B144 A Chemical Waste Treatment Facility Fire and Explosion

Chin Chin Lim, The Forensic Experts Group, Singapore 577177, SINGAPORE; Michael Ming Kiong Tay, The Forensic Experts Group, Singapore 577177, SINGAPORE; Hui Ying Yvonne Sim, The Forensic Experts Group, Singapore 577177, SINGAPORE*

Learning Overview: After attending this presentation, attendees will be aware that although little information may be available for a case, identifying the key aspects of the case, exploratory analysis, and designing appropriate simulation experiments can turn a case around. This bottom-up approach gathers details and data, extracts information, and applies domain knowledge to obtain answers and insights to questions. Attendees will realize that a single event seldom leads to an incident. The latter is usually triggered by an event, followed by a series or cascade of related confluent events and conditions (i.e., a domino effect).

Impact on the Forensic Science Community: This presentation will impact the forensic science community by sharing the processes behind determining the contributory factors and root cause of the fire and explosion.

Fires and explosions occurring within a chemical waste treatment facility can result in serious injuries and property damage. This case study reconstructs the events leading to a fire and explosions during chemical waste treatment. It highlights the value of conducting simulations to study the behavior of liquids and shares investigative challenges and limitations.

Treatment of a batch of chemical waste in a chemical treatment facility can potentially cause unexpectedly triggered explosions and an intense fire that can potentially spread to an extensive area. This can also cause injuries and destruction of properties within the affected area and lead to significant damage and liability claims. What triggered the fire and explosions? Forensic experts were engaged to investigate their contributory factors and root cause.

A waste treatment company had routinely and uneventfully collected, treated, and incinerated hydrocarbon waste streams. On the day of the incident, the liquid waste was transported to the treatment facility and transferred into smaller containers. As part of the treatment, the employees involved were adding and mixing isopropyl alcohol/water into the waste liquid a short distance from the incinerator area when highly flammable fumes were released, and an explosion and a major fire occurred.

Experts were engaged at a late stage to determine the trigger for the explosion. As part of the work scope, it was also determined that it was necessary to consider whether the mixing process of the waste could have been a trigger. The challenges were not having first-hand information from direct examination of the incident site and not being able to analyze the residual waste remaining at the incident site. The experts were only able to rely on prior investigations conducted at the relevant time by third parties.

These prior investigations found that the waste liquid had been contaminated with isobutene. Based on the chemical composition of the waste mixture obtained, forensic experts conducted simulation experiments on: (1) the behavior of isobutene in the chemical waste mixture; and (2) the mixing process to study the physico-chemical behavior of the resultant liquid, chemical compatibility, and the effect of addition rate.

The findings were instrumental in reconstructing the events and identifying the likely contributory factors and root cause of the incident. A combination of factors was found to trigger the explosion and fires: chemical incompatibility, volatility, temperature differential, mixing in a blending container with a valve open to the atmosphere, displacement of ignitable headspace vapors from the blending container by the added chemical, accelerated addition of the chemical, and proximity to the incinerator. The simulation experiments provided evidence of pressure build-up and ejection of liquids from the container. The ignitable vapors from the liquids likely accumulated on the floor and were drawn through negative pressure to the nearby incinerator, resulting in ignition and flash-back to the containers of waste.

Besides reconstructing the pre-incident events and conditions, the experts proposed a safer approach when encountering out-of-the-ordinary waste so that companies can prevent a reoccurrence and improve their management system.

Fire and Explosion, Forensic Simulation, Chemical Waste Treatment