

CHAPTER 5

FLAME & EXPLOSION

Flame Definition

- Relatively fast
- Exothermic
- Gas phase reaction
- Subsonic propagation
- Usually emits light

Deflagration

Combustion wave that travels **sub-sonically** relative to the speed of sound on the unburned combustible mixture is known as ***deflagration***

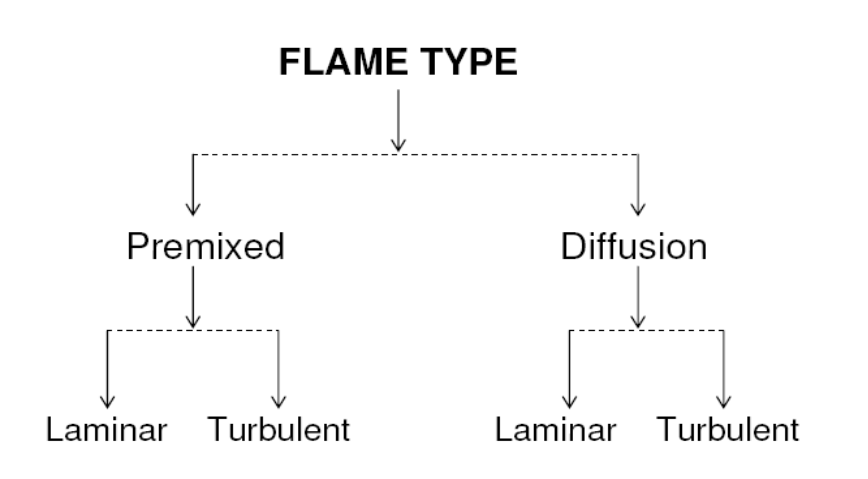
Sub-sonically - less

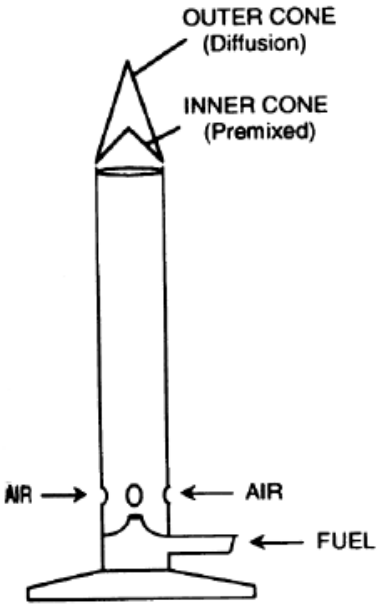
Detonation

Combustion wave that travels **super-sonically** relative to the speed of sound in the unburned combustible mixture is known as ***detonation***

super-sonically - greater

Type of Flame





Laminar premixed flame

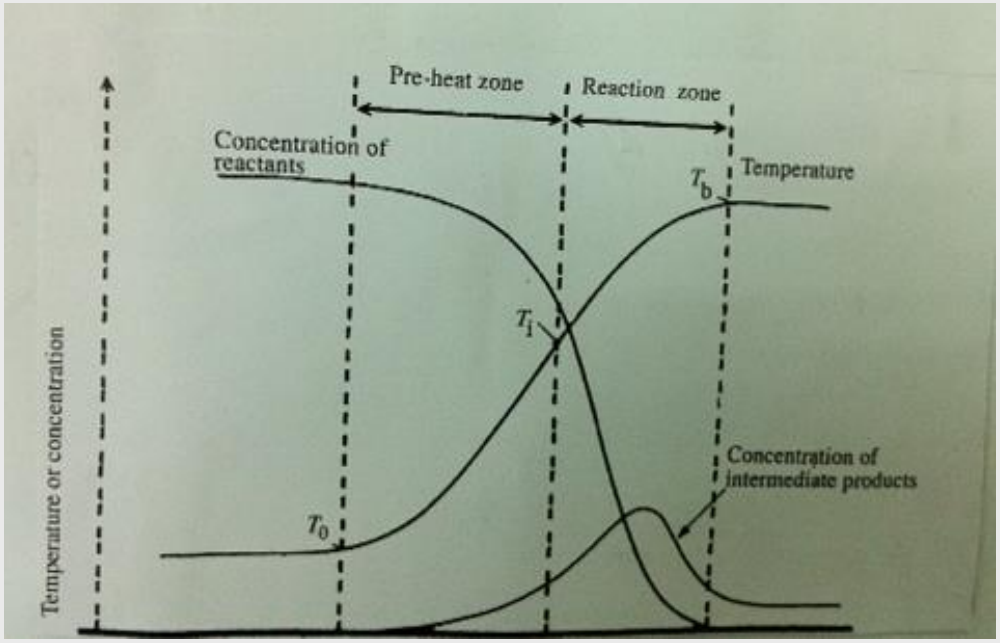
Laminar diffusion flame

Turbulent premixed flame

Turbulent diffusion flame

Laminar Premixed Flame

Structure of LPF



Variation of T or C thru the flame

Three region - Pre-heat zone, Reaction zone
Post flame region

Temperature continue rises eventually
meanwhile concentration decreases gradually

