Incident Title	**Anhydrous Ammonia Release**	
Incident Type	Toxic Gas Release	
Date	31st July 2024	
Country	USA	
Location	Sterling, VA	
Fatalities	**Injuries**	**Cost**
0	33 (of which 4 were serious)	US$ 3 m (2025) – Ref. 1

Incident Description

Credit: US Chemical Safety Board

The food processing plant and storage facilities at the site are served by an industrial-scale refrigeration process using ammonia (NH_3) as a refrigerant. The refrigeration process chills water used in food production lines and maintains refrigerators/freezers at the temperatures needed for food storage.

On 31-Jul-24, a refrigeration process upset caused overpressure of a surge drum. Its pressure safety valve (PSV) lifted, discharging NH_3 to a common relief header and atmospheric vent stack. An employee entering the plant walked through an invisible vapour cloud, causing irritation to their eyes and nose. Minutes later, a white cloud was observed intermittently discharging from the vent stack (no alarm). The refrigeration technician manually shut down the compressors and the production manager ordered site evacuation. The on-call refrigeration manager closed the "king" (emergency shutoff) valve and operated a 3-way selector valve to isolate the offending PSV (identified by external frost buildup) and place the twin standby PSV in service.

While evacuating the building, 33 people inhaled NH_3 vapour and suffered various symptoms requiring treatment (4 were admitted to hospital). Two food production lines were shut down for 16 and 38 days, respectively.

Incident Analysis

Basic cause was as-designed activation of a pressure safety valve (PSV) on a refrigeration system heat exchanger surge drum due to an overpressure event probably caused by a food processing plant upset and exacerbated by a flow restriction in the closed-loop surge drum vent line.

Critical factors included: 1) The relief header atmospheric vent discharged close to the employee car park and building entrance, 2) The PSV discharge contained aerosol droplets of liquid ammonia (NH_3) which enabled formation of a rapid slumping vapour cloud reaching immediately dangerous to health or life (IDLH) ground level concentrations (300 ppm), 3) Building wake effects contributed to personnel exposure and evacuation delays, 4) There was no automated emergency shutdown system for the refrigeration system.

Root causes included: 1) Inadequate process hazard analysis (two-phase atmospheric PSV discharge, building wake effects), 2) Inadequate design (avoid aerosol/liquid in atmospheric relief, discharge to safe location), 3) Inadequate process monitoring (absence of data historian), 4) Inadequate emergency preparedness (gun drills for NH_3 release scenarios, alternative evacuation routes and muster points based on wind direction), 5) Inadequate communication system (no site-wide evacuation alarm), 6) Inadequate training (failure to activate refrigeration system emergency shutdown button).

Lessons Learned

1) Ammonia (NH_3) clouds may be invisible in certain conditions so proper personal protective equipment (PPE) should be worn when identifying leaks.
2) Building wake effects should be evaluated in dispersion modelling to ensure adequate dispersion and to validate proposed evacuation routes.
3) Distinctive alarms should be provided for different responses to NH_3 release scenarios (e.g. shelter in place or evacuate).
4) ANSI/IIAR 2 "Standard for Design of Safe Closed-Circuit Ammonia Refrigeration Systems (2021)" should be updated to include design guidance or requirements to prevent aerosol droplets/liquid in atmospheric discharges.

More Information

1) "Hazardous Ammonia Release at Cuisine Solutions, Inc. Facility", US Chemical Safety Board (CSB) Report No. 2024-03-I-VA: Investigation Report.

Industry Sector	Process Type	Incident Type
Food & Drink	Refrigeration System	Toxic Gas Release
Equipment Category	**Equipment Class**	**Equipment Type**
Not equipment-related	Not applicable	Not applicable

Peter Marsh
Director – XBP Refining Consultants Ltd.