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1. PYROTECHNIC RECOGNITION

Explosion is a rapid, physical, chemical or nuclear transformation of a system accompanied by a transformation of the potential energy into mechanical work – destruction of the environment (e.g. bursting, fracturing, splitting, splintering, spraying or relocation of objects in the surroundings). The phenomenon is accompanied by an acoustic effect such as a sound and a visual effect such as a flash.

1.1. Types of explosions

Physical explosion

It is a very rapid transformation of the matter while releasing a considerable volume of energy in the form of heavily compressed starting substances or gaseous products produced during a transformation e.g. under the influence of a strong electrical current (a lightning), a rupture of a steam boiler or a compressed gas cylinder.

Nuclear explosion

Rapid generation of nuclear energy occurring as a result of an uncontrolled chain reaction of heavy element fission (nuclear weapons). In the so-called thermonuclear weapons, the force of nuclear explosion is multiplied by causinga nuclear synthesis of nuclei of light elements.

Chemical Explosion

Rapid (millisecond-lasting), exothermic chemical processes occurring in solid and liquid explosives and explosive gaseous mixtures.

Chemical explosion properties:

– **velocity of reason** e.g. 1 kg of TNT detonates during approximately 0.00001s,

– **high velocity of transformation** e.g. in crush explosives from 1,000 do 8,500m/s,

– **exothermic** e.g. for crush explosives, the explosion temperature is approximately 3,000 degrees C.,

– **production of large quantities of gaseous products and related overpressure** (chiefly steam, carbon oxide or dioxide, nitrogen and oxygen) – e.g. from 1 kg of explosives approximately 1,000 liltres of post-explosion gases are produced. Overpressure is dependent on the distance from the blast epicenter.

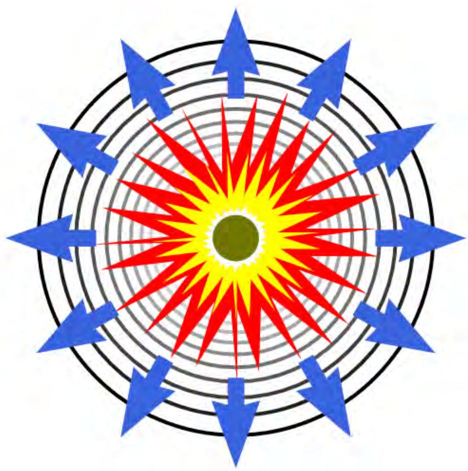

Figure 1. Overpresure model of explosion

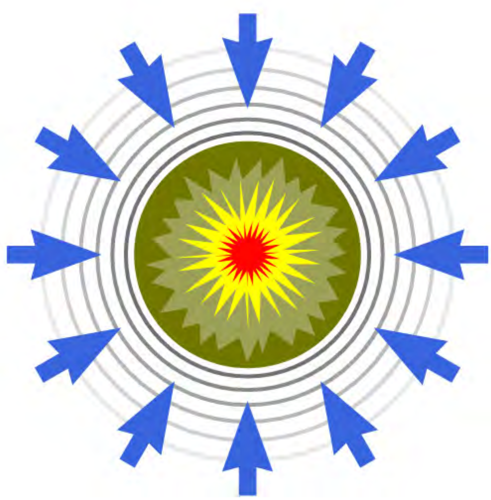

Figure 2. Underpresure model of explosion

1.2. Types of transformations

Detonation

Detonation is an blast transformation occurring in an explosive at constant and highest velocity in the form of a detonation wave which travels faster than sound.

Explosion

Explosion is a temporary form of a blast transformation of undermined velocity. Depending on the conditions, it may turn into detonation or deflagration.

Deflagration

Deflagration is otherwise known as explosive combustion, a type of blast transformation where thermal energy transmission from the reaction zone to the zone of an explosive material occurs through conductivity and radiation. Linear velocity of the dissipation process is significantly lower than sonic velocity in the same material (>340 m/s) and is external pressure-dependent.

1.3. Explosives

Explosives are solid or liquid chemical substances or mixtures of substances, which are chemically reactive and produce gas of such temperature and pressure and such speed that they may cause damages in their environment, as well as products filled with explosives.

Sensitivity of explosives is the capability of such explosive to be initiated by a specific external impulse. It is the smallest amount of external energy which should be supplied to cause an explosive reaction. This property is an initiating impulse. The smallest the initiating impulse required for causing an explosive reaction is, the more sensitive explosives are.

Factors defining sensitivity of explosives:

– **physical state** – explosives in a liquid state tend to be more sensitive than explosives in a solid state; case explosives demonstrate lower propensity for detonation than the pressed ones do;

– **temperature** – sensitivity increases with its growth;

– **density** – higher density causes (usually) lower sensitivity;

– **admixtures** – additives harder than explosives, the so-called *sensitisers* e.g. metal fillings, crushed glass, sand – increase, while those of lower hardness, the so-called *flegmatising agents* e.g. oils, petrolatum, paraffin – reduce sensitivity of explosives.