Flame Character

By visible radiation

Blue - excess air

Blue green - less air

Bright yellow to dull orange
soot appear –improper burning –
excess fuel

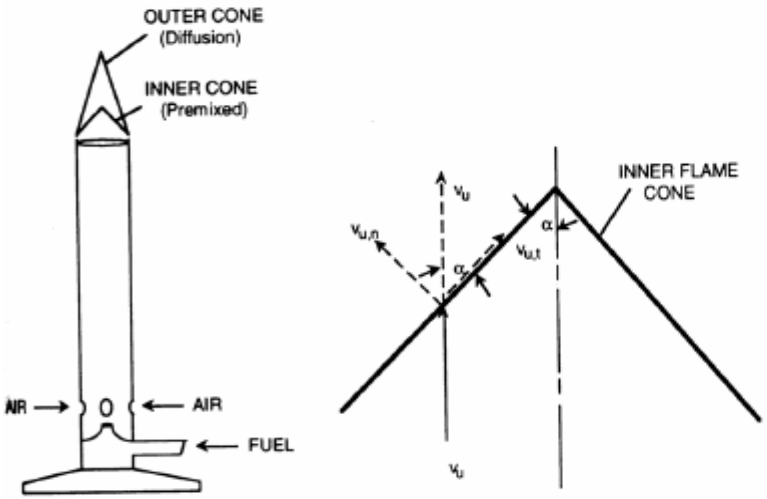
Laminar Speed, S_L

$S_L = V_u/A_f$

A_f – area of flame cone

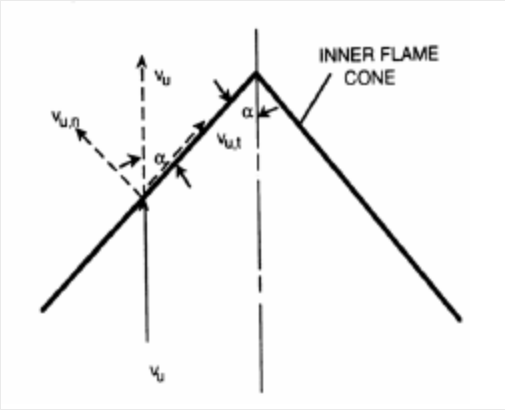
Characterize propagation velocity

$$S_L = -V_{u,n} = V_u \sin\alpha$$



V_u - velocity of fuel-air mixture at the flame front

α - angle between the burner axis and the cone flank.



V_u, depend upon;

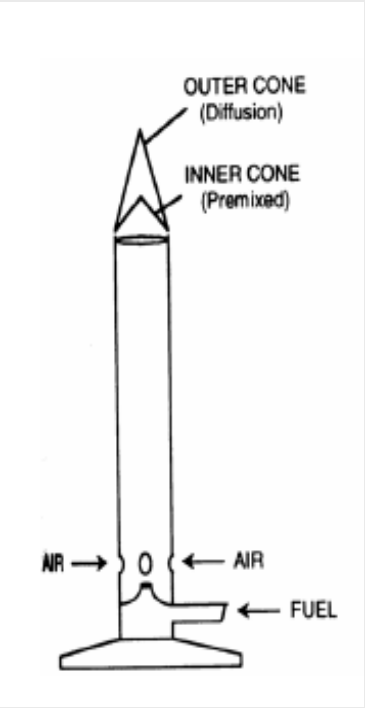
- desired flow rate
- burner nozzle diameter

$V_{u,n}$,depends upon the;

- fuel type
- composition and temperature of fuel-air mixture
- burner tube diameter

The temperature of fuel-air mixture at the burner tip depends on

- heat transfer from the reaction zone
- heat loss to the surrounding
- size, shape and material of construction of burner wall.

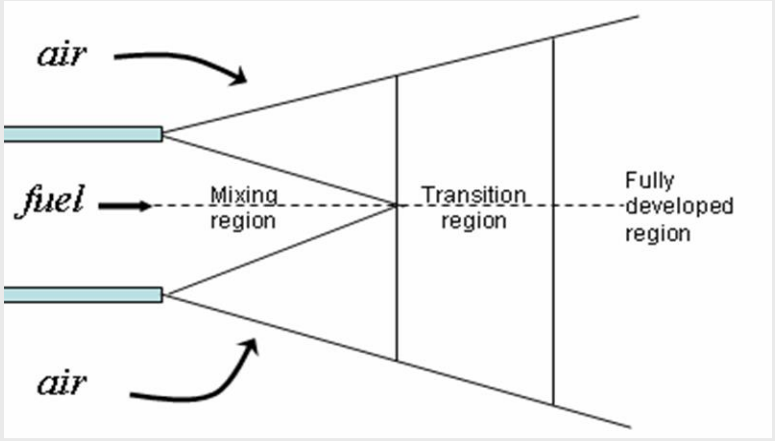


Laminar Diffusion Flames

Diffusion flames (either laminar or turbulent) are characterized as combustion state controlled by mixing phenomena.

Mixing is slow compared with reaction rate so mixing controls the burning rate.

Fuel and air do not mix before being introduce into the flame zone

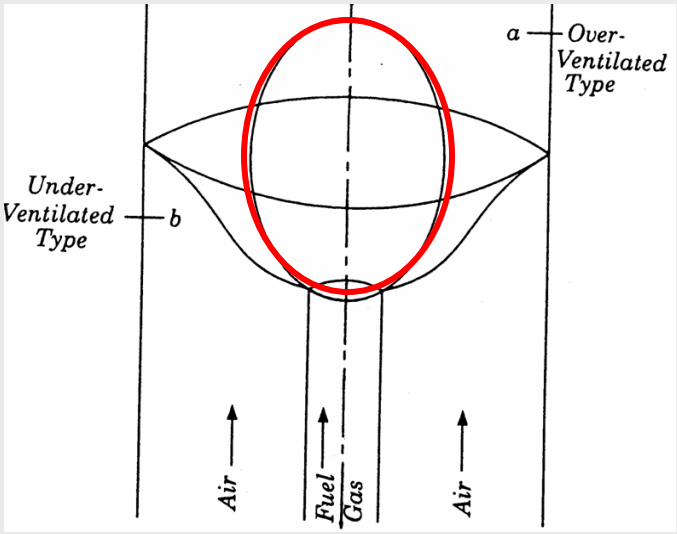


Shape of Laminar Jet Flame

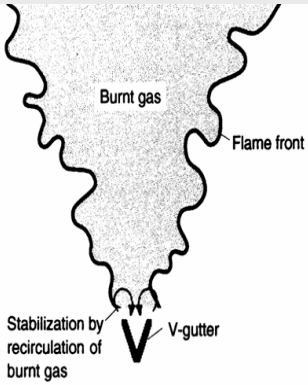
Depends on the mixture strength – quantity of air supplied

Fuel is admitted into a large volume of quiescent air

If excess fuel or air supply is reduced below initial mixture strength of stoichiometric



