

# Design of HSE Management Information System for Chemical Enterprises

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In this paper, the author designs the HSE management information system for chemical enterprises. The author takes the HSE management as a systematic project and takes into account the actual needs of Chinese chemical enterprises and designs and implements a HSE system that is more in line with the actual business for chemical enterprises in China. The HSE management information system designed in this paper can fully meet the characteristics of chemical enterprises in China and has achieved good results. HSP management system is an advanced management system which can effectively improve the internal management efficiency and management capabilities of chemical enterprises in China.

## 1. Introduction

In HSE management system, H refers to health, that is the physical and mental health of employees with no physical or mental illness; S refers to safety, that is, to ensure that in the process of labor production, employees' physical and mental health and safety will not be damaged and enterprise property will not suffer losses. This requires enterprises to continuously improve their working conditions and identify and improve unsafe factors; and E refers to environment, which is the sum of all kinds of natural and social environments and will have an impact on human production activities and living. In the actual work, the above three are inseparable, especially in the actual production and management of chemical enterprises, health, safety and the environment are influencing each other, so health (H), safety (S) and environment (E) must be incorporated in the internal management of modern industrial enterprises form a unified whole and jointly construct a management system, namely HSE management system. As the construction of the HSE management information system of China's chemical enterprises is still in its infancy, in this paper, the author focuses on the design and implementation of the HSE management information system for chemical enterprises and takes building of the HSE management information system for chemical enterprise as the research purpose, so as to ensure the implementation of the regulations of the chemical enterprises. Through the HSE management information system, the author aims to improve the corporate image of chemical enterprises and prevent the occurrence of safety and environmental incidents.

## 2. Literature review

HSE is the abbreviation of Health, Safety and the environment management system. The HSE management system is an organic whole that organizes organizations, responsibilities, practices, procedures, processes and resources to organize and implement health, safety and environmental management. These elements are in the advanced, scientific and systematic mode of operation. The integration of machine and ground is interrelated and interactive, forming a dynamic management system. Qiu and Xu said in the research that the system was first proposed by internationally renowned petrochemical enterprises (Qiu and Xu, 2015). Xie and others pointed out that in January 1996, the SC6 sub-committee of ISO/TC67 issued ISO/CD14690 "health, safety and environmental management system for oil and gas industries", and in February 2001 Sinopec group issued the China Petrochemical Corp safety, environment and health (HSE) management system, the standard of Health (HSE) management, safety, environment and health (HSE) management standard of oil

refining and chemical enterprises, construction enterprise safety, environment and health (HSE) management standard, etc., have formed the system standard of HSE management system (Xie et al., 2015).

