

**O**n April 9, 1998, two volunteer firefighters died in Albert City, Iowa, and six responders were injured when a burning LP-Gas tank exploded in a boiling liquid expanded vapor explosion (BLEVE). According to NFPA's fire investigator Robert Duval, who went to Albert City to speak with the state fire marshal and local sheriff's department and to examine the site of the BLEVE, the factors that led to the Albert City tragedy are worth considering now, while such fires are still relatively rare.

"It's definitely a type of fire that's out of the ordinary," Duval says. "Fires like this don't happen every day. On the other hand, it's not a fluke."

NFPA's fire investigations database turned up two similar fatal fires that took place on farms in 1993 and 1997, the first in Warwick, Québec, Canada, and the second in Illinois. Like the Albert City fire, these two occurred on farms where propane was used to heat buildings. In each case, the tanks' relief valves were operating when firefighters arrived, but they couldn't stop flames from impinging on the tanks and weakening the tank shells. And in each case, tanks ruptured in BLEVEs that sent pieces of metal flying at high velocities in random directions, killing those caught in their path.

Back in the '60s and '70s, when derailments of rail cars carrying liquid propane posed a real challenge, the railroads, the gases industry, and the fire service all worked to improve LP-Gas storage, handling, and firefighting. One of the best-known railroad incidents occurred in Crescent City, Illinois, in 1970, when 10 tank cars carrying more than 34,000 gallons (128,700 liters) each derailed. Three BLEVEs resulted, generating enough force to blow people, railroad ballast, ties, and track into the street, destroying most of the business district and several homes. Sixty-four people, many of them firefighters, were injured.

After several BLEVEs of this type, the railroad industry retrofit all tank cars carrying liquefied flammable gases by adding thermal protection, which protects against high temperatures that can weaken metal. Shelf couplers were also developed to prevent cars from uncoupling vertically, and head shields were fitted to protect against punctures from the couplers. Since these retrofits were completed in 1980, there have been no BLEVEs of tank cars in the United States.

The three fatal BLEVEs on farms over the past five years point to the need, once again, to train firefighters in the safe handling of LP-Gas fires and to enforce NFPA code requirements addressing the safe storage and handling of LP-Gas that have proven effective over the past two decades.

#### **What is a BLEVE?**

A BLEVE is a type of pressure-release explosion that occurs when liquefied gases, which are stored in containers at temperatures above their boiling points, are exposed to the

# BLEVE Kills Two

**Alisa Wolf**

*A fatal LP-Gas tank explosion on an Iowa farm points to the need to raise awareness about the safe storage and handling of LP-Gas and the firefighting tactics that have proven effective over the past two decades.*



Photograph: NFPA



Photograph: ©Iowa State Fire Marshals Office

*A piece of the tank was propelled directly north, narrowly missing two firefighters as it whizzed through the storage building (top). It was stopped by a silo (below).*

atmosphere, causing rapid vaporization. This happens when a container fails. A BLEVE can occur when flame impinges on the tank shell at a point or points above the liquid level of the tank's contents, or when a tank shell is corroded or gouged. The heat from the fire causes the metal to weaken and fail as the internal pressure increases, and liquid-to-vapor expansion provides the energy that creates cracks in the container, causing the container to fail, and propels pieces of the container outward. The result is the mixing of vapor and air that results in the characteristic fireball that occurs when the fire ignites the vapor. During the process, the container's pressure relief valve operates, creating a large vertical torch and a screaming noise.

Those who experience large burning LP-Gas fires describe flames of up to 100 feet (30 meters) or more that slash the air and can brighten a night sky for miles, creating an eerie daylight. Those who've been close enough to a burning tank to hear the relief valves sound describe ear-piercing shrieks of "near sonic velocity," according to Bill Mahre, a private fire investigator working for the propane company on

the scene in Albert City the morning after the blast. Responders described to him a near-deafening, high-pitched noise that competed with human voices on the fireground. When the tank BLEVEd, the sound of it woke people county-wide, and the force of it threw a deputy sheriff standing 200 feet (61 meters) away 15 or 20 feet (5 to 6 meters).

