Explosives

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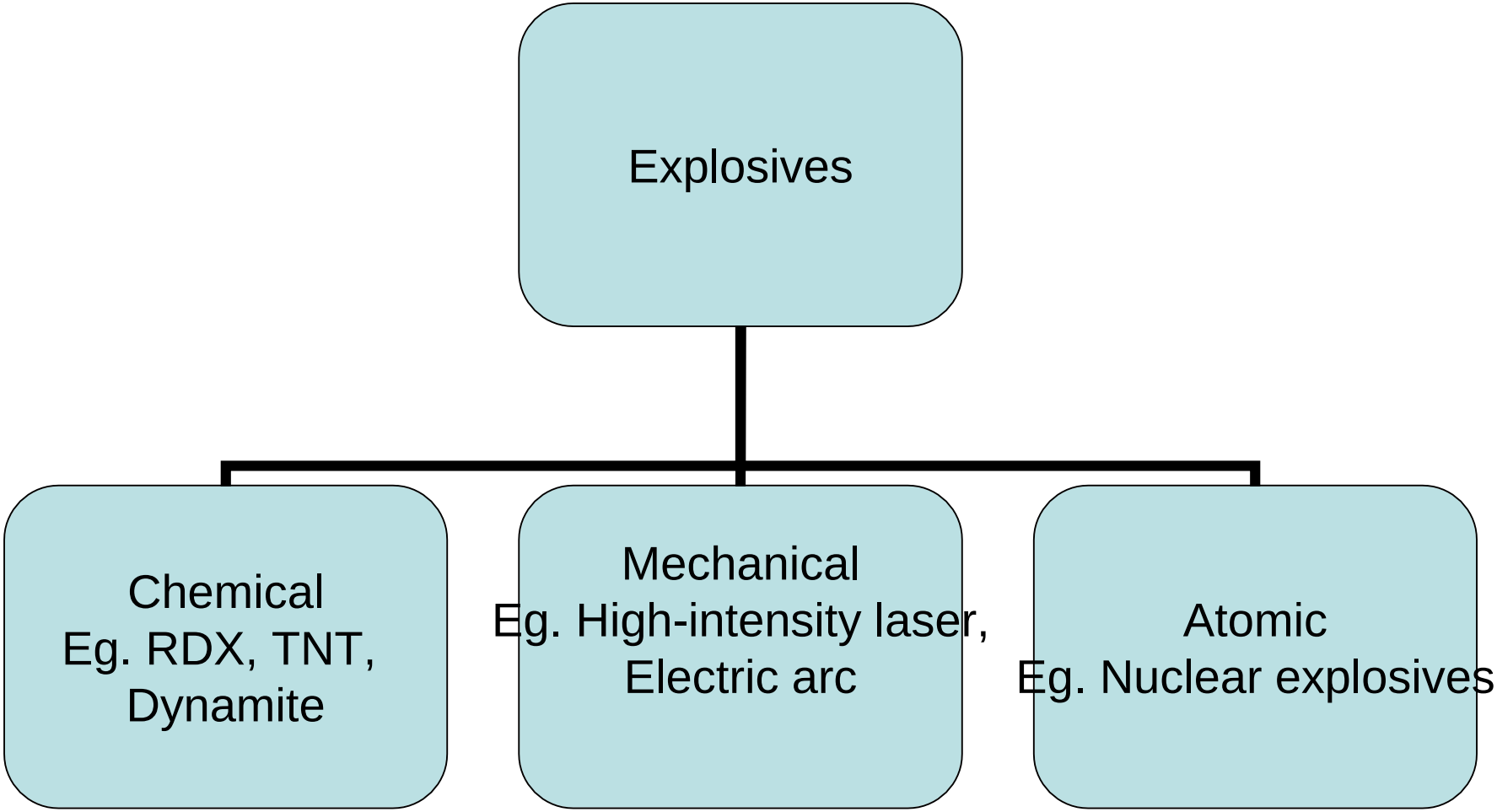
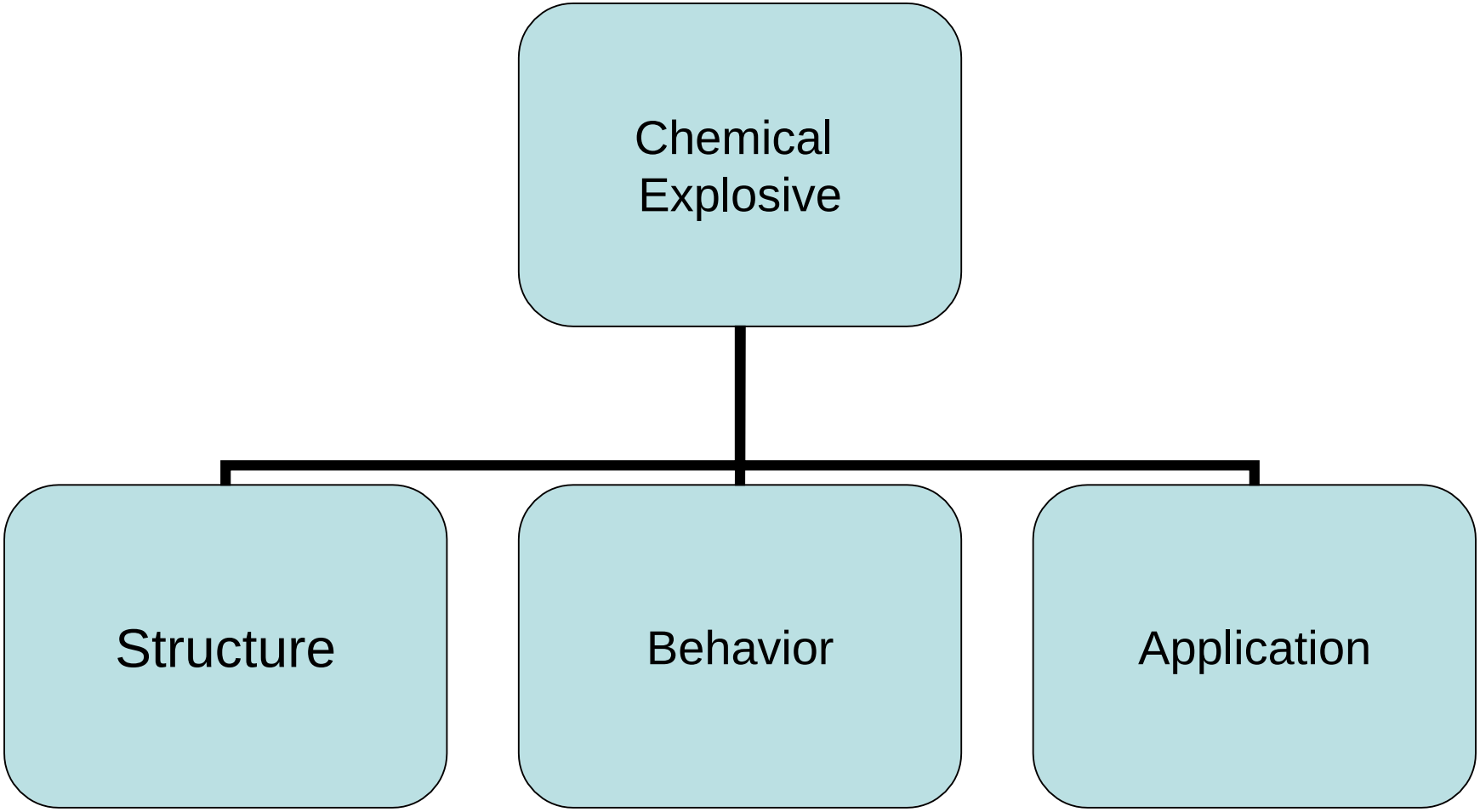
What is Explosive?

