FIRE AND EXPLOSIONS

By Vincent Dunn

Explosion, kill and injure firefighters. Firefighters work in a deadly-uncontrolled-work-environment called the fire ground. Explosions collapse walls, blow firefighters across streets, and cause hurricanes of flying glass and shrapnel. Flame and heat accompany explosions burn firefighters.

Explosion Defined

Fire protection engineers define the term explosion as an "effect" produced by a sudden violent expansion of gases. Some "effects" of an explosion are loud noise and shock waves, which can collapse walls and shatter windows. Searing heat, black clouds of smoke and balls of flame are other deadly effects produced by the sudden violent expansion blast called an explosion.

Fire protection engineers classify explosions into three broad categories: physical explosion; physical/chemical explosion; and chemical explosion. For example, a water heater boiler rupture is a physical explosion. The container ruptures, but there is no ensuing explosion of the water. A propane cylinder BLEVE (boiling liquid expanding vapor explosion) is a physical/chemical explosion. There is a physical explosion - a rupture of the cylinder, then an instant chemical explosion of the flammable propane. A smoke explosion (backdraft) is classified as a chemical explosion. The smoke and gas react with oxygen and heat in a burning room.

The chemical reaction and explosive ingredients present in a smoke explosion (backdraft) or natural gas explosion are the same as in any ordinary combustion explosion: fuel, oxygen and heat. The fuel in a combustion engine explosion driving an automobile is gasoline. The fuel in a gas explosion is methane gas and the fuel in a smoke or backdraft explosion is smoke; the explosive smoke is carbon monoxide (CO). CO has an explosive range of 12% to 74% when mixed with air.

Investigating Explosions

Many types of explosions occur at fires. Firefighters operate at manhole explosions, gas main explosions, flammable liquid and gas cylinder explosions, oil burner explosions, vehicle gas tank explosions, terrorist bomb explosions and smoke explosions. Four common explosions at structure fires are: 1.explosions caused by leaking gas piping,

2.BLEVEs of propane gas cylinders, 3.explosions caused by flammable vapor left over from an arsonist's accelerant and 4.bombs.
Before a fire investigator declares the cause of an explosion at a structure fire to be one of the above, a post-fire analysis must rule out all other possibilities. For example, if the gas piping is intact, if no ruptured propane cylinders are found and there are no traces of an accelerant flammable liquid residue or bomb fragments, then the explosion may be recorded as a smoke explosion (backdraft).

Firefighters should know three important facts about any type of explosion:

1. Explosive atmosphere. A room or fire area that explodes requires only 25% of its space to contain the explosive mixture. If the explosive mixture is in one corner of a large, smoke-filled room, the entire area could explode when firefighters enter to search and let fresh air enter with them.

2. Effects of shock wave pressures. It does not take much explosive pressure in a confined space for an explosion to cause destruction and death. The higher the peak pressure developed by the explosion, the more deadly the blast. Listed at right are the destructive effects caused by explosion pressures:

EFFECTS OF EXPLOSION DESTRUCTIVE PEAK PRESSURE
GLASS SHATTERING : 0-5 PSI
FIREFIGHTER KNOCKDOWN: 1.PSI
WOOD PARTITION COLLAPSE : 1-2 PSI
CINDERBLOCK WALL COLLAPSE: 2-3 PSI
BRICK WALL COLLAPSE : 7-8 PSI
FIREFIGHTER LUNG DAMAGE : 15 PSI
THRESHOLD FOR FATALITIES: 35 PSI
50% FATALITIES: 50 PSI
99 FATALITIES: 99 PSI

3. Elements of an explosion. There are several phases of an explosion: the original shock wave blast of the explosion; the flying shrapnel of the exploding container; and, depending on the pressures of the blast, there is the enclosing building carried along with the blast, such as parts of walls, roof, floors, doors, windows and ceilings. At ground zero in a street manhole explosion between buildings, when the shock waves of the blast rise up between buildings, a vacuum and implosion may be created. Atmospheric pressure inside nearby buildings collapses glass and parapet walls back onto the sidewalk and street. An explosion's generated heat may cause secondary fires and secondary structural collapse. Ground shock waves may break gas, water, electric and sewer pipes, Subway tunnels and building foundations are sometime affected.

Reducing Death Injury

Smoke explosions. Firefighters know that explosions happen suddenly and are unpredictable. They cannot be prevented during a fire. Explosions are a constant part of the firefighter's deadly uncontrolled work environment. , However, warning signs of smoke explosions are taught to firefighters. They are: reversal of air pulling smoke back into a smoke-filled doorway; black smoke pushing out around a closed door; or window frames and glass windows stained with smoke condensation and pulsating from the pressure of the fire.

Gas meter explosion. Firefighters are trained when fighting gas meter fires to shut off the supply. They are trained not to extinguish a gas fire with a hose stream. They are trained to let the gas fire bum and protect exposures from fire until the gas can be shut off.

Gas pipe explosions. After a fire is extinguished, and before overhauling begins, gas and electric supplies are shut off. During a serious fire, gas pipe joints may fail and leak explosive gas. When performing structural overhauling where walls and ceiling must be opened to examine for hidden fire spread, gas and electric supply to the area is shut off, limiting the danger of explosion due to leaking gas and electric spark ignition.

BLEVE explosions. When encountering a burning propane cylinder, firefighters are trained to: 1. Cool the vapor space of the cylinder.

