# 212D6212
# TEKNIK PELEDAKAN


Nirmana Fiqra Qaidahiyani
PS Teknik Pertambangan
FT Universitas Hasanuddin

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Subjects

1. Use Forms of Explosives
2. Estimating Properties of Explosives
3. Explosive Selection Criteria
4. Blasting Accessories
5. Initiation and Priming Systems

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Subjects

6. Nonelectric Initiators
7. Qualitative Description of a Shock Wave
8. Fracture Mechanism in Blasting of Rock
9. Rock and Rock Mass Properties and Their Influence on The Results of Blasting
10. Characterization of The Rock Masses for Blast Designing

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Subjects

11. Real Effects in Explosives
12. Theories of Scaling
13. Blasthole Loading
14. Preliminary Blast Design Guidelines
15. Controllable Parameters of Blasting

# Subjects

16. Bench Blasting
17. Drilling Patterns and Hole Sequencing
18. Initiation Sequence and Delay Timing
19. Explosives as a Source of Fragmentation Energy
20. Evaluation of Blast Results

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Subjects

21. Blasting in Underground
22. Overbreak Control
23. Perimeter/Contour and Controlled Blasting
24. Environmental Effects of Blasting
25. Blasting Safety

nirmana.site123.me nirmana.fiqra.q@gmail.com

# References


Cooper, P.W. *Explosives Engineering*. 1996. Canada: Wiley-VCH.

Calvin, J., Konya, and Walter, E.J. *Rock Blasting and Overbreak Control*. 1991. United States: Federal Highway Administration.

Hustrulid, W. *Blasting Principles For Open Pit Mining*. 1999. Netherlands: A.A.Balkema/ Rotterdam.

Jimeno, C.L. et al. *Drilling and Blasting of Rocks*. 1995. Netherlands: A.A.Balkema/ Rotterdam.

