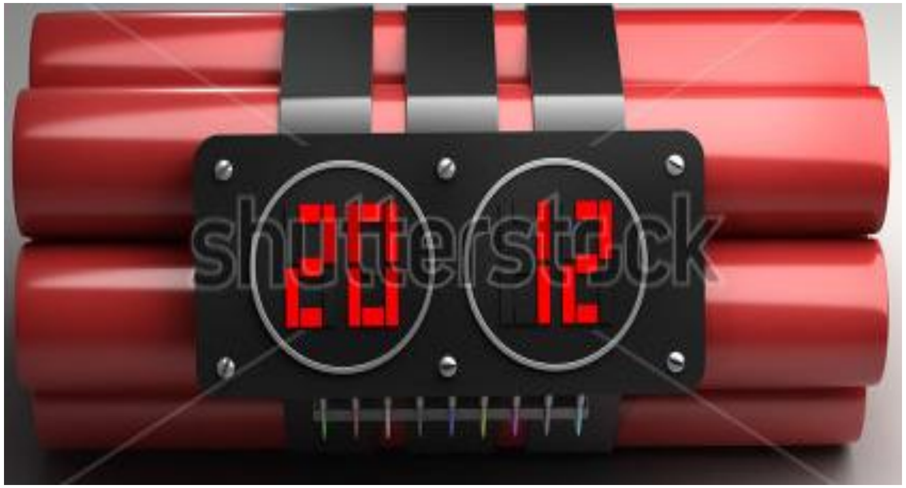
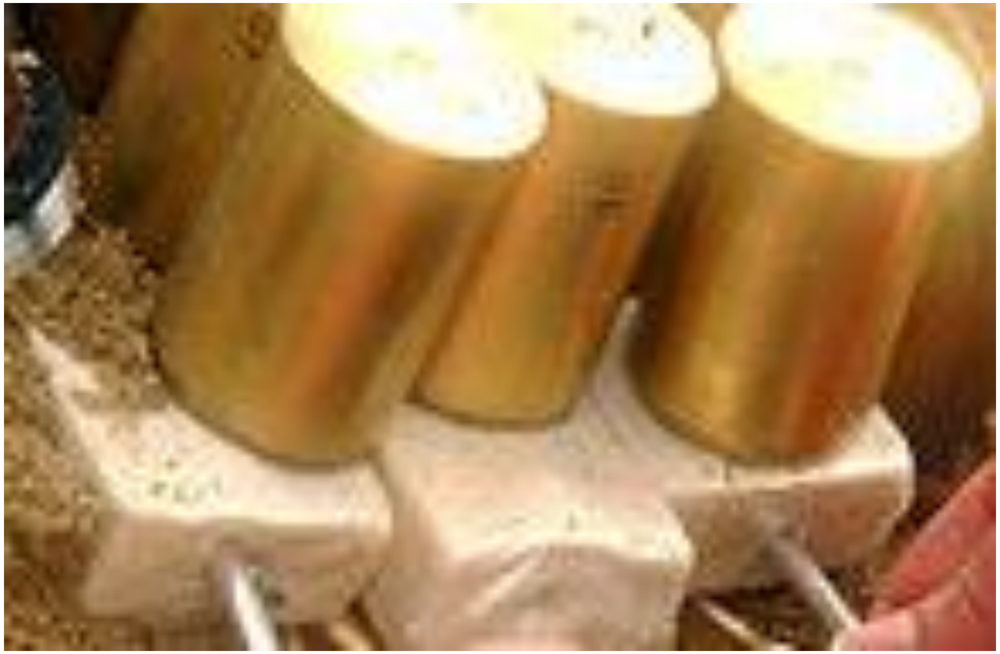
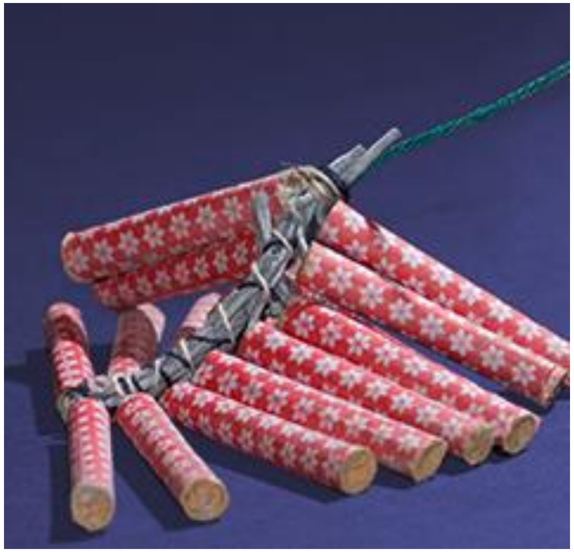
Explosives







Charging a development end with explosives

What is an explosive?