After the Albert City BLEVE on April 9, responders told Mahre that it was "absolutely silent. There was only the noise of the truck engines. It was completely dark and quiet." Responders also reported that only a few spot fires remained on the ground and in the surrounding buildings. The fireball seems to have completely consumed the LP-Gas.

### The chain of events

The fire at the Herrig brothers' turkey farm was reported at approximately 11:10 on a Thursday night. Teenagers riding the farm's all-terrain vehicle without permission had driven over two pipelines carrying liquid propane from the 18,000-gallon (68,100-liter) tank to two vaporizer units. Fortunately, the teens were able to escape the vapor unharmed and go to a nearby farmhouse to phone 911. The ensuing vapor cloud that leaked from the ruptured pipes was probably ignited by the pilot light on one of the vaporizers, according to Mahre.

According to Ted Lemoff, NFPA's principal gases engineer, the kids were lucky.

"Their engine could have stalled, and those kids could have been rendered unconscious by lack of oxygen in the propane-enriched air," Lemoff says, explaining that, although propane isn't toxic, it displaces the oxygen in the air and can become an asphyxiant in high concentrations, making it deadly in seconds.

By the time the teens escaped the gas and called for help, the tank was venting from the relief valves at the top of the vessel. When firefighters arrived at approximately 11:21 p.m., they also noted fire below the tank and reported that the tank's relief valves were shrieking.

The three exposed buildings surrounding the tank were an office and storage building to the west, a large turkey coop to the east, and another storage building to the north, all of wood-frame construction and a combination of metal and wood exterior siding. A gravel road bordered the area approximately 65 feet (20 meters) south of the tank.

The fire chief, Bruce Nehring, had a sheriff's deputy notify the local electrical utility that power lines were potentially exposed to the flames, then he staged the all-volunteer fire department to protect the exposed buildings with hose lines. Since there was no water supply in the area, firefighters relied on tankers, with a portable tank at the scene and the department's tanker making runs into town for refills. The remaining two engines and a rescue unit set up on the tank's north side and began operations, while mutual aid was en route.

Two firefighters, Larry Walsh and Tom Archer, advanced a hose line from the northwest engine and positioned themselves immediately northwest of the tank. Fire Chief Nehring joined them there to monitor conditions (see Figure 1). Two other firefighters, Assistant Chief Pat Cronin and John Lange, advanced a hose line from the engine staged northeast of the tank, approximately 90 feet (27 meters) away from it. The chief indicated that he planned to allow the gas in the tank to burn itself out.

Eighteen minutes after the fire was reported and 8 minutes after

apparatus arrived at the scene, the tank BLEVEd, breaking into four large and several smaller pieces that rocketed in four different directions.

### Casualties and damage

The largest portion of the tank, a piece approximately 23 feet (7 meters) long, hurtled over 300 feet (91 meters), sliced into the large coop east of the tank, crushing turkeys beneath it. Another piece was propelled directly north, narrowly missing Firefighters Karl Erickson and Mike Julius as it whizzed through the storage building, finally coming to a stop when it hit a silo more than 150 feet (46 meters) from the tank's original location. The force of this piece also carried Julius into the building and up against the far wall. He crawled through the wreckage to join the others, says NFPA's Duval, only to find them digging frantically in a crater created when the tank piece hit the ground, thinking that he'd been buried.