1.3.1. Division of explosives

Explosives are categories in terms of their:

I. **Chemical constitution**, including:
   1) **chemical individual** (individual explosives) such as:
      - nitro-compounds (TNT, picric acid, hexyl);
      - nitrogen acid esters (nitroglycerine, nitroglycol, cellulose nitrate, penthrite);
      - nitroamines (hexogen, octogen);
      - chloric and perchloric acid salts (ammonium chlorate, ammonium perchlorate);
      - hydrazonic acid derivatives (lead(II) azide, copper azide);
      - fulminic acid derivatives (mercury(II) fulminate);
      - acetilne derivatives (acedilides – mainly silver and copper acetilides);
      - other explosive compounds (tetrazene, organic peroxides).
   2) **explosive mixtures**, in two main groups:
      - explosive mixtures where at least component is an explosive e.g. a mixture of ammonium perchlorate and paraffin. An explosive mixture may also contain more explosive compounds. Such mixtures are mining explosive mixtures;
      - mixtures, which do not contain a single explosive component. The group includes black powder and similar mixtures and a large group of pyrotechnic mixtures.

II. **Application (purpose) presented in Figure 3:**

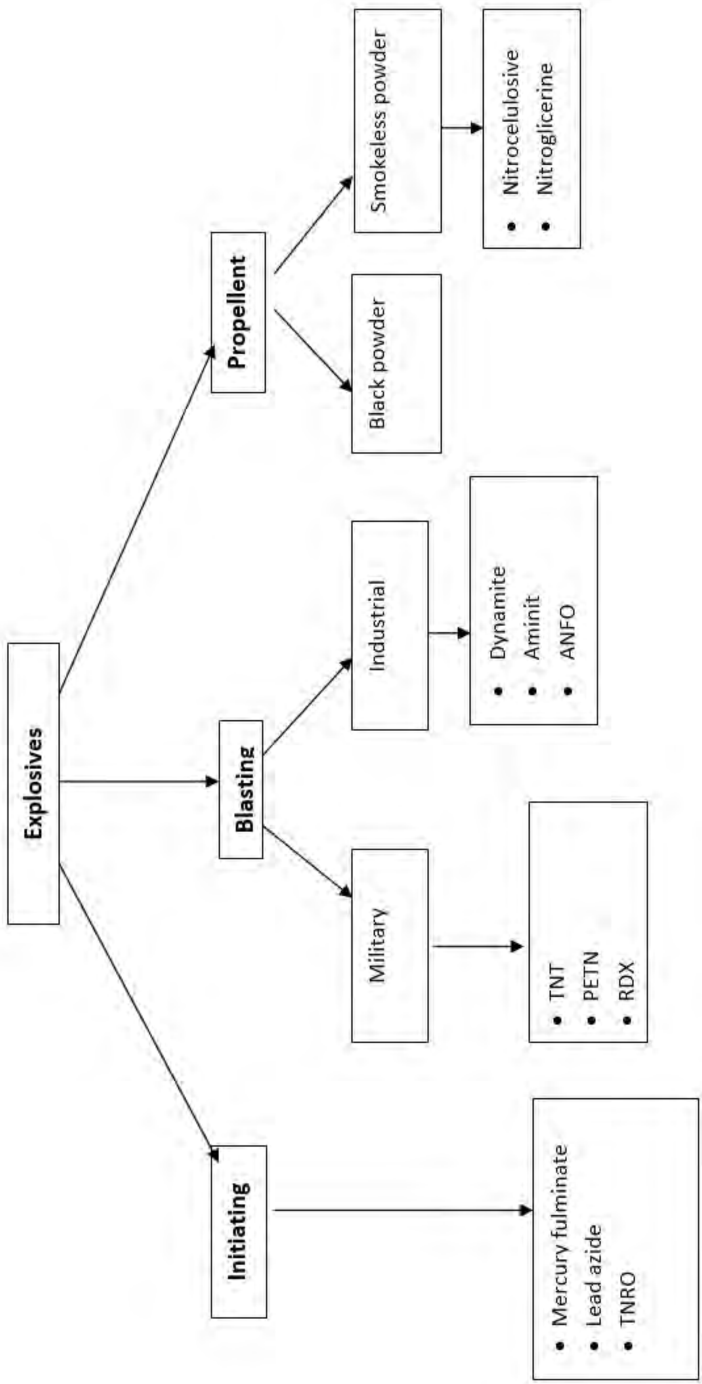

Figure 3. Application of explosives

1) **initiating explosives** i.e. chemical compounds or mixtures of chemical compounds who are capable of explosive detonation when impacted by an external stimulus e.g. a flame, blow, friction, used in iniatining agents to initiate an explosive transformation (detonation) in other explosives, such as:
   - mercury fulminate;