2. Shut off the gas by the control handle, if possible.

3. If the flow of burning gas cannot be shut off, withdraw to a safe distance and allow the propane gas to burn.

Flammable vapor explosions. After a fire is extinguished and explosive or flammable liquid residue left by an arsonist is discovered in the burned-out rubble, firefighters are trained not to disturb the area, to withdraw, do not overhaul and notify the fire investigators to respond.

Explosion occupancies identified.

Firefighters are trained to identify the occupancies where explosions occur. Explosion occurs in stores more than in residences. Stores, unlike residences, are more likely to contain explosive and flammable solids, liquids and gases. These include paint stores, hardware stores, woodworking shops, motor vehicle garages, restaurant kitchens, construction shanties, flower and garden shops, stores under renovation and buildings illegally storing propane cylinders. Fire inspections should require fire suppression system to be installed in these occupancies. Also, like truss construction these dangerous occupancies should be the subjects of fire pre-planning and notification to the first-in firefighters. First-responding incident commanders should be notified of the explosion danger and the pre-plan when responding to that location.

Manhole explosions. When a manhole cover is emitting smoke and popping off the street, firefighters stretch a hose and stand a safe distance from that and other nearby manhole covers. They do not park fire apparatus in the street near other manhole covers. Nearby cellars are checked for fire and smoke spreading to or from the manhole to the cellar through electric or gas conduits. The utility company is called to the scene and firefighters await electric supply shutoff.

Vehicle fuel tank explosions. When extinguishing a vehicle fire, firefighters use the reach of a hose stream and stand away from fuel tanks and explosive bumpers.

Bombs. When an explosive is found at, a scene, firefighters do not disturb the device. They evacuate people, withdraw to a safe area, notify the bomb squad, and stretch a hose line and prepare for an explosion, collapse and fire.

Explosion fragments. At an explosion flying fragments such as glass, brick and shards of splintered wood cause most injuries. Shrapnel should be foremost in the minds of firefighters operating at a scene of a potential explosion. Eye shields should be down.

Explosion Mitigation Tactics.

There are firefighting tactics that can reduce the effects of a low-peak-pressure explosion when operating at a fire. They are venting, quenching and flanking, and setting

up a collapse zone.
Venting a roof skylight over a burning store is one of the most effective methods of protecting firefighters from the blast of an explosion. When roof conditions permit, the quick removal of a
glass skylight by firefighters can vent a smoke-filled store and break up an explosive mixture. Even if the smoke explosion occurs, the blast will be diverted upward out of the roof vent opening away from the firefighters advancing the hose line.
Quenching the superheated confined fire area is another safety and survival tactic firefighters can use to prevent explosions. Before firefighters enter a room or store where there is a suspected, danger of an explosion, a charged hose line should be positioned near the entrance. Firefighters in full protective equipment should immediately discharge a hose stream into a fire area when it is opened up. This water may cool a potentially explosive atmosphere.

Before air and searching firefighters enter a burning, confined, potentially explosive fire area, the stream of a powerful water discharge might break up the explosive atmosphere. This is not as effective as roof venting, but sometimes it is the only alternative.
Flanking When there can be no venting or the quenching by a quick dash of a hose stream is not possible, firefighters can protect themselves from a low-peak pressure explosion by flanking a doorway to a burning room operating hose lines. Flanking a doorway with hose streams will only protect firefighters from low-pressure explosions. Some explosions create low-pressure blast pressures of 0.5 pounds per square inch (psi), which break windows, or 1 (psi), which can knock down a firefighter standing in an open doorway. A blast of 2-3 (psi) will collapse a wood partition. It takes a peak pressure of 7-8 (psi) to collapse an eight-inch-thick wall.
When flanking a store, the officer in command can order two hose lines into position, one on each side of a door or window of a burning store that is suspected of being an explosion hazard. After the hose lines are charged with water and firefighters are in full protective equipment, the front store glass door or window is vented by breaking from a safe distance. Both flanking hose lines, safely out of the path of any potential explosive blast coming out of the opening, can be directed into the burning store.The **Collapse Zone**
The perimeter of a burning building is a deadly area. Window venting by firefighters inside performing search and rescue may be required to improve visibility. This window venting can rain glass down around the perimeter of the burning building. In addition, at fires chimney tops, TV antennas, slate and tile shingles, and copingstones collapse from roofs. Air conditioners fall from windows, and people descending fire escapes throw suitcases or jump. Sometimes, a deadly high-peak-pressure explosion will collapse walls out into the street. If you are outside the collapse zone and away from the building a distance equal to the height of the wall in front of you, you will be protected from some of these hazards.
Lessons Learned
Admittedly, the above safe operating procedures are half measures. But sometimes it is all we can do. As firefighters we must work inside and close to burning buildings or the fire will grow and spread to adjoining building and become even more dangerous to the community and firefighters. If we did not work inside, and around a burning buildings,

each year there would be many more people dying than the 3,to 4 thousand who die each year at fires. Firefighting is inherently dangerous and as stated above the fire ground is a deadly uncontrolled work environment.

The explosion protection of last resort is a firefighter's full protective gear: helmets, eye shields, hoods, gloves, boots, bunker pants, coats and facemasks. Protective fire gear may be hot and cumbersome and slow you down, but if you are caught in an explosion, it may determine whether you survive.