

CARGO TRUCK TANKS

An Often-Unrecognized Confined Space Hazard

By Daniel J. O'Connell

Trucks with cargo tanks used in the service industry need routine maintenance to ensure their safety and keep product flowing. But such turnarounds are a source of concern for the industry. As production mounts and traffic increases, truck congestion at service facilities causes delays, impacting worker safety (Chakraborty, Kumar & Malguri, 2016). Several potentially deadly hazards such as falls exist in such operations. But a largely unrecognized and often fatal hazard is confined spaces in truck tanks.

In the allied service trade where tank truck maintenance is outsourced to specialized vendors, work has many potential hazards. Specialty trades conduct inspection, sanitation, maintenance and repair. To get the job done, employees frequently enter confined spaces and work at height. Productivity often means balancing personal safety, health and performance.

Truck drivers and service technicians frequently climb onto tank vehicles using side ladders, stairs, walkways, catwalks and caged work platforms. Additionally, service workers frequently use compressed air, steam and high-pressure water to conduct tank clean-out operations. Employees commonly access tank cargo holds by entering manways, hatches and portals at the dome or top of a tank container. In these activities, employees may be exposed to toxic, flammable, oxygen-deficient and chemically asphyxiating atmospheres (Harle, 2017). These hazards call for a new paradigm in OSH regarding truck tanks.

KEY TAKEAWAYS

● Tank truck inspectors, technicians, welders and clean-out specialists frequently enter confined spaces to perform work.

● Confined space hazards in tank trucks are an often-unrecognized threat to workers; employers must take precautions to prevent serious incidents.

● This article reviews the distinct hazards for cargo tanks and proactive measures that can reduce these hazards.

Improving Production & Morale

Addressing these issues can produce quantifiable benefits, including improved production and enhanced employee morale. Establishing an effective safety and health program at a job site is one of the best ways of protecting the company's most valuable asset, its workers. Losing workers to injury or illness, even for a short time, can cause significant disruption and cost. It can also damage workforce stability and a company's reputation (OSHA, 2016).

Case 1

A tank wash lead man was cleaning the inside of a cargo tank trailer in a wash bay. He opened the manway (dome), then connected a compressed air hose to the rear washout coupling to ventilate the tank. The employee was later found unresponsive by an assistant tank washer inside the tank directly beneath the manway hatch. The victim was airlifted to a hospital but died the next day.

The tank was reported to have contained Styrofoam and polyol, a urethane-based product, and a mixture of nine other chemicals. Previously, nitrogen gas had been used to offload the tank trailer at a customer site. Residual nitrogen in the tank combined with the chemical's oxygen displacing characteristics produced an immediately dangerous to life and health (IDLH) condition, due to oxygen-deficient atmosphere directly at the manway opening.

As the worker positioned himself over the open hatch to inspect the cargo hold, he was overcome, lost consciousness and fell into the tank (OSHA, 2011).

What Is a Tank Truck?

According to EPA (2018), a tank truck is a motor-driven vehicle with a completely enclosed storage vessel or container used to transport liquid, solid or gaseous materials over roads and highways. The storage vessel or tank may be detachable, as with tank trailers, or permanently attached. The commodities or cargos transported come in direct contact with the tank interior. A tank truck may have one or more storage compartments. There are no maximum or minimum vessel or tank volumes. Tank trucks are also commonly referred to as cargo tanks or tankers.

Routine tasks performed in cargo tank confined spaces include:

- internal tank washing, material/heal removal, decontamination;
- mechanical, electrical repair, component service (valves, sensors, wiring);
- hot work and welding, baffles, tank compartments, shell repair;
- tank certification/recertification.

Cargo tank truck workers can include drivers; inspectors, certifiers and management; emergency responders; product loaders and unloaders; transloaders (intermodal); service technicians; washout specialists; and welders. In 2013, the tank truck industry hauled 2.48 billion tons of freight, which accounted for 25.6% of all truck freight. About half of all tank truck tonnage was petroleum products (49.2%). Sand-based shipments comprised 15.2% and nearly 10% was chemicals (NTTC, 2015).



The Dangers of Gas-Inerting Tanks

Gas inerting is used by industry to purge or ventilate cargo tanks. It involves removing the oxygen content from the tank using an inert gas such as nitrogen, carbon dioxide or argon. The aim is to control moisture and reduce oxygen levels, effectively reducing the hazard of fire or explosion during the loading of flammable liquids (CSB, 2003).