Since 1980s, the United States DuPont chemicals company has set up and perfected the HSE management system as an important measure to realize the business strategy, especially the health and safety (Suleiman and Svendsen, 2015). DuPont Co believes that all industrial accidents should be attributed to management errors. The DuPont Co attributed the factors that cause danger and injury to three elements: the design of equipment, the harm of materials and human behaviour. For the design defects of the equipment and the harm of the material, the company is solved through the management and scientific design and research, and the individual's safety behaviour is analysed from the perspective of risk management. DuPont Co's outstanding experience in management has three main aspects. First, establish the safety principle of the company. Put safety at the level of business strategy to consider that "safety is our tradition and security reassuring us". The basic principle is that all occupational injuries and occupational diseases are preventable. This is a realistic goal rather than a theoretical goal. Second, the cause of all the accidents is management. From the perspective of management, we should reflect on all the unsafe factors from the perspective of management and use the advanced nature of management to eliminate the possibility of all accidents. The personal safety behaviour of DuPont Co is also analysed from the perspective of management. It believes that the condition of employment is that every employee must bear the responsibility of safety, and the main purpose of training safety training as a basic requirement for safety is to make the operator understand and not be afraid of the company, rather dismiss the illegal employees and not be willing to attend their funeral. Third, equipped with advanced emergency measures. Their main experience is not only a set of two types of chain and alarm systems, but also a complete system of experience, prevention, maintenance and system management. In the United States, the first batch of systems that are first implemented include the EDMS (Electronic Document Management System) to meet the requirements of OSHA 1910.119 and industrial SO 9000 (Sabzyan et al., 2015). Later, the requirements of the annual SARA 313 report led the chemical company to implement the environmental information system. Each place uses self-developed systems to compile environmental data. Headquarters needs a lot of effort to consolidate all the information to meet the requirements of the July 1st reporting period. Under such circumstances, the major companies soon realized the need for a unified enterprise wide information system (Yang et al., 2014). In recent years, several major chemical companies have merged with other chemical companies. Therefore, international chemical companies should standardize and integrate business processes and chemical systems to achieve cost savings. Bowling and others pointed out that the integration of HSE information system is at the forefront of such integration. The practice of the international chemical company over the past twenty years shows that the centralized management and unified standard HSE system has become the development trend of this field and the goal of the integration of large oil companies. Bowling believes that after nearly 20 years, the international chemical company has paid a high cost from decentralized system construction to centralized management (Bowling et al., 2015). Internationally, HSE applications have gradually formed a system. Most of the software is designed for environmental, health, and security issues based on the management ideas of workers 509000 and 5014000. HSE solutions revolve around risk management and compliance management, enabling business personnel and managers at all levels to reduce the risk of all links on the value chain and to comply with all kinds of laws, regulations and systems (Mills et al., 2014). An important trend of HSE business management is to integrate HSE into every business link. HSE application software embodies this idea well. The functions and processes of each module of HSE are integrated with the functions and processes of ERP. Some software simply uses HSE as a module of ERP, which is integrated seamlessly with the core ERP modules such as human resource module, material module, factory maintenance module and so on. For example, the function of SAPo HSE becomes a few links of the whole business process (Sa et al., 2014). Even if the HSE package is used as a single software package, it also provides an open interface to accept data from each module of the ERP, such as equipment maintenance records, training records, etc., or to send data to ERP modules, such as maintenance work orders, training plans, and so on.

Workflow is widely used in HSE application software. It automatically triggers related task notifications by the system and sends relevant personnel through modern means of communication, such as E-mail, so that all kinds of regulations and systems can be better observed and improve work efficiency. Mobile phone short message, GPRS, PDA and other technologies are also used in HSE software, such as the announcement of accident notification (as auxiliary) through mobile phone SMS, and GPRS collection of equipment status, emission data, etc. through PDA. To sum up, the above research work mainly studies the overall development trend of HSE information, the information application level of all HSE services and the characteristics of HSE system deployment, but the design and research of the HSE management information system for chemical enterprises is very few. Therefore, based on the above research status, this paper focuses on the design of HSE management information system in chemical enterprises. Through a variety of regular and standardized management activities to achieve health, safety and environmental management objectives, the purpose is to

guide the organization to establish and maintain a required health, safety and environmental management system, and then improve the level of health, safety and environment management.

### 3. Methodology

HSE information system is developed on the basis of the software Essential. It is a typical 3-layer architecture, which makes each level of functions and logic clear and the upper layer only needs to understand the details of the adjacent B/S, which greatly reduces the degree of coupling between layers. From Figure 1, we can clearly see how the main components communicate with each other:

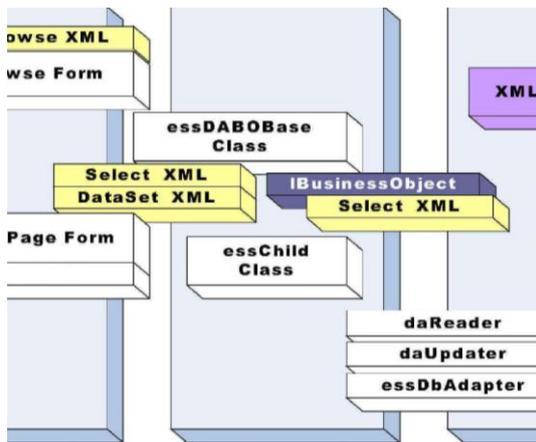


Figure 1: Layers of Components

The system mainly has 3 layers: view page presentation layer, business logic layer, data access layer. The view layer calls the business layer to implement the specific business process, while the business layer calls the corresponding data layer to complete the query update operation of the background table. In this way, the entire system business process is divided into a clear 3-layer structure, the front end mainly serves as the page display work, the middle business layer mainly implements all the logic required for the page and the backend data access layer is mainly concerned about the realization of the background table access operation. This not only improves the intelligibility of the system, but also reduces the degree of coupling between the system's three-tier structure, which contributes to the modularization of system development, facilitates the collaborative work of developers and facilitates the subsequent functional expansion of the system and reduces the difficulty and workload of future maintenance systems.

#### 3.1 Data access layer

The data access layer is used to implement all typical data processing activities, including data acquisition, modification, updates and database internal triggers, stored procedures and other related activities, thereby separating data services from other components of the application.

The data access layer of HSE information system implements a general database access technology based on the .NET platform. This technology is based on ADO.NET and component technology and provides dedicated access classes for various mainstream databases (such as Oracle, SQL server, etc.). And it supports for common data sources, achieves fast and concise database access and support cross-platform database systems, simplifies the deployment and development of database application software, and significantly improves software development efficiency. In order to be flexible in programming and to facilitate the modification of the code, a convenient way to access the database is to use XML (extensible markup language) to construct a SQL sentence and to re-parse XML at the data access layer to obtain the desired SQL sentence. Since the entire process is clear, there is no need to care about the differences in SQL sentences between various databases. Since XML is created using text, the entire file is easy to create or modify, and more importantly, the changes do not have to be recompiled after the modification is complete. Figure 2 shows the main class diagram of the data access layer.

