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1. Learning Outcomes

After studying this module, you shall be able to learn about

- Explosives
- Explosion and its different types
- Types of explosives
- Different types of Improvised Explosive Devices

2. Introduction: Explosives

An explosive is a substance, may be an element, a compound or mixture, which is capable of exerting pressure on its surroundings on explosion/transformation.

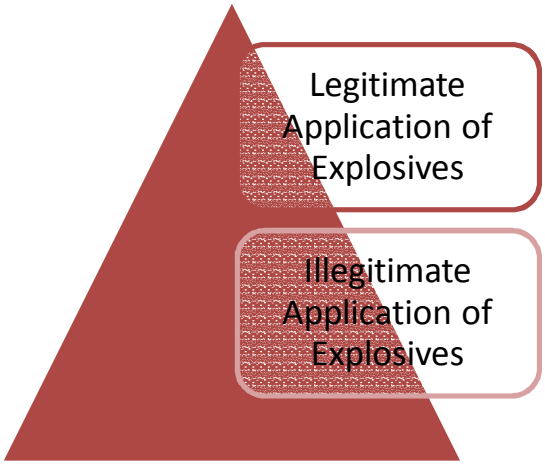
Role of Forensic Science in Explosives Examination

Forensic Science plays a role in relation to explosives. Explosives studied by forensic personnel mainly related to mass destruction episodes where bombs are used for illicit activities. The explosive residues collected from the crime scene are examined for many causes specially in order to identify the explosive material, the source and intention of explosion.

Figure:- 1 Scene of a Mass Murder

2.1 Applications of Explosives

An explosive have many applications, which are legal and do not cause harm to any human, animal or any human being.



Legitimate Uses: An explosive might be used in blasting rocks for Mining, Oil Explorations, in Satellite and space craft propulsions, in constructing roads railway line etc,in fireworks displays, and may also be used as Military Explosives which we will discuss latter.

Illegitimate Uses: The criminals are using the explosives for causing destruction to individuals or a nation by blasting bombs. The illegitimate use of explosive cause high destruction to the integrity of any nation and is severely punishable under Indian Penal Code, Explosive Act and The Explosives Substance Act.

The some common examples of explosives are RDX, TNT, TETN, ANFO, and Dynamite etc.

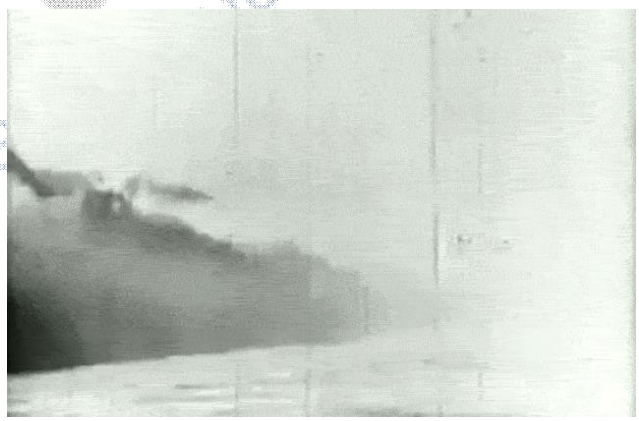


Figure:-2 Ripple Rock, British Columbia, Canada

Ripple Rock was an underwater, twin-peaked mountain, hazardous to ships passing through the Seymour Narrows of the Discovery Passage in British Columbia, Canada. It was destroyed with the help of 1,270 metric tons of Nitramex 2H explosives.

3. Role of Forensic Science in Explosives

Forensics plays an important role in the investigation of explosions where explosive substances/materials are the main ingredients. Explosives can be detected prior to explosions (during trafficking) and also after the explosion by forensic spot tests and also by hi-tech forensic analytical tools.

4. Explosion

In simplest term we can define an explosion as rapid increase in volume and release of energy along with the generation of high temperature and release of gases.

4.1 Types of Explosion

An explosion may be Exotic or Chemical. The common example of Exotic Explosion is Nuclear Explosion and also the use of high intensity laser arc to heat a substance to its plasma state. Laser and electric energy are presently used only to start reactions instead to produce required energy.

