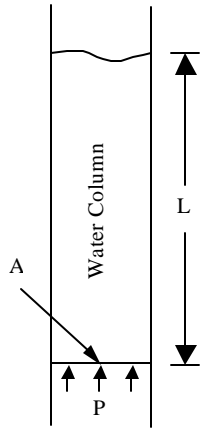


## Energy Lost to Water Column Above GasGun Stimulation



P = Pressure  
 L = Length  
 A = Area  
 t = Time  
 F = Force  
 m = Mass  
 a = Acceleration

V = Volume  
 v = Velocity  
 W = Weight  
 g = Acceleration due to gravity  
 ρ = Density  
 s = Distance

### Values:

$$P = 20,000 \text{ psi}$$

$$t = 20 \text{ msec.}$$

$$L = 1000 \text{ feet}$$

$$\rho = 62.4 \text{ lb/ft}^3 \text{ (density of water)}$$

$$g = 32.2 \text{ ft/sec}^2$$

$$A = 0.213 \text{ ft}^2 \text{ (6 1/4" open hole)}$$

### Formulas:

$$F = ma \text{ or } a = F/m$$

$$F = PA$$

$$m = W/g$$

$$W = V\rho$$

$$V = AL$$

$$s = \frac{1}{2}at^2$$

### Calculations:

$$a = F/m = PAg/W = PAg/AL\rho = Pg/L\rho$$

$$a = \frac{20,000 \text{ lb/in}^2 * 144 \text{ in}^2/\text{ft}^2 * 32.2 \text{ ft/sec}^2}{1000 \text{ ft} * 62.4 \text{ lb/ft}^3} = 1,486 \text{ ft/sec}^2$$

### Distance water column moves in 20 msec is:

$$s = \frac{1}{2}at^2 = \frac{1}{2}(1486)(.02)^2 = 0.3 \text{ ft} = 3.6 \text{ in}$$

### Conclusion:

Energy produced by the GasGun is restricted to the pay zone.

**Energy lost:****Formulas:**

$$E(\text{Energy}) = KE(\text{Kinetic energy}) + PE(\text{Potential energy})$$

$$KE = \frac{1}{2}mv^2$$

$$PE = W_s$$

$$v = at$$

**Calculations:**

$$v = at = 1,486 \text{ ft/sec}^2 * .02 \text{ sec} = 29.7 \text{ ft/sec}$$

$$W = AL\rho = 0.213 \text{ ft}^2 * 1000 \text{ ft} * 62.4 \text{ lb/ft}^3 = 13,300 \text{ lb}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(W/g)v^2 = \frac{1}{2}(13,300 \text{ lb}/32.2 \text{ ft/sec}^2)(29.7 \text{ ft/sec})^2 = 182,000 \text{ ft-lb}$$

$$PE = W_s = 13,300 \text{ lb} * 0.3 \text{ ft} = 4,000 \text{ ft-lb}$$

$$E = KE + PE = 182,000 \text{ ft-lb} + 4,000 \text{ ft-lb} = 186,000 \text{ ft-lb}$$

$$\text{Energy in GasGun}^a = 40,000,000 \text{ ft-lb}$$

$$\% \text{ of energy lost} = 186,000 \text{ ft-lb}/40,000,000 \text{ ft-lb} = 0.46 \%$$

**Conclusion:**

99.54% of the energy in the GasGun goes to fracturing the formation.

<sup>a</sup> Total energy of GasGun is derived from the energy produced by a 3 1/4" x 10' GasGun tool.