



2017 8th International Conference on Fire Science and Fire Protection Engineering
(on the Development of Performance-based Fire Code)

Firefighting Emergency Capability Evaluation on Crude Oil Tank Farm

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Abstract

Firefighting emergency capabilities absorb more and more attention due to the sharp expansion of crude oil tank scale and frequent accidents of tank fire. An emergency capability evaluation model was developed towards crude oil tank farm based on the data of crude oil tank fire accidents and the concept of layers of protection analysis (LOPA). The model consists of four first-grade-index, fifteen second-grade-index, and fifty-eight third-grade-index. The analytic hierarchy process (AHP) was used to achieve the weight of each index at the different levels. The fuzzy evaluation was integrated to construct the emergency capability evaluation model. The model was validated in a petrochemical plant to identify the weaknesses of firefighting emergency system of the tank farm, and the countermeasures were provided based on the results to minimize the risks of the tank farm.

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Peer-review under responsibility of the organizing committee of ICFSFPE 2017.

Keywords: firefighting, tank farm, emergency capability, layer of protection analysis

1. Introduction

With the rapid development of the chemical industry, the demand for petrochemical products increases dramatically. The oil depot's scale has expanded dramatically compared with ten years ago. The crude oil tank farm has been drawn attention because of its serious consequence of fire or explosion. On July 16, 2005, a powerful fire and explosion devastated the tank farm of Dalian Petrochemical Company, which revealed the weakness of firefighting emergency capabilities in the tank farm. Firefighting emergency system in a tank farm plays a vital role in dealing with the fire and explosion, which will escalate the scale of the accident if the system loses out of control.

A total of 242 cases of tank accident were analyzed statistically between 1960 and 2003. The fire and explosion accounted for about 85% totally [1]. The LASTFARE project team examined the amount of fire from 33, 906 different storage tanks around the world, in which the seal ring fire is the main fire type [2]. The fires of 107 vertical storage tanks above ground during 1951~2003 were statistically analyzed [3]. Lightning is the main cause of fire for vertical storage tanks, which accounted for about 60%. According to the analysis of large and medium-sized oil depot fire in the world, causes of fire for crude oil tanks are improper operation, equipment failure, lightning protection failure, improper maintenance, tank leakage, pipeline leakage, and et. al [4]. According to the evaluation of the emergency response capability of petrochemical enterprises, the emergency system was constructed based on the characteristics and tasks of the emergency rescue of petrochemical enterprises [5]. The index system of fire emergency rescue in an urban community was built, and the validity and feasibility of the model were verified through an example [6]. The FDS software was used to simulate the fire of the

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crude oil storage tanks, and the emergency response capability was evaluated [7]. Some issues related to emergency capability assessment on crude oil storage tank farms are the lack of scientific evaluation criteria, methods, and assessment model.

This paper aims to establish an assessment system of firefighting emergency capability towards crude oil tank farm, which will provide a tool to evaluate the emergency ability of firefighting and to reduce accident losses under emergency.

2. Firefighting emergency capability assessment model of tank farm

The model consisted of three parts: Selecting the system index, determining the weight of the index, and selecting the evaluation method. The details are described as follows.

2.1. Basis of model construction

The key to constructing the model is the selection and classification of indicators, which relate to the comprehensiveness and reliability on the emergency rescue work of the tank farm. The purpose of the LOPA is to determine whether there are sufficient measures of the protective layer to prevent the development of the accident. Thus, the concept of LOPA can be used to analyze the cause of the accident layer by layer. By examining the process of failure of the firefighting emergency measures layer by layer, the purpose is to combine the thought of the protective layer with the firefighting system and emergency management in the tank farm, and then the evaluation index will be established. Therefore, the concept of LOPA is used in this study as the framework to construct an assessment system of firefighting emergency capability towards crude oil tank farm.

By using LOPA concept as the framework, the assessment system was constructed by the accident investigation and statistics, near miss investigation, communication with the employees, guideline comparison, and literature review.

2.2. Content of assessment system

The assessment system of firefighting emergency capability towards crude oil tank farm was established through three levels, which are shown as Figures 1 to 2d.

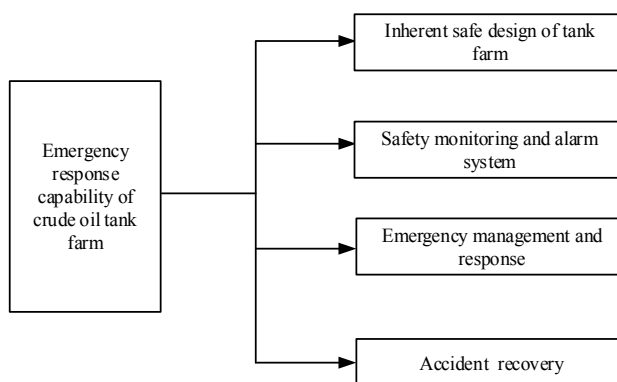


Fig. 1. Indicators of the first level

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