- An explosive is a material that, under influence of thermal or mechanical shock, decomposes rapidly and spontaneously with the evolution of a great deal of heat and much gas which creates tremendous amount of pressure.

Types of Explosives




Chemical
Explosive
Structure
Behavior
Application

Acc. To Structure

- Nitro
- Nitro ester
- Nitramines
- Nitramides
- Guanidine
- Diazo compounds.

Behavior

- High explosive
  - Primary
  - Secondary
  - Tertiary

- Low explosive

  Eg. Propellants

Application

- Industrial

  Eg. Nitro, N.G., Cellulose, Black powder

- Military

  Eg. RDX, TNT, PETN

High Explosives

- Detonates at very high rates from 1 to 9 X 10^3 m/s and the reaction front is a shock phenomenon moving actively throughout the material.
- Used at Military warheads, mining and demolition.
- High explosives are subdivided into three classes differentiated by sensitivity.

Primary Explosives

- Primary explosives are extremely sensitive to shock, friction and heat to which they will respond by burning rapidly or detonating.
- Used in blasting caps to translate a signal into an action, i.e. an explosion.
- A small quantity-usually milligrams is sufficient to initiate a large charge of material that is usually safer to handle.

- Primary explosives include :
  - Lead azide
  - Mercury fulminate
  - Nitrigen trichloride
  - Nitrogen triiodide
  - Lead styphnate
  - HMTD
  - Silver azide
  - Sodium azide
  - TATP, TCAP

Secondary Explosives

- Called as base explosives
- Insensitive to shock, friction and heat.
- They may burn when exposed to heat or flame in small, unconfined quantities but detonation can occur.
- These are sometimes added in small amounts to blasting caps to boost their power.

- Eg. Dynamite, TNT, RDX, PETN, HMX
- PETN is considered a benchmark compound, with materials that are more sensitive then PETN being classified as primary explosives.
- Pyrotechnics is a field of study with the manufacture of fire works but more scope that includes items for military and industrial uses.

- Items such as safety matches, oxygen candles, explosive bolts and the automobile safety airbag all fall under the purview of pyrotechnics.
- The use of explosions, flashes, smoke or flames on stage is known as proximate pyrotechnics.

Tertiary Explosives

- Also called blasting agents, are so sensitive to shock that they can’t be reliable detonated by practical quantities of primary explosive.
- An explosive booster act as a bridge between a low energy explosive and a low sensitivity explosive.
- It increases the energy of an initiating explosive to the degree sufficient to trigger the secondary charge.

- An initiator (such as detonation cord, shock tube, cannon fuse) does not have the energy to trigger large high explosive charges (such as PETN, TNT or ANFO).
- So, a booster is used to upgrade the energy so that the main charge is activated.
- Explosive booster are typically constructed by mixing high sensitivity and high energy compounds at various ratios.

Industrial Explosives

- Used for controlled explosion in the field of industries or controlled explosion of explosives in various other field.
- Used for mining and quarrying, coal mines, building construction (For destruction of old building), geophysical exploration, metal cutting and forming major engineering jobs construction of tunnels dams.

Black powder

- Black powder has been the preferred blasting agent because it is less shattering in its effects.
- It’s a mixture of KNO3 – 75% , S – 15%, Charcoal – 10%.
- Its flames has great igniting power, which is undesirable where combusting gasses or solids are present but useful for igniting propellents.

Blasting agents and slurry explosives

- Blasting agents and slurry explosives have become the principle industrial explosives because they may be handled by simple machinery almost completely without danger and also their cost is very low.
- These are usually ammonium nitrate mixtures sensitized with non-explosive fuels such as oil or wax.
- Such mixtures produce energies surprising that of dynamite.