Walsh and Archer, the two firefighters operating the hose line directly northwest of the tank and as close as 90 to 108 feet (28 to 33 meters) away from it, were killed instantly by the third largest piece of tank, which rocketed more than 230 feet (70 meters) from the original tank location. This piece made up about 20 percent of the total tank, said Mahre. The piece narrowly missed Chief Nehring, but the fireball scorched his turnout gear, burning through the back of his coat and the rear and sides of his bunker pants and badly burning him. Cronin and Lange, who'd been standing 150 feet (46 meters) northwest of the tank, were thrown to the ground. Cronin suffered burns to his face, and Lange sustained multiple injuries. A third firefighter approximately 100 feet (30 meters) west of the tank was also thrown to the ground and suffered minor injuries. And a sheriff's deputy, Kelly Snyder, taking cover



Photograph: NFPA

*The largest portion of the tank hurtled more than 300 feet (91 meters), slicing into the large coop east of the tank and crushing turkeys beneath it.*

in a ditch by his parked car about 200 feet (61 meters) from the site, suffered numerous bruises and scrapes when the blast carried him 15 to 20 feet (5 to 6 meters) and dropped him to the ground.

The blast scattered other pieces of the tank around the open field across the street, some landing almost 250 feet (76 meters) from the site. A piece of one of the vent pipes was found embedded more than 2 feet (.6 meters) deep in a gravel driveway more than 200 feet (61 meters) west of the site.

"There was no fire damage to buildings," says Mahre. "Only the metal flying did damage."

A mutual aid department that arrived shortly after the blast put out spot fires while others attended to the injured and provided lighting to assist investigators until morning, freeing others to attend to the wounded. In the end, two firefighters were dead and six people were injured.

After observing where the metal on a piece of the tank started to thin out before the BLEVE occurred and consulting delivery estimates, Mahre, a member of the National Propane Gas Association Education and Training Safety Committee, determined that the 15-ton (14-metric ton) tank contained about 10,000 gallons (37,900 liters) at the time of the explosion—it was a little more than half full.

"There was a razor sharp edge where the liquid level would have been," says Mahre.

### Lessons learned

The Albert City fire chief's plan was to protect the three exposed buildings around the burning tank by cooling them with water, while allowing the gas to burn itself off. Were firefighters too close to the tank?

NFPA's Lemoff suggests that in the light of recent BLEVEs, firefighters need to step back when responding to LP-Gas fires and ask themselves whether they're willing to risk being caught in a BLEVE to save property.

## Lessons Learned

- Don't assume that operating relief vents will prevent a BLEVE. A BLEVE can occur any time direct flame impinges on an LP-Gas vessel at its vapor space. A BLEVE can also occur with a non-flammable gas, such as chlorine, ammonia, nitrogen, and helium.
- NFPA 58, *Liquefied Petroleum Gas Code*, requires a fence around aboveground piping and LP-Gas tanks with capacities of 2,000 gallons or more. This is an important requirement, and it should be enforced.
- To prevent a container from exploding, firefighters must apply a steady stream of water with a minimum of 500 gpm at each point of flame impingement. This may not be possible in many rural areas, where firefighters have to rely on rural water supply operations.
- Incident commanders charged with deciding whether to fight an LP-Gas fire or retreat should take into account the proximity of mutual-aid companies.
- Historically, when tanks BLEVE, the ends blow out, but this isn't always the case. Pieces may fly every which way. Positioning firefighters away from the ends is no guarantee of safety.

- 1. Larry Walsh
  - 2. Tom Archer
  - 3. Gary Hogrefe
  - 4. Bruce Nehring
  - 5. Karl Erickson
  - 6. Mike Julius
  - 7. Lori Huegerich
  - 8. Tim Hueton
  - 9. Brian Johnson
  - 10. Darold Brown
  - 11. John Willeford
  - 12. Craig Herring – property owner
  - 13. Pat Cronin
  - 14. John Lange
  - 15. Erik Erickson – on truck
  - 16. Doug Youngberg
  - 17. John Forbes
  - 18. Kent Claussen
- Firefighter, except where noted
  - Firefighter injury
  - Firefighter fatality
  - Fire apparatus

