Jacketed Penetrators (Tungsten, DU with Steel Sheath)

Perforation Limit in Oblique Single Targets

The perforation limit of jacketed penetrators into oblique RHA targets can be calculated with help of the perforation equations for tungsten, DU and steel mono-block penetrators. The relationship of sheath thickness T to total-diameter D is decisive.

The function for f(T/D, can be derived from a work of **Sorensen et al.**[1] .

B.R. Sorensen et al. / International Journal of Impact Engineering 22 (1999) 71–91 89

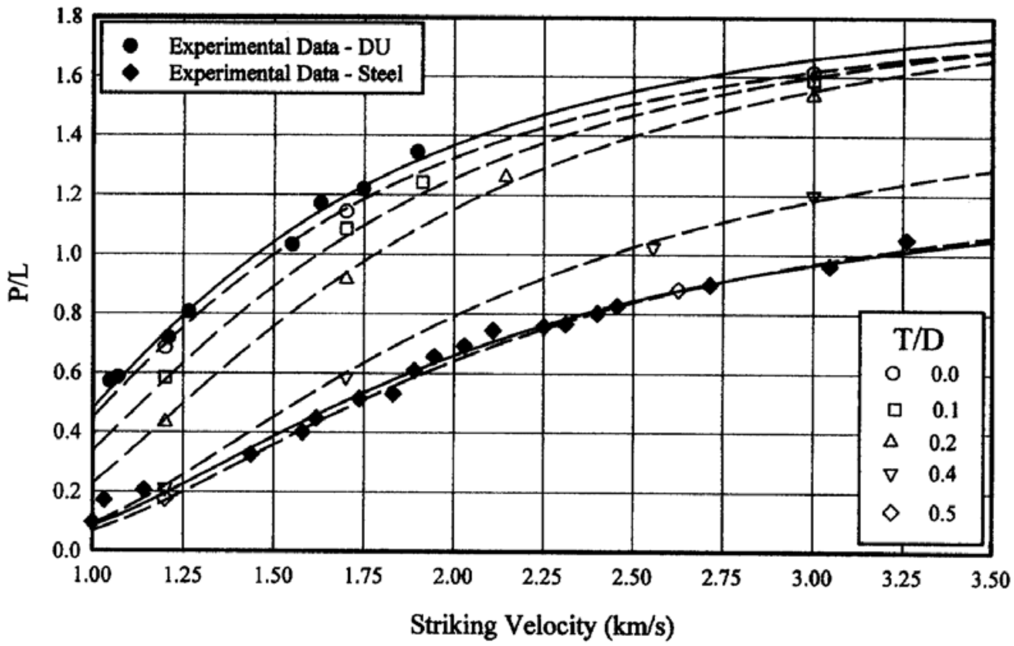


Fig. 14. Resulting curves from the "best" set of inputs to the jacketed rod penetration model.

Ansatz: $P_{JP} = (P_{WHA} - P_{Steel}) \cdot f(T/D) + P_{Steel}$ resp. $P_{JP} = (P_{DU} - P_{Steel}) \cdot f(T/D) + P_{Steel}$

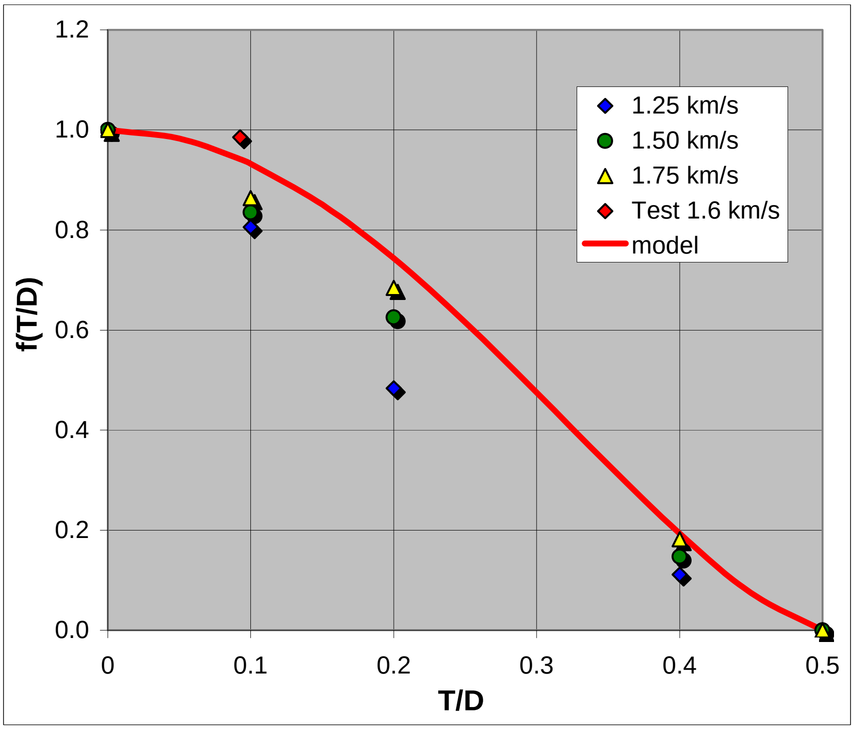
P_{JP}	Jacketed Rod Perforation
P_{WHA}	Mono-block Tungsten Rod Perforation
P_{DU}	Mono-block DU Rod Perforation
P_{Steel}	Mono-block Steel Rod Perforation

