

## Case analysis of catastrophic underground pipeline gas explosion in Taiwan



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### ABSTRACT

This study is related to underground pipeline gas explosions that occurred in the southern region of Taiwan in July 2014. This disaster, which resulted in substantial numbers of fatalities and injuries in addition to about 6 km of damaged roads, was the largest petroleum catastrophe in Taiwan's history.

Because pipeline gas explosions of such a large extent are rare, the Kaohsiung District Prosecutors Office and Kaohsiung Fire Department launched an investigation in which an author of this paper participated. The aim of this paper is to explore the causes of the explosions, thereby contributing to the prevention of similar cases in the future.

First, the causes of the large explosions are thoroughly investigated. Second, metallographic studies are conducted on the ruptured pipelines. Finally, the results are summarized, and conclusions are drawn.

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### 1. Introduction

A series of underground gas explosions occurred in a busy district of Kaohsiung, Taiwan, on 31 July 2014. Fig. 1 shows the location of the incident and the affected area. The death toll was 32, including 5 firefighters and 2 volunteer firefighters. In addition, 321 people were injured, making this disaster the largest petroleum catastrophe in Taiwan's history. The blasts, which were triggered by underground pipeline gas leaks, split the roads in two and overturned cars and trucks (Fig. 2). The fireballs soared into the sky, and flames reached 15 stories high. Some vehicles and victims were thrown onto the rooftops of buildings several stories high. The gas leak spreads through the sewer system to cause explosions that extended to large areas. In addition, about 6 km of roads were damaged [1,2].

Although many major accidents have occurred in processing industries, gas pipeline explosions over such a large area are rare [3–6]. Although it is common for gas leaks from broken pipelines to result in “point-like” or “linear” blasts, “planar” explosions are rarely seen. A similar case is the April 22, 1992, explosion that occurred in Guadalajara, Mexico's second-largest city. The erosion of oil pipeline enabled large amounts of gasoline vapor to spread through the sewer system. Numerous gasoline explosions occurred in the sewer system and destroyed 8 km of streets in the downtown area. This large gas explosion was the first to occur in a metropolitan city. Officially, 206 people were killed, and nearly were 500 injured [7,8].

It is imperative to investigate the causes of this type of accident. Therefore, the Kaohsiung District Prosecutors Office conducted investigations into the causes of the Taiwan pipeline explosions together with the Kaohsiung City Fire Department with the cooperation of the Metal Industries Research & Development Center, a professional organization related to pipe materials. With reference to the indictment issued by the Kaohsiung District Prosecutors Office [9], the investigation report from the Kaohsiung Fire Department [10], and the report from the Metal Industries Research & Development Center [11], the present study investigates the causes of the explosions with the aim of preventing similar catastrophes in the future.

