An emergency rescue analysis of a hazardous chemical deflagration accident

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Abstract. The hazardous chemical explosion and combustion accidents have the characteristics of wide scope, high risk, complex situation, and difficult to deal with. After the occurrence of accidents, timely, accurate, and efficient response is an urgent need to protect the safety of people's lives and property. This article takes a hazardous chemical deflagration accident in North China in 2020 as an example. It conducts research from three aspects, including the basic situation of the case, the handling of the explosion accident, the successful experience of handling of the explosion accident. The rapid response and efficient disposal methods of accidents, the enhancement of disaster prevention and disaster relief capabilities, and the formation of a long-term mechanism to ensure the safety of people's lives and property are expounded in this article, in order to provide a reference for similar accident management.

1 Introduction

At least 158 people were killed, more than 6,000 people were injured and 300,000 people were homeless by a deadly explosion at the port of Beirut, the capital of Lebanon, at 18:00 on August 4, 2020. Lebanese Prime Minister Hassan Diab stated that the explosion was caused by the ignition of about 2,750 tons of ammonium nitrate ignited by combustible and explosive materials, which were stored in the port warehouses since 2014 but never had been properly disposed. At approximately 14: 48 on March 21, 2019, the Tianjiayi Chemical Co, Ltd, located in the ecological chemical park of Xiangshui County, Yancheng City, Jiangsu Province, suffered a particularly serious explosion, causing 78 deaths, 76 serious injuries, and 640 hospitalizations, the direct economic loss rise to 1.986 billion yuan. The explosions of hazardous chemicals, such as the explosions in Beirut, Lebanon and Xiangshui, sounded the alarm once again about the control of dangerous chemicals.

Hazardous chemicals refer to highly toxic chemicals and other chemicals which are toxic, corrosive, explosive, combustible, and combustion-supporting, meanwhile, they are harmful to humans, facilities, and the environment. Hazardous chemical explosion accidents have the characteristics of wide scope, complex situation, high casualties, high risk and difficult to deal with [1-5].

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The control of hazardous chemicals is a global problem, and accidents occur frequently due to mismanagement or other reasons. According to incomplete statistics, in the past 30 years, it is as many as 295 serious and typical safety accidents involving hazardous chemicals in China, including 262 explosion accidents, accounting for 88.9%, resulting in heavy property damage and casualties.

A hazardous chemical deflagration accident occurred in North China in 2020, which is the most complicated, highest safety risk and the most difficult to dispose of in the field of hazardous chemical gases at home and abroad recent years. The following takes this accident as an example to discuss the emergency response to this hazardous chemical explosion accident, hereinafter referred to as "North China X explosion accident".

2 Basic situation of the accident

In this article, it analyses the background of the "North China X explosion accident" from various aspects such as the construction and situation of the accident institution, and the situation of explosive materials. The details are as follows:

The accident house was located in a district in North China. It was built of brick and wooden beam structure. There were lights in the house, no one was guarded on site, and no video surveillance equipment.

The site of the accident house was basic farmland, after the accident, a total of 757 gas cylinders of different specifications was cleared out on site. Among them, there was an ethylene oxide 800L tank, two 40OL tanks; three 10OL ethylene oxide gas cylinders; In addition, empty bottles and recycled waste gas cylinders were mainly stored in the house during the incident.

Considering the test results of 100 L ethylene oxide cylinders, combined with the flammable and explosive properties of ethylene oxide (The boiling point of ethylene oxide is 10.7 degrees Celsius, the explosion limit is 3%-100%, and the minimum ignition energy is 0.065 mJ), the expert group tentatively determine that the first explosive combustion material in this accident was the ethylene oxide.

3 The handling of explosion accidents

In this article, it analyses the background of the "North China X explosion accident" from various aspects such as the construction and situation of the accident institution, and the situation of explosive materials. The details are as follows:

1) There were many types of gas cylinders, and the situation was complex and changeable. The person in charge of the enterprise concealed the situation and was unable to provide details of the gas cylinders on site.

2) There were many ways of harm and high safety risks. The cylinder body and safety accessories were damaged after the explosion impact. Once improperly handled, there was a great possibility of instantaneous explosion, fire and poisoning.

3) The disposal was difficult and professional. The accident site was a dangerous explosion area. Special explosion-proof equipment must be used and professional protective clothing must be worn. Gas cylinders must be handled carefully.

4) The social influence was wide and the political influence was great. In the process of eliminating accident hazards, it was bound to affect the normal activities of nearby enterprises, such as production, residents ' lives, and transportation, and affect the safety and stability of the area.

