CHEMICAL ENGINEERING TRANSACTIONS
VOL. 66, 2018
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet
Guest Editors: Songying Zhao, Yougang Sun, Ye Zhou

ISBN 978-88-95608-63-1; **ISSN** 2283-9216
DOI: 10.3303/CET1866170

Study on Intelligent Emergency Management Information System for Petroleum and Petrochemical Enterprises

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This study analyzes the emergency management informationization, explores the current problems of emergency management and the direction of future development, and specifically proposes the construction content and construction plan of the intelligent emergency management information system for petroleum and petrochemical enterprises, which mainly consist of four modules, including on-site monitoring, emergency plan, alarm and command, emergency response, and the corresponding sub-modules. It expounds the emergency response plan when the accident happens, which provides a reference for the construction of an intelligent emergency management information system for petroleum and petrochemical enterprises.

1. Introduction

Emergency management is gradually strengthened in the researches on the reduction of accidents on personnel, property and environment. For example, the United States established FEMA (Federal Emergency Management Agency) in 1979 to form a comprehensive emergency management system based on risk, covering all areas of disaster prevention, protection, response, recovery and disaster reduction (Comfort et al., 2016; Washington, 2015). China's “13th Five-Year Plan” for production safety and previous State Administration of Work Safety have clearly pointed out the acceleration of the construction of the emergency response platform, emphasizing scientific and safety rescue to avoid casualties caused by blind rescue. In 2018, Ministry of Emergency Management was established, giving a strong impetus for exploring China's integrated emergency management model. Scholars from Europe (Cenci et al., 2016), Japan (Kinoshita et al., 2012), and Australia (Paschen and Beilin, 2016) have conducted in-depth studies on risk assessment, response capabilities, and disaster recovery capabilities in the field of emergency management.

According to statistics on 592 accidents in a large-scale petrochemical enterprise in China from 2000 to 2016. Fire and explosion poisoning and suffocation accidents account for 38% of the deaths caused by accidents. Compared with accidents in direct operations, once a fire and explosion accident occurs, it has the characteristics of great difficulty in emergency rescue, wide spread and serious damage. Therefore, it is necessary to strengthen the emergency management of petroleum and petrochemical enterprises, so as to reduce the impact of accidents, especially the emergency management of fire and explosion and poisoning and suffocation accidents. When encountering emergency accident, the psychological and mental errors in emergency response may aggravate the serious degree of consequences. At the same time, emergency rescue personnel urgently need to know how to deal with the accident in the state of emergency. If the emergency plan is embedded in the emergency management information system, in the event of an accident, the emergency management information system can pop up the processing flow of the emergency plan in real time, automatically trigger and direct the personnel to set up the correct plan, thereby greatly improving the accuracy and efficiency of the emergency management. Therefore, the use of information technology can greatly improve the level of emergency management.

Please cite this article as: Kong X., Zhao D., 2018, Study on intelligent emergency management information system for petroleum and petrochemical enterprises, Chemical Engineering Transactions, 66, 1015-1020 DOI:10.3303/CET1866170

2. Emergency Management Information Development Status

2.1 Emergency management urgently needs the strong support of informationization

It often exists two aspects of problems in the emergency management of enterprises and informationization can better solve these problems.

(1) Unstandardized emergency plan and unstreamlined emergency response.

Petroleum and petrochemical enterprises lack specialization and less effectiveness in the formulation of emergency plans. There are no specific emergency plans for different equipment and facilities. The plans are out of step with the actual situation of accidents. The emergency response fails to make full use of the advantages of informationization, thus cannot automatically complete the integration of information.

(2) The allocation of emergency resources is scattered and out of order, thus cannot be deployed in real time.

In emergency resource allocation, the resources of some enterprises are too scattered and out of order, which makes it difficult to understand the detailed information of emergency resources from a timely and accurate perspective, thus the resources cannot be deployed in real-time for an emergent accident (Wang and Gao, 2012).

2.2 Practices of emergency management informationization of international petroleum and petrochemical enterprises

Due to the greater inherent risks in the petroleum and petrochemical industry, large international oil and petrochemical enterprises have built their own emergency management informationization plans in the field of emergency management. The emergency command system constructed by Dow Chemical Company realizes real-time video monitoring in key areas, and has the functions of gas concentration detection, alarm point positioning and accident simulation. BP uses virtual reality technology to help emergency teams to better understand the situations they may face. BASF establishes a three-level emergency response mechanism: the first level is consultation, wherein the protection advice is given after receiving reports of chemical leakage; the second level is guidance, wherein engineers and eco experts are sent to the scene to provide professional guidance; the third level is rescue, wherein the professional firefighters and environmental protection engineers conduct on-site rescue.