     It is a white or grey crystalline body with sweet metallic taste, poisonous properties, poisonous properties causing irritation of the mucous membrane of nose, eyes and larynx and, when moist – eczema-resembling skin irritation.
   - lead azide;

     A white, fine-crystalline substance. It is not hygroscopic and it is insoluble in water. It is characterised by a very short passage from ignition to detonation and that is why it detonates when impacted by any type of external stimuli, even if in very small quantities.
   - TNRO – lead trinitroresocynian;

     It is a fine-crystalline, dark yellow solid, easily ignitable from a flame or an electric spark. It is a low hygroscopic solid, practically it does not dissolve in water and in organic solvents.
   - tetrazene;

     A light yellow, non-hygroscopic and insoluble crystalline substance of sensitivity similar to mercury fulminate. Due to its relatively high sensitivity, predominantly used mixed with other initiators (2–3%) to enhance their sensitivity (sensitiser).
   - organic peroxides;

   White chemical compounds of crystalline structure, produced mainly in home laboratories, such as:
   - HMTD – Hexamethylene triperoxide diamine (urotropine peroxide);
   - TATP/TCAP/CTATP – triacetone triperoxide (acetone peroxide).
2) **blasting explosives**, i.e. materials whose main explosive transformation is detonation. This group of explosives is used to fill different munition (missiles, bombs, grenades, mines) and rock shooting works in the mining industry, including:
   - military, of normal potency, such as:
     - trinitrotoluene – TNT

       Hard, light yellow or light brown crystalline substance with a bitter taste, insoluble in water, soluble in alcohol and acetone. Ignited, it burns with a heavily smoking flame but does not explode. Shot through with a rifle missile does not explode and does not ignite. Its forms: powdered, pressed and cast (Fig. 4).

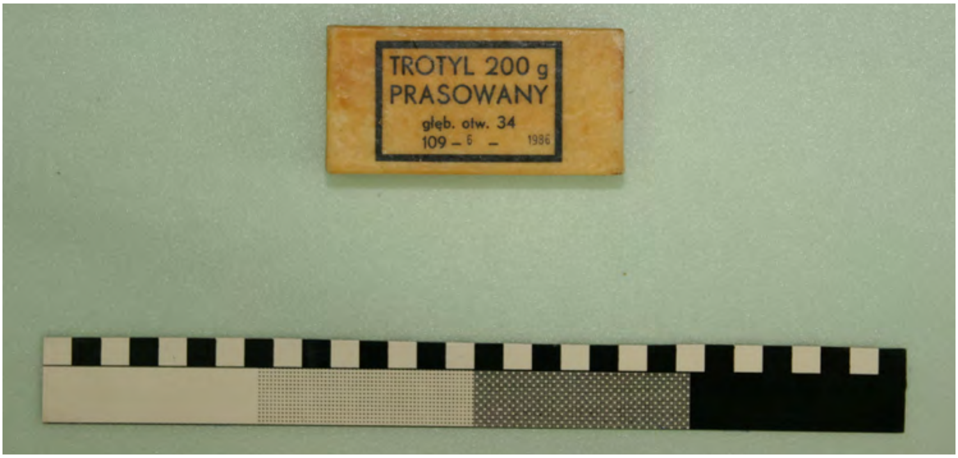

Figure 4. TNT cube (author's photo)

- melinite (picric acid) – TNF
  A hard, light yellow, very bitter crystalline substance, weakly soluble in cold water, its solubility in warm water slightly improved. Solution dyes skin and animal tissue yellow. It is 1.5 times more sensitive to mechanical stimuli than trotyl. May explode when shot through.
- tetril
  Tetril is a white-yellow powder material. It is slightly salty-tasting powder. It is non hygroscopic. It dyes skin red. It is very sensitive to friction and shock and detonates easier than trotyl and melinite.

– military, of increased potency, such as:
- nitroglycerin (NG)
  Chemically pure is a colourless, oily substance. Technical product is usually light yellow. Of all explosives used in practice, nitroglycerin is the least durable substance. It is very sensitive to shock and friction and, in this respect, its properties are similar to initiating explosives. Liquid nitroglycerine is more sensitive to shock while crystalline glycerine is less sensitive.
- penthrite – PETN
  A white, crystalline substance. It is toxic – it causes headache when touched with hands. Weakly soluble, in moisture does not loose its properties. It explodes when shot through with a rifle missile. It is difficult to ignite.
- hexogen – RDX

A while, tasteless and odourless crystalline substance, which is non-hygroscopic and insoluble in water. Its sensitivity to mechanical stimuli and detonation is higher than sensitivity of trotyl and tetril. Does not explode when shot through with a rifle missile.