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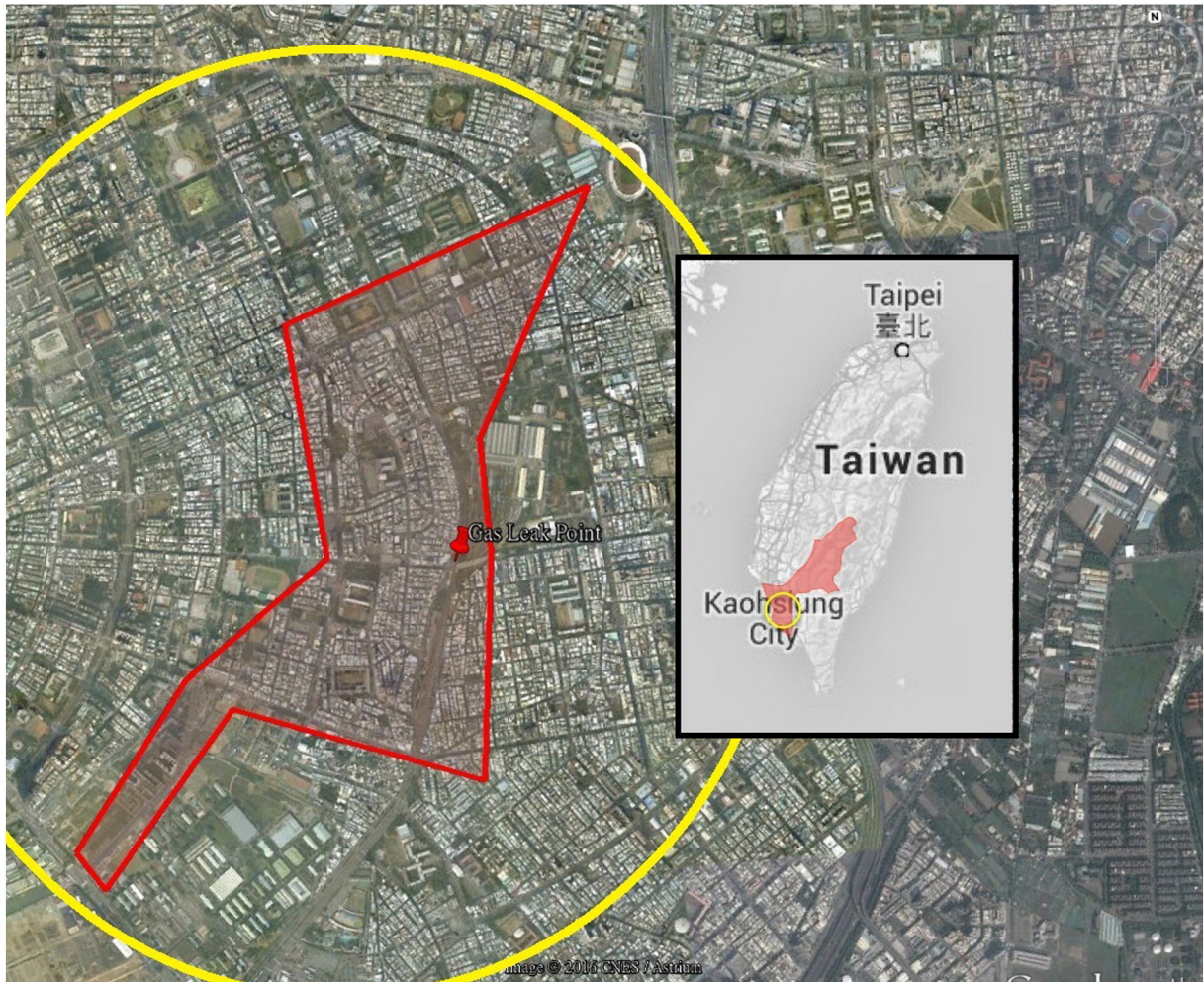


Fig. 1. Location of the incident and the affected area.

## 2. Gas explosion events

On July 31, 2014, prior to the explosions, the odor of gas was noted, and white smoke was seen emitting from manholes near Kaisyuan 3rd Road and Ersheng 1st Road in Cianjhen District. Residents near the scene reported the odd odor to the Kaohsiung Fire Department at 20:46 China Standard Time. Firefighters arrived on the scene and sprayed water on the roads to lower the gas concentration. The commander first conducted preliminary investigations with multi-gas detectors and erected an upwind command post. Firefighters also secured the nearby area to prohibit any heat sources. Considering that light rail works were underway at that locality, it was assumed that certain gas pipelines might have broken during the construction. Later inquiries from the Rapid Transit Systems indicated no such breakage, and the gas corporation made it clear that no natural gas pipelines were installed at that locality. The Kaohsiung Fire Department required the Kaohsiung Public Works Bureau to provide pipeline map data in order to determine the leak source. It was discovered that the underground pipelines belonged to Chinese Petroleum Corp., henceforth referred to as CPC, and China Petrochemical Development Corp., henceforth referred to as CPDC; these pipelines were ruled out as sources of the gas leaks. To meet the demands of the investigations, a special response team known as the Southern Center for Emergency Response of Toxic Substance arrived at the site at 22:33. The team sampled the leaked gas and confirmed the presence of alkenes at 23:50. At 23:55, CPC reported that one of the pipelines was owned by LCY Chemical Corp., henceforth referred to as LCY. The explosions occurred along Kaisyuan Road 1 min later at 23:56.

## 3. Investigation of the causes of the event

After the gas explosions, the Kaohsiung District Prosecutors Office together with the Kaohsiung Fire Department investigated the causes. Beneath Kaisyuan 3rd Road, 8" vinyl pipelines of CPC, 6" propylene pipelines of CPDC, and 4" propylene pipelines of LCY were discovered, whereas gas pipelines of two other companies were found under adjacent road sections. The Kaohsiung

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