Due to the existence of organic compounds containing $-NO_2$, $-ONO_2$ and $-NHNO_2$ groups and others an explosion is a impulsive chemical reaction which is driven by great release of heat and energy. This type of eruption is known as Chemical Explosion.The chemical explosion is of three types such as Decomposition, Deflagration and Detonation.

The chemical disintegration of an explosive is a gentler process which occursduring its storage. This can happen over years or days or hours or may be within a fraction of a second. Deflagration and Detonation are two spontaneoustypes of Chemical decomposition.

Deflagration of the explosive substance is proliferated by a blaze front which travelsgradually through the explosive substance. Low explosive experiences the process of Deflagration.

In Detonation of an explosive is propagate by an explosive shock wave navigatingto the explosive material. Detonation is happens in High Explosives.

Figure:-8 Detonation of 16 tons of Explosives

10. High Explosives-Primary High Explosives

The explosives which are extremely sensitive to mechanical shock, friction, and heat, to which they will respond by burning rapidly or detonating are known as Primary High Explosives.Lead Azide, Lead Styphnate, DDNP and Tetrazene are some of the examples of Primary High Explosives.

Figure:-9Mercury Fulminate (Primary High Explosive)

Secondary high explosives are also known as base explosives. They are comparativelyunresponsive to shock, resistance, and heat. They may ignite when exposed to heat or flame in trivial, liberated quantities. These are sometimes added in small amounts to blasting caps to boost their power.The secondary high explosives may further divide into Boosters and Main Charge.

Secondary High Explosive	
Boosters	**Main Charge**
RDX	Dynamite

Figure:-10 Classification of Secondary High Explosives

11. High Explosives-Secondary High Explosives-Boosters

An explosive booster acts as a bridge between a low energy explosive and a low sensitivity explosive such as TNT. It increases the explosive shockwave from an initiating explosive to the degree sufficient to detonate the secondary charge. PETN and RDX are categorized as Boosters.

Figure:- 11 Scanning Electron Microscope image of RDX- (A Booster)

Dynamite

Dynamite is a absorbent material soaked in nitroglycerin. Nitroglycerine is made much more stable by the use of absorbent material. A blasting cap is used to detonate dynamite - a blasting cap creates a small explosion that triggers the larger explosion in the dynamite itself.The rate of detonation of Dynamite is 4,900 to 25,400 feet per second.

Nitroglycerin dynamite will crystalize after a long period of storage. At an abrupt temperature variance of *3 degrees* dynamite to detonate without warning.

Figure:-12 Dynamite

12. Homemade Explosives-Molotov Cocktail

A Molotov cocktail consists of a glass bottle semi-filled with flammable liquid, usually gasoline (petrol) or alcohol (generally methanol or ethanol), the mouth of the bottle is fitted with a cork or other type of airtight bung (rubber, glass, or plastic), and a cloth rag fixed securely around the mouth.

The weapon is used by first soaking the rag in a flammable liquid immediately prior to using it, lighting the rag and throwing the bottle at the target. The bottle shatters on impact, spilling the flammable liquid over the target, which is then ignited by the burning rag.

Figure:-13 Molotov Cocktail

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13. Improvised explosive device-Briefcase Bomb

An Improvised Explosive Device is a device, assembled in contravention to the existing rules of Law of Nation adopting unconventional or semi-conventional methods of assembling a standard device, ammunition/explosives or commercial, with a criminal/anti-national intention.IED is also known as homemade bomb.For Example- Roadside bombs, Letter Bomb, Bombs incorporated in Briefcase/vehicle etc

Figure:- 14 Briefcase Bomb with Mechanism

14. Components of an IED

IEDôs are formed by incorporating destructive, lethal, and noxious, pyrotechnics or incendiary chemicals.An IED is basically composed of Explosives, a Detonator, a Power Source (Battery) and an Initiation Mechanism (Switch).

