When Things Go Boom in the Night
BY ROBERT B. WHITEMORE, CFI, WHITEMORE FIRE CONSULTANTS, INC.

One of the more challenging aspects that experts face on behalf of various clients pertains to the investigation of explosions that may or may not become involved in a fire. These types of losses can provide some very complex challenges. Like fires, explosions can vary in severity, but are uniquely different from a typical fire origin and cause investigation.

Due to the length, the following is a condensed, edited version of Mr. Whitemore’s article. For a complete version, please visit: www.whitemorefire.com under “publications.”

Explosion Basics
In order to understand some of the issues involved in handling explosion cases, it is helpful to try and understand what an explosion is and what steps are necessary to handle and investigate such losses. Typically, explosions are categorized into two types; mechanical and chemical. Chemical explosions are far more common and deal with gases, vapors and dusts. These types of explosions are generally described as “deflagrations” or “low order” explosions. “High order” or “detonations” are normally associated with explosives such as TNT, ANFO, PETN, etc.

When a fuel/air vapor explosion occurs, certain patterns or data are left which are subject to interpretation by investigators. When an explosion occurs, typically the gases that ignite expand in a spherical pattern emanating from the epicenter or origin of the explosion. The gases and displaced air movement away from the epicenter produce a pressure wave or blast front that impacts any objects within the path of the front. This pressure wave is what causes the damage to property and persons in the path of the blast.

An explosion typically has two phases; a positive and negative phase. The positive phase is when the pressure wave or migrating blast front of expanding gases propagate away from the epicenter of the explosion. This is the phase of the explosion that causes the most damage. Following the rapid displacement of air migrating away from the epicenter of the explosion, the negative pressure phase of the incident occurs. This phase takes place when a low pressure condition occurs at the epicenter of the explosion with the rapid outward movement of air from the origin. This phase is less powerful than the positive phase, however, it can result in the movement of objects opposite of the initial direction of the explosion.

When an explosion occurs within a container, structure or vessel various effects of the explosion may occur. One such effect is the “shrapnel” effect. This is when debris or fragments of the container, structure or vessel are propelled during the explosion. In some cases, the “shrapnel” can travel long distances and cause additional damage to persons and/or property. It may be necessary to systematically search the area surrounding the blast to recover critical evidence that may assist you in determining the cause of the explosion.

Another effect of an explosion is a “thermal” effect. This occurs as a result of the gas, vapor or dust igniting and causing the expansion of the hot gases away from the epicenter. The pressure wave or blast front can have sufficient temperatures in which to ignite combustible material and/or cause burn injuries. Depending upon the circumstances, you may or may not have a fire that results from the initial explosion. In gas explosions when the fuel/air ratio is below the optimum ratio (typically slightly less than stoichiometric), or “lean”, there may be little or no fire following the initial blast. When the fuel/air ratio is above the optimum ratio for the gas, or “rich”, we oftentimes see a sustained fire or “pockets” of fire burning after the blast.
In some cases, a ruptured gas line may ignite, resulting in a “torch like” effect coming from the delivery piping that ignites the combustible material in the area.

A third effect that is sometimes involved in an explosion is called the “seismic” effect. This occurs when the explosion transfers some of the energy from the event into the ground, resulting in seismic activity or earth/ground tremors. The size of the explosion dictates whether this phenomenon will occur.

Explosions can also be categorized as “seated” or “nonseated”. Seated explosions typically are defined as having a crater or area of greatest damage located at the epicenter of the explosion. Seated explosions are often associated with explosives, boilers, vessels, containers, etc., where the explosion leaves a discernible crater or epicenter with the pressure wave extending away from the central point resulting in the damage. In many cases, seated explosions pertain to high order incidents, which further define the explosion as a “detonation”. This means that the velocity of the pressure wave exceeds the speed of sound (1,125 ft/s or 768 mph).

Non-seated explosions take place when the gas, dust or vapor is dispersed throughout an area and then ignited. This may result in widespread damage with no clear epicenter or crater. The speed of non-seated explosions is significantly slower than detonations and are described as “deflagrations”. Deflagrations are subsonic with the velocity of the pressure wave or blast less than the speed of sound. The vast majority of the explosions we encounter during our investigations fall under the category of deflagrations; in many instances LP-gas or natural gas incidents.

Investigation Basics

In fire cases, investigators attempt to determine the origin and a valid ignition source. The main focus of an explosion investigation centers on isolating and identifying the source of the fugitive gas, vapor or dust and how it became sufficiently mixed with air to create the proper fuel/air ratio capable of causing the explosion and to minimize any further damage and/or destruction of the scene. This is particularly important when dealing with either natural and/or LP-gas explosions where fugitive gas originates within the confines of the building. Having the ability to document the gas delivery system “as found” is extremely important as the investigation commences. In some cases, the damage may be too significant in order to make a definitive determination. However, in many cases, even though the damage may be extensive, the gas delivery system may be sufficiently intact to conduct pressure tests in the field and determine the source of the fugitive gas.