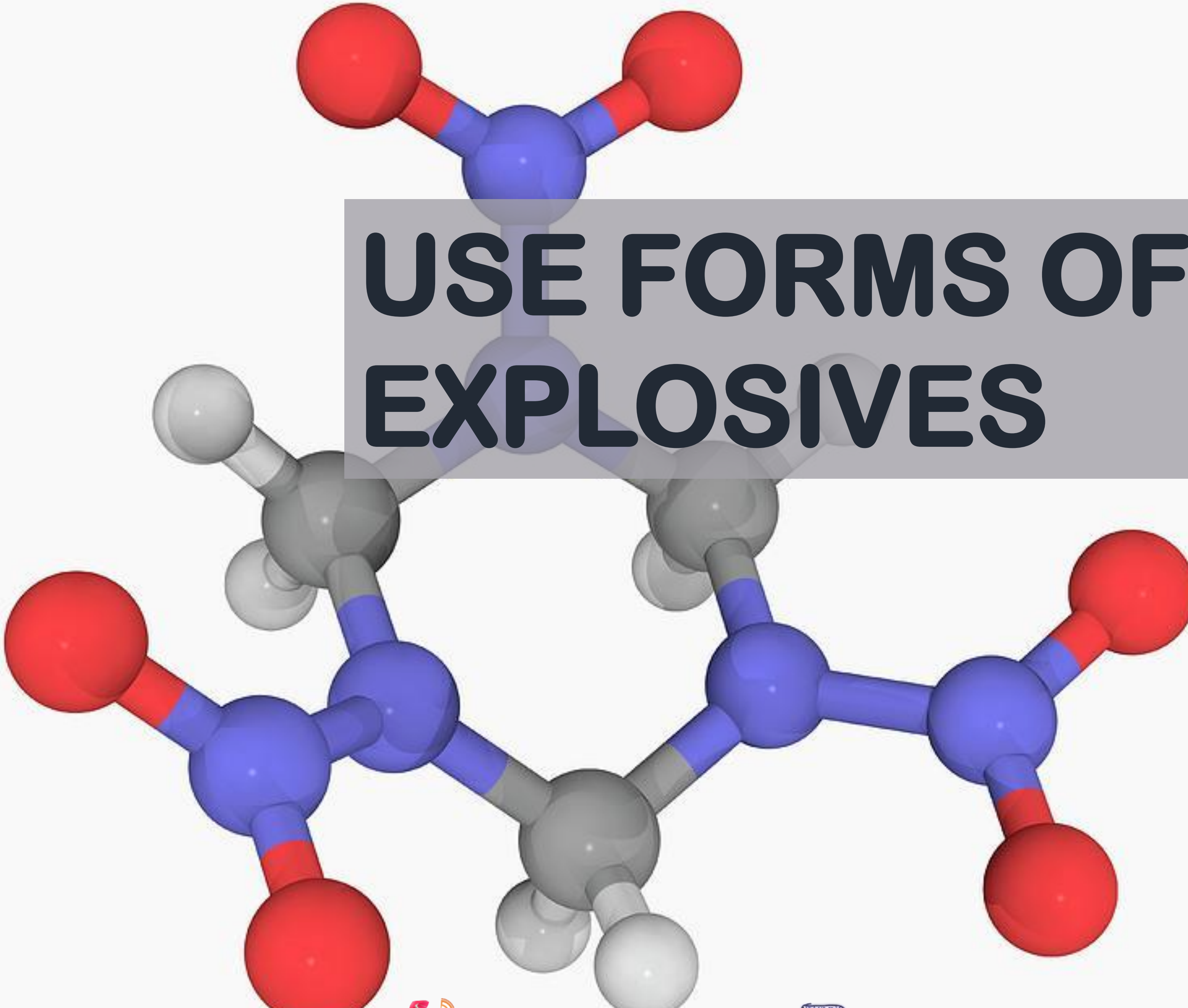

nirmana.site123.me nirmana.fiqra.q@gmail.com

# References

Rustan, A. *Rock Blasting Terms and Symbols*. 1998. Netherlands: A.A.Balkema/ Rotterdam.

Richard, A. et al. *Explosives and Blasting Procedures Manual*. United States: Bureau of Mines.

# USE FORMS OF EXPLOSIVES



- ✓ Majority of uses for explosives <u>require mechanical properties</u> that the pure explosives materials do not have.
- ✓ In order to change the mechanical properties, as well as some of the thermal, output, or sensitivity properties, the pure explosives are often <u>blended with other explosives and other chemically inactive materials</u> so that can then be worked in various ways to form specific explosive products.

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Types of Products

- Pressings
- Castings
- Plastic bonded, machined (PBX)
- Putties
- Rubberized
- Extrudable
- Binary
- Blasting agents



nirmana.site123.me nirmana.fiqra.q@gmail.com

# Pressings

Some powders are extremely sensitive to electrostatic buildup or friction during pressing; *others* will not flow well enough into pressing dies or molds. To alleviate these problems, various additives are blended with the explosives.

# Pressings

**Molding lubricants** are generally either graphite or stearates. **Phlegmatizing (stolidly) agents** such as petroleum jelly and mineral oil are used. **Antistatic agents** are also added to some pressing mixes.

# Castables

All of the modern castable formulations are based on mixtures of relatively higher-melting crystalline explosives and molten TNT. Since TNT has a negative oxygen balance, oxidizers (such as nitrates and positive oxygen balance explosives) are often added to it.

# Castables

Many of the castable explosives are also machinable, but their machinability is *not as good as* that of the Plastic Bonded (PBX).

# Plastic Bonded (PBX)

**The PBXs** are powdered explosives to which plastic binders have been added. The binder is usually precipitated out of solution in the preparation process such that it coats the explosive crystals. Agglomerates of these coated crystals form pressing "beads". The beads are then either die pressed or isostatically pressed at temperatures as high as **120°C.**

# Putties

Putties are mixtures of finely powdered RDX, $(O_2NNCH_2)_3$, and plasticizers. The mixture is puttylike and can be molded by hand to any desirable shape.

# Putties

Many different putty compositions have been made, but only one is prevalent in the US. That is Composition C-4 which has the following formulation:

- ✓ RDX : 91.0%
- ✓ Diethylhexyl sebacate : 5.3%
- ✓ Polyisobutylene : 2.1%
- ✓ 20-weight motor oil : 1.6%

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Putties

The British military have a similar mix called PE-4 which has 88% RDX and 12% plasticizer.

# Rubberized

Mixtures of RDX or PETN mixed with rubber-type polymers and plasticizers can be rolled into rubbery gasketlike sheets for dimensional stability and simplicity handling. They can be cut to specified shapes and glued to a desired surface.