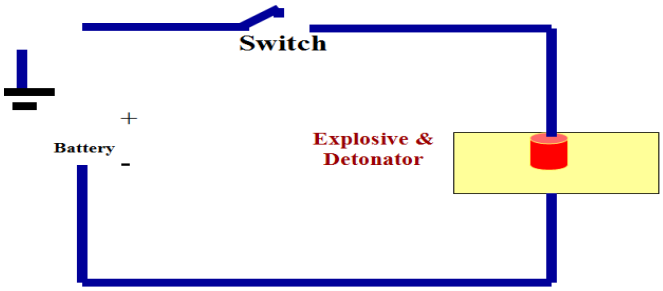

Figure:-15 Schematic Diagram of an IED's Component

15. Search Procedures for Locating an IED

The following doôs and Donôtsô should be followed while searching for an IED:

1. Donôt touch or handle suspicious object
2. Donôt simulateas if merely one device is planted
3. Use maximum two persons per room or for all area up to 250 Sq. ft.
4. Clearly mark the area to be searched
5. Trust nothing and assume nothing to be safe
6. Obtain maximum information about the device
7. Listen to any unusual voice/ sound before entering a room
8. Be careful about *booby trap*, at the door itself and also throughout the search
9. Make a visual survey of the entire area of the room
10. Search the area back to back
11. Report about the area and suspected object
12. Ask for help from expert

16. Booby Trap

In simplest terms we can define a booby trap as a device, whichis made with an intentions to surprise, harm or kill an individual. A booby trap is typicallyaccidentally triggered by the presence or movements of the victim. Booby Trap often has some form of entice to attract the victim towards it. Sometimes the booby trap is planted on busy roads or is triggered when the victim performs some action like opens a door, picks up something, switch something on or off etc.

Figure:-16 Booby Traps

20. Characteristics of Explosives

The following are some of the important characteristics of an explosive which are very important to determine whether the explosive is suitable for a particular use:

- Availability and cost
- Sensitivity
- Sensitivity to initiation
- Velocity of detonation
- Stability
- Power, performance, and strength
- Brisance
- Density
- Volatility
- Toxicity
- Explosive train
- Oxygen balance (OB% or Ω)
- Chemical composition
  - Chemically pure compounds
  - Mixture of oxidizer and fuel

Availability and Cost:-Depending on the availability of raw materials, its cost, complexity and its safety for manufacturing operations the formation of an explosive depends.

Sensitivity:-Sensitivity is the ease with which an explosive can be detonate or ignited. An explosive is sensitive to shock, friction or heat. Sensitivity should be considered in selecting an explosive suitable to its particular use.

Sensitivity to initiation:-Sensitivity to initiation is defined by the power of the detonator which is certain to prime the explosive to a sustained and continuous detonation.

Velocity of detonation:-It is thatspeed with which the reaction process spreads in the mass of the explosive, which is asignificantfeature of explosive and differs according to the kind of explosive.

Stability:- One of the main characteristic of explosive is its ability to be stored without detonation which is known as stability. The stability is affected by temperature of its storage, chemical constitution of explosive, exposure to sunlight and its electrical discharge.

Power, functioning, and potency:-The power or functioning of an explosive is its ability to do work which is determined by some tests to measure the substance for its proposed use.

Brisance :-Brisance is defined as the shattering effect (break) which is notable and separate from their total work capacity. Brisance regulates the efficacy of an explosion in disintegrating shells, bomb casings, and grenades. The swiftness with which an explosive touches its peak power is a degree of its brisance. The brisance is tested by sand crush test.

Density:-Density is the mass of an explosive per unit volume.

Volatility:-Volatility of an explosive is the promptness with which it vaporizes. It influences the chemical composition of explosive followed by reduction of stability, which increases the hazard of handling.

Toxicity:-Some of the explosives are toxic to that extent which requires special handling due to hazards caused by them. Besides explosives some of their derivatives, decomposition products, residues, and released gases can also be toxic. The harmful product may be any heavy metal (such as lead, mercury etc), nitric oxides released from TNT and others.

