SHAI Loss Estimates

Loss estimates studies are provided for a variety of reasons, some of which include:

- To determine the level of fire and explosion protection requirements based on facility layout;
- Corporate risk management need to determine loss exposures for finance and insurance reasons;
- Risk management and insurance brokers information which is provided for insurance needs;
- Used for all phases of the risk assessment process; and
- Loss estimates are based on considering the reasonable adverse conditions which may exist at the time of the loss with due regard to the size, location within the site, construction, partial cutoffs, occupancy, protection of hazards, exposure protection installations, public protection, and any other factors pertinent to the risk.

Loss estimates are typical broken down as:

1. **NLE (Normal Loss Expected)** - The estimated total gross dollar loss resulting with protective systems in service, which function as designed, and human intervention efforts are as planned in response to a single failure event (e.g., mechanical, electrical, process, human element). For example, a fire occurs and an automatic sprinkler operates as designed and controls the fire. Typically provided is one scenario considered the most severe NLE -- which is the highest dollar loss estimate of all considered NLE scenarios

2. **PML (Probable Maximum Loss)** - The largest estimated total gross dollar loss resulting when a single failure event occurs (e.g., mechanical, electrical, process, human element), in concert with assumed reasonably adverse conditions (e.g., one automatic protection system is out-of-service protecting the area where a fire occurs, while surrounding protection systems remain in service and operate as designed).

3. **MFL (Maximum Foreseeable Loss)** - The estimated total gross dollar loss resulting when all protection is out of service and there are no human intervention efforts when an event occurs (e.g., all fixed water based fire protection systems and their water supplies are out of service when a fire occurs and there is no subsequent fire department intervention).

4. **Catastrophic (VCE) -** The greatest physical damage expressed in monetary terms that could be sustained by a location as a result of a single incident involving explosion and /or fuelled by flammable inventory of the plant and/or catastrophic failure of boiler or structural object. This type of loss may involve effects from a vapor cloud explosion, BLEVE, or natural weather occurrence such as an earthquake or hurricane.

Key Benefits of SHAI's Loss Estimates Study:

- Provides critical and necessary information as part of the risk assessment and risk ranking process for new construction, facility modifications and conceptual design changes to process and manufacturing processes;
- To generate loss estimates which may help determine insurance limits needed;
- Provides an independent assessment of the loss estimates, from the view of individuals who have spent over 25 years in your industry specifically doing this on behalf of company risk managers, insurance companies and insurance brokers.

Loss Estimates and Vapor Clouds:

Depending on a specific site potential for and consequence from a flammable vapor cloud ignition and explosion (VCE), a vapor cloud scenario may be used to demonstrate a relevant loss estimate. There are numerous methods for calculating modeling related to VCEs, i.e. TNT, TNT equivalency, empirical, multi-energy, Baker-Strehlow, phenomenological and computational fluid dynamic modeling.

When a VCE is used to demonstrate a potential loss estimate, it is typically a larger loss associated with a MFL or CAT loss potential.

To further explain a vapor cloud explosion is a process where combustion of a premixed gas cloud, i.e. fuel-air or fuel/oxidizer is causing rapid increase of pressure. Gas explosions can occur inside process equipment or pipes, in buildings or off-shore modules, in process areas or in unconfined areas. When talking about a vapor cloud explosion as an event, it is a more general term. It is then common to include the events both before and after the gas explosion process.

If the gas cloud, formed from the release, is not within the flammability limits or if the ignition source is lacking, the gas cloud may be diluted and disappear. Ignition may occur immediately, or may be delayed by up to several minutes, all depending on the circumstances. In case of an immediate ignition (i.e. before mixing with air or oxidizer has occurred) a fire will occur.

One of the most dangerous situations will occur if a large combustible premixed fuel-air cloud is formed and ignites. The time from release start to ignition can be from a few seconds up to several minutes.