Turbulent Premixed Flames

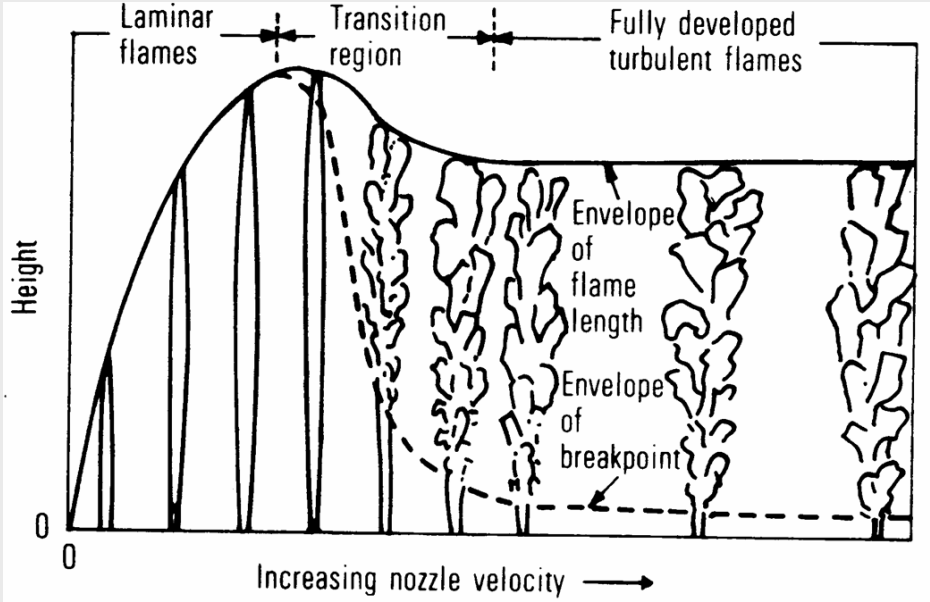


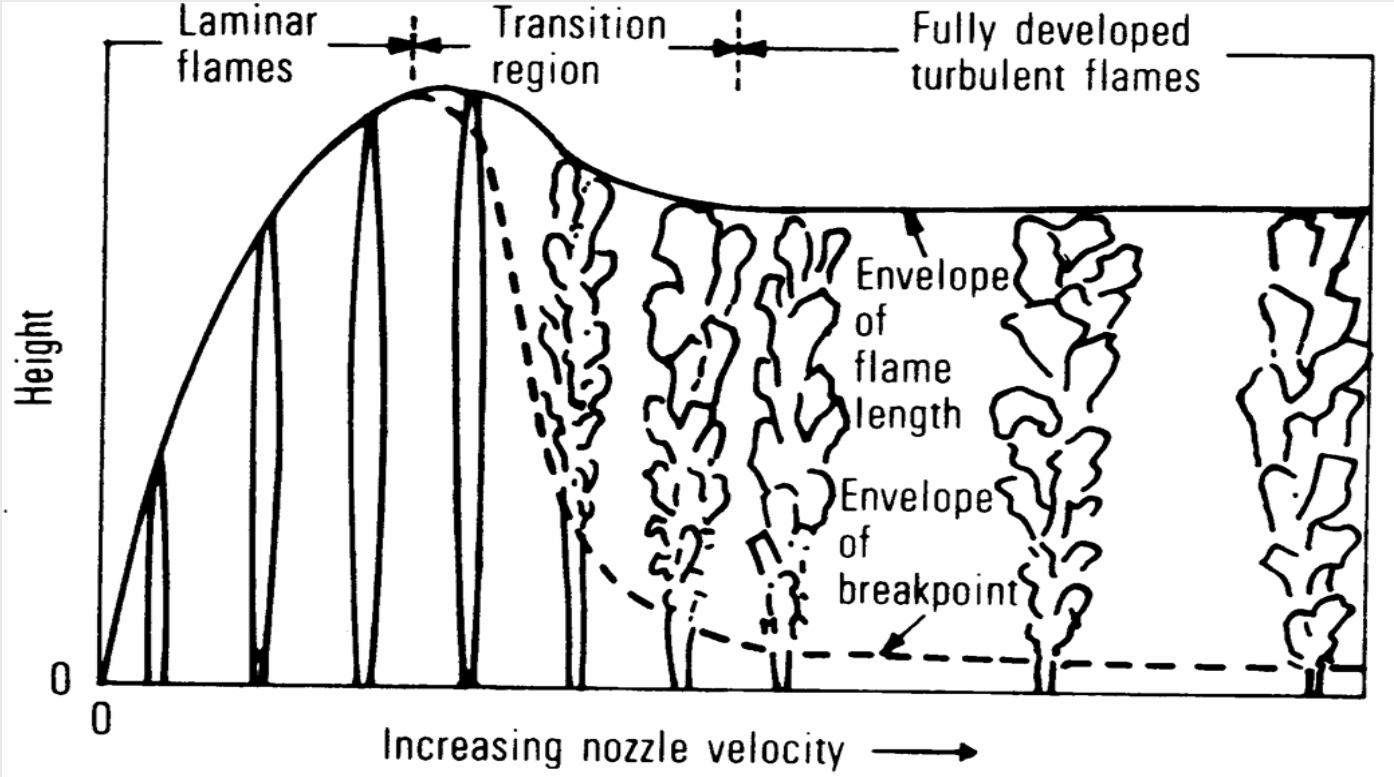
Schematic illustration of an instantaneous picture of a "V-shaped" turbulent premixed flame stabilized by a bluff-body

If the incoming unburned flow were laminar, the premixed flame would form a planar 'V'. If the incoming unburned flow were turbulent, the premixed flame angle changes depending on the local approach velocity of the reactants. Consequently the premixed flame takes on a shape as above

Turbulent Diffusion Flames

As the velocity of the fuel nozzle is increased, the character of the flame changes from laminar diffusion to turbulent type