Preserving the scene as quickly as possible is an important first step for the adjuster handling the loss. In many cases, critical evidence can be displaced as a result of the effects of the blast. Such displacement may leave components of the gas delivery system located throughout the scene. A recent loss in Iowa involving the explosion of an above-ground 18,000 gallon LP-gas resulting in the tragic deaths of two local volunteer firefighters. The firefighters responded to the incident and were attempting to “cool” the tank down when the explosion occurred. The cause of the incident was the result of an ATV damaging above-ground liquid and vapor lines leading to/from vaporizers located on a turkey farm. The liquid line at the bottom of the tank fractured, spewing liquid LP-gas into the environment, creating a large vapor cloud that was ignited by an unidentified source. The broken liquid line continued to fuel the fire on the bottom side of the tank, extending around the perimeter of the vessel impinging upon the upper vapor portion of the tank. This eventually led to the catastrophic rupture of the vessel.

Following the incident, the scene and surrounding area was secured for purposes of
attempting to reconstruct the events that led to the incident. When the BLEVE (boiling liquid expanding vapor explosion) occurred, pieces of the tank and tank appurtenances were propelled in a 360° radius surrounding the blast site. Critical evidence was located up to 1/4 mile away from the site and recovered. Teams of volunteer firefighters joined forces and canvassed the fields in search of any portion of the tank. Surveying flags were placed by the artifacts and each one was photographed, documented and logged as to the specific location. The tank and appurtenances were then reconstructed which assisted investigators in determining the specific chain of events that led to the horrific event.

During the winter, with heavy snow cover and frost located throughout various parts of the country, it is important to remember that in a fugitive gas leak involving natural and/or LP-gas, the leak may not have originated within the confines of the building that exploded. Numerous explosions have occurred where a fugitive gas leak originated outside of the building and migrated underground into a basement or crawlspace until the appropriate fuel/air vapor was reached and ignition occurred. Depending on the porosity of the soil, the snow and/or frost can serve as a cap on top of the ground, allowing the gas to spread laterally and not dissipate into the atmosphere through the top soil. The gas can flow into basements, crawspaces, foundations, etc., where the gas can accumulate and ignite.

Another issue that must be considered during the winter involves the actual amount of snow cover in a particular region. Both NFPA 58 and NFPA 54, along with the recommendations of various manufacturers, require that regulators for gas systems be installed with the vent pointing downward in order to prevent it from becoming blocked. (Regulators have vents that are open to the atmosphere that allow the diaphragm within the regulator to fluctuate according to the flow demands.) If the regulator vent becomes blocked, then the regulator and diaphragm can’t “breathe” which allows for the potential of a high pressure gas to pass through the regulator into the low pressure side of the system. While this is a rare condition, it is something to keep an eye out for when sizing up your scene.

If you are involved in explosions cases and have the opportunity to interview any individuals involved in the incident, one question that is always important to ask is whether or not they smelled a “gas-like” odor similar to “rotten eggs.” Fuel gases such as natural and LP-gas do not have a natural odor, and as a result, are required to be “odorized” to alert the general public in the event of a gas emergency in their residence, business or any other place of assembly. Documenting the odorant within the gas can also be important, particularly in those cases where deaths or injuries have occurred. This can be accomplished by a simple “sniff” test of the gas, and in some cases, the taking of a gas sample to determine the amount of odorant present.

Applicable Codes and Regulations in Explosion Cases
When explosions occur, you must often refer to the appropriate code(s) that may apply to such events. With respect to natural gas systems, typically most city, county and/or states look to the National Fire Protection Association (NFPA) which develops codes, standards, guides and recommended practices that are adopted throughout the United States. Specifically, NFPA 54, the National Fuel Gas Code, applies to natural gas systems and some other gas delivery systems.

The National Fuel Gas Code is the American National Standard that applies to the installation of fuel gas piping systems and equipment and appliances that are supplied with natural gas; manufactured gas; liquefied petroleum gas (LP-gas), in the vapor phase only; LP-Gas-air mixtures; mixtures of these gases; and gas-air mixtures in the flammable range. [NFPA
NFPA 58, the Liquefied Petroleum Gas Code, is the code that applies to the storage, handling, transportation and use of LP-Gas. Sometimes the specific code that may apply to certain aspects of an LP-Gas or natural gas system can be very confusing. First, natural gas systems that provide natural gas from the utility via their pipeline delivery systems are regulated by the Code of Federal Regulations. Specifically, 49 CFR 192 governs natural gas delivery system installations up to the outlet of the service entrance (i.e. meter and regulator set) at the point it enters the building. Once the piping enters the building, NFPA 54, the National Fuel Gas Code applies to the piping, line pressure regulators and appliances within the structure.

LP-Gas systems are slightly different and, in part, are governed by other codes. In an LP-Gas delivery system, the storage tank, first stage regulator and piping leading to the 2nd stage regulator up to the outlet of the regulator are all governed by NFPA 58, the LP-Gas Code. Once the piping for the LP-Gas delivery system enters the building, the applicable code is NFPA 54, the Fuel Gas Code. In all, three separate codes; 49 CFR 192, NFPA 54 and NFPA 58 will typically govern the majority of the natural and/or LP-Gas installations that you may encounter.

As always, it is important to begin assessing the magnitude of the incident as soon as possible and start to assemble the team of professionals to assist you. Specialized experts may be necessary to assist you in evaluating these types of cases however, your legal counsel and/or Origin and Cause experts can help you assess your needs. By having a plan of action in-place to handle explosions, you can be prepared when things go “Boom in the Night.”