Air Blast Calculations
Examples & Homework
MNGN 444
Spring 2016
Recommended Literature


EXAMPLE 1
Calculate the side-on overpressure and positive impulse that 10kg of Semtex 1A (76%PETN + 6%RDX) will generate at 20 meters from the center of the blast. Consider an elevation of 10,000 ft and an ambient temperature of 23°F.

Source: Explosives Engineering – Cooper
Solution

1. TNT Equivalent for Semtex 1A:

\[ RE \, Factor = 1.35 \rightarrow W = 1.35 \cdot 10\, kg = 13.5\, kg \]

2. Ambient pressure and temperature at 10,000 feet:

\[ P_a = 10.11\, psi \approx 0.7\, bar \]
\[ T_a = 23^\circ F \approx 268\, K \]

3. Scaled distance:

\[ Z = \frac{R}{\left(\frac{WT_a}{P_a}\right)^{1/3}} \rightarrow Z = \frac{20}{\left(\frac{13.5 \cdot 268}{0.7}\right)^{1/3}} = 1.156 \]
Peak Overpressure: \( P_s = 0.13 \cdot 0.7 = 0.091 \text{ bar} = 9.1 \text{ KPa} = 1.32 \text{ psi} \)

Positive Impulse: \( i_d \approx \frac{t_d \cdot P_s}{2} = \frac{32 \cdot 9.1}{2} = 145.6 \text{ KPa} \cdot \text{ms} = 21.12 \text{ psi} \cdot \text{ms} \)
CDOT called you a couple of days ago complaining about the efficiency of their avalauncher rounds. They need a larger effective range but increasing the projectile payload is not a viable solution because they cannot modify the gas guns or the projectile body. You decide to optimize the use of the explosive energy by attaching a stick in the nose of the projectile.

- The projectiles payload is 1kg of Composition B.
- Consider that you can trigger an avalanche with 2 psi.

1. What would be the ideal length of the spike that gives you maximum effective range?
2. What would be the maximum effective range?
3. What is the horizontal distance from the charge in meters where the triple point first shows up?

For this problem, do not take into consideration: snow thickness and altitude/temperature corrections.
1. TNT Equivalent for Composition B:

\[ RE \text{ Factor} = 1.33 \rightarrow W = 1.33 \cdot 1\text{ kg} = 1.33\text{ kg} \]

2. Ideal spike length:

\[ L = H \cdot W^{\frac{1}{3}} \rightarrow L = 5 \cdot (1.33)^{\frac{1}{3}} = 5.5 \text{ m} \]

3. Maximum effective range:

\[ R = \bar{R} \cdot W^{\frac{1}{3}} \rightarrow R = 15.5 \cdot (1.33)^{\frac{1}{3}} = 17 \text{ m} \]

Without the spike the effective range is 12m. The spike increase would increase the range an extra 34%
4. Triple point formation:

\[ d = L \cdot \tan 40^\circ \rightarrow d = 5.5 \cdot \tan 40^\circ = 4.61 \text{ m} \]

What are we missing?
Solution

5. Shock Strength:

\[ \text{Slant Range} = \frac{L}{\cos 40^\circ} \rightarrow \text{Slant Range} = \frac{5.5}{\cos 40^\circ} = 7.18 \, m \]

\[ \text{Shock Velocity} = 374.56 \, m/s \rightarrow M = \frac{374.56}{340} = 1.1 \]
HOMEWORK
Homework 1

Using the information presented in Example 2. What is the horizontal distance from the charge in meters where the triple point first shows up?
Find a analytical relationship between the incident overpressure ($P_{in}$) and Mach stem overpressure ($P_{stem}$) as function of the Mach number of the incident shock ($M_{in}$) and the angle of incidence ($\beta$).

$$\frac{P_{stem}}{P_{in}} \propto f(M_{in}, \beta)$$

Plot this relationship representing the ratio between the incident overpressure ($P_{in}$) and Mach stem overpressure ($P_{stem}$) on the vertical axis. The incident Mach number on the horizontal axis ($M_{in}$ values from 1 to 3), and the $\beta$ values in contour lines (isolines) for 40°, 50°, 60°, 70°, and 80°.