Facing the task of emergency disposal, all party responded quickly, assembled quickly, studied and judged scientifically, and launched the special emergency response plan and on-

site handling work plan for hazardous chemicals immediately. The emergency response to this accident was divided into four stages:

3.1 The first stage: emergency rescue

After the accident, the Municipal Emergency Command Centre immediately mobilized the Municipal Emergency Management Bureau, the Municipal Fire Rescue Teams, the X District Emergency Management Bureau and other institutions, as well as 13 fire trucks to be on the scene for disposal. According to the material characteristics of the gas cylinders and the fire situation, firefighters controlled the spread of the fire to prevent the situation from expanding, and they implemented long-distance water spraying to cool down, avoided explosions, and they isolated the scene to prevent unrelated personnel from approaching.

After the open fire was extinguished urgently, there were still a number of gas cylinders leaking at the scene, a large amount of unknown gas and smoke were produced, and there was a risk of secondary explosion. In order to prevent secondary accidents, the police blocked the roads to the accident site and conducted emergency evacuation of nearby villagers; and the environmental protection department simultaneously monitored the accident site and the surrounding environment in real time; firefighters continued to spray water to cool the gas cylinders to prevent gas and the smoke spread to the surrounding area; the Municipal Emergency Management Bureau mobilized hazardous chemical experts to rush to the scene to participate in the disposal work.

3.2 The second stage: preparation for disposal

Directed rescue and disposal work on the spot, set up an on-site headquarters. The Municipal Emergency Management Bureau communicated with the professional rescue teams and experts, researched and drafted preliminary professional disposal work recommendations, and reported preliminary opinions on emergency handling to the experts on the scene command.

The on-site headquarters fully dispatched all forces, fully studied and judged the situation on the spot, thoroughly studied the emergency response plan according to the accident site, and coordinated all relevant institutions to do a good job of the site. After thorough research, the working idea of "disposing on-site and storing off-site" for gas cylinders was determined, and the tasks and responsibilities of each institution were basically clarified.

The on-site headquarters sent professional technicians and experts into the accident site to investigate and further study and judge the accident. At the same time, they sent unmanned aerial vehicles to take real-time aerial images of the scene to pay attention to changes in the situation on the scene. They organized a work scheduling meeting to re-research and analysis of the scene situation and development situation, listen to the opinions and suggestions of experts from all parties, refine the on-site disposal work plan, expand the professional disposal force, clarify the division of tasks for all parties, reconfirm the necessary emergency material supplies ready in place, once again comb the on-site gas cylinder disposal process, and once again clear on-site emergency response measures.

The on-site headquarters held a meeting to deploy the next stage of on-site disposal work: First, each institution should formulate a detailed work plan based on the division of tasks; second, each institution should fully consider the unexpected situations that may occur at the accident site, and formulate targeted emergency measures. Third, the fire brigade, health committee, public security bureau, traffic management bureau, weather bureau, environmental protection bureau and other relevant departments in district X must arrive at the designated place at the designated time and prepare for the gas cylinder disposal site.

3.3 The third stage: cylinder cleaning

All on-site emergency response personnel and required emergency rescue materials were ready, and all on-site preparations were in place.

The on-site headquarters of the Municipal Emergency Bureau issued an instruction to organize personnel to enter the scene to carry out accident site disposal in accordance with the disposal principle of " safety first, adequate protection, easy first then difficult, classified disposal".

According to the division of responsibilities, the fire rescue team was responsible for on-site emergency command and emergency disposal. The emergency management department and hazardous chemical experts should provide on-site technical support; departments of environmental protection, health, public security, meteorology and more should do a good job of relevant guarantees, and the local governments should do a good job of disposal cooperation and logistical guarantees.

Under the unified command of the on-site headquarters, various departments worked together to clean up a total of 757 gas cylinders of different specifications, with a total volume of 27,000 liters, involving 41 hazardous chemicals such as ethylene oxide and acetylene. Explosive and toxic gases accounted for 68.3%, and other compressed and liquefied gases accounted for 31.7%. The gas cylinders were initially cleaned and classified and placed in safe areas around the site.

Fig. 1. Cylinders cleaned out on site.