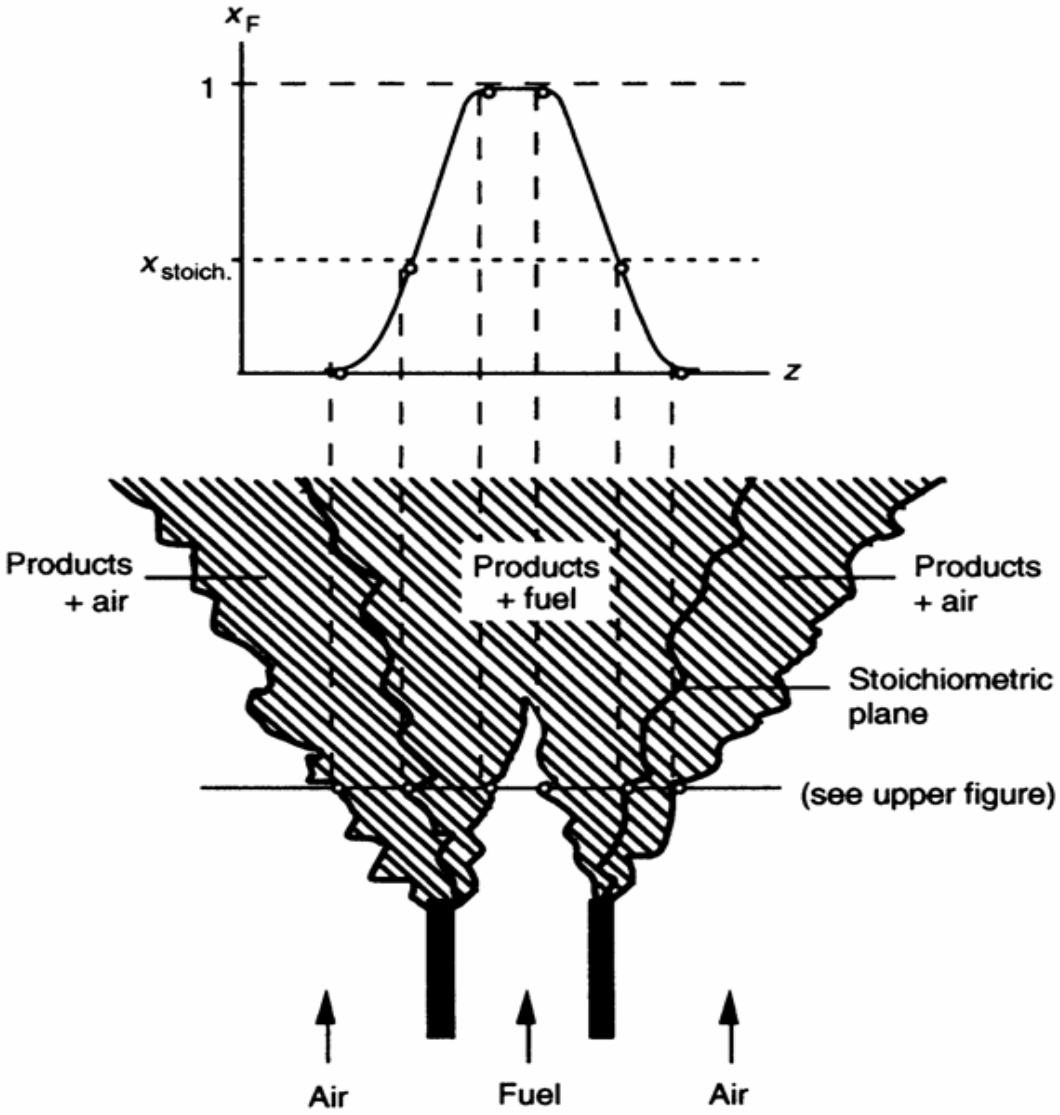


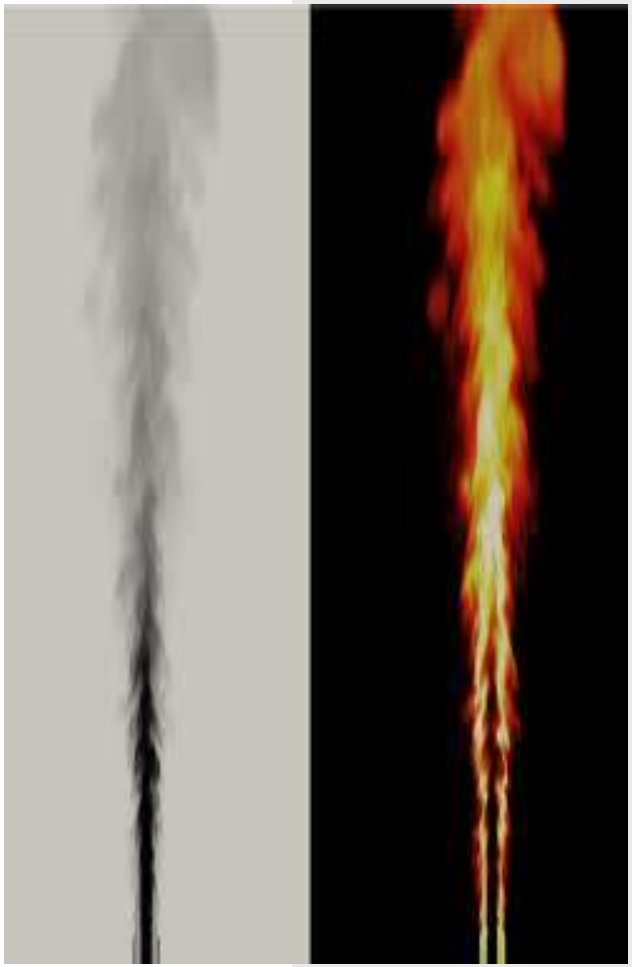

A laminar jet diffusion flame in normal gravity (left) and in microgravity (right).

At low nozzle velocity the mixing rate is slow and the flame is long and smooth (laminar)

The laminar flame height increases linearly with nozzle velocity up to a point where the flame becomes ‘brushlike’ (turbulent)

Turbulent Non-Premixed Flames





Schematic drawing of a momentary picture of a turbulent nonpremixed jet flame

Definition of Explosion

- Sudden and violet release of energy
- The violence depend on the rate at which energy is released

Definition: combustion of 'premixed' combustible mixture (gas cloud), causing rapid increase in pressure.