All inert gases increase the atmospheric hazard potential to workers entering cargo tanks. Tank service employers must be constantly alert to this common hazard and take ample precautions to prevent catastrophic employee injury or fatality (NIOSH, 2014).

The proper use of safety signage and tags at the exterior of a container provides workers a status and visual warning (Figure 1). Signs on a tank vehicle are no guarantee of safe condition or atmosphere. The “clean-slip” tag indicates a tank has been certified clean but does not guarantee a safe atmosphere or condition. Workers must be aware of potential hazardous inerting gas that may linger or remain within a tank vehicle after cleaning. Tank truck technicians have suffered fatal consequences when entering tanks with such clean slips. Service providers and loaders must affix proper warning signs on tank vehicles to preclude entry when nitrogen or other inerting gases or hazardous/toxic conditions exist.

IDLH

An IDLH environment includes any condition in a confined space that poses an immediate or delayed threat to life, or that would cause irreversible adverse health effects and interferes with an individual’s ability to escape unaided (self-rescue). This definition includes inerted containers having an oxygen-deficient atmosphere containing less than 19.5% oxygen by volume (NIOSH 2003; 2007).

Considering continued workplace fatalities in the transportation and industrial sector, it is apparent that many employers and workers are unaware of the hazards of oxygen deficiency. According to CSB (2003):

Every year people are killed by breathing “air” that contains too little oxygen. Because 78% of the air we breathe is nitrogen gas, many people assume that nitrogen is not harmful. However, *nitrogen is safe to breathe only when mixed with the appropriate amount of oxygen.*

The use of inert gases in containers and tanks creates an IDLH condition. Workers approaching a tank or container must use extreme caution even within close proximity to a recently opened top hatch. Low oxygen flow can impact a person standing close to an open portal, causing sudden syncope (fainting), possibly leading to a fall directly into the vessel or tank.

Before approaching tank vehicle entry portals, employees must perform air testing to determine whether safe oxygen levels are present. When oxygen levels are insufficient for entry, start ventilation to reduce hazardous atmospheres and elevate the level of respirable oxygen. When ventilation is not an option, resort to respiratory protection such as a self-contained breathing apparatus or supplied-air respirator. Workers who must approach an open vessel should stay at a safe distance until air testing has been completed. Operations using inert gases such as nitrogen are required to affix a hazard warning to the dome cover.

Case 2

A truck driver was working around a tank truck in a service bay. The tanker had been gas inerted and contained a nitrogen

FIGURE 1
WARNING SIGNAGE & TAGS



conditioner that was added to the tank for shipping liquid egg. A common trade practice of the food products industry is to stabilize loads in tank trucks by removing the oxidation potential by injecting a nitrogen conditioner, a process known as blanketing.

Blanketing is the process of applying a gas to the vapor space of a container or vessel in order to control its composition. Some sensitive materials, especially in the food, pharmaceutical and nutraceutical industries, may experience quality degradation when they come into contact with oxygen, moisture or other contaminants.

Blanketing creates a slight positive pressure inside storage containers, which prevents air and other contaminants from infiltrating and causing oxidative degradation and spoilage. The result is increased shelf life (Carlson, Dumoit, Yanisko, et al., 2011).

The tank contained half a load (about 18,000 lb) of liquid product, which was being unloaded back into the silo after it was determined that the egg was too warm for shipping. Hours later, another worker found the driver, who had fallen inside the tanker truck and had been asphyxiated (OSHA, 2014).

Hidden Hazards

Multiple documented fatalities have resulted from unintended inhalation of oxygen-depleted air or nitrogen gas at entry portals. Exposed workers can rapidly lose consciousness and fall directly into an open tank and quickly asphyxiate. Common victims in tank truck fatalities are lone workers who breached critical safety rules, including failure to pretest the air at the hatch. Remaining alert to the hidden hazards of inerted cargo tanks is a top priority for technicians and specialists.

Some liquid products possess a static accumulating tendency, resulting in buildup of electrical energy during onboarding or transfer of flammable liquids to a cargo tank container. According to American Petroleum Institute (2015), "Hydrocarbon vapors in a flammable mixture with air can ignite if exposed to a source of ignition (such as a static discharge) resulting in a fire which could injure people or damage property." Cargo tanks therefore must be grounded in advance, to prevent static electricity from developing during material loading.