1. **An explosive** is a substance or mixture of substances which, when initiated is rapidly converted into more stable substances, mostly gaseous, which occupy a much larger volume than the explosive in its original configuration.

2. **An explosive** is a compound or mixture of compounds which when initiated by an external impulse (heat, impact, friction, or shock, etc.) has the properties of forming an explosion and is very rapidly converted to gases at high temperature. Self-propagating exothermic reaction - gives off energy and pressure.

Properties of Explosives

The main explosive properties are:

1. Effective energy
2. Velocity of detonation
3. Density
4. Detonation pressure
5. Sensitivity
6. Water resistance
7. Fume characteristics
8. Storage life

Effective energy

Strength of an explosive is the relative effective energy.

Relative weight effective energy is defined as the effective energy of an explosive compared to the effective energy of an equal weight of standard ANFO

Velocity of detonation

The velocity of detonation (VOD) is the rate at which the detonation wave travels along an explosive column.

The greater the VOD the greater the power or ‘shattering’ effect of an explosive.

High VOD explosives are more suitable in hard rock and low VOD in softer rock.

The VOD range in commercial explosives is 2500 -7500 m/s.

Density

The density of a explosive determines the charge weight per meter of hole The density of an explosive is important because the explosives are purchased, stored and used on a weight basis

- The density of the explosive determines amount of explosives that can be loaded in a given hole diameter.

- The loading density

Detonation pressure

The detonation pressure is the pressure associated with the reaction zone of a detonating explosive. It is measured behind the detonation front, during propagation through an explosive column. This pressure can be estimated using the following formula:

$$p_d = \frac{1}{2}\rho_e c_d^2 10^{-6}$$

Where:

P_d = Detonation pressure (MPa)

ρ_e = Density of explosive (kg/m^3)

C_d = Velocity of detonation (m/s)

Sensitivity to Initiation and Detonation Stability

The explosive should not be highly sensitive to initiation and detonation. It must be possible to initiate an explosive and the detonation must be stable.

Normally, the explosive is initiated by the use of a detonator. Some explosives are initiated by using special primers consisting of an explosive with a high detonation velocity. The detonation of an explosive must be stable.

Sensitivity

Safety in handling is demanded whenever, explosives are being transported

Explosives are subjected to extensive tests before they can be approved by appropriate authorities.

Water Resistance

Water resistance is the ability of an explosive to withstand water penetration.

The water resistance of an explosive depends on the packing as well as its inherent ability to repel water.

Explosives which have inherent water resistance properties can be used in water filled blast-holes if proper packaging material, such as plastics, are used.

Fume Characteristics

Fumes produced contain:

Non- toxic eg. CO_2, N & steam

Poisonous eg. CO, Nox

Carbon monoxide (CO)

- 0.1 % extremly toxic, collapse,
- 1% immediate death
- Colourless, odourless, tasteless

Preferred explosives produce less noxious gasses

Oxides of nitrogen

NO - Nitric oxide

N_2O - Nitrous oxide &

NO_2 - Nitrogen dioxide - Most toxic

At 100 ppm (0.01%) – coughing

At 200 ppm (0.02%) – Fatal

Storage Properties

- Explosives deteriorate and shelf life is affected by climate and magazine
- Therefore, explosive manufactures specify the storage properties or shelf life
- Nitroglycerine products are the most susceptible to deterioration during storage

Oxygen balance of explosive substances

Oxygen balance (OB) is an expression that is used to indicate the degree to which an explosive can be **oxidized**.

If an explosive molecule contains just enough oxygen to form carbon dioxide from carbon, water from hydrogen molecules, all of its sulfur dioxide from sulfur, and all metal oxides from metals with no excess, 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; the combustion will then be incomplete, and large amount of toxic gases like carbon monoxide will be present. The sensitivity and strength of an explosive depend upon oxygen balance.

The oxygen balance is calculated from the empirical formula of a compound in percentage of oxygen required for complete conversion of carbon to carbon dioxide, hydrogen to water, and metal to metal oxide.