Pressure depend on how

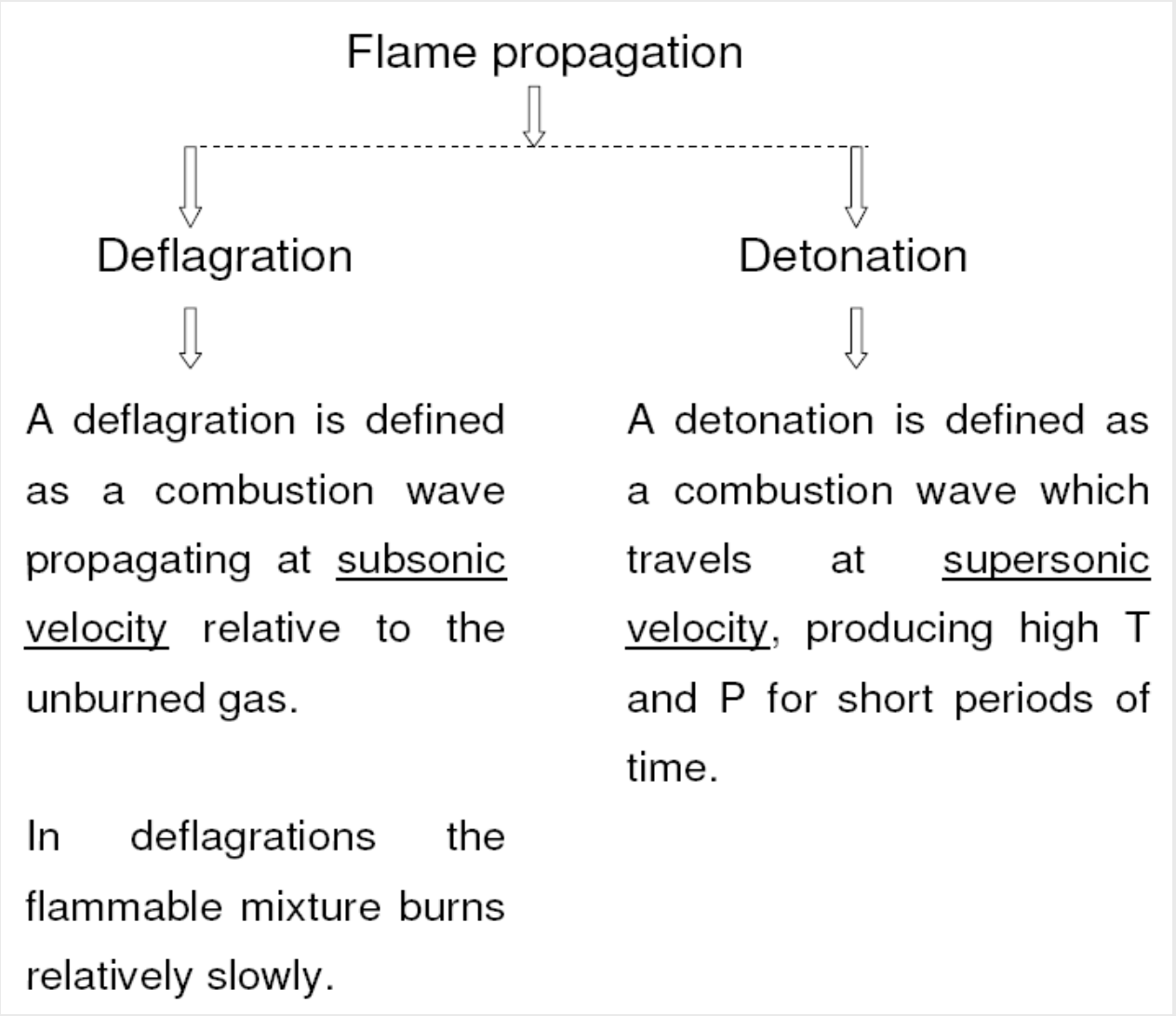
- fast the flame propagates
- the pressure can expand away from the gas cloud

Explosion

Three basic types of energy released in an explosion:-

- physical energy – e.g. pressure & strain energy
- chemical energy – derived from chemical reaction
- nuclear energy – chemical explosion