Inerting a cargo tank allows the internal concentration of oxygen to be decreased below the level that can support combustion. Following purging with nonflammable gas, the tank's oxygen concentration should be continuously monitored and the confined space continuously ventilated using the inert gas for up to 24 hours before loading (Table 1). This practice ensures that the concentration of oxygen does not increase, and the tank remains explosion and moisture-free.

Transportation workers must always assume that any confined space such as a tank trailer or rail car may contain nitrogen or chemical vapors from the product being hauled (CTRC, 2016). As noted, warning tags must be affixed to the primary access-way or hatch. Air testing equipment should be readied before the dome cover is opened, and workers should remain back. A remote sensing probe or tube can be inserted directly into the opening, allowing an immediate readout of conditions.

TABLE 1
OXYGEN DEFICIENCY CHART

Atmospheric oxygen concentration (%)	Possible results
20.9	Normal
19.0	Some unnoticeable adverse physiological effects
16.0	Increased pulse and breathing rate, impaired thinking and attention, reduced coordination
14.0	Abnormal fatigue upon exertion, emotional upset, faulty coordination, poor judgment
12.5	Very poor judgment and coordination, impaired respiration that may cause permanent heart damage, nausea and vomiting
< 10	Inability to move, loss of consciousness, convulsions, death

Note. Adapted from Compressed Gas Association 2001.

WHAT IS A CONFINED SPACE?

Cargo tank motor vehicles are regulated by OSHA as confined spaces. These tanks have openings large enough and configured so that employees can bodily enter and perform assigned tasks (inspection and service). Tank entry often has limited or restricted access/egress; clearly unsuitable for continuous occupancy, a tank vehicle will be classified as a nonpermit confined space.

A tank vehicle becomes a permit-required confined space when hot work contaminates the tank atmosphere with hazardous gases or fumes that accumulate and contaminate the breathing zone. Entrants and welders must use special respiratory protection and ventilation to protect themselves. Also, cargo tank motor vehicles designated for hazardous materials service are also classified as permit-required confined spaces. This includes cargo tanks containing a previous lading with a hazardous atmosphere or one with the potential for engulfment. Engulfment includes the surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance. These materials can be aspirated by a worker into the lungs and cause death by filling or plugging a person's respiratory system.

Prior to entry, conduct further tests of the top, middle and bottom levels of the tank to detect trapped or layered gases. Then gas testing can be conducted continuously to ensure that acceptable entry conditions are maintained. In some cases, forced air or exhaust ventilation may be required to reduce or control atmospheric hazards to an acceptable level.

Safe tank confined space practices include:

- Affix warning signs or labels near the vessel openings. For example, "Warning: Contains nitrogen asphyxiant. Nitrogen will displace ambient oxygen necessary to sustain life" (BASF, 2006).
- Advise off-site recipients to assume that vessels and shipping containers are oxygen deficient.
- All cargo tank workers and crew must be properly trained to recognize the hazards presented by inerted or blanketed cargo tanks, and trained on confined space entry and rescue.
- A fire extinguisher of proper type and size must be located within a maximum of 50 ft of any loading or unloading operation.

- Workers must be specifically instructed and drilled in safe entry and rescue procedures.
- Cargo tank employers and staff must have zero tolerance for unplanned entry into confined spaces or breach of company safety rules.
- Due to potential for hazardous off-gassing, cargo tank accessways or top openings must be rigorously controlled. Accessways and hatches must be remotely tested with a fully charged and calibrated gas detection instrument.
- When applicable, top hatches, manways and openings must be labeled with adequate warnings including prohibited entry prior to air testing and the requirement for a written confined space permit.

- Entrants and workers must have familiarity with gas testing instruments, proper air test procedures and have immediate access to gas testing equipment.

Use the Right Tool

It is also critical to select the correct atmospheric test instrument and ensure that it is used properly. Testing instruments can be confusing and some instruments only detect a single gas such as hydrogen sulfide or carbon monoxide. When testing the flammability of a permit space it is critical to first identify the oxygen level in the atmosphere. In fact, many flammable gas testing instruments are oxygen-dependent and readouts may be skewed or inaccurate in oxygen-depleted atmospheres.

However, a test performed only to determine the oxygen level might indicate that conditions are acceptable for entry despite presence of a highly flammable or explosive atmosphere. OSHA requires that employers test and monitor entry spaces with instruments that detect all aspects of hazardous atmospheres that may be encountered in the spaces (OSHA, 1993).