Compositions of Industrial explosives

Designation	% Sensitizer	Oxidizer
SE-TNT	17-60 TNT	AN, SN, BN, SC, Nap, C
SE-SP	20-60 SP	AN, SN, BN, SC, Nap, C
SE-HSSP	20-60 HSSP	AN, SN, C
SE-TNT/Al	5-20 TNT/Al	AN, SN, Nap, C
SE-SP/Al	10-25 SP/Al	AN, SN, C

Nitroglycerin and Dynamite

- Nitroglycerin was the first high explosive to be employed on large-scale.
- Which is in liquid form so some what difficult to handle and also freeze at 13o C.
- Dynamite was originally made by absorbing nitroglycerin into kieselguhr clay or wood flour or ammonium / sodium nitrate 75% N.G. present in absorbing media even through it is in solid form.

- Because of nonfreezing explosive, Dynamite for use in cold weather.
- Dynamites containing other material designed to lower freezing point of the mixture are used eg. Glycol dinitrate.
- Nitrocellulose can be gelatinized by nitro glycerin and the resultant firm gel is commonly known as gelatin dynamite.

Propellants, Rockets and Missiles

- Propellants for Guns :-
  - The oldest propellant known is black powder but replaced by smokeless power.
  - Smokeless powder is colloided cellulose nitrate, plasticizer such as dibutyl phthalate is added and usually about 1% of diphenyl amine or similar amine designed to improve its storage life.

- Single base :- When the only one explosive used is nitrocellulose of over 13% nitrogen content.
- Double base :- When two or more explosive ingredients are used (Nitrocellulose and Nitroglycerine)

Propellants for Rockets

- There are a great variety of choices in the design of efficient propulsion system; liquids, solids and casteble solid units are all in use.
- Rocket propulsion system derive their energy from chemical sources.
- Rocket propellants are low explosives which consist of fuels which include their own oxidant or other reactant necessary to cause the planned reaction. The thrust of the escaping hot gases pushes the device forward.

- High performance systems under fine control are used for the launching of missiles and spacecraft for exploratory and scientific missions and for military offense and defense.
- Liquid propellants :- Liq. O_2 [Lox]

  Liq. H_2 [LH_2]

- Solid propellants :- Nitrocellulose in nitroglycerin

Miscellaneous industrial explosive uses

- There are a number of industrial procedures which make use of small quantities of explosives which are highly important.
- Explosive rivets can be placed without breaking devices.
- Explosive thrustors, pin pullers, separators and release devices were extremely reliable on the space missions and find use in industrial emergency devices.

- Forming, shaping and cladding metals by explosive welding have become important manufacturing techniques.
- Explosive welding is used to form plate heat exchangers.
- Shearing and punching of metal works very well.
- Ejection seats are explosive powered.
- Electrical cable and connectors are now being attached by firing explosive charges.

Pyrotechics

- Pyrotechic mixture have a number of uses: illuminating flares, marine signal rockets, the red signal flare used by trucks and trains for signalling.
- These products consist of mixtures of strong oxidizing agents, easily oxidizable materials and various other materials such as Ba(NO3)2, Mg, Al, Sodium Oxalate, Ca-stearate, black power.

Matches

- All matches fall within two categories : Safety matches and strike-anywhere matches.
- The match head contain phosphorus sesquisulfide (P4S3), Potassium or barium chlorate, ground glass and glue.
- Safety matches are ignited by the generation of heat on the striking surface of the box, the coting of which consists mainly of red phosphorus ground glass and glue.

- No phosphorus sesquisulfide is used in safety matches, but antimony sulfide is used in the heads as a flame producing agents.

Military Explosives

- The explosives which used for military purposes are known as military explosives.
- Cost is less vital in the case of military explosives and the accent is on performance and good storage life.
- A complete round of ammunition is necessary to fire a shot.
- Military ammunition varies in size from caliber 0.3 inches (7.6 mm) to 17 inches (432 mm) weapons.

- The essential ingredients for complete round of high-explosive ammunition is shown in fig.----
- The unit consists of a thin cartridge case holding the primer, igniter and propellant charge.
- The case is designed to fit smoothly into the gun and on explosion, to expand, sealing the breech of the gun so that the escape of gases to the rear is prevented, thus allowing the full effect of the propellant to be exerted on the projectile half of the shell.