# Extrudables

PETN mixed with *uncured* Sylgard 182$^{TM}$ silicone rubber and curing agent at **80% PETN** and **20% rubber**, forms a thick viscous material that can be extruded under moderate pressures (less than 100 psi). After extrusion in holes, molds, or channels, the temperature can be raised to polymerize and cure the Sylgard, leaving a tough rubberlike material.



nirmana.site123.me nirmana.fiqra.q@gmail.com

# Binary

In this product form, the explosive consists of two materials stored and shipped in separate packages. Each of the materials is considered to be nonexplosive until mixed. The exact materials are **proprietary**.



nirmana.site123.me nirmana.fiqra.q@gmail.com

# Binary

After mixing, the various products form either a liquid, slurry, or wetted powder. They are all cap sensitive which means they can be initiated directly with a standard commercial blasting cap.

# Blasting Agents

A blasting agent is defined as any material or mixture, **consisting of a fuel and oxidizer**, intended for blasting, not otherwise characterized as an explosive and in which none of the ingredients is classified as an explosive. The finished product, as mixed for use or shipment, *cannot be initiated* by a **Number 8** test blasting cap (detonator) in the unconfined state (in the open air).

Blasting agents, therefore, must be initiated by means of a booster.

# *What is a Number 8 Test Blasting Cap?*

*Please find the references and summarize it in* ***not more than one page****.*

*You can use the following references, but not be limited, as your guide:*

*Rustan, A. "Rock Blasting Terms and Symbols". 1998. pp. 19. Netherlands: A.A.Balkema/Rotterdam.*

# *What is a Number 8 Test Blasting Cap?*

*Damon, G.H. et al. "Safety Recommendations for Ammonium Nitrate-Based Blasting Agents". 1977. United States: Bureau of Mines.*