Tanks must be emptied of any hazardous material lading including the liquid and vapor lines or void areas of the tank. These areas and components must be sufficiently and safely cleaned and purged before entry. Additionally, tank vehicles may have a convoluted internal configuration with the potential to entrap or restrict an entrant's ability to self-rescue.

Always use the buddy system, never enter without notification to the entry leader or attendant and always ensure proper use of PPE, including a significant engineered overhead anchor point and use of fall protection and respiratory protection as required.

Importantly, employers must ensure that trade- and work-specific confined space training is completed prior to entering or working in a tank vehicle confined space.

To prevent injury and fatality and to reduce confusion regarding confined space classification, remember that all confined spaces contain hazards. Also note that even if a space is not classified as a permit-required confined space under OSHA, hazards may still be present that can affect workers such as exposed wiring and hazardous atmospheres (Pearce, 2017). (See the "What Is a Confined Space?" sidebar.)

When entry operations include internal tank inspection or tasks are performed within a cargo tank hold, employers must deploy proactive confined space safety strategies. Once the hazards of the space have been identified, eliminated or controlled by adequate engineering and administrative means, work can progress. If engineering or administrative controls are not possible, use PPE to protect workers.

FIGURE 2
PRE-ENTRY EVALUATION FORM

CTMV CONFINED SPACE EVALUATION-PERMIT				Emergency Numbers (Fire Department):																																																													
Permit Authorized One Shift Only																																																																	
Duration of Entry (below):		Tank Entry Location: _____																																																															
Start:	Terminate:	Supervisor Signature:																																																															
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Purpose of Entry: _____																																																																	
Atmosphere Tests: (Perform in order) → Hazards of Internal Tank Trailer/Truck: Circle all applicable conditions below: 1. Contains a hazardous atmosphere. 2. Contains an engulfment hazard. 3. Contains an entrapment hazard. 4. Other _____ <small>* TLVs per ACGIH ®</small>		<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left;">I. Test Item</th> <th style="text-align: left;">Initial Results</th> <th style="text-align: left;">Allowable Limits</th> <th colspan="3" style="text-align: left;">Re-entry</th> </tr> </thead> <tbody> <tr> <td>Oxygen</td> <td></td> <td>19.5% - 23.5%</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Flammability</td> <td></td> <td>< 10% LEL</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Hydrogen Sulfide</td> <td></td> <td>< 1.0 ppm*</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Carbon Monoxide</td> <td></td> <td>< 25 ppm*</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Other</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	I. Test Item	Initial Results	Allowable Limits	Re-entry			Oxygen		19.5% - 23.5%				Flammability		< 10% LEL				Hydrogen Sulfide		< 1.0 ppm*				Carbon Monoxide		< 25 ppm*				Other																																
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Case 3

An employee was cleaning the inside of a 6,000-gallon tanker truck containing wastewater, a process that is usually accomplished by using water jets from the top of the tank. The water jet process prevents workers from having to enter the tank to perform work. But for unknown reasons, the employee entered the tank without cleaning tools or PPE. The employee was found unresponsive inside the tank when a coworker came to bring him lunch. Emergency responders discovered a low oxygen level inside the tanker. The employee died of asphyxiation at the hospital (OSHA, 2012).

As these fatality cases illustrate, work inside cargo tanks can be unpredictable and often deadly. Specialty cargo tankers hauling chemical and perishable loadings are often expeditiously cleaned, serviced and turned around for immediate reloading. Industry demand for a quick turnaround also can mean that tank safety is a secondary consideration (Chakraborty, et al., 2016). Injuries and fatalities occur most frequently when workers fail to protect themselves from the hazards of toxic atmospheres and inerted containers.

A review of 380 OSHA reports of independent tank truck incidents from 1984 to 2017 indicates that the majority of serious injuries and fatalities involved falls from trucks, explosions, asphyxiation in confined spaces and burns.

Cargo Tank Motor Vehicles Work Tasks

Many factors are involved in servicing a cargo tank transport vehicle, with entry into confined spaces as a frequently required duty. Because accessways and entry portals are positioned at the top of a cargo tank, workers must climb onto the trailer to gain access to a cargo tank hold. Duties at the top of a tank involve fall hazards encompassing the following 10 common trade practices (CTRMC, 2016):

- 1) ensuring security;
- 2) checking equipment (e.g., cleanouts, manhole, venting);
- 3) extracting samples;
- 4) loading/unloading product;
- 5) assessing liquid content levels;
- 6) initiating air unloading or vapor recovery;
- 7) performing maintenance and routine inspections;
- 8) washing tank;
- 9) removing snow;
- 10) discharging heel (i.e., congealed materials).

