Fatality due to acute HF exposure

A fatal accident occurred in a palynological laboratory in Australia, resulting in the death of a technician. This article looks at the factors that may have contributed to its occurrence.

A standard geology technique, which involved the dissolving of sedimentary rock with mineral acids (hydrochloric and hydrofluoric acid), was being undertaken in a fume cupboard. The technician involved was believed to be seated when he knocked over a small quantity (between 100 - 230ml) of hydrofluoric acid (HF) onto his lap, splashing both thighs. The only personal protective equipment worn was two pairs of wrist length rubber gloves and a pair of polyvinyl chloride sleeve protectors. As a result of the fact that the technician was working alone, it is unclear whether the spill was from the digestion cup or the 2-1 bulk acid container. The technician sustained burns to 9% of his body surface area, despite washing his legs with water from a makeshift plumbing arrangement that supplied water at 6 litres/min. No calcium gluconate gel was applied to the affected area and contaminated clothing was not removed during the flushing with water. Following flushing, the technician, who appeared to be in severe pain and shock, immersed himself in a chlorinated swimming pool at the rear of the workplace, where he remained for approximately 35-40 minutes before ambulance help arrived.

The injured man was hypothermic and hypocalcaemic on admission to an intensive care unit at a nearby hospital, and soon became unconscious. His condition continued to deteriorate despite, subcutaneous injections of calcium gluconate and administration of intravenous calcium and magnesium. His right leg was amputated 7 days after the incident.

He subsequently died from multi-organ failure 15 days after the hydrofluoric acid spill.

Points from accident investigation

Investigation showed that this death could have been prevented if adequate personal protective equipment had been worn during the handling of concentrated hydrofluoric acid.

Full length PVC coveralls with sleeves to the wrist or a full-length PVC apron with sleeve protectors, a face shield, rubber boots, safety goggles and mid-arm length PVC gloves should have been worn by the deceased when HF was being used in the fume cupboard.

The deceased did not have access to an emergency shower to remove the HF, instead the skin was washed from a hose that provided water at a very low flow rate. Because of the low flow rate, the volume of water may have spread the HF onto other parts of the skin.

No calcium gluconate gel was applied following dermal exposure. Inhalation may also have been another route of exposure due to the relatively high vapour pressure of HF acid.

Ergonomics

An ergonomic assessment of the work station indicated the following: (i) The working height of the fume cupboard was too low (by between II 0 and 160mm) for the technician to work comfortably in a standing position. Sitting increased the body surface area. (ii) Instability of the digestion cups due to lightweight construction (height 75mm, diameter of base 59mm, diameter at top 78mm), made of 2mm polyethylene. (iii) Lack of available space in the fume cupboard, entrance of the fume cupboard was 470mm wide and 410 mm high. (iv) As a result of the design of the container, decanting from the 2-1 hydrofluoric acid container was awkward, involving the pronation of the forearm.

The laboratory personnel could have minimised the likelihood of a spill through the introduction of cup supports for the digestion cups. Other ergonomic factors which may have reduced the likelihood of a spill include:

1. Provision of a fume cupboard that had more working space;

2. Use of smaller sized bottles or better designed 2-1 70%w/w hydrofluoric acid containers (to minimize awkward pouring postures) or introduction of a graduated dispensing unit to negate pouring the acid;

3.Provision of an appropriate bench height for the operator.

Overall, it was noted that the laboratory did not comply with requirements of national standards in the areas of emergency procedures, safe handling and disposal of the chemical and laboratory design.

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Note:

1. HF is used at a number of locations at UST.
2. HF is an extremely dangerous material and all forms, including vapors and solutions, can cause severe, slow-healing, burns to tissues. At low concentration, skin burns may not be felt immediately although the delayed effects could be serious. In addition to the strongly corrosive hydrogen ions, HF generates fluoride ions which can readily penetrate skin and tissue, and result in necrosis of subcutaneous tissue. If the penetration is sufficiently deep, decalcification of the bones may result. Severe health effects or death will result from depletion of calcium from blood and tissues. Chronic exposure to low level of HF vapor may irritate respiratory system and cause problem to the bones. Even brief exposure to high levels of the vapor may cause severe damage to the respiratory system. Contact with the eyes could result in blindness.
3. Fume hood must be used for all HF work. Safety shower and emergency eyewash must be available in or near the lab.
4. As indicated in the article, proper personal protective equipment (PPE) includes PVC coverall with sleeves to the wrist or full length PVC apron with sleeves protectors, mid-arm length gloves, face shield, safety goggles and rubber boots. Suitable gloves include those made with PVC and neoprene. Selection of specific PPE depends on nature of the operation and the quantity of HF involved.
5. Supervisors must ensure all staff and students working with HF are aware of this hazard and are adequately trained to handle, use and dispose of this material safely.
6. Supervisors must also make sure that staff and students working with HF are familiar with specific emergency procedures.
7. Supervisors must ensure the availability of protective equipment and the antidote, calcium gluconate cream at the work site. Contact HSEO for replenishment of supply.
8. Users must observe all safety precautions including implementation of safety control measures and the use of proper personal protective equipment.

Joseph Kwan

Director, Health, Safety and Environment Office