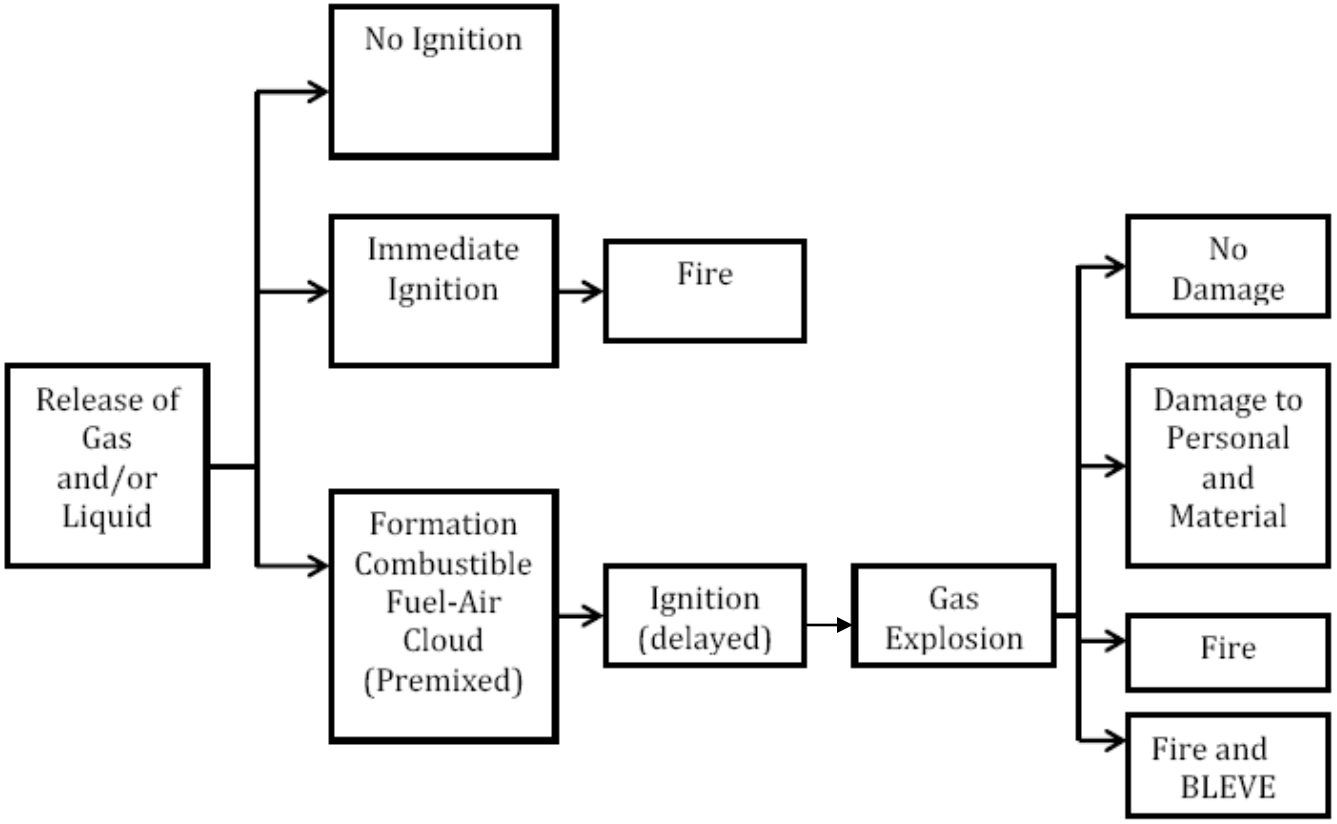
Deflagration or Detonation Explosion



Subsonic: – U < C

Supersonic: D>C

Events occurred before and after gas explosion



Types of explosion

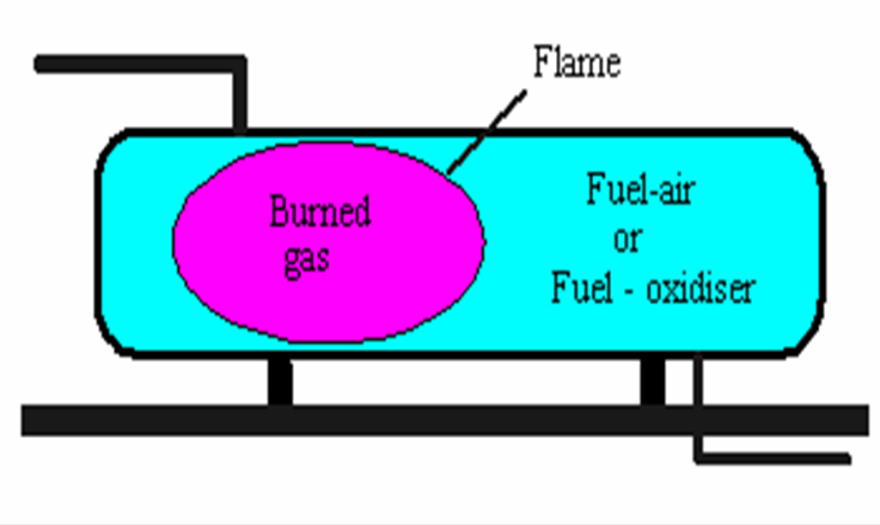
- Confined Gas Explosion
- Vented Confined Explosion
- Partially Confined Vented Explosion
- Unconfined Gas Explosion
- Unconfined Vapour Cloud Explosion (UVCE)
- Boiling Liquid Expanding Vapour Explosion (BLEVE)

Confined Gas Explosions

Often the accidental release of gas will occur in some from of containment provided by a building or section of industrial plant. This will lead to a confined gas explosion.

Confined explosions are also called internal explosions.

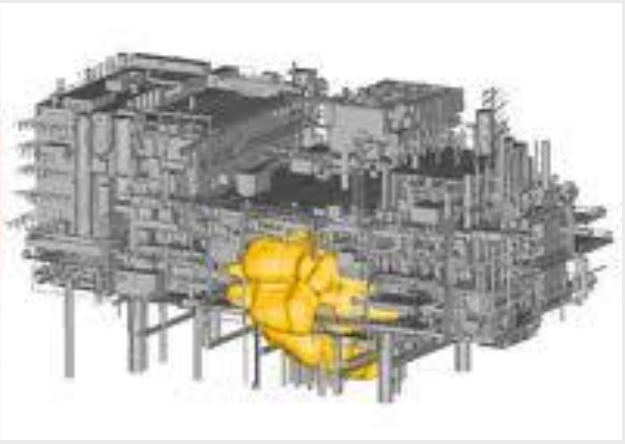
Confined explosion , vented explosion



Under conditions of complete confinement most fuel gases can produce a maximum pressure rise of about 8 bar. Most buildings and heating plant are incapable of withstanding such pressures.

However internal gas explosions rarely cause complete destruction because either by design or fortuitously the pressure is relieved at an early stage of the explosions are termed **vented confined explosions**.

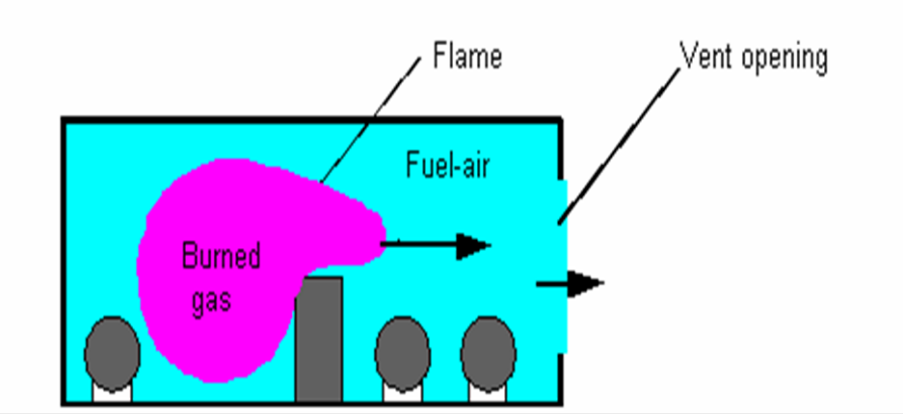
Confined explosion , vented explosion



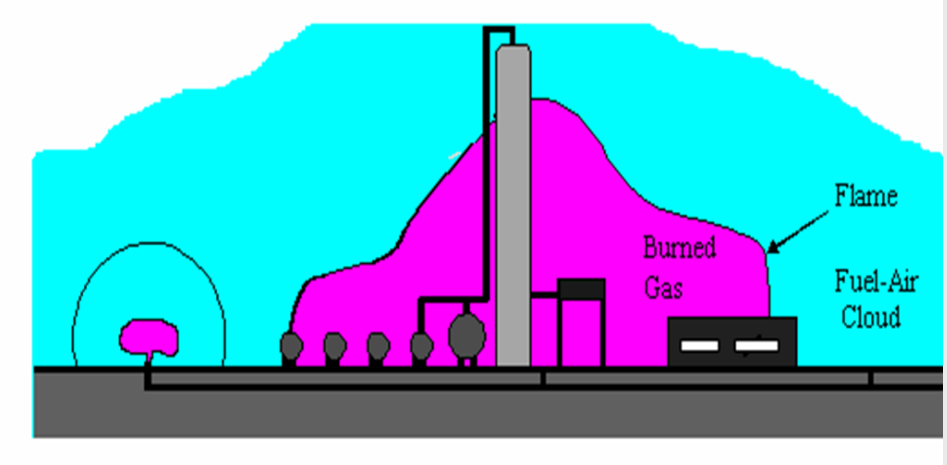
In general explosions which occur in buildings or plant are initially **confined** but due to failure of part or whole of the structure become at an early stage **vented explosions**.