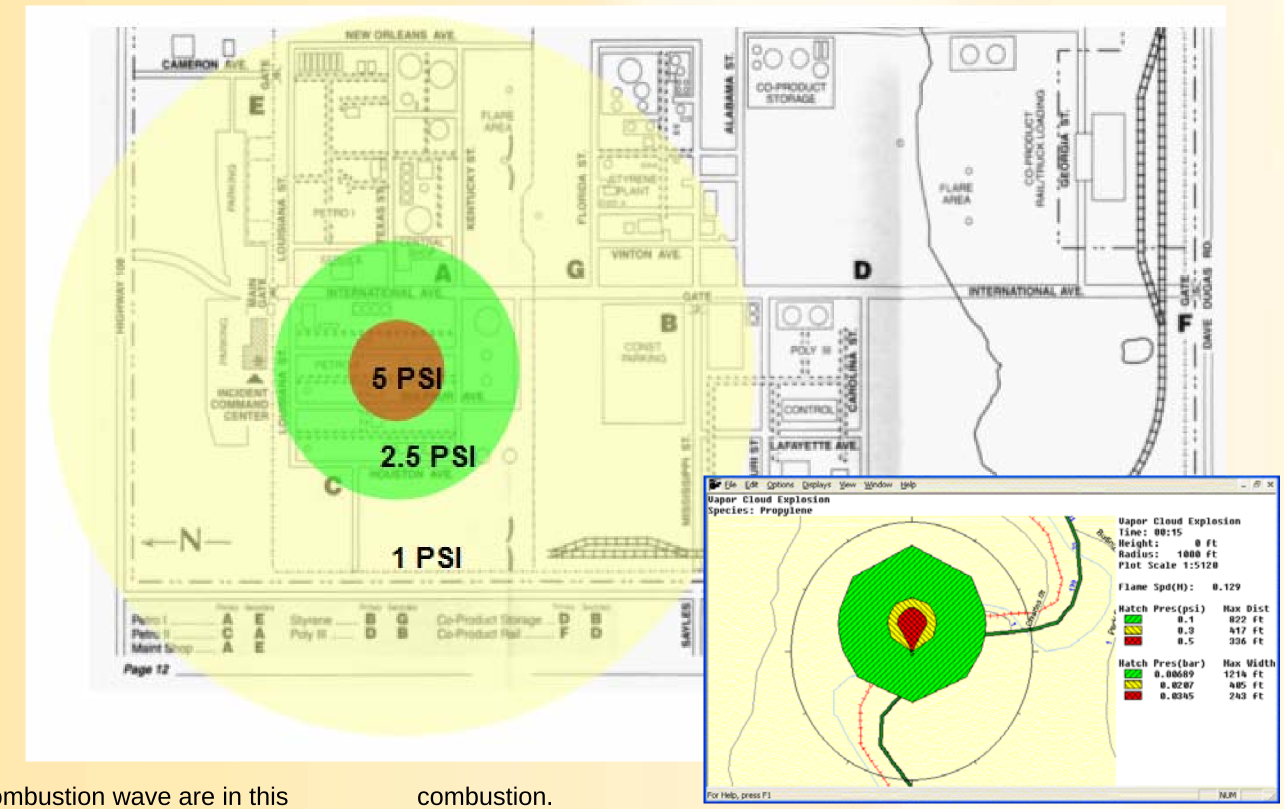
The amount of fuel can be from a few kilograms up to several tons.

The pressure generated by the combustion wave will depend on how fast the flame propagates and how the pressure can expand away from the gas cloud (governed by confinement). The consequences of gas explosions range from no damage to total destruction. The pressure build-up due to the gas explosion can damage personnel and material or it can lead to accidents such as fires and BLEVE's (domino effects). Fires are very common events after vapor cloud explosions.

When a vapor cloud is ignited the flame can propagate in two different modes through the flammable parts of the cloud. These modes are:
a) deflagration
b) detonation

The deflagration mode of flame propagation is the most common. A deflagration propagates at subsonic speed relative to the unburned gas, typical flame speeds (i.e. relative to a stationary observer) are from the order of 1 to 1000 m/s. The explosion pressure may reach values of several barg, depending on the flame speed.

A detonation wave is a supersonic (relative to the speed of sound in the unburned gas ahead of the wave) combustion wave. The shock wave and the combustion wave are in this case coupled. In a fuel-air cloud a detonation wave will propagate at a velocity of 1500-2000 m/s and the peak pressure is typically 15 to 20 bar.



In an accidental gas explosion of a hydrocarbon-air cloud (ignited by a weak source - a spark) the flame will normally start out as a slow laminar flame with a velocity of the order of 3-4 m/s. If the cloud is truly unconfined and unobstructed (i.e. no equipment or other structures are engulfed by the cloud) the flame is not likely to accelerate to velocities of more than 20-25 m/s, and the overpressure will be negligible if the cloud is not confined.

In a confined situation, such as a closed vessel, a high flame velocity is not a requirement for generation of pressure. In a closed vessel there is no or very little relief (i.e. venting) of the explosion pressure and therefore even a slow combustion process will generate pressure (constant volume combustion.

The consequences of a gas explosion will depend on:

- type of fuel and oxidizer
- size and fuel concentration of the combustible cloud
- location of ignition point
- strength of ignition source
- size, location and type of explosion vent areas
- location and size of structural elements and equipment
- mitigation schemes

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Gas explosions may be very sensitive to changes in these factors. Therefore it is not a simple task to estimate the consequences of a vapor gas explosion.