- The primer contains a small amount of a priming mixture [eg. KClo3 + Pb(CNS)2 + Sb2S3 + TNT + ground glass].
- This mixture explodes under the impact of firing pin and produces a flame which ignites the black powder charges of the igniter which in turn ignites the propellant charges of coarse-grained smokeless powder.

- The burning of the smokeless powder causes the rapid emission of heated gas, which ejects the projectile from the gun.
- At the target, upon impact or upon functioning of the time fuse mechanism, a small quantity of a primary explosive (the detonator) is set off; this causes explosion of the booster-an explosive of intermediate sensitivity (between that of a primary explosive and the bursting charge) which picks up the explosive shock from the detonator, amplifies it and ensures complete detonation of the bursting charge.

- The bursting charge of high explosive is usually TNT alone or mixed with ammonium nitrate.
- Most bursting charges are mixtures, for example
  - amatol (TNT + NH_4NO_3)
  - Comp. B (RDX + TNT)
  - Pentolite (PETN + TNT)
  - Tetratol (Tetryl + TNT)
  - Octol (Al + TNT + NH_4NO_3)

- Industrial and military explosives both use the same chain initiator-primer (blasting cap), booster, bursting charge (blasting agent), pattern, except for fuze, which is some type of mechanical or electronic device to cause explosion on impact, delayed on impact or by proximity as desired.
- Many military explosives have at least some industrial use, which is not surprising.
- Many military and industrial uses are similar, such as smokeless powder, black powder and primeres.

- Military units tend to be larger, the performance demanded requires better quality control, and the effect of really long-time storage under difficult conditions must be minimized.
- Eg. TNT, Tetryl, Ammonium picrate, PETN, RDX.

Incendiaries

- Flammable mixtures are the oldest chemical weapons known to humans; the destruction of many ancient cities was due to the use of fire.
- An incendiary, strictly speaking causes ignition of combustible materials at that target, eg. Wooden building or petroleum products.

- Incendiaries take the form of bombs, bomblets, artillery shells and grenades.
- Incendiaries are two types :
  - Metallic and Petroleum
- Metallic incendiaries provide intense sources of ignition.
- Petroleum units scatter less intense sources widely.

- Metallic incendiaries include bombs with metallic cases, usually made of a combustible magnesium alloy filled with a mixture of barium nitrate and aluminum with thermite to ignite the case.
- Thermite is a mixture of aluminum powder and iron oxide which ignited, burns fiercely at a high temp. and cannot be extinguished by means of water.

- Some readily ignitable material such as black powder, is employed to ignite the thermite.
- Some time white phosphorus or a small amount of tetryl is added as a deterrent to fire.
- Petroleum incendiaries contain gasoline thickend with various ingredients. The first satisfactory thickener was rubber, but the other thickeners such as isobutyl methacrylate polymer, which was dissolved in gasoline in combination with calcium soap, were discovered.

- Perhaps the most important thickener is Napalm.
- This is a granular aluminum soap prepared by precipitating aluminum sulfate in excess alkali with two parts of acids from coconut oil, one part of naphthenic acid and one part of oleic acid.
- The soap is capable of withstanding elevated temp. and produces a gasoline jelly at ordinary temp. by simple mixing.

Toxic Chemical Weapons

- Toxic chemical weapons are used for unprepared enemy.
- Chlorine gas was used as a chemical weapon but it has low molecular weight and high giffusion rate, so it was less effective.
- Contact poisons such as “mustered gas” were more effective. Such agents are more effective because of low vapour pressure.
- Used as a defensive weapon to destroy enemy but as an offensive weapon they require difficult decontamination before advancing troop can enter.

- Toxic agents designed to produce temporary incapacity are of value in controlling riots and civil disobedience.
- Such materials may produce sneezing, tears, vomiting and / or nausea.
- Gas masks are rarely effective and self-contained breathing apparatus is required for adequate protection.