Partially-Confined Gas Explosions

Partly confined explosions occur when a fuel is accidentally released inside a building which is partly open - Typical cases are compressor rooms and offshore modules - The building will confine the explosion and the explosion pressure can only be relieved through the explosion vent areas, i.e. open areas in the walls or light relief walls that open quickly at low overpressure.



Unconfined Gas Explosion



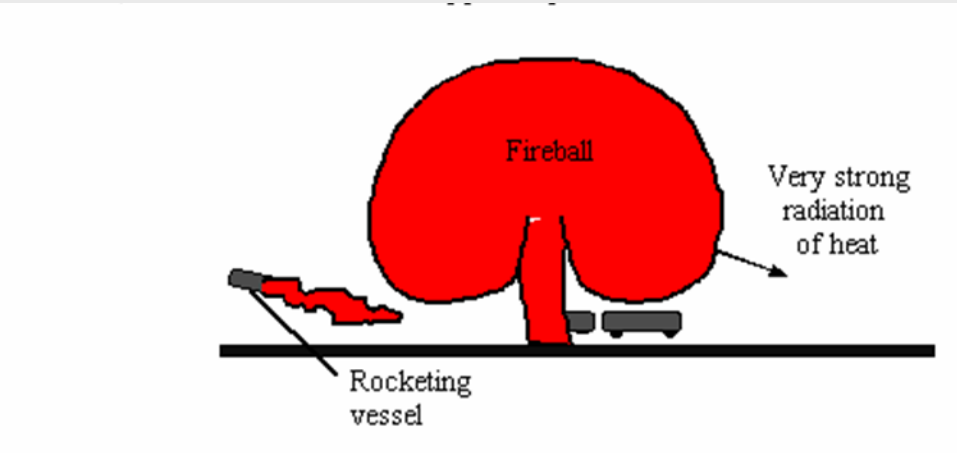
If an unconfined cloud detonates the explosion pressure will be very high, in the order of 20barg and in principle independent of confinement and obstructions.

Unconfined vapour cloud explosion (UVCE)

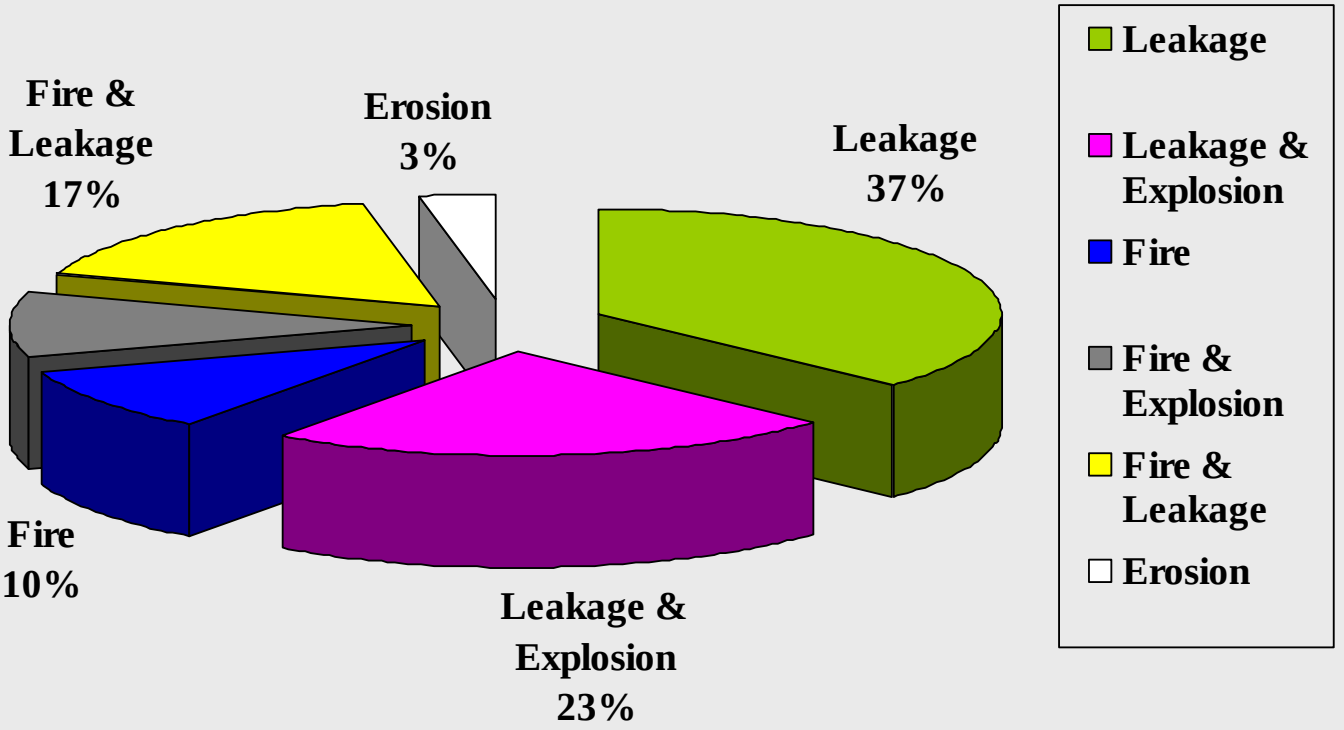
Boiling Liquid Expanding Vapour Explosion (BLEVE)

The BLEVE is an explosion due to flashing of liquids when a vessel with a high vapour pressure substance fails.