- octogen – HMX
  Its chemical and explosive properties resemble those of hexogen. It is more durable than hexogen. Its high production cost prevents its wide application.

– used in the mining (industry) sector, such as:

- dynamite
  Material invented by Alfred Nobel and patented in 1867. Initially, it contained 75% of nitroglycerine and 25% of diatomaceous earth. Diatomaceous earth saturated with nitroglycerine is doughy and can be rolled in cartridges without the risk of a premature explosion. Modern dynamite contains approximately 10% of nitroglycerine and other components used in its production may be: diatomaceous earth, magnesium carbonate, wood flour, nitrocelulosis and ammonium nitrate (Fig. 5).

Figure 5. Dynamite (author's photo)

- Aminit
  An explosive mixture with the ammonium nitrate as its main component. Another component is typically a substance with explosive properties e.g. trotyl or with flammable properties e.g. wood flour or aluminium dust. Amonit is weakly sensitive to thermal and mechanical stimuli. Depending on the additional substance mixed with ammonium nitrate, amonit is referred to as:

– amatol – a mixture with trotyl;
– amonal – a mixture with aluminium dust;
– saletrol "ANFO" – a mixture with liquid fuel e.g. engine oil.

3) **Propellent explosives** i.e. such with their basic form of explosive transformation is explosive burning (deflagration) such as:
   – gunpowder (black powder)
     Is a mechanical mixture of potassium saltpetre, charcoal and sulphur. Explodes from fire, from a spark, a thunderbolt, shooting a rifle mission and and also from rapid warming. Is hygroscopic, on contact with moisture it emits sulphur and becomes useless when wet. It is used for many purposes, including:
     • production of flammable cords;
     • filling gunpowder paths of time fuses;
     • for production of ballast, ensuring loads of smokeless powder.
   – smokeless powder
     Is a type of powder, which burns in parallel layers without smoke (Fig. 6) Divides into:
     • gunpowder on volatile solvent, known as nitrocelulosive,
     • powder on a hardly volatile solvent, including: nitroglycerine and nitroglycol powder.

Nitrocelulose powder is grey and green and nitroglycerine powder is brown, they both demonstrate low sensitivity to friction and shock. They do not ignite when shot through with a rifle missile. Used for production of propellants for small arms and artillery.

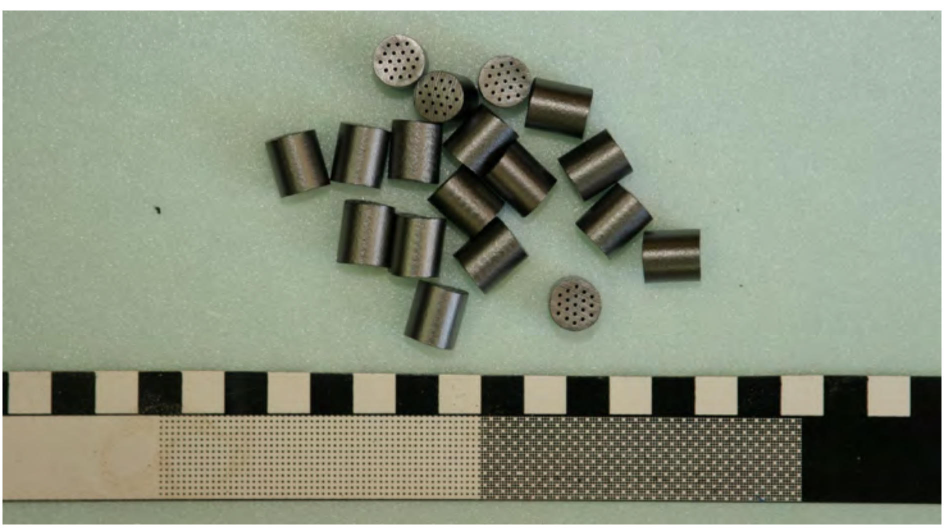

Figure 6. Smokeless powder (author's photo)

4) **Pyrotechnic masses and mixtures** i.e. flammable mixtures, which give thermal, luminary, smoke, sound and incidentary effects used both in the military and civilian technology. In particular, the igniting and illuminating chemicals have been developed. Most pyrotechnic masses usually contain oxidants and flammable substances in the form of mixtures. In pyrotechnic termite and flame mixtures, magnesium and aluminium (their alloys and mixtures) are used while organic compounds are typically used in smoke mixtures. Nitrates and perchlorates are the main oxides in flame pyrotechnic masses while metal oxides are the main oxides in smoke mixtures. Furthermore, additions are introduced to the composition of pyrotechnic mixtures, e.g. flame-colouring salts, binder improving pressing and giving the required mechanical properties to the mass as well as stabilisers and phlegmatising agents to ensure securing in production and storage.

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