3.4 The fourth stage: cylinder disposal

The on-site headquarters held a meeting to deploy the gas cylinder disposal work and put forward the "three point in place" worked requirements of personal protection in place, monitoring and detection in place, and disposal measures in place. On-site disposal personnel adopted the highest level of protection. Peripheral cleaning personnel wore activated carbon masks, safety monitoring personnel in absorption and disposal work wore self-priming gas masks, and X area personnel who participating in the bottle opening test wore air respirators and filter gas masks for safety protection. They entered the site in batches to calibrate and appraise the gas cylinders, found out the bottom number of the gas cylinders on site, mastered the main components of all the gas cylinders, stored the sorted gas cylinders in zones and categories, and disposed of them one by one.

The emergency response sited headquarters coordinated emergency response, fire protection, public security, publicity, environment, meteorology, health, local governments, professional social forces, and industry experts and other resources. A total of more than 30 institutions and more than 2,000 people participated in the on-site disposal. Fifteen hazardous chemical productions and management enterprises and hazardous waste disposal enterprises were mobilized to carry out on-site disposal. The fire rescued departments successively dispatched 19 fire rescue stations, 59 fire trucks, and 352 officers to the scene for disposal.

The public security departments evacuated and resettled more than 500 surrounding people, and the environmental protection departments monitored the environment of the surrounding residential areas. After 6 day and night of intensive and orderly joint disposal work by multiple departments, no secondary accidents occurred during the disposal period, the disposal personnel were in normal health, all the gas cylinders were disposed of, and the on-site emergency disposal work was all over.

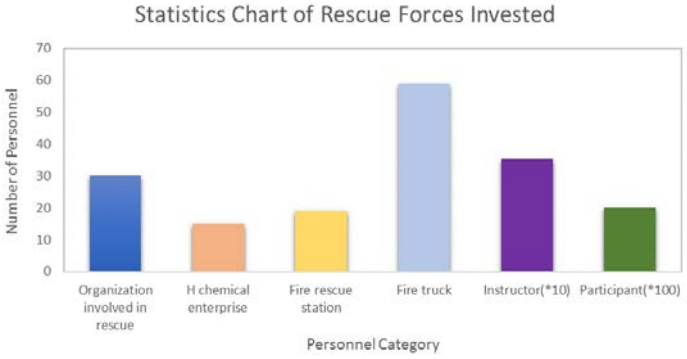

Fig. 2. Statistics chart of rescue forces invested.

4 The Problems and Lessons of the accident

Considering the existing evidence materials and expert opinions, the accident investigation team believes that the direct cause of the accident is mainly due to the following two possibilities: One is that the ethylene oxide gas cylinder has a physical explosion under high temperature conditions, resulting in leakage, burning and explosion when encountering a fire source; second, under high temperature conditions, self-polymerization reaction occurs in the ethylene oxide cylinder and directly explodes. One of the reasons for accelerating the self-polymerization of ethylene oxide may be that the ethylene oxide cylinder is not evacuated or filled with stable gases such as nitrogen, resulting in the mixing of air and other impurities in the ethylene oxide cylinder. The main problems reflected in the accident are as follows.

4.1 The problem of operating beyond the scope of the business license

The involved institution was suspected with the problems such as engaging in hazardous chemical business activities beyond the business method approved by the business license, illegally repackaging, and illegally storing hazardous chemicals.

4.2 The problem of illegal modification of gas cylinders

After conducting extended investigations and surprise inspections of the institution, it discovered that the institution was suspected of illegally modifying gas cylinders, filling non-dedicated gas cylinders with mixed gas, and illegally storing ethylene oxide, etc. problem.

4.3 The problem exposed in the transportation of hazardous chemicals

The institution involved used ordinary vehicles that were not qualified to transport chemical products to transport chemicals for a long time, and distributed hazardous chemicals through logistics units or freight software that was not qualified to transport hazardous chemicals.

4.4 The problem of insufficient supply on critical moments with the low frequency use equipment

Fire and rescue teams are equipped with a certain number of combustible gas detectors, toxic gas detectors and other instruments, but they are used low-frequency, which objectively causes the insufficient situation of the equipment to meet the disposal needs or even cannot be used regularly during an emergency. Relevant departments are not professional enough, their work is not solid enough, and the training and use of equipment in grassroots organizations are lacking. In the case of relative lack of funds, we can consider the establishment of commercial companies to sell various testing ceremonies, and in an emergency, call and purchase directly from commercial companies, so as to be prepared and take precautions.

5 Conclusion

The rescue and disposal work of this accident was a complete success. The specific successful experience includes: the disposal command and dispatching, coordinated and orderly cooperation, professional and scientific disposal, and close cooperation.

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