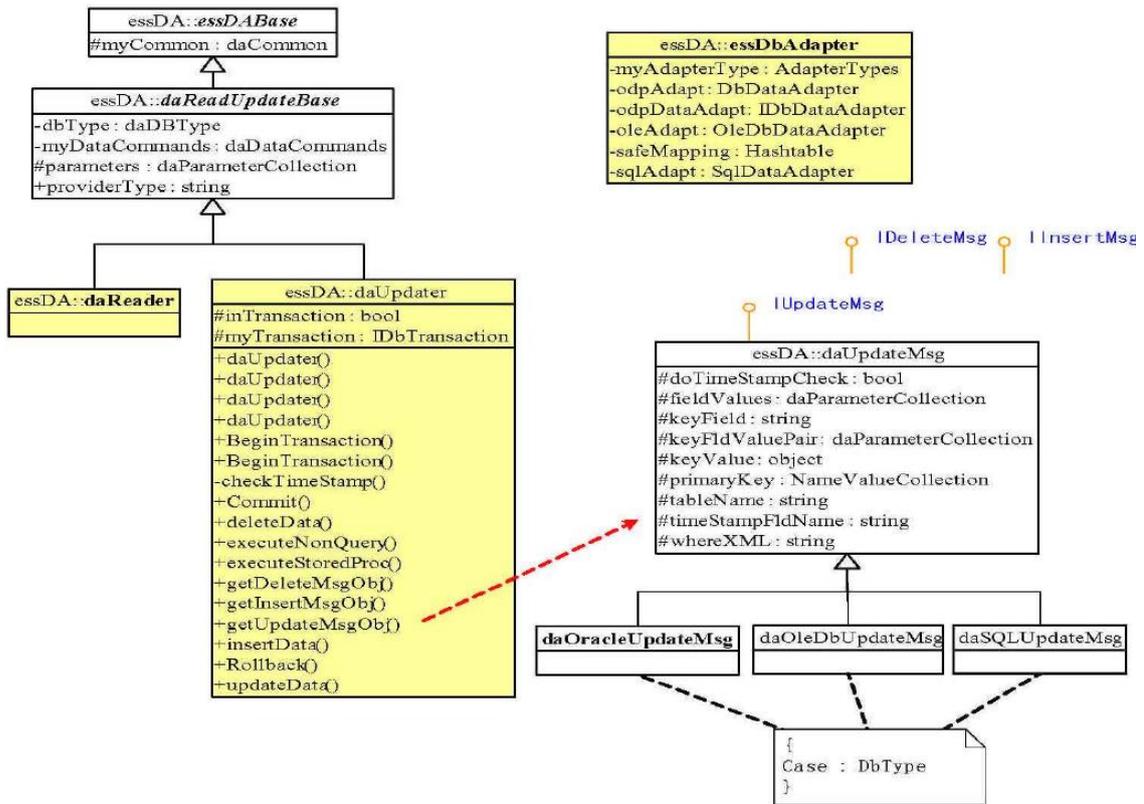


Figure 2: Data access layer class diagram

essDABase: Declare an object of data access parser of type. Through this parser, the file analysis can be completed.

daReadUpdateBase: Initialize the command set of the related database, obtain the type of the target database and obtain the daDataCommands database statement of the corresponding database to complete the parsing of XML.

daUpdater: control database transactions, perform the corresponding database operations, mainly delete, insert and update operations; specific daReader class to achieve select operation. In the daUpdater, three interfaces (IDeleteMsg, IInsertMsg, IUpdateMsg) are defined and corresponding database operations for different databases are defined in each interface.

### 3.2 Transaction layer

Transaction layer is the application logic layer or application server, which is often referred to as the middle layer. Business logic layer is equivalent to the ontology of the application program. It contains the logic related to the core business rules. That is, the specific business processing logic is logically programmed into the program. It is the “bridge” that connects the presentation layer and the data layer. It can perform certain business rules in response to requests sent by users. Transaction layer is the most important part of an application. Transaction layer is mainly responsible for the data processing functions of the entire program. For ease of maintenance, a large number of base classes are designed for use here. When designing a program, it only needs to derive a new class from the corresponding base class, implement the methods defined in the parent class in the new class and assign a property defined in a class, which makes it simple to implement a more complex function. In terms of data processing, XML is used as a temporary repository for data storage. It is only necessary to create data sets based on the fields of the database (the data set is derived from the DataSet for the purpose of quickly building the DataSet framework) and then set data sets in BO to complete the data storage and access capabilities.

### 3.3 Presentation layer

Presentation layer is the part that is directly displayed to clients in the application and is sometimes referred to as the client interface layer by clients. Presentation layer can realize the dialogue between the user and the

back-end business layer, provide the interface and is also used to collect data and display data after processing, it is a bridge to connect clients and systems.

Presentation layer is mainly responsible for the front-end display of the Web program. The system repackages Microsoft's server controls here. It only needs to drag the control onto the page and then sets the corresponding fields in the data set in the DataSource. Set the page base class as the base class provided by the ESS framework and then write the derived class of BO created by the logic program to the program. The page can be automatically bound during the loading process, without writing any Code, drop-down control will automatically bind a data set and automatically select the data set in the database. The operation of the program to manipulate the database is basically only four operations: query, add, delete and modify. The system sets up a separate page for the query. It only needs to set XML query path and title in the URL. The page will display all the data in the database in a unified style. According to the field retrieval data, page turning, sorting and other functions are automatically implemented, it only needs to write and provide parameters. Figure 3 shows the interaction diagram of the 3-layer main components.

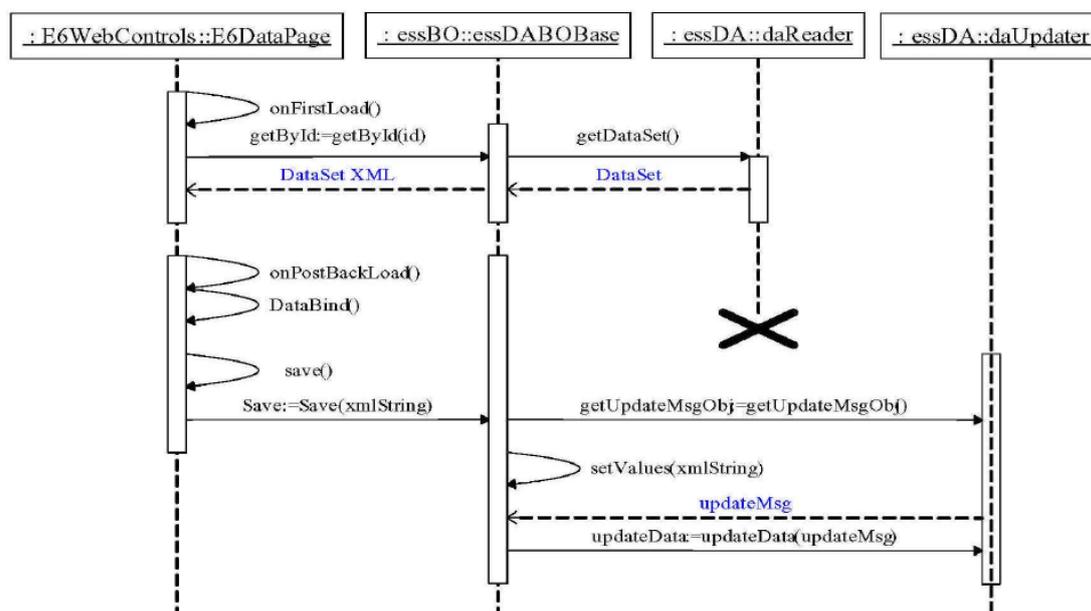


Figure 3: Interactive time series of the three main layers of components

### 3.4 Other related systems

Because the management in the grass-roots units and basic production activities are highly integrated and inseparable, HSE information system and ERP system have a great deal of cross-information. Some software vendors use information systems as one or several modules of ERP system. Most chemical enterprises do not have a complete system, which will greatly increase the difficulty of building an information system.

In view of the fact that the ERP has not been implemented currently, the input function of the above interface information is specifically established in HSE information system to meet the needs of business management, including departments, personnel, materials, equipment accounting, etc., so as to ensure that in the absence of ERP or other application systems, it does not affect the normal implementation and application of HSE information system.

## 4. Results and discussions

Since 2008, on-site implementation has been carried out in 5 pilot companies (1 oilfield company, 2 refinery companies and 2 sales companies) in different sectors. In addition, through centralized training, guidance has been given to key system users of nearly 100 other non-pilot subordinate enterprises. All module development and pilot implementation has now been completed. Through the use of the system, pilot companies have promoted the standardization and institutionalization of HSE information management, enabled leaders and management departments at all levels to dynamically understand the status of HSE management, provided information support for supervision and management, reduced management costs and achieved good results.

Nearly 100 other non-pilot enterprises have reported "results" data through the HSE system for non-pilot enterprises. So far, the Safety and Environmental Protection Bureau of Sinopec can timely browse HSE information of all enterprises in the upper, middle and lower levels through the HSE system at the headquarters level and can comprehensively learn about the current status of HSE management in Sinopec and can perform statistical analysis on these data. Deep excavation provides a scientific and rational basis for headquarters leaders and improves the management efficiency and decision-making ability.

## 5. Conclusions

HSE is a management system that is very suitable for chemical enterprises. Chemical enterprises in China are actively constructing HSE systems suitable for the characteristics of their business and organizational structure. Sinopec has completed the design of the "Sinopec HSE Management System" and has the conditions for application and comprehensive promotion. The HSE management information system for chemical enterprises designed in this paper has good adaptability and practicality and can effectively improve the management efficiency and management level of China's chemical enterprises. In the next stage, it should continue to improve the performance of HSE management system, mainly in the following aspects: the application of advanced statistical methods and management models, to achieve deep processing of module data, so that the scientific added value of HSE management information system can be further improved; mining the correlation between different professional module data to discover the intrinsic logic correlation; better meeting the actual needs of chemical enterprise production site; combining HSE management system with mobile terminal and develop handheld terminals supporting the system.

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