*https://www.law.cornell.edu/cfr/text/27/555.11*

*https://www.atf.gov/file/21986/download*

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Blasting Agents

- ANFO
- Light ANFO
- Watergels/Slurries
- Emulsions



nirmana.site123.me nirmana.fiqra.q@gmail.com

# ANFO

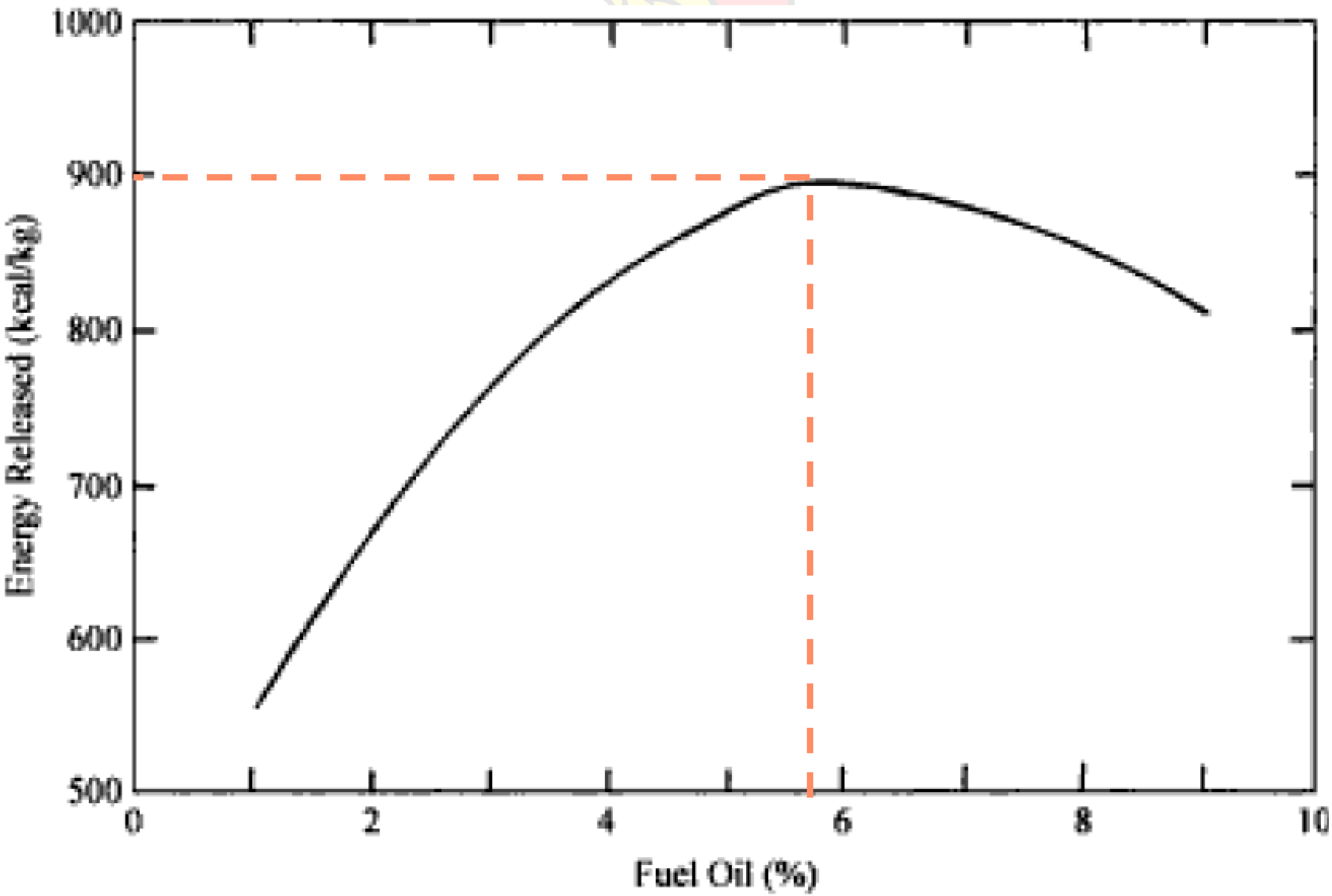
Blasting agents are primarily mixtures of **ammonium nitrate (AN)** and a fuel, **fuel oil (FO)** is regularly used, at about **94.5%** and **5.5%** by weight respectively. This mixtures of **ANFO** makes it up **the most common blasting agent used in open pit mining** presently.

# ANFO

Its basic reaction is:

$$3NH_4NO_3 + CH_2 \rightarrow CO_2 + 3N_2 + 7H_2O + 912 \text{ kcal/kg}$$

nirmana.site123.me nirmana.fiqra.q@gmail.com




Relative ANFO Energy as a Function of The Percent Fuel Oil Used (Hagan, 1980)

# ANFO

As shown in previous figure, the maximum strength is obtained when about 5.5% fuel oil by weight is added.

When too little fuel oil is added, the energy drops rapidly and **various nitrous oxides ($NO_x$) are formed**.

When too much fuel oil is added, the energy also decreases and **the deadly gas carbon monoxide (CO) is formed**.

nirmana.site123.me nirmana.fiqra.q@gmail.com

# ANFO

The density of crystalline AN is about 1.73 $g/cm^3$ and that for fuel oil about 0.75 $g/cm^3$. By an oxygen-balanced ratio of 94.5/5.5 then the overall density for such a mixture would be 1.675 $g/cm^3$.

However, normal ANFO is about *50% by volume air* and thus the density becomes about **0.84 $g/cm^3$**.

# ANFO

The various blasting agents differ from each other not only in the particular mix used, but also in the particle sizes of the ingredients and in the packaging.

Most blasting agents, when properly boosted, have a **detonation velocity** in the range of **2,400 to 4,800 m/s**.

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Major Advantage with ANFO

**Low cost** per unit of energy delivered

# Major Disadvantage and Limitation of ANFO

Its **lack of water resistance**.

'Damp' holes should be pumped dry, charged and shot as quickly as possible. Even in 'wet' conditions good blasting results can be obtained with ANFO but **only if the ANFO is kept dry**.

# Light ANFO

There are some situations where bulk blasting agents which **have strengths less than bulk ANFO** are desired. One such situation is the minimization of back break/blast damage from pit perimeter holes.