Calculation of Oxygen Balance

$$B_o = \frac{\left[d - \left(2a + 0.5b + \frac{x}{y} \cdot \varepsilon \right) \right] \cdot 16}{M} \cdot 100$$

Where:

16 = Mass of oxygen atoms

ε = metal moles in the composition of the explosive substance

y = number of oxygen atoms necessary for the complete oxidation of the metal

X = number of metal atoms in the explosive substance

d = total number of oxygen atoms in the explosive substance

a=total number of carbon atoms in the explosive substance

b=total number of hydrogen atoms in the explosive substance

Calculation of Oxygen Balance – Traditional method

Consider the following explosives chemical reactions:

$3NH_4NO_3 + CH_2 =$

1. Complete the chemical reaction: Left side and right side
2. Balance equation: left side and right side
3. Consider some explosive properties
   - Effective energy, VOD, Density, DP, Sensitivity and Fume characteristics

Example: $3NH_4NO_3 + CH_2 =$

Products of chemical reaction of explosives (fumes produced):

- Water or steam
- Gases – noxious and less noxious gases
- Therefore explosive ($3NH_4NO_3 + CH_2$) will produce:

  H_20, CO and N

Thus: $3NH_4NO_3 + C\ H_2 = (H_20$, CO and N)

Now balance the equation

Balancing explosive chemical reaction equation

Left side		Right side	
Element	Number	Element	Number
N	3 + 3 = 6	H	7 x 2 = 14
H	(3 x 4) + 2 = 14	O	7 + 2 = 9
O	3 x 3 = 9	C	1
C	1	N	3 x 2 = 6

Balanced equation: $3NH_4NO_3 + CH_2 = 7H_20 + CO_2 + 3N_2$

Consider some explosive properties:

- Fume characteristics: H_20, CO_2 and N are less toxic
- The reaction has balanced oxygen
- The explosive has high density and detonation pressure and will produce more energy.

Zero Oxygen Balance (ZOB)

Consider the following explosives chemical reactions:

1. $3NH_4NO_3 + CH_2 = 7H_20 + CO_2 + 3N_2 + 930$ kcal/kg
2. $2NH_4NO_3 + CH_2 = 5H_20 + CO + 2N_2 + 810$ kcal/kg
3. $5NH_4NO_3 + CH_2 = 11H_20 + CO_2 + 4N_2 + 2NO + 600$ kcal/kg

Revision Questions

1. a) Given 70 Kilo-bars detonation pressure of emulsion explosive and 230 m/s velocity of detonation, calculate density of the explosive

   b) With reference to your answer, explain the type of explosive and effect on rock blasting

2. A mine working on a rock of Andesite with an estimated production of about 120,000 tonnes per month. What is the estimated requirement of explosives per month? Assume that the SG of Andesite is 2.7 and the powder factor for andesite is 0.7 kg/m^3

3. Complete the following explosive chemical reaction and analysis it using explosives properties:

   $21NH_4NO_3 + 2C_6H_2CH_3(NO_2)_3 =$

Q1. $$p_d = \frac{1}{2} \rho_e c_d^2 10^{-6}$$

Q2.

Volume of andesite to be produced = Production per month / SG =

Explosives required = Volume produced / Powder Factor.

Q3. (See the example)

Q5. Calculate the required:

a) Bits; b) Shank adapters, c) Sleeves; and d) Rods

Given:

Production	=	1,000,000 tonnes
Density	=	4 tonnes/m^3
Specific drilling	=	0.5

Average service life (life span) of:

51mm button bit	=	450m
Shank adapters	=	3,500m
Sleeves	=	250m
R32 rods	=	150 holes
R32 rod length	=	1.8m

Solution to Q5 (drilling 5)

Production is 1,000,000 tonnes; convert to m^3 by applying drilling density of 4 tonnes/m^3

Total drilled metres = Production (m^3) x specific drilling

Required components = Total drilled metres/Service life

Solution

Drilled metres = Production x specific drilling = 250,000 x 0.5 = 125,000m

Required components = Drilled metres/Service life
Required bit = 125,000/450 = 277.78
Therefore 278 bits are required to drill125,000m

Required shank adapters = 125,000/3,500 = 35.7
Therefore 36 adapters required to drill 125,000m

Required sleeves = 125,000/250 = 500 sleeves
Required R32 rods = Drilled metres/no. of holes x rod length = 125,000/(150 x 1.8) = 462.96
Therefore 463 rods required to drill 125,000m