- Common tear gases includes chloroacetophenone, bromobenzylcyanide and o-chlorobenzylmalonitrile.
- White phosphorus, which burns to P2O5, hexachloroethane – zinc combustion, which forms ZnCl2 and sulphure trioxide and shlorosulphonic acid, which gives off HCl & H2SO4 are used to create chemical nuclei for fog formation. Oil vapours mists are used in smoke genders. Coloured smoke are made by burning pyrotechnic mix. Which volatilize various heat resistant organic dyes.

Screening Smokes

- Smokes or persistent fogs are used to hide areas on a temporary basis, smokes are disappeared by mechanical, chemical and thermal means.
- Most fogs are created by forming low volatile droplets of water which remain dispersed in air.
- White phosphorus, which burns to P_2O_5, hexachloroethane – zinc combustion, which forms $ZnCl_2$ and sulphure trioxide and shlorosulphonic acid, which gives off HCl & H_2SO_4 are used to create chemical nuclei for fog formation. Oil vapours mists are used in smoke genders. Coloured smoke are made by burning pyrotechnic mix. Which volatilize various heat resistant organic dyes.

Characteristics of Explosives

- Availability & Cost
- Sensitivity – Impact, Friction, Heat
- Stability
- Brisance
- Density
- Heat of expansion
- Rate of detonation
- Volatility
- Hygroscopicity
- Toxicity

- Availability & Cost ;

  Explosives must be produced from cheap raw materials that are non-strategic and available in great quality. In addition, manufacturing operations must be reasonably simple, cheap and safe.

- Sensitivity :

  The term related with the amount and intensity of shock (Impact), friction or heat.

  Impact :

  sensitivity is expressed in terms of distance through which a standard weight must be dropped cause the material to explode.

Friction :

Sensitivity is expressed in terms of what occurs when a weighted pendulum scrapes across the material. (snaps, crakes, ignites and / or explodes)

Heat :

Sensitivity is expressed in terms of the temperature at which flashing or explosion of the material occurs.

- Stability :

  Stability is expressed is the ability of an explosive to be store without detonation.

  Chemical constitution :

  Common compound s can undergo explosion when heated indicates that there is something unstable in their structures.

  It is generally recognized that certain groups NO2,

NO3, Peroxide, azide … are intrinsically in a condition of internal strain.

Increased strain through heating can cause a sudden disruption of the molecule and consequent explosion.

In some cases, this condition of molecular instability is so great that decomposition takes place at ordinary temperatures.

- Temp. of storage :

  The rate of decomposition of explosives increase at higher temp. All of the standard military explosives may be considered to be of a high order of stability at temp. -10^{o}C to +30^{o}C , but each has a high temp. at which the rate of decomposition becomes radily accelerated and stability is reduced.

  Most explosives become dangerously unstable at temp. exceeding 70^{o}C.

Exposure to sun :

If expose to the ultraviolet rays of the sun explosive compounds that contain nitrogen groups will rapidly decompose, affecting their stability.

Electrical discharge :

Electrostatic or spark sensitivity to initiation is common to a number of explosives.

Brisance :

In addition to strength, explosives display a second characteristic , which is their brisance or shattering effect, which is distinguished from their total work capacity.

The rapidity with which an explosive reaches its pressure is a measure of its brisance.

Brisance is probably a combination of strength and velocity.

It is directly related to detonation pressure.

Sand block test :

The brisance of an explosive is measured by exploding a measured quantity of it in sand bomb, a heavy walled vessel filled with a standard coarse of sand which is crushed by the explosion. Screening measures

Trauzl block test :

This test measures the strength of the explosive by measuring the strength ballooning of soft lead cylinder in which the explosive is inserted and exploded. Results are reported in terms of the increase volume, expressed in cubic centimeters cause the detonation of the explosive.

Density :

High load density can reduce sensitivity by making the mass more resistant to internal friction.

However, if density is increased to the extent individual crystals are crushed, the explosive become more sensitive.