Limits:

T/D=0	DU respectively tungsten mono-block penetrator
T/D=0.5	Steel mono-block penetrator

[1] IJIE 22 p71-91: Numerical analysis and modeling of jacketed rod penetration, Brett R. Sorensen et al.

For the ordnance velocity range - 1.25 to 1.75 km/s - f(T/D) can be picked out from figure 14 :



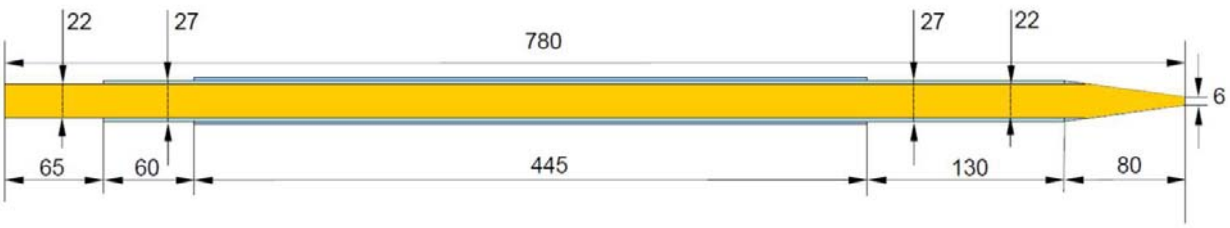
In the area of T/D=0.1 the Sorensen values seem to be too small, what the test result shows. The difference may be the influence of the aspect ratio L/D and the penetrator shape (Sorensen: L/D = 10 - cylindrical penetrator). At point 0 a horizontal asymptote is advantageous, what can be get with a cosinus. The model in the graph bases on the following simple equation:

$$f(T/D) = (\cos(pi*T/D))^{1.4}$$

Therefore: $\mathbf{P_{JP} = (P_{WHA} - P_{Steel}) \cdot (\cos(pi*T/D))^{1.4} + P_{Steel}}$

Swiss test results with full tungsten and jacketed penetrators:

Dimensions of the tested jacketed penetrator (the full tungsten penetrator had the same outer dimensions)



Material properties:

Tungsten: density 17'100 kg/m^3
Steel sheath: BHN 440
Target: 402 mm RHA with BHN 245
T/D = 2.5/27 = 0.093

Test results (limit obliquity):

Tungsten mono-block rod:

v_{imp} = 1.573 km/s
θ_{50} = 56.6°
P_{WHA} = 730 mm

Jacketed penetrator:

v_{imp} = 1.598 km/s
θ_{50} = 57.1°
P_{JP} = 740 mm

Both rods were fired with the same sabot and charge. The difference in the velocity was the result of the smaller jacketed penetrator mass. In order to be able to compare both penetrators, I normalized the full tungsten rod to the velocity and obliquity of the jacketed penetrator.

Normalized results of the tungsten mono-block rod:

v_{imp} = 1.598 km/s
θ_{50} = 57.1°
P_{WHA} = 745 mm

Both penetrators show rather exactly the same perforation.

Results with the perforation equation for mono-block rods at normalized conditions:

P_{WHA} = 735mm (-1.3%)

P_{Steel} = 408 mm

Perforation prediction for the jacketed penetrator with the new ansatz:

T/D = 0.093

$f(T/D) = (\cos(pi*0.093))^{1.4} = 0.941$

$\mathbf{P_{JP}} =$ (735 - 408)* 0.9412 + 408 = **716 mm** (-3.2% compared with test result)

The correspondence between prediction and test result is quite well.

Steffisburg, January 2010 — Willi Odermatt