Pre-Entry Evaluation

Prior to entry into a tank vessel, entrants are advised to conduct a pre-entry confined space evaluation to determine the specific hazards for each tank and to document this data on the checklist form (Figure 2, p. 49).

Employers that provide trade-specific confined space training using such evaluations substantially lower the risk of serious injury and fatality. Since hazard identification and evaluation addresses only part of the problem, employers must take immediate action to control or remove hazards prior to allowing employees to enter a tank vehicle confined space.

The pre-entry evaluation permit is an effective way of identifying, evaluating and controlling hazards in a tank truck confined space. This form or other types of permits can be used for entry into tank vehicles by workers involved in confined space entry work.

The pre-entry evaluation permit has been prepared in a checklist format, which helps prevent workers from forgetting or

omitting critical safety steps during the evaluation process. The checklist format identifies tank-specific hazards and allows entrants and attendants the best controls and protective equipment, enabling them to identify:

- tank-specific hazards;
- controls;
- atmospheric tests/temperature;
- PPE;
- rescue communication procedures;
- air monitoring/pressure levels;
- entry requirements;
- entrant log in;
- ventilation procedures;
- respiratory protection;
- emergency contacts;
- date/location/signature.

Develop & Implement a Comprehensive Training Program

After completing the truck tank confined space pre-evaluation, the next important step is to develop and implement comprehensive training. Employers must ensure that training is cargo-tank-specific, not just generic. Employers must focus on the distinct types of cargo tank containers handled by their facilities and to the specific application for each facility. That way, workers learn about the actual hazards they will encounter on the job and will be better equipped to respond. Workers with limited English skills should receive instruction in their respective language (ANSI/ASSE, 2016a).

Federal Motor Carrier Safety Administration (FMCSA, 2009) provides training recommendations, including the following important industry pointers:

- Establish a thorough training process for new hires.
- Provide regular and ongoing education/training for current drivers.
- Set clear policies and provide a training manual covering company policies and specific tasks drivers must perform.
- Include training on important topics pertaining to DOT specifications, including (at least) inspection, equipment operation, driving/vehicle operation, loading/unloading and safety.
- Set clear expectations to drivers about how equipment should be maintained and what to do in the event of a problem.

Many federal OSHA standards issued in the last 20 years include requirements for employee training. OSHA also has clearly indicated that merely ensuring that employees are provided with safety-related training materials and video is not sufficient.

As a result of the training they receive, employees must be able to perform certain tasks such as operating a gas tester to determine whether safe entry conditions exist in a tank. In a tank-based drill, workers must facilitate a confined space rescue using available emergency retrieval equipment. Other OSHA standards that require demonstration of a specific skill include:

- Personal protective equipment, 29 CFR 1910.132(f)(2): Employees must demonstrate that they know how to use PPE.
- Confined spaces, 29 CFR 1910.146(g)(1): Employees who work as entrants, attendants or entry supervisors should have the understanding, knowledge and skills necessary for the safe performance of their assigned duties.
- Respiratory protection, 29 CFR 1910.134(k)(1): Each employee should be able to demonstrate how to inspect, put on, remove, use and check the seals of respirators.

Conclusion

The present model for cargo tank confined space work requires reexamining our efforts to protect workers and prevent catastrophic injury. The OSH profession must establish a new, proactive paradigm, with interventions to offset the root causes of severe occupational injury and illness. Employers must provide workers with the equipment, training and safe methodologies to conduct safe entry into confined spaces.

This effort must include improved training on respiratory protection and emergency response, with frequent practical drills. Workers must be encouraged to follow all company rules and common-sense safety practices.

Considering the consequences of noncompliance, injury and fatality, the legal embroilment, regulatory fines and potentially catastrophic financial loss, facility operators must weigh their options and responsibilities carefully. When company managers act and set the example, the safety culture will be strengthened, reducing injuries, illnesses and fatalities. Companies can then enjoy a quantifiable improvement in production, profit and worker morale. **PSJ**

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Acknowledgments

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