Document to Calculate Penetration Depth

NAVY 1940s "Universal" Formula

Inputs:

$D := 0.224\ in$ $\qquad$ $D := \frac{D}{in} = 0.224$

$W := 9.0126337 \cdot 10^{-3}\ lb$

$V := 2808$ ft/s $\qquad$ $W := \frac{W}{lb} = 9.0126 \cdot 10^{-3}$

Outputs:

$T := (0.000469) \cdot W^{0.5506} \cdot D^{-0.6521} \cdot V^{1.1001} = 0.579$ inches

YES @ t=0.579in

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ARMY 1982 Lambert-Zukas (V50) Penetration Formula

Inputs:

$T := T \cdot in = 1.47\ cm$

$\theta := 0\ rad$

$D := 5.56\ mm = 0.556\ cm$

$\alpha := 4000$

$L := 20.6630\ mm = 2.066\ cm$

$M := W \cdot lb = 4.088\ gm$

$T := \frac{T}{cm} = 1.47$

$D := \frac{D}{cm} = 0.556$

$L := \frac{L}{cm} = 2.066$

$M := \frac{M}{gm} = 4.088$

Outputs:

$$Z := \frac{T \cdot (sec(\theta))^{0.75}}{D} = 2.643$$

$$V_L := \alpha \cdot \left(\frac{L}{D}\right)^{0.15} \cdot \sqrt{\frac{\left(Z + e^{-Z} - 1\right) \cdot D^3}{M}} = 1307.672 \quad \text{m/s}$$

4124 ft/s > 2808 ft/s; **NO**

Error likely due to alpha armor constant, no reliable data to determine where the value originates from nor how to compute it.

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Original F-Formula

Inputs:

$T := T \cdot cm = 0.579\ in$ $\qquad T := \frac{T}{in} = 0.579$

$D := D \cdot cm = 0.219\ in$ $\qquad D := \frac{D}{in} = 0.219$

$\theta := 0\ rad$

$M := M \cdot gm = 0.009\ lb$ $\qquad M := \frac{M}{lb} = 0.009$

Outputs:

$$F_{std} := 6 \cdot \left(\frac{T}{D} - 0.45\right) \cdot \left(\theta^2 + 2000\right) + 40000 = 6.632 \cdot 10^4$$

$$V_L := \left(\frac{1}{41.57}\right) \cdot F_{std} \cdot \sqrt{\frac{T}{D}} \cdot \sqrt{\frac{D^3}{M}} \cdot \frac{1}{\cos(\theta)} = 2798.222 \quad \text{ft/sec}$$

2798 ft/s ~ 2808 ft/s; **YES @ t=0.579in**

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NAVY 1930s "Thompson F-Formula"

Inputs:

$T := T \cdot in = 0.015\ m$ $\qquad T := \frac{T}{m} = 0.015$

$D := D \cdot in = 0.006\ m$ $\qquad D := \frac{D}{m} = 0.006$

$\theta := 0\ rad$

$M := M \cdot lb = 0.004\ kg$ $\qquad M := \frac{M}{kg} = 0.004$

Outputs:

$$F := 1.8288 \left(\frac{T}{D} - 0.45\right) \left(\theta^2 + 2000\right) + 12192 = 2.021 \cdot 10^4$$

$$E_K := 8.025 \cdot \frac{T \cdot D^2 \cdot F^2}{\left(\cos\left(\theta\right)^2\right)} = 1.49 \cdot 10^3$$

$$V := \sqrt{\frac{E_K}{\frac{1}{2} \cdot M}} = 853.753 \quad \text{m/s}$$

2801 ft/s ~ 2808 ft/s; **YES @ t=0.579in**

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Wijk's Penetration Model

$m_p := W \cdot lb = 0.009\ lb$

$V_0 := 2808\ \frac{ft}{s} = 855.878\ \frac{m}{s}$

$d_p := 0.224\ in$

$Y_T := 1250\ MPa = \left(1.813 \cdot 10^5\right)\ psi$

$\beta := 5$

$$P := \frac{2 \cdot m_p \cdot \left(V_0\right)^2}{\pi \cdot \left(d_p\right)^2 \cdot \beta \cdot Y_T} = 0.371\ in$$

YES @ t=0.371in

Pol's Model

$b := \frac{0.224\ in}{2} = 0.112\ in$

$t := 0.475\ in$

$L := 0.490\ in$

$\rho := 7860\ \frac{kg}{m^3} = 0.284\ \frac{lb}{in^3}$

$W_p := \frac{\pi}{2} \cdot b^2 \cdot Y_T \cdot t = 191.717\ J$

$$W_d := \frac{2 \cdot \pi \cdot \rho \cdot V_0^{\ 2} \cdot b^4 \cdot t^2}{3\ in \cdot L^2} = 29.22\ J$$

$$W_b := \frac{\pi^2 \cdot b \cdot t^2 \cdot Y_T}{4} = 1277.192\ J$$

$$V_b := \left(\frac{2 \cdot \left(W_p + W_d + W_b\right)}{m_p}\right)^{\frac{1}{2}} = 856.112\ \frac{m}{s} \quad V_b = 2808.768\ \frac{ft}{s}$$

2809 ft/s ~ 2808 ft/s; **YES @ t=0.475in**

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Intermediate Speed Penetration (panoptesv)

$V_0 = 855.878\ \frac{m}{s}$

http://panoptesv.com/RPGs/Equipment/Weapons/Projectile_physics.php

$A := \pi \cdot (0.224\ in)^2 = 101.698\ mm^2$

$Y_c := 1250\ MPa$

$c_d := 1$

$\rho_t := 7860\ \frac{kg}{m^3} = 7.86\ \frac{gm}{cm^3}$

$x_c := \frac{m_p}{A} \cdot \frac{1}{c_d \cdot \rho_t} = 0.511\ cm$

$v_{thr} := \sqrt{2 \cdot \frac{Y_c}{c_d \cdot \rho_t}} = 563.974\ \frac{m}{s}$ **< 914.4 m/s; USE xmB FORMULA**

$x_{mA} := x_c \cdot \ln\left(1 + \frac{V_0^2}{v_{thr}^2}\right) = 0.241\ in$

$x_{mB} := m_p \cdot \frac{V_0^2}{(2 \cdot A \cdot Y_c)} = 0.464\ in$

YES @ t=0.464in

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