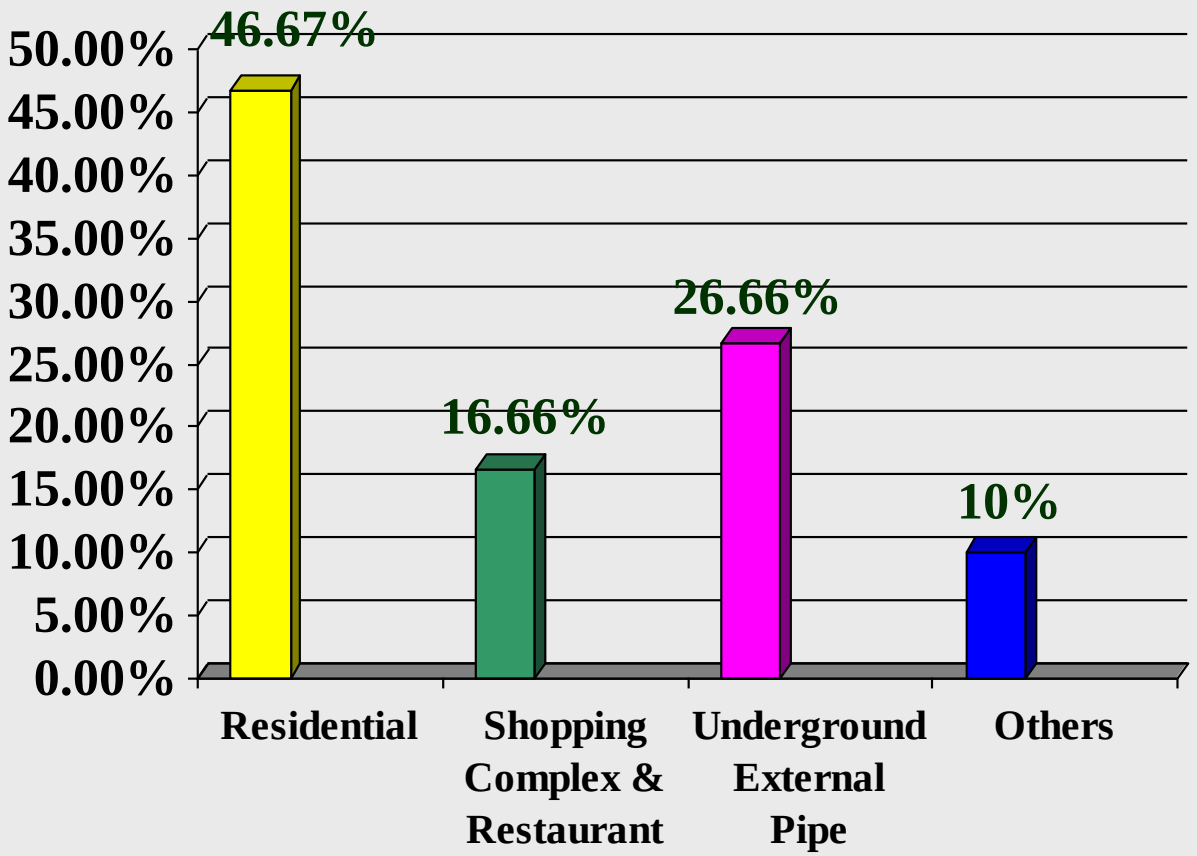
Fireball from liquid petroleum gas explosion



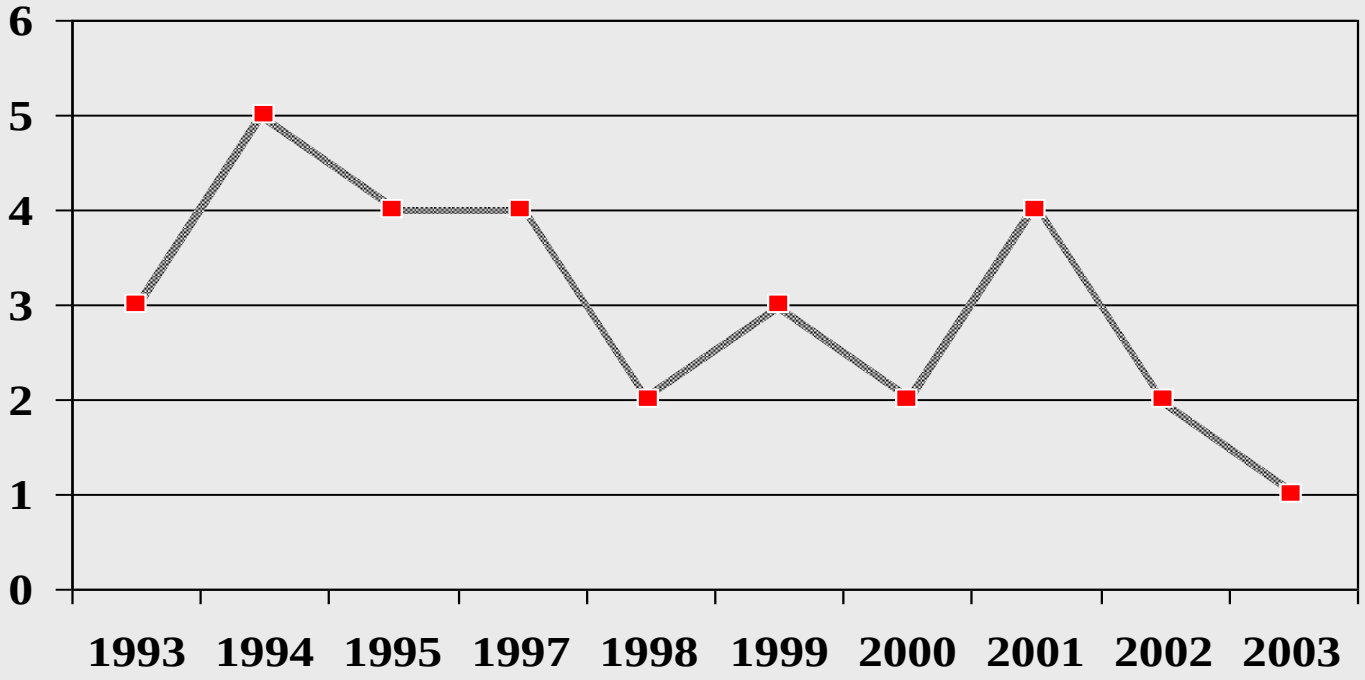
Summary of Gas accident



Gas Accident Analysis



Number of Gas Accident



Causes of Gas Explosion

Majority of the explosion occurred due to leakage thus spillage of combustibles whose vapour density was greater than air.

The nature of the initial fire or explosion which follows the ignition of a spill depends on four factors

- the nature of fuel
- the rapidity of the spill coupled with the wind conditions and/or location of buildings
- the delay before ignition source is found
- the nature of the ignition source

Causes of Gas Accident

Human errors
Lack of safety knowledge
Absence of safety device
Lack of gas facilities inspection

Question?

THE END

Thank You for the Attention