Figure:-20 Released toxic gases in a Bomb Blast

Explosive Train:-Explosive material may be slotted in the explosive train of a device or system. For example pyrotechnic leads to the ignition of booster, which causes the main charge to detonate. Now letôs understand what is an Explosive Train. It is defined as a triggering sequence of events that end up in the detonation of explosives.

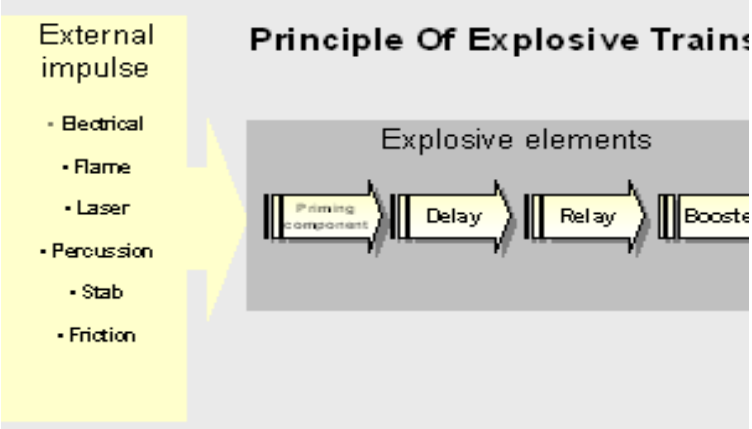

Figure: 21 Components of an Explosive Train

Oxygen Balance:-Oxygen balance is the degree to which an explosive can be oxidized. The sensitivity, strength, and brisance of an explosive depend on oxygen balance to some extent and approach to their maxima as oxygen balance approaches zero. If an explosive contains oxygen to convert all of its carbon to carbon dioxide, all of its hydrogen to water, and all of its metal to metal oxide with no excess molecules, the molecule is said to have a zero oxygen balance. The molecule is said to have a positive oxygen balance if it contains more oxygen than is needed and a negative oxygen balance if it contains less oxygen than is needed.

Chemical Composition:- An explosive can be characterized based on their Chemical composition which is either a chemically pure compound, such as nitroglycerin, or a mixture of a fuel and an oxidizer, such as black powder or grain dust and air.

a) **Chemically pure compounds:-**Some chemical compounds are unstable. Every molecule of the compound separates into two or more new molecules (mostly gases) with the liberation of energy e.g. Nitroglycerin, Acetone peroxide, organic peroxideTNT,Nitrocellulose,RDX, PETN, HMX.

b) **Mixture of oxidizer and fuel:-**An oxidizer is a pure substance (molecule) that in a chemical reaction can contribute some atoms of one or more oxidizing elements, in which the fuel component of the explosive burns. On the simplest level, the oxidizer may itself be an oxidizing element, such as gaseous or liquid oxygen. e.g. Black powder (Potassium nitrate, charcoal and sulfur), Flash powder, Ammonal, Armstrong's mixture, Sprengel explosives, ANFO, Cheddites. Oxyliquits, Panclastites.

21. Summary

- Explosives are the substances, elements, compounds or mixture capable of exerting pressure on its surroundings on explosion/transformation.
- Explosives can be used legitimately such as blasting rocks for mining, in space craft propulsions etc and can be used for illegal purposes such as in blast for causing destruction to individual or nation.
- The explosives can be classified as Low, High or Miscellaneous.
- Low explosives experience deflagration at degrees that vary from a few centimeters per second to about 400 meters per second.
- High explosives undergo detonation with explosive velocity ranging from 3 to 9 km/s.
- Gunpowder, is a admixture of sulfur, charcoal and potassium nitrate and is the first chemical explosive
- Primary high explosives are extremely sensitive to mechanical shock, friction, and heat.
- Secondary high (base) explosives are relatively insensitive to shock, friction, and heat.
- The rate of detonation of Dynamite is 4,900 to 25,400 feet per second.
- A glass bottle semi-filled with flammable liquid and whose mouth is stoppered with a cork or other type of airtight bung with a cloth rag fixed securely around the mouth is known as a Molotov Cocktail.
- An IED is basically composed of an Explosive, a Detonator, a Power Source (Battery) and an Initiation Mechanism (Switch).