# Light ANFO

Wilson & Moxon (1988) conducted both laboratory and field tests in which **low density materials** such as polystyrene, bagasse (the stalks remaining after extracting the sugar from sugar cane), sawdust, perlite, etc were mixed together with ANFO and detonated. Their results indicate that **the VOD of ANFO can be significantly reduced by the addition of a low density additive.**

# Light ANFO

Since the greatest effect of **decrease on $P_{DET}$** is obtained if both **the VOD and the density are significantly lowered**, the most attractive systems for large scale use (of those tested) are:

- ✓ ANFO/bagasse,
- ✓ ANFO/sawdust,
- ✓ ANFO/polystyrene
- ✓ ANFO/peanut skin.

# Light ANFO

The additives used in the experiment are believed to lower the detonation pressure of ANFO by acting as a low grade fuel which reacts or burns more *slowly* in the presence of ammonium nitrate than does fuel oil. The mixtures are also very poorly oxygen-balanced which further reduces the VOD.

# Watergels/Slurries

**ANFO** was first introduced to the mining community in 1955. Due to **its** *low cost, relatively high weight strength and good handling properties*, it met with nearly immediate acceptance and success. **It** had certain drawbacks, however *no water resistance, low density, low energy range*, which meant that **it** was not suited for all applications.



nirmana.site123.me nirmana.fiqra.q@gmail.com

# Watergels/Slurries

In 1958, Melvin A. Cook, then at the University of Utah, published his now classic book “The Science of High Explosives” (Cook, 1958). In it, he reported the development of water-compatible bulk explosives (**slurry explosives**) and their use for underwater blasting at the Knob Lake operation of the Iron Ore Company of Canada. His original **slurries** consisted of *AN-TNT-*$H_2O$. In advance, some of the *basic reactions* involved can be found in the book of Hustrulid, W. *Blasting Principles For Open Pit Mining.* 1999. Netherlands: A.A.Balkema/ Rotterdam.

# Watergels/Slurries

These early **slurries** had densities and explosion pressures which were higher than ANFO *but heats of explosion which were lower*. Due to the density and weight strength combination, the bulk strengths of these slurries were higher than for ANFO.

nirmana.site123.me nirmana.fiqra.q@gmail.com

# Watergels/Slurries

In overcoming the drawbacks associated with ANFO as presented before, these **slurries** offered exciting application possibilities to, not the least, hard rock blasting under wet conditions.



nirmana.site123.me nirmana.fiqra.q@gmail.com

# Watergels/Slurries

These early slurries were not formed by a simple mixing of AN, TNT (or some other fuel) and water, stirring, and then pouring the resulting mixture into the hole. Rather it involved (Sudweeks, 1985)

- ✓ Pre-dissolving the ammonium nitrate in a small amount of water (to form a solution),
- ✓ Thickening the solution with a guar gum (cluster bean) or starch (from cereals and potatoes),

# Watergels/Slurries

- ✓ Adding fuel components as soluble or finely divided insoluble materials (solid 1),
- ✓ Adding dry oxidizers to reduce the overall water content (solid 2),
- ✓ (optionally) cross-linking the gum thickeners to produce a gelled product.

# Emulsions

An **emulsion** is defined as an intimate mixture of two liquids that do not dissolve in each other.

# Emulsions

Some examples of emulsions found in everyday life (Hopler, 1991) are:

| Oil-in-water | Water-in-oil |
|---|---|
| Latex paints | Margarine |
| Mayonnaise | Printing inks |
| Ice cream | Butter |
| Milk | Shoe polish |

# Emulsions

Interest in explosive emulsions began in in the early 1960s (Sudweeks, 1985). In this application, the oxidizer salt solution (normally ammonium nitrate *(AN)* plus sodium nitrates and/or calcium nitrates in water) is suspended in the oil phase.

# Emulsions

It is still a ‘mixture’ of fuel and oxidizer similar to black powder, dynamite, and ANFO, but the particle size comes as close as possible to mimicking the intimacy of combination found in molecular explosives such as TNT.

# Characteristic Size of **Oxidizers**

| Explosive | Size (mm) | Form | VOD (km/sec) |
|---|---|---|---|
| ANFO | 2.000 | All solid | 3.2 |
| Dynamite | 0.200 | All solid | 4.0 |
| Slurry | 0.200 | Solid/liquid | 3.3 |
| Emulsion | 0.001 | Liquid | 5.0-6.0 |

# THANK YOU

nirmana.site123.me
nirmana.fiqra.q@gmail.com