# MNTC 314

## ASSIGNMENT 1

## Problem 1

Calculate the heat and products of detonation for the following compositions:

a. AN: 96%, Fuel Oil: 4%

b. AN: 95 %, Fuel Oil: 5 %

c. oxygen balanced ANFO

c. AN: 94%, Fuel Oil: 6%

d. AN: 93%, Fuel Oil: 7%

Provide a summary table showing heat and products of detonation.

What is the relationship between oxygen balance and energy output? Provide a graph to illustrate this.

What is the relationship between maximum velocity of detonation and oxygen balance? Provide a graph to illustrate this. Assume that the density of the explosive is 0.85 g/cm3.

How would the addition of 5% Al would affect the heat and the velocity of detonation? Use only case c. for this calculation. Assume that Al will occupy volume in the interstitial voids of the ANFO composition. Provide information on the type of Aluminium preferred for this application and justify your answer.

The heats of formation are given in the following table:

|  |  |
| --- | --- |
| Heats of formation | |
| Component | Heat of formation, kcal/mole |
| NH4NO3 | -87.27 |
| CH2 | -6.8 |
| CO2 | -94.05 |
| CO | -26.42 |
| NO2 | 8.091 |
| H2O(g) | -57.8 |
| H2O(l) | -68.3 |
| Al2O3 | -399 |

Atomic weights are (C:12, N:14, O:16, H:1, Al:27)

# Problem 2

The measurement of the dynamic pressure around a blasthole is usually costly and difficult to

achieve because of high pressures and the violence associated with the blasting environment.

Computer simulations are often complicated, costly as well, and require considerable skill to run the sophisticated multi purpose programs available. Simple engineering solutions based on statistical interpretation of measurements are often useful to estimate the magnitude of such pressures. A commonly used form is given by Cole (1948):

where R is the distance, W is the mass of the charge assumed concentrated at its centre of gravity and K and m are constants. In the case of TNT, Keevin and Hempen (1997) have given K = 53.1 and m=1.13. You can use the same formula for other explosives; however W would be the weight of TNT that would produce the same energy as the explosive of your choice. The resulting pressure in the above equation is in MPa when R is in m and W in kg.

The pressure history at a distance in water can be expressed by the following equations (Joachim and Welch, 1997):

where

where t is time in seconds.

To calculate energy delivered by a wave it is usual (Cole, 1948) to extend time to 6.7 t0

1. At what distances from a 454 g pentolite (50% PETN/50% TNT by mass) primer do you expect detonators to detonate sympathetically in water, assuming that the critical energy for shock initiation of PETN is 0.167 MJ/m2?
2. What about an emulsion with a critical energy for shock initiation of an emulsion if the critical energy for shock initiation is 2 MJ/m2?

The critical energy fluence criterion can be expressed in the following:

or

or

where P is the pressure pulse, t is time, tf is the time at the end of the pulse (its overall duration), and C is the sonic wave velocity in the material. Up is the particle velocity.

## Problem 3

Pressures have been measured away from a detonating emulsion (density 0.90 g/cm3, velocity of detonation 4000 m/s) charge in parallel holes filled with a substance simulating an explosive. The diameter of the holes was 32 mm. The measurements are shown in Table 1.

Table 1

|  |  |
| --- | --- |
| Centre to Centre distance, mm | Pressure, MPa |
| 304 | 18.15 |
| 336 | 17.29 |
| 368 | 14.86 |
| 400 | 12.70 |
| 432 | 11.30 |
| 464 | 11.00 |
| 496 | 10.55 |
| 528 | 9.00 |
| 560 | 9.00 |
| 592 | 8.16 |
| 624 | 7.80 |
| 656 | 7.31 |

Attenuation relationships are of the following forms:

The attenuation relationship is of the form:

where P is the pressure at a distance R, R0 is the radius of the charge and P0 and m are constants from the statistical interpretation of the above data.

1. Statistics will give you a value of P0. Is this close to the expected value? Try to justify similarities or differences.
2. Provide the parameters of the fit of the above equations and select what you think the best equation is.
3. If the diameter of the blastholes in an underground tunneling application is 45 mm, below what distance do you expect to have malfunction problems, knowing that the critical pressure for malfunction of charges is 14 MPa?

### References

Cole, R. H. 1948. Underwater Explosions. Princeton University Press, Princeton, NJ.

Joachim, C. E., and C. R. Welch. “ Underwater shocks from blasting”. Proceedings of the Twenty-third Annual Conference on Explosives and Blasting Technique, Las Vegas, Nevada. *International Society of Explosive Engineers, Cleveland, OH* (1997).

Keevin, T. M., and G. L. Hempen. "The environmental effects of underwater explosions with methods to mitigate impacts. 99 pp." *St. Louis, MO: US Army Corps of Engineers* (1997).