Jacketed penetrators having different thickness

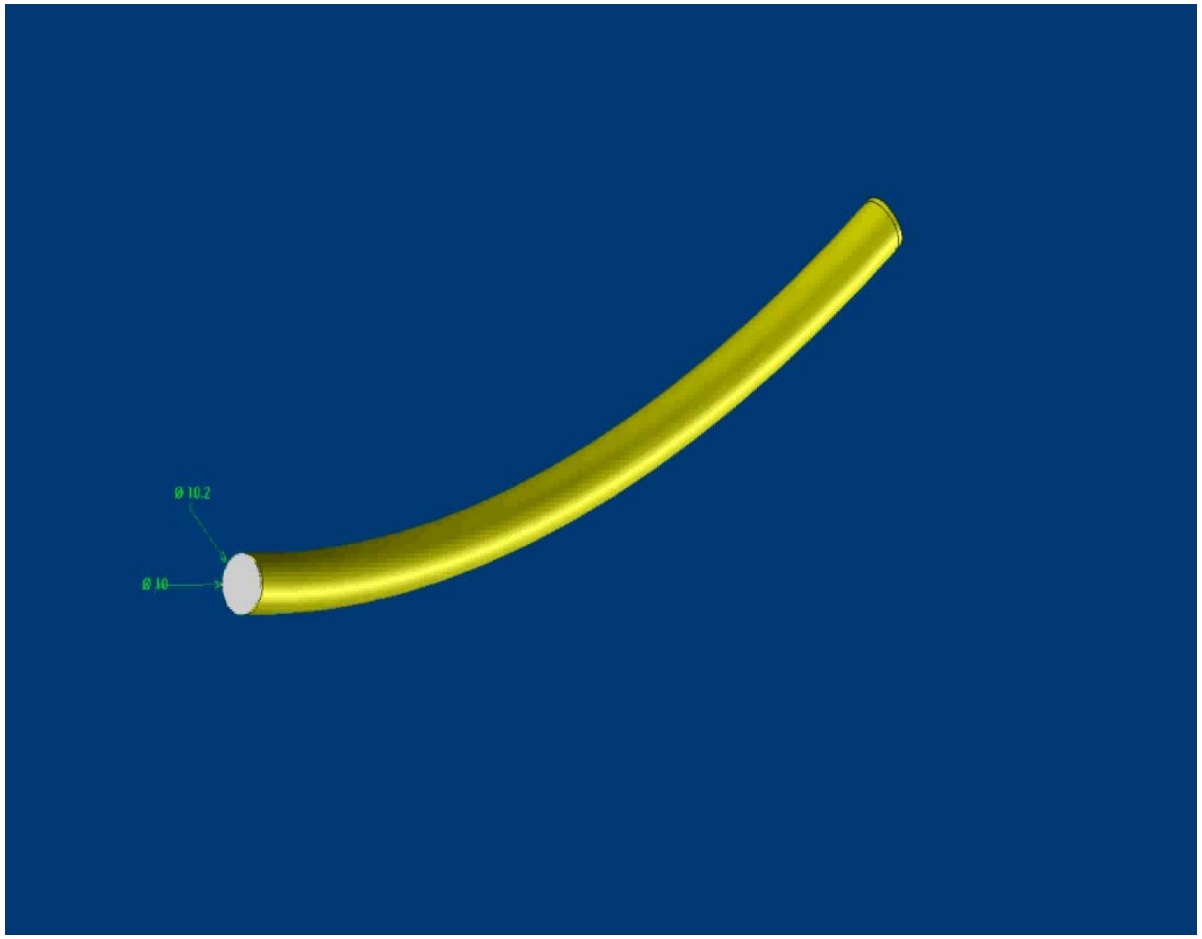
Penetrator performance and production

TNO | Knowledge for business

Contributors to this work:

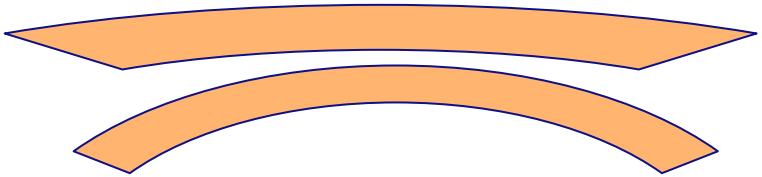
- Dr. Erik Carton
- Dr. Marianne Stuivinga
- Mark Dijkstra, Msc
- Dr. Niels van der Meer
  - TNO Defence, Security and Safety
  - Lange Kleiweg 137, 2280 AA Rijswijk, The Netherlands
  - Phone: +31 15 2843581
  - Fax: +31 15 2843939
  - Email: niels.vandermeer@tno.nl

Increasing the jacket thickness make the penetrator stiffer