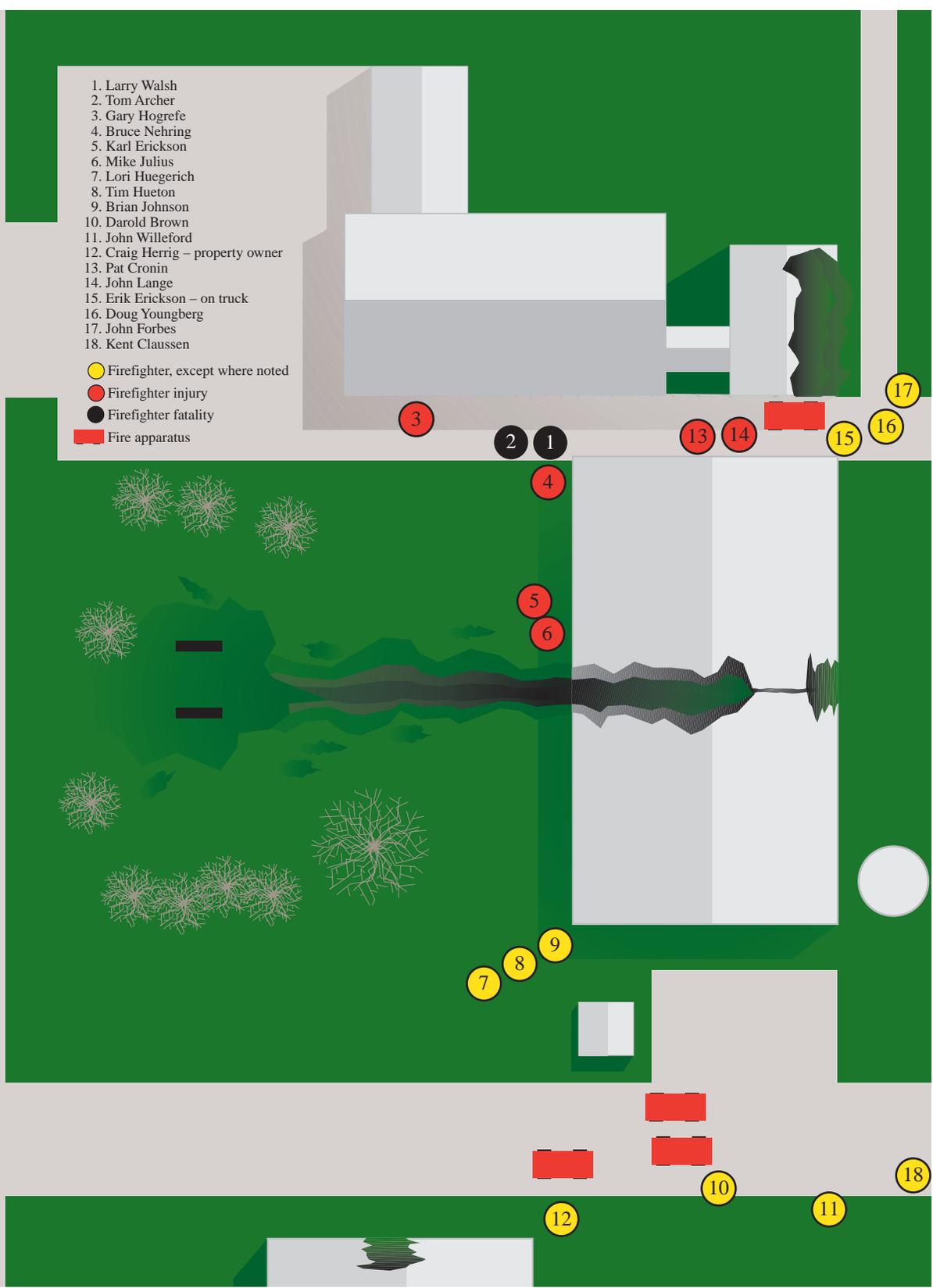


Diagram: Christopher J. McCusker

Aerial View of Albert City Fireground

“Firefighters have to question their approach, especially when no human life is at stake,” Lemoff says. “They have to ask, ‘What’s the exposure? What are we really trying to do?’”

As part of sizing up the incident, says Senior Fire Service Specialist Stephen Foley of NFPA, the incident commander must ask the question, “Is the risk worth the benefit?” which is addressed in Chapter 2 of NFPA 1500, *Fire Department Occupational Safety and Health Program*.