2.3 Development direction of emergency management informatization

(1) Alarm information integration

The enterprise hazard warning information, production anomaly information, toxic and flammable gas monitoring and early warning information shall be comprehensively integrated to achieve centralized abnormality monitoring. The monitoring, response and disposal functions shall cover daily / emergency events in firefighting, security, production and environment.

(2) Automatic emergency disposal

According to the emergency plans embedded in the emergency management information system in advance, once the alarm information reaches the level of emergency response, it automatically sends operation instructions to the corresponding personnel according to the emergency plan, and greatly improves the accuracy and timeliness of the command.

(3) Scientific emergency decision

Visualization of accident site, equipment state, rescue force, emergency resources, and disposal progress shall be realized. By means of intelligent prediction and simulation of accident consequence, the development trend and influence of accident shall be deduced, thus providing basis for decision analysis (Hess et al., 2014).

3. System Architecture Module

3.1 Main content of intelligent emergency management information system construction

(1) According to the risk identified by the risk management and control module, digital control of the emergency plan is realized.

(2) In combination with the exception management module, the alarm information of key equipment and facilities is integrated, automatically triggering the alarm notification.

(3) Emergency response is initiated in accordance with the emergency plan, automatically sending emergency plan instructions.

(4) According to the alarm site, video surveillance, toxic and hazardous gas monitoring, equipment operating conditions, and emergency supplies management system are automatically invoked.

3.2 Module construction

Emergency management information system can be considered dividing into four major modules, including on-

site monitoring, emergency plan, alarm and command, and emergency response, wherein on-site monitoring provide services for the other three modules. The specific module is constructed as shown in Figure 1.

On-site monitoring	Video surveillance	Gas monitoring	Equipment operation	Emergency resources
Emergency plan	Comprehensive plan	Special plan	On-site disposal plan	Emergency drill
Alarm and command	Abnormal events	Abnormal alarm reception	Event grading	Emergency preparation
Emergency response	Plan initiation	Emergency command	Accident dynamic report	Emergency recovery

Figure 1: Module construction plan

4. On-site monitoring

After a production safety incident occurs, the site is monitored in real time through informational means to provide information support for emergency disposal.
Retrieve real-time images;
Monitor and detect the leakage and spread of toxic and hazardous gases on site;
Monitor the operating conditions of key equipment and facilities;
Pay attention to the inventory of emergency supplies.
It implements centralized monitoring and alarm of fire alarm, toxic gas detection, flammable gas detection, process abnormality, perimeter alarm and other abnormal information, and sends the alarm to relevant regulatory authorities synchronously, so that the related departments shall cooperate to supervise and dispose the abnormality once occurs. The monitoring and early warning plan is shown in Figure 2.

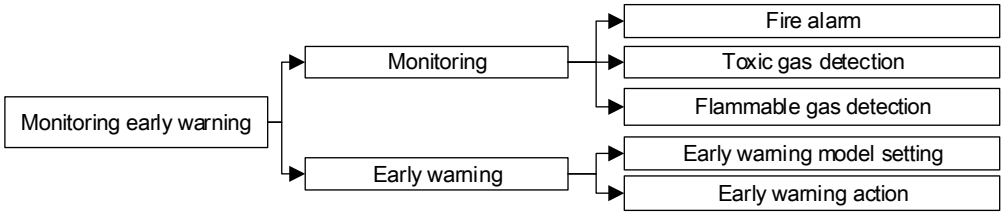

Figure 2: Monitoring and early warning plan

Integrating enterprise automatic fire alarm system to obtain various alarm signals such as temperature, smoke, and flame detectors in real time, and to correlate these signals with the area/plant/device where the equipment is located for real-time alarming.
Integrating the enterprise toxic gas detection system or real-time database to obtain signals such as concentration and distribution of various toxic gases in real time, and to correlate these signals with the area/plant/device where the equipment is located for real-time alarming.
Integrating the enterprise flammable gas detection system or real-time database to obtain real-time signals of various flammable gas concentrations, distributions, etc., and to correlate these signals with the area/plant/device where the equipment is located for real-time alarming.
Setting monitoring thresholds for various monitoring data of fires, toxic and flammable gases, and process abnormalities and grading the early-warning levels according to the management requirements and business needs, which are combined together into an early-warning model.
Setting the actions after triggering the early warning. The system automatically pops up the warning information, then early warning area is highlighted, then on-duty computer buzzes and then the information is displayed on the big screen.

