

Research and Implementation of Safety Assessment Software for Chemical Plant

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This paper studied the design and implementation of safety assessment software for chemical plant. The common safety assessment methods and accident consequence models are analysed, and the research idea and design scheme of safety assessment with computer technology are determined. Then a set of assessment software has been developed using Visual Basic 6.0 Database Access technology, including document management module, assessment method module, accident prediction module, occupational health module and system help module. Visual Chm software is used to prepare legal and regulatory documents. This file can be called at any time for reference of relevant standard and norms during assessment, which provides standard support for the preparation of safety checklist. Therefore, the assessment software developed in this paper can quantitatively assess risks of petrochemical production, storage and other plants, featuring engineering value.

1. Introduction

With the development of the petrochemical industry, a large number of dangerous chemicals such as flammable, explosive, toxic, harmful and corrosive continue to emerge. They appear in the fields of production, processing, handling, storage, transportation and operation as raw materials for industrial production or products (Ammara et al., 2016). The hazardous nature of chemicals poses a significant threat to production and human livelihoods (Xu et al., 2016). Many world-striking major accidents such as fires, explosions and leakage of toxic substances occurred in the late 1970s (Shen et al., 2016). It is critical to identify the dangerous and harmful threats and take effective measures to ensure safe production of petrochemical enterprises (Oudejans et al., 2016). Subject to major accidents such as fires, explosions and leakage of toxic substances in petrochemical enterprises, this paper analyses and compares the characteristics and interrelationships of various assessment methods and summarizes the impact of key parameters in accident consequence model on the accident consequence (Kavak et al., 2016). Using object-oriented programming and database technology, the safety assessment system is programmed and developed including database management module, assessment method module, accident prediction module and occupational health module etc. (Nasad et al., 2016). This application software can be widely used in the pre-assessment of enterprise security, the comprehensive assessment of the status quo and the simulation of accident consequences, which makes the assessment easier (Nikolsky et al., 2016).

2. Methods

2.1 Consequence model of leakage of toxic substances

(1) Accident mechanism

Break of toxic substance tanks or leakage of pipelines can cause poisoning in certain areas if the dispersed air mass diffuses into the surrounding space (Oliveira et al., 2016).

(2) Classification of leakage sources

1) Continuous leakage source, referring to long time continuous leakage of materials through small holes, such as reactors, tanks, pipe holes or valves, flanges, pumps and other seal failure (Taran et al., 2016).

2) Instantaneous source of leakage, referring to long time continuous leakage of large number of materials through large holes in short time, such as break of large pipelines or rupture disk, explosion of reactors due to over-pressure, causing instantaneous leakage of large number of materials (Imaeda et al., 2016).

(3) Atmospheric stability and diffusion coefficient

The modified Pasquill - Turner (PT) stability classification method is adopted for classification of atmospheric stability (Pang et al., 2016). According to the actual situation in our country, the P-T stability classification is modified and the atmospheric stability is divided into six categories: Strongly Unstable, Unstable, Weakly Unstable, Neutral, Weakly Stable and Stable, denoted by A, B, C, D, E, and F respectively (Table 1) (Ammara, et al., 2016).

Table 1: Atmospheric stability level

Ground speed(m/s)	Strong solar	Medium solar	Weak solar	Cloudy	Low cloud	Cloud cover
<2	A	A-B	B	D		
2≤~<3	A-B	B	C	D	E	F
3≤~<5	B	B-C	C	D	D	E
5≤~<6	C	C-D	D	D	D	D
≥6	C	D	D	D	D	D

2.2 Occupational Health assessment model

When there are several environmental hazards in the workshop, section and department of the project, the composite index is used as the health assessment index (Zhang, et al., 2016).

(1) Composite index

$$I = \sqrt{(P_i)_{\max}} \sum (P_i) / N \quad (1)$$

where I is the composite index.

$(P_i)_{\max}$ - The maximum individual index (the maximum of the individual index for each test point) (Xenos et al., 2016); $\sum(p_i)$ - The sum of the individual index of each item (Chen et al., 2016);

N- The number of concurrent monitored items (Li et al., 2016).

(2) Comprehensive health assessment level (Table 2):

Table 2: Comprehensive health assessment level

General index	Health classification	General occupational health standard
<1.0	I	qualified
1.0-1.2	II	basically qualified
1.2-1.5	III	deadline governance
>1.5	IV	unqualified

The diffusion coefficient is calculated in two ways: one is the statistical theory, and the Taylor formula is used to determine the diffusion parameters (Zhang et al., 2016). The other is the empirical formula obtained through the diffusion test of large t (Sun et al., 2016). Pasquill classifies atmospheric diffusivity into six (A-E6) stability categories based on conventional meteorological data such as cloud t, cloudiness, solar radiation and surface wind speed (Yilmaz et al., 2017).