“NFPA 1500 states that if there are no saveable lives or property,” Foley says, “do not put personnel at risk.”

This may mean pulling personnel out of the area whenever a tank’s relief valves are working, says Bruce Swiecicki, vice president of Technical Services for the National Propane Gas Association.

“As soon as LP-Gas tank relief valves begin shrieking, it’s too late to apply cooling water to the tank,” Swiecicki says, quoting from one of the association’s bulletins. “The next action should be immediate withdrawal of all personnel, as a BLEVE is imminent.”

A cooling operation can only prevent a container from exploding if firefighters apply a steady stream of water and, according to NFPA 58, *Liquefied Petroleum Gas Code*, the major consideration for applying cooling water to LP-Gas containers and equipment to keep them cool and prevent BLEVEs is an adequate water supply for constant, long-term application. In the Albert City fire, water had to be shuttled in—not an unusual situation on a farm, but one that should have been factored into the fireground strategy. And given the lack of water supply, the decision to protect the exposed buildings when there was no threat to human life contributed to the tragedy. NFPA also found that the firefighters were staged dangerously close to the LP-Gas tank when flame impinged on it.

According to NFPA’s fire investigation and analysis, there was nothing wrong with the way the tank was installed. But one significant aspect of NFPA 58 was overlooked—the requirement for protecting propane pipelines from physical harm. Had a fence been installed according to NFPA requirements, the feed lines would have been protected, and the all-terrain vehicle wouldn’t have been able to enter the area around the tank. A fence would also have protected the tank from vehicles on the nearby road.

### Other incidents

While this type of incident doesn’t occur every day, the Albert City BLEVE isn’t an isolated case. In Warwick, Québec, on June 27, 1993, a 1,000-gallon (3,785-liter) propane tank close to a burning barn on a cattle farm was shooting flames more than 15 feet (5 meters) into the air, and the relief valves were operating. The tank BLEVED and split into two large pieces as firefighters were attempting to cool it with water. The blast sent one of the pieces into an open field nearby, and the other piece traveled more than 150 feet (46 meters), bounced off a fire engine, and then flew another 750 feet (229 meters) before striking a vehicle parked on the road and trapping the occupant. The explosion killed four firefighters and injured three firefighters and four civilians.

In Burnside, Illinois, on October 2, 1997, two volunteer firefighters were killed and another two were seriously injured when a 1,000-gallon (3,785-liter) LP-Gas tank exploded when it became exposed to a fire in a grain dryer. The tank was reported to have been venting when the



*This NFPA photograph was taken after the largest piece of tank, which measured more than 23 feet (7 meters) long, had been hauled out of the turkey coop.*

fire units arrived. Firefighters took shelter behind a storage building while cooling the tank with water. Within minutes of their arrival, however, the tank BLEVED, sending large pieces of tank and nearby structures in all directions, striking several firefighters and an engine. According to the coroner’s report, the firefighters died of skull fractures and cranial trauma.

No one wants to see history repeat itself with another series of LP-Gas tank fire fatalities, and the best way for firefighters to protect themselves is by using extreme caution and learning the proper techniques for fighting such fires. According to Swiecicki, the National Propane Gas Association has recently received one of the first grants from the Propane Education and Research Council to develop an emergency response training curriculum that will be made available, free of charge, to every firefighting organization in the United States. Many fire academies also have LP-Gas fire training facilities, as does Texas A&M University. Other organizations that offer LP-Gas fire training opportunities include Ranger Insurance Company, a national organization based in Houston, Texas, and the Western Propane Gas Association, both of which demonstrate firefighting techniques on truck simulations.

When there is any doubt about an LP-Gas fire’s severity, says Duval, “incident commanders should not hesitate to order a withdrawal of forces to safe positions. When lives aren’t in danger, they should allow the fire to burn out or a BLEVE to occur.”

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*Alisa Wolf is editor of NFPA Journal.*

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