5. Emergency plan

According to the risk identified by the risk management and control module, digital control of the emergency plan is realized.

①Strengthening the rationality of preparation of the plan. Improve the daily management function of emergency plan in the existing information system, including preparation, review, publication and filing of emergency plan.
②Improving the actual operability of the plan. Digitize and structure the plan to support scenario construction of major risk emergency plans and card-based management of on-site disposal plan and support accurate delivery of emergency instructions.
(1) Classification of emergency plan
(a) Comprehensive plan
Realize the compilation, evaluation, publicity and issuance of comprehensive plans at all levels, establish the business process for releasing and updating the plans, and support the scenario construction.
(b) Special plan
Combine with the characteristics of the production of enterprises to realize the compilation, revision, and training of special plans.
(c) On-site disposal plan
Implement on-site disposal plan training, structure the card-based and emergency responsibilities in accordance with the position, and support the accurate delivery of emergency instructions. The emphasis of emergency plan digitization is the field disposal plan.
(2) Emergency plan module function
(a) The emergency plan is modeled to support the automatic sending of emergency instructions.
A structured template of emergency plans for the enterprise's major risks is provided. Each of the rescue contents includes emergency procedure, responsible post, responsible person, contact telephone number, and emergency supplies.
(b) Emergency plan management process is established for major risks.
Based on the enterprise's major security risks, the expert team of the plan are organized and registered for compilation of the plan, which will be inset into the emergency management informationization system by the major risk contractor after the audit.

6. Alarm and command

Through the functions of alarm, event grading, and emergency preparation, the procedures and responsibilities of the alarm and command are clarified so as to reduce the response time, realizing efficient and quick disposal of the emergency. By deploying the alarm module of the exception management, the alarm information is acquired at the first time, so that the alarm can be quickly and effectively received and the emergency response ability can be improved.
(a) Abnormal alarm reception: After an abnormal event alarm occurs, the person on duty will be automatically matched according to the alarm condition, the responsible person will be notified by one- key for the confirming and registering the alarm condition, and the notifications will be sent to the on-duty person and the related responsible person and dynamically shown on the display or other terminals based on the GIS.
(b) Event grading: In accordance with the risk identification result of the equipment and facility, the risk database of the equipment and facility and the alarm grading model are established. After the alarm condition information is confirmed, the alarm condition grading is automatically carried out to provide support for alarming grading. The system supports the automatic grading of alarm conditions, such as red, orange and yellow grades.
(c) Emergency preparation: Emergency preparation in emergency management information system mainly refers to emergency notification, personnel preparation, preparation of rescue vehicles and equipment.
Abnormal alarm reception consists of three sub-modules, including alarm reception, alarm identification and grading and emergency notification, which achieve rapid and effective alarm reception and improves emergency response capabilities. Abnormal alarm reception plan is as shown in Figure 3.

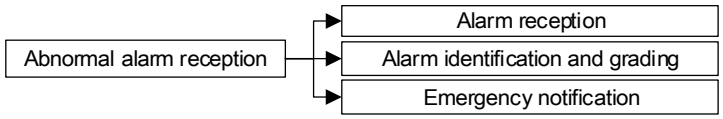

Figure 3: Abnormal alarm reception plan

Alarm recording, alarm information recording, voice text conversion, display of alarm sites on the map, video linkage of alarm sites. The person on duty is automatically matched according to the alarm condition, and the responsible person will be notified by one- key for the confirming and registering the alarm condition.
Establishing the alarm condition grading model, so that after the alarm information is confirmed, the alarm

condition grading is carried out automatically.
Contact group management, SMS editing, one-key notification (telephone voice message notification, SMS notification, and emergency broadcast notification), information reception, and telephone answering statistics.

7. Emergency response

Emergency response is the corresponding emergency strategies taken for the abnormal situations based on the enterprise's process operating parameters, materials online analysis data, equipment operating parameters and other abnormal conditions. The emergency response process is as shown in Figure 4.

