of accident, primary causes, process status, utilities, departments etc. Significance and operating variables also affect the business strategy in chemical site.

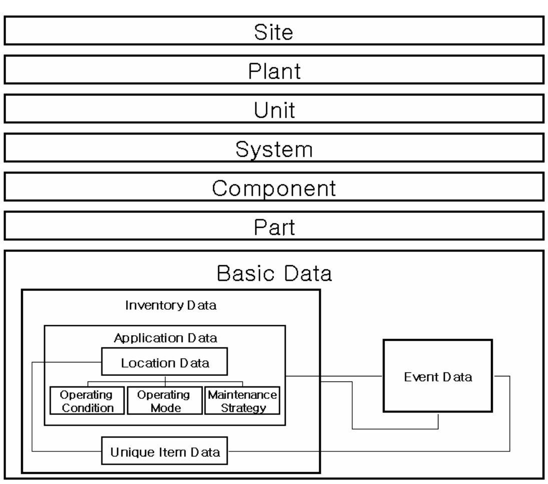

Figure 2. Database taxonomy and structure.

This study describes an overall systematic decision-making procedure of preventing or minimizing safety accident under the given budget as shown in Fig. 3. To decide the investment of safety related facility, two inputs are required: 1) the priority of investment and 2) the criteria of investment. To list up the priority of investment requires analyzing plant accident data and process data with the general safety information by using matrix computation method that we propose. To set up the criteria of investment requires surveying business-level executives regarding acceptable safety damage such as casualty, cost loss and business interruption.

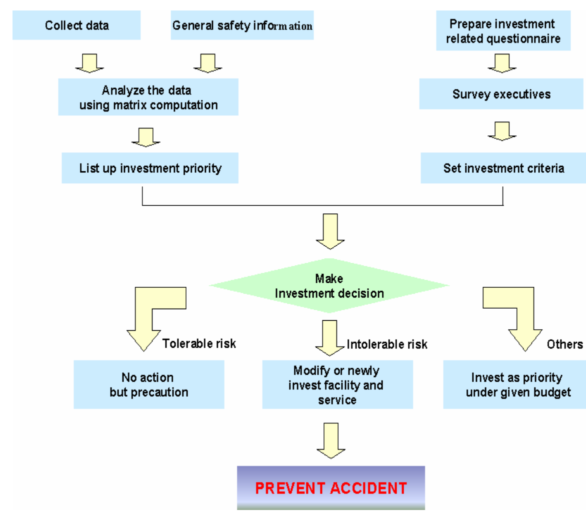

Figure 3. Safety related business decision-making procedure.

Based on the above two preparations such as the priority and the criteria, the decision is made according to the three risk probability regions: 1) definitely tolerable risk region, 2) definitely intolerable risk region and 3) other region in between the two. If the risk of a hazard is tolerable, the company does not need to invest any money into the relevant event and, in many cases, just careful attention is necessary. If the risk is definitely intolerable, the company must invest money to modify the process or purchase new facility and related service regardless of the budget if the plant needs to be run continuously. If the risk is between definitely tolerable and intolerable region, the investment is negotiable with the given budget that is, the investment to each event is selected by the priority under the condition that the given budget allows. As following this decision procedure, the company invests money only to necessary facility and service for preventing safety accident under the given budget.

Safety Information Management System

We developed ySIMS (Yonsei Safety Information Management System) which is composed of 5 major subsystems for human knowledge, safety history, process and business information. Thousands of actual data were classified and the classification was found to be similar to Heinrich's 1 : 29 : 300 theorem, which proved that near miss was directly related to the cause of real accidents

[Yoon, Kwon, Kang and Moon (2000)]. We collected 5,500 accident data for one and a half year including more than 60 accident cause factors. When this system applied to the company, the number of accidents of serious class A and B was significantly reduced in 6 months after the systematically chosen investment by 70% and 62% that was from 33 to 10 and from 122 to 47 respectively.

ySIMS manages safety, plant and business information and it integrates all the information with a decision support procedure for various problems. This approach enables to decide priority and criteria of investment for safety related facility and to maintain records for future use. ySIMS is the improved version of database system and data warehouse as in Fig. 4.

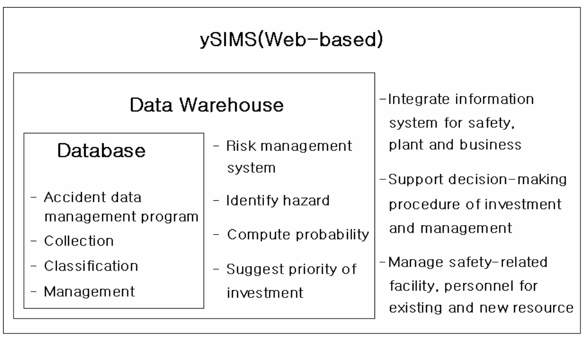

Figure 4. Development history of database, data warehouse and web-based system for ySIMS.

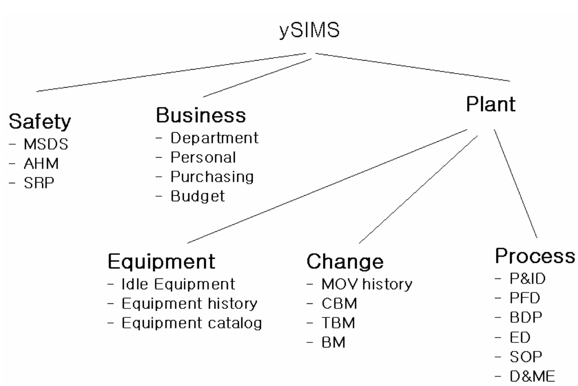

Figure 5. Hierarchy of web-based system.

The ySIMS includes five major systems such as TIM (Technical Information Management) system, HIM (Hazard Information Management) system, PIM (Plant Information Management) system, MCM (Maintenance of Change Management) system and BIM (Business Information Management) system of integrating for safety, process and business. Each major system includes several sub-databases as in Fig. 5. For example, the TIM system includes databases of P&ID (Piping and Instrumentation Diagram), SOP (Standard of Procedure), BDP (Basic Design Package) and ED (equipment data). HIM system includes database of MSDS (Material Safety Data Sheet), AHM (Accident History Measurement), AM (Accident Measurement) and SRP (Safety Regulation & Policy).

Conclusion

The aim of this study is to integrate safety, process and business information and to prevent major accidents in chemical industry. This paper proposes a new quantitative decision-making procedure for suggesting final investments and integrating of safety, plant, technology and business information. It supports safety managers and executives for their decision-making procedure in investing new resources. After applying the procedure and software ySIMS, a Korean petrochemical company reduced safety accidents by approximately 65 % with information manage and investment in one and a half year.

The result of this work is 1) to prevent safety damage, injury, financial loss and business interruption, 2) to construct a digital database of including enterprise information, 3) to reestablish a safety management system and 4) finally to accomplish the new methodology of safety decision-making procedure.

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