



Deadly Exposure: The West Virginia DuPont Phosgene Release

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Phosgene

- At room temperature, phosgene gas is colorless and highly toxic.
- Symptoms may not manifest until 48 hours after initial exposure; however, phosgene poisoning results in respiratory issues such as pulmonary edema, pulmonary emphysema, and potentially death.

DuPont Belle's Phosgene Processing

- DuPont Belle (located on the Kanawha River in West Virginia) used phosgene in the creation of intermediate chemical products. The phosgene was stored in 1-ton cylinders in a partially-walled, outdoor shed. Inside the shed, two cylinders were connected to the manufacturing process via two hoses lined with polytetrafluoroethylene (PTFE) and overbraided with stainless steel. One hose on each cylinder transferred liquid phosgene to a vaporizer while the other pressurized the cylinder with nitrogen.
- DuPont did not require enhanced Personal Protective Equipment (PPE) (i.e., encapsulated suit and breathing air) for switching cylinder feeds between barrels (which occurred two to three times a day), but only when swapping an empty cylinder with a full one.
- At the time of the incident, DuPont employed approximately 440 workers at the 105-acre Belle plant.
- Until the incident, the Belle facility had the best safety record of any DuPont production plant.

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What Happened

- On Saturday, January 23, 2010, at 1:45 p.m. local time, a phosgene transfer hose connected to a partially filled cylinder burst as an operator was inside the shed checking the status of the cylinders. The worker was not wearing enhanced PPE and was exposed to 2 pounds of phosgene that had remained in the hose from a previous transfer operation.
- The operator called for assistance and was taken to the plant's medical center by a supervisor.
- At 1:59 p.m., the front gate guard—unaware of the chemical release—was instructed via radio to call an ambulance for a medical emergency. When emergency dispatchers called DuPont for more information, they encountered busy lines.
- At 2:14 p.m., responders met the exposed worker at the plant medical center and were notified of the worker's phosgene exposure. The worker had washed his face and hands and changed clothes while waiting for responders, but did not shower or undergo decontamination activities.
- An X-ray revealed no congestion in the victim's lungs; however, 4 hours after exposure, the worker's condition rapidly deteriorated. The worker died at 9:27 p.m., January 24, 2010.
- Although there was one additional confirmed and one possible phosgene exposure after the initial release, the workers involved later showed no signs of the effects of exposure. No report of exposure to the public occurred the day of the incident.

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Underlying Issues

Hose Failure

- U.S. Chemical Safety Board (CSB) investigators found that the manufacturer's tag was secured to the hose with white plastic adhesive tape. Extensive corrosion was localized under the area covered by the tape. The permeable PTFE and braided stainless steel provided an ideal environment under the tape for vapor from liquid phosgene retained in the hose between the valves to collect and convert to hydrogen chloride and caused stress corrosion cracking.
- DuPont was aware of the possible issue, but calculated the risk and cost-effectiveness of purchasing replacement hoses to be too high.
- Although Belle Process Hazard Analyses (PHAs) identified the potential for liquid phosgene thermal expansion in other process equipment, it did not identify it in the phosgene system itself or identify failure modes for the transfer hoses.
- The hose that failed on January 23, 2010 had been in use for over six months, in violation of the plant's original 30-day change-out schedule. DuPont did not provide a back-up method to ensure timely change-out and the maintenance software was not documented or reviewed in accordance with Management of Change (MOC) processes.



Varies corroded PTFE stainless steel braided hoses at DuPont Belle. Source: CSB

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Near-Miss Event

- On the morning of the incident, maintenance personnel replaced the phosgene hose on the phosgene tank not involved with the incident because of a suspected flow restriction. As the hose and valve assembly was decontaminated in a water bath, the adhesive tag fell off and revealed a corroded section of the stainless steel braid and collapsed PTFE liner.
- When the worker saw this, he told coworkers that they were lucky in catching the hose before it ruptured. Supervisors were not informed of the issue and it was not captured as a near-miss event. The worker planned to tell the supervisory staff on Monday, when they would return to work after the weekend, and expected a full investigation.
- This notification would have fallen outside of the DuPont Belle policy for reporting incidents within a 24-hour period.
- Though supervisors were not typically onsite on weekends, management and safety and health experts were at the facility that morning of Saturday, January 23, 2010 for a safety pause meeting.

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Aftermath

- The CSB investigators made several recommendations to the involved organizations, specifically to OSHA and DuPont Belle. The CSB recommended that OSHA revise standards for the storage of highly toxic materials in compressed gas cylinders to incorporate provisions that are at least as effective as the National Fire Protection Association (NFPA) 55, Compressed Gases and Cryogenic Fluids Code.
- The CSB outlined recommendations for Belle that involve improving the existing maintenance management program by supplementing the computerized system with sufficient redundancies and conducting MOC reviews for all changes to preventative maintenance orders for all Process Safety Management-critical equipment in the computerized maintenance management system. Additionally, revisions were suggested for the near-miss reporting system and investigation policy so that it is operational at all times.
- The CSB also recommended that the Belle plant revise their emergency response protocol to require that a responsible and accountable employee be available at all times to provide timely and accurate information to emergency dispatchers.



DuPont Belle, Belle, West Virginia. Source: CSB

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Relevance to NASA

- Hydraulic pressurized systems are common at NASA centers and facilities. Large quantities of ammonia were used at Centers to support and onboard to sustain Shuttle operations. Many leaks occurred during Shuttle processing, which resulted in immediate exposure and environmental risks
- Even more potentially hazardous was the use of hydrazine as a hypergolic fuel for Shuttle maneuvering system thrusters. NASA compiled lessons from hypergol spills and fires in NASA/TP-2009-214769, A Summary of NASA and USAF Hypergolic Propellant-Related Spills and Fires.
- NASA personnel and NASA contractors can sign up for informative training courses in Ground-Based Pressure Vessel Safety and High Pressure Systems Operation and Flexible Hose Safety in SATERN, the Agency's learning management system.
- Timely reporting of equipment degradation or damage, or any hazardous condition, to the person with the authority to mitigate the hazard source or eliminate human exposure risk saves lives and enables mission success.



Hydrazine propellant tank used by the MAVEN spacecraft.
Source: NASA