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Gossman Forensics – Louise Denlinger, David Gossman

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Hydrofluoric Acid – Spills and Exposures

In September, 2012, a plant in Gumi South Korea received a tanker truck loaded with hydrofluoric acid (HF). As workers transferred the acid from the tanker, an accidental leak resulted in a discharge of approximately eight tons of hydrofluoric acid. Five workers were killed and eighteen others at the incident scene were injured. Toxic vapors from the hydrofluoric acid spread across the region and over 4,200 people in the vicinity sought medical treatment from ailments relating to the spill. More than 570 acres of farmland were affected, 9,100 tons of vegetation burned and at least 3,200 livestock experienced health effects or death. The acid corroded at least 1,200 vehicles and approximately eighty other businesses in the area were affected. Losses were reported to be at least $20 million. Six weeks after the incident, many people were still unable to return to their residences due to toxicity levels. Fortunately, this type of incident is uncommon, but it demonstrates the wide-reaching consequences of any chemical spill and especially of an unplanned release of hydrofluoric acid.

White cloud of hydrofluoric acid vapor rising from the Gumi National Industrial Complex

Source: Korea Joongan Daily September 29, 2012

Chemical Spills

In the incident in Gumi South Korea, investigations show that human error and failure to follow safety protocols may have been leading factors. According to the U.S. EPA, equipment failure, inadequate safety procedures and operator error are typical causes of the majority of chemical spills. Equipment failure encompasses much more than what might first come to mind and includes any type of equipment/system malfunction due to engineering, mechanical or design failures and/or when equipment is misused or used outside of its intended purpose.

Inadequate safety procedures or safety analysis/reviews are frequently found to be an issue during an incident investigation. This was the case in the incident in Gumi South Korea for both the workers and first responders. The firefighters who arrived on the scene initially were unaware that the white vapor cloud was due to HF and treated it as though it resulted from fire; adding water to the HF only fueled the reaction. The workers failed to follow safety procedures during the transfer of the HF and

in the use of personal protection equipment. As with many small and large scale spills, improper labeling and/or inadequate warning labels was a factor.

Operator error is a significant factor in a large number of incidents. This is usually due to a lack of training and understanding of the materials, warnings and safety procedures. Many incidents can be prevented by heeding warning signs and providing training in safety and procedures for handling chemicals.

Hydrofluoric Acid Exposure

Hydrofluoric acid (HF) is a liquid inorganic acid solution and is commonly used in laboratories, research and industry. HF is essential in semiconductor and electronic fabrication, mineral processing and glass etching. It is a dangerous acid because it is highly corrosive, capable of dissolving most minerals, metals and some plastics, and highly soluble in water. HF is even able to dissolve glass. When HF comes into contact with water, a violent reaction occurs.

To get a sense of the toxic corrosivity of HF, when 5% of the body surface area of an average adult male comes into direct contact with HF, death can occur. In general, 1% of the body surface area is equivalent to the palm of the hand. Estimates of the lowest lethal concentrations for hydrogen fluoride range from 50-250 ppm for a five minute exposure.

Hydrofluoric acid is a highly toxic, corrosive solution and is readily absorbed into the skin. Dermal contact with low concentrations of HF can be deceptive since pain from exposure may not occur for up to 24 hours after exposure. Skin that is exposed to high concentrations of HF typically will have a rapid occurrence of pain and necrosis. First aid treatment for dermal contact with HF is not limited to washing off the skin and requires treatment with calcium gluconate antidote. Assessing the severity of the dermal exposure with HF based on the skin surface of the burn may result in an improper diagnosis. Upon exposure, the fluorine ions are able to move through the skin easily and penetrate into the deep tissue areas. These fluorine ions are able to reach the bone and bind to the calcium ions in the tissue. The fluoride ion affects tissue integrity and metabolism by liquefaction necrosis, decalcification and destruction of bone, and production of insoluble salts. The acid components will bind to both the calcium and magnesium in the tissue and form insoluble salts. These salts interfere with cellular metabolism and cause cellular death and necrosis.

Exposure to HF isn't limited to large scale spills. Many homeowners and workers use aluminum brighteners and cleaners, rust removers and car and truck wash cleaning products. These products can contain HF and in many cases burns result from inadequate warning labels, improper use, and lack of training and/or use of personal protective equipment. Many of the injuries from HF in the home or workplace may be attributed to improper labeling and lack of signal word labeling, such as "Danger," "Warning," or "Toxic" by either the manufacturer or by the seller's representatives. Labeling can be unclear or omit the medical effects of exposure dangers, first aid treatment, or the need for proper personal protective equipment. Small scale spills or dermal contact with HF can be extremely dangerous to the homeowner or worker unfamiliar with HF.

Conclusion

Large or small chemical spills of hydrofluoric acid that result in property damage, injuries and/or fatalities are often extremely complex and can involve several causation factors. Improper storage, product labeling inadequacies, transfer procedures, safety plan inadequacies, and chemical interactions/reactions are often some of the potential factors in an incident. A successful outcome of an investigation and/or litigation requires an expert with a strong chemistry background. The team at Gossman Forensics is experienced with the investigation of hydrofluoric acid exposure. We offer specialized knowledge in reaction chemistry, hazardous materials, chemical labeling, health and safety, environmental chemistry and laboratory testing.

Forensic Science Insights is a publication by Gossman Forensics, a division of ChemRight Laboratories, Inc. Please contact David Gossman, Chief Investigator, at 563-652-2822, by email at dgossman@gossmanforensics.com or visit us on the web at GossmanForensics.com. Copyright 2018.