3. System software design

3.1 Programming language

Visual Basic language has become one of the popular programming languages in recent years. The Visual Basic system "encapsulates" the complexity of Windows programming in a very clever way, using a combination of Basic language and new visual design tools, designing the application through graphic objects. Visual Basic is one of the computer languages which adopt the event-driven programming. Event-driven is a kind of programming method suitable for Graphical User Interface (GUI). When designing the program by the event-driven method, the programmer do not have to write each step that is executed in order, but just write the program for the user's action, such as selecting the command button, dragging the mouse, clicking an icon etc. Based on the above advantages, Visual Basic language is adopted as the development platform.

3.2 System structure design

This software is designed modular. Each module has a function for a specific task. The modules are independent of each other. This design idea facilitates program debugging and expansion.

Document management module

The document management module includes the modules of legal standards related to safety production, the module of hazardous characteristic parameters of hazardous chemicals and the assessment result module.

Assessment method module

The assessment method module includes the risk assessment method, Dow Chemical Method (Edition 7) and the Mond Fire, Explosion and Toxicity Index. During the assessment process, the physicochemical properties and basic data used in various methods are called from the Hazard Property Database. The assessment results are stored in the assessment result database in the form of tables. The assessment method interface provides a mapping function. The report of assessment result mapping data can be called from the database for compare and summary.

Accident prediction module

The fire, explosion and poisoning accident model was selected to calculate the accident consequence parameters and the damage scope via analysis of fire, explosion and poison leakage accidents and in compliance with the relevant norms and standards at home and abroad. The accident prediction module includes pool fire model, boiling liquid expanding vapor explosion (BLEVE) model, steam cloud explosion model and leakage of toxic substances model. The drawing function of software is used in the design of accident prediction module, so as to draw the curve of influence of certain parameters on the accident consequence, and dynamic trend of the accident consequence following the parameters.

Occupational health assessment module

The occupational health assessment module is used to assess whether the occupational hazards of the workplace can meet the occupational health standard.

3.3 Realization of software

The realization of software has four steps:

(1) Entry information

Enter the relevant data through the user interface to enter the database relationship table.

(2) Processing

The program automatically collects relevant data and information according to the ideas and structure of the assessment hierarchy, and organizes the calculation. Part of the processed data is displayed as an intermediate result on the screen, and the other data is stored as an assessment result in the database relation table.

(3) Store

Exchange and store input information and processing results.

(4) Results

Display the assessment content. The user can view the assessment results through the program, or view the unit's assessment results by drawing the crystal reports. Figure 1 shows the flow chart of the realization of function.

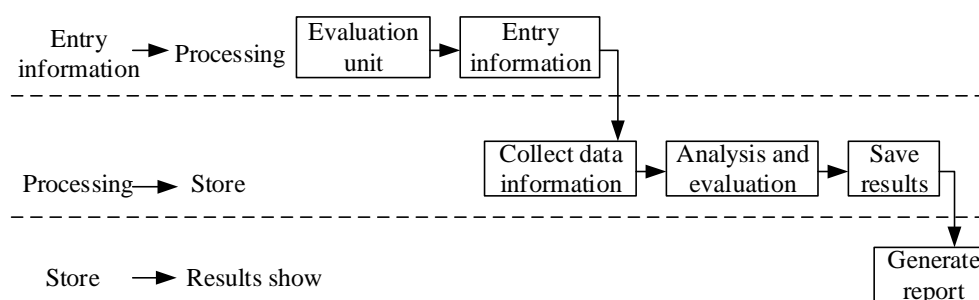


Figure 1: Flow chart of the realization of function

4. Realization of function

4.1 Assessment method module

The risk assessment method is selected. Figure 2 shows the flow chart of risk assessment method.