Volatility :

- Volatility means a substance vaporizes is an undesirable characteristic in military explosives.
- Explosives must be no more than slightly volatile at the temp. at which they are loaded or at their highest storage temp.
- Volatility affects the chemical composition of the explosive such that a marked reduction in stability.

Hydroscopicity :

The introduction of moisture into an explosive highly undesirable since it reduces the sensitivity, strength and velocity of detonation of the explosive.

Toxicity :

Due to their chemicals structure, most explosives are toxic to some extent.

Any explosive of high toxicity is unacceptable for military use.

Heat of explosion :

Ordinary fuels gives more heat on combustion than the explosives, the energy is librated instantaneosly.

Rate of detonation :

The rate of detonation accounts for the time during which the explosive reaction takes place.

It is measured by burning the explosive at a constant volume in an apparatus, called time pressure bomb.

The measurement is carried out by piezoelectric quartz or tourmaline crystal gauges by pressure changes w.r.t. time.

Propellants
Propellants for Rockets

There are a great variety of choices in the design of efficient propulsion systems, liquids, solids and castable solid units are all in use.

Rocket propulsion system derive their energy from chemical sources.

Rocket propellants are low explosives which consist of fuels which include their own oxidant or other reactant necessary to cause the planned reaction.

The thrust of escaping hot gases pushes the device forward, according to the principle that forces act equally in opposite directions.

High performance systems under fine control are used for the launching of missiles and spacecraft for exploratory and scientific missions and for military offense and defense.

Careful selection of the propellant ingredients is important to give high chamber temperature and pressure.

The gases produced should be low molecular weight.

The fuel should be one which provides the greatest amount of heat for the smallest amount of weight.

The forgoing factors are the most important ones in the equation defining specific important ones in the equation defining specific impulse or pounds of thrust per pound of weight of propellant burned per second, wherein the square root of the absolute temp. T divided by square root of the average molecular weight M of the exhaust gases determines the value of the specific impulse S.I. = ----------

Liquid Propellants :

Liquid propellants are those added to the combustion chamber as liquids.

This includes all liquids used in a single propellant system, serving as fuel, oxidizer, catalyst.

Liquid fuels are for the most part, used in bipropellant system in which fuel and oxidizer stored in two fuel tanks and fed separately to the combustion chamber.

Monopropellants combine the fuel tanks and oxidizer in one mixture.

A few of the better known liquid propellants are listed below with some of their characteristics.

Liquid propulsion system are the means for achieving the propulsive energy required for human space travel.

Large high performance rockets now use Lox and LH2 propellants because of their high specific impulse and low cost.

Greater storage efficiency is achieved by catalytic conversion of nearly all the hydrogen to the para form.

Solid propellants :

Solid propellants have advantages over liquids in that they are simple in design and more easily stored, handled and serviced. They cost less, because the ingredients are combined in a mold which serves to confine the materials and impart the desired grain configuration, they can be launched expeditiously and predicted burning rates can be achieved.

Originally, solids were classified into two groups :

Heterogeneous propellants in which oxidizer and reducer present in two distinct phase.

Homogeneous in which oxidizer and reducer present in a single or colloidal phase, eg. Nitrocellulose dissolved in nitroglycerin.

Small percentages of additives are used to control the physical and chemical properties of the solid propellant.

The properties of solid propellants are shown :

- Solid propellants have a variety of applications : as propulsion units for missiles, target drones and supersonic sleds.
- Rockets used for the separation of stages during flight and for setting ullage in the liquid propellant tanks are usually of the solid type, for example some details of the minute Man ICBM solid propellant rocket stages are available.
- Glass filament wound causing for both the first and second stages of the submarine launched Polaris carry a powerful solid propellant.

- Artificial satellites are another type of spacecraft that require rocket propulsion for launching.
- Several have been placed in the earth’s orbit, some for communication (Telstar), for metrological observations (zeros), for scientific measurement for human space flight and to detect nuclear explosions.