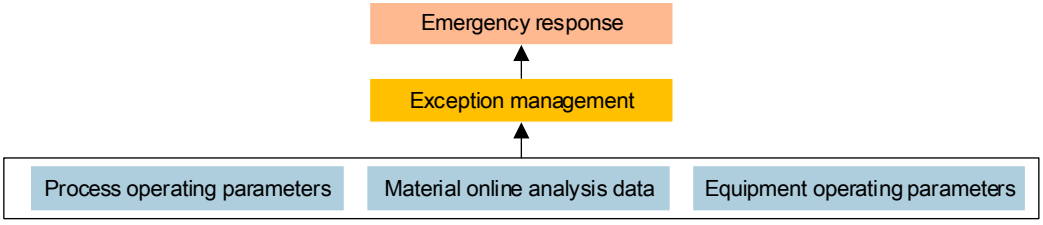

Figure 4: Process of emergency response

(1) Plan initiation
Based on a structured and visualized emergency response plan, the emergency plan is initiated through SMS and voice messages according to the judgment on the alarm conditions. Disposal flow, task assignments, emergency resource allocation and other instructions are issued automatically to achieve clearer and more efficient distribution of emergency disposal flows and responsibilities.
(2) Emergency command
Through instruction tracking, it realizes real-time knowledge of on-site emergency treatment progress, which dynamically provides data source and basis for accidents. It includes the on-site emergency instructions for the on-site information based on the completion of the instructions fed back by the personnel that are handling the accident, and emergency disposal according to the completion of the instructions fed back from the site, as well as the professional disposal progress of comprehensive firefighting, process and equipment
(3) Accident dynamic report
The system publishes the accident dynamics in real time for all parties to inquire and browse.
(a) Accident dynamics: The system automatically releases the accident dynamics in real time according to the alarm condition judgment, instruction tracking, on-site voice and video data.
(b) One-key reporting: The enterprise provides a system report template to realize one-key report to the managers of the enterprise at all levels.
(4) Emergency recovery
Emergency recovery refers to the fact that the disaster-bearing body such as personnel, property and environment is restored to the state before the accident after being affected by the accident.
The emergency rescue linkage platform for petroleum and petrochemical enterprises realizes the dynamic management of the location and status of emergency resources of enterprises at all levels. The system provides functions such as information entry, browsing, joint defense area division, event reporting, accident positioning, search of various emergency resources, emergency resource scheduling. When an enterprise has a major accident and needs assistance from other enterprises, the emergency resources within the joint defense area can be rapidly deployed according to the emergency resources required by the accident and the predetermined joint defense area, so that rescue can be effectively carried out. Linkage disposal plan is as shown in Figure 5.

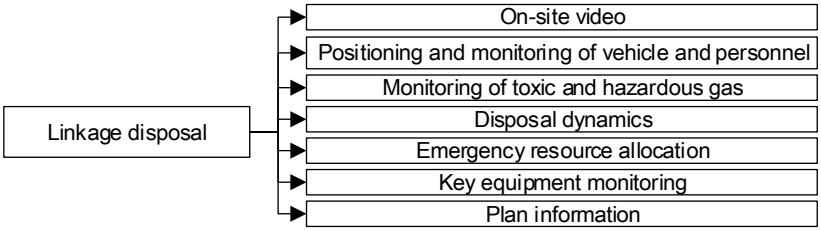

Figure 5: Linkage disposal plan

Managing the enterprise video through tree structure, and positioning and displaying the video around the accident site.
Developing the location data receiving interface to display the positioning information of firefighting vehicles, emergency command vehicles, and rescue personnel on the map, and display vehicle running trajectories in real time.
Developing poisonous and flammable gas monitoring data receiving interfaces for real-time display.
Summarizing the situation of firefighting vehicles and rescue teams in the process of accident disposal, collecting pictures, live audios and others on site, to formulate a dynamic progress report, for scrolling display on terminal devices or on screens.
The query, display and dispatch of key emergency resources on the map, with autonomous updating and marking of information such as emergency supplies storage site, hazardous product warehouse, tank area, oil depot, plant area and risk area.
Integrating the existing key equipment monitoring system pages of the enterprise for centralized display.
Implementing the information processing of the plan for scrolling display on the terminal devices or screens.

8. Conclusions

The establishment of an intelligent emergency management information system for petroleum and petrochemical enterprises is of great significance in enhancing the interconnection of emergency information and eliminating information islands. It can improve the accuracy and efficiency of response to emergency events and effectively reduce the occurrence of secondary and derivative accidents, and reduce the adverse social impact caused by emergencies, thus enhancing the corporate image.

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