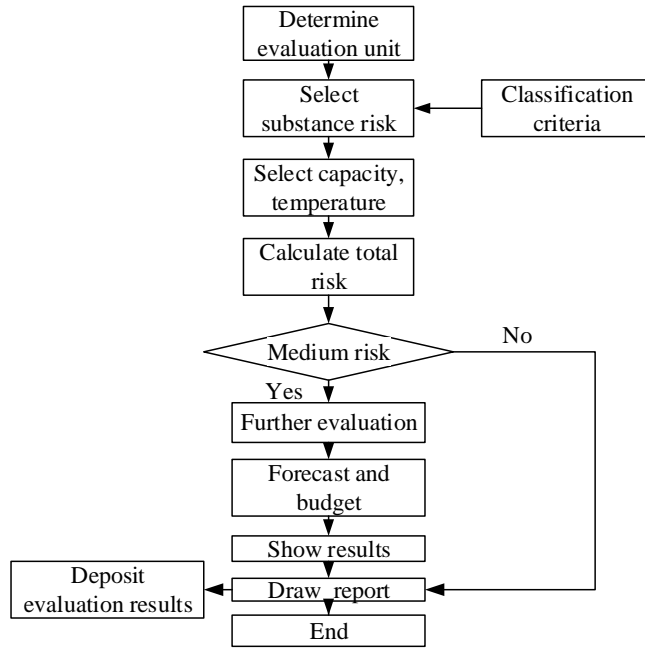


Figure 2: Flow chart of risk assessment method

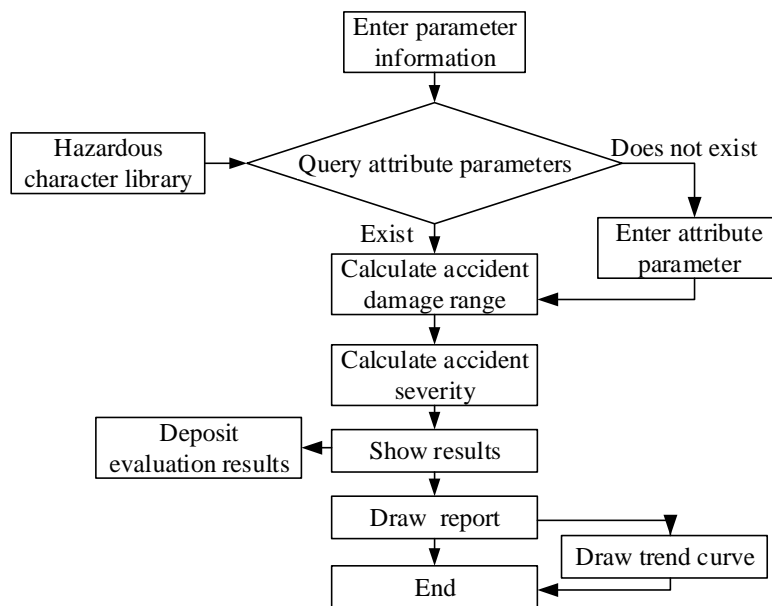


Figure 3: Realization of accident consequence analysis

4.2 Accident prediction module

The accident prediction module provides three kinds of consequence models: fire, explosion and leakage of toxic substance. The fire model includes two kinds of accident models: pool fire model and boiling liquid expanding vapor explosion (BLEVE) model. The four models provided by the program have similar calculation flow (Figure 3).

4.3 Occupational health assessment module

The occupational health assessment module provides a method for evaluating whether occupational hazards such as dust, poisons and noise in workplaces are in compliance with national health standards. There are similarities between the assessment of individual occupational hazards and multiple occupational hazards. Figure 4 shows the flow chart of occupational health assessment.

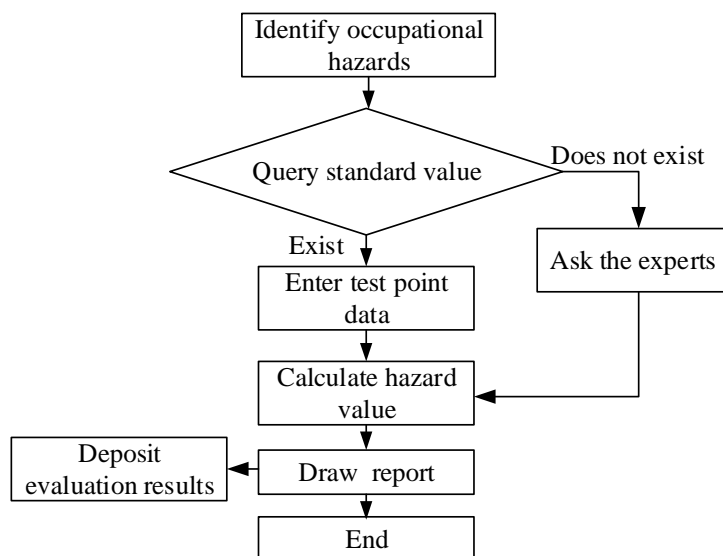


Figure 4: Flow chart of occupational health assessment

5. Conclusion

In this study, Access database technology was used to establish a database of hazardous substances parameters. The program provides the functions of querying, modifying, adding and deleting of the database etc. More than 30 latest related standards and norms on the safety production of petrochemical enterprises were collected. Visual Chm software is used to prepare legal and regulatory documents. This file can be called at any time for reference of relevant standard and norms during assessment, which provides standard support for the preparation of safety checklist. A set of assessment software has been developed using Visual Basic 6.0 Database Access technology, including document management module, assessment method module, accident prediction module, occupational health module and system help module. The drawing function of Visual Basic is used in the design of accident prediction module, so as to draw the curve of trend of the accident consequence following the parameters. Finally, the flow charts of main modules of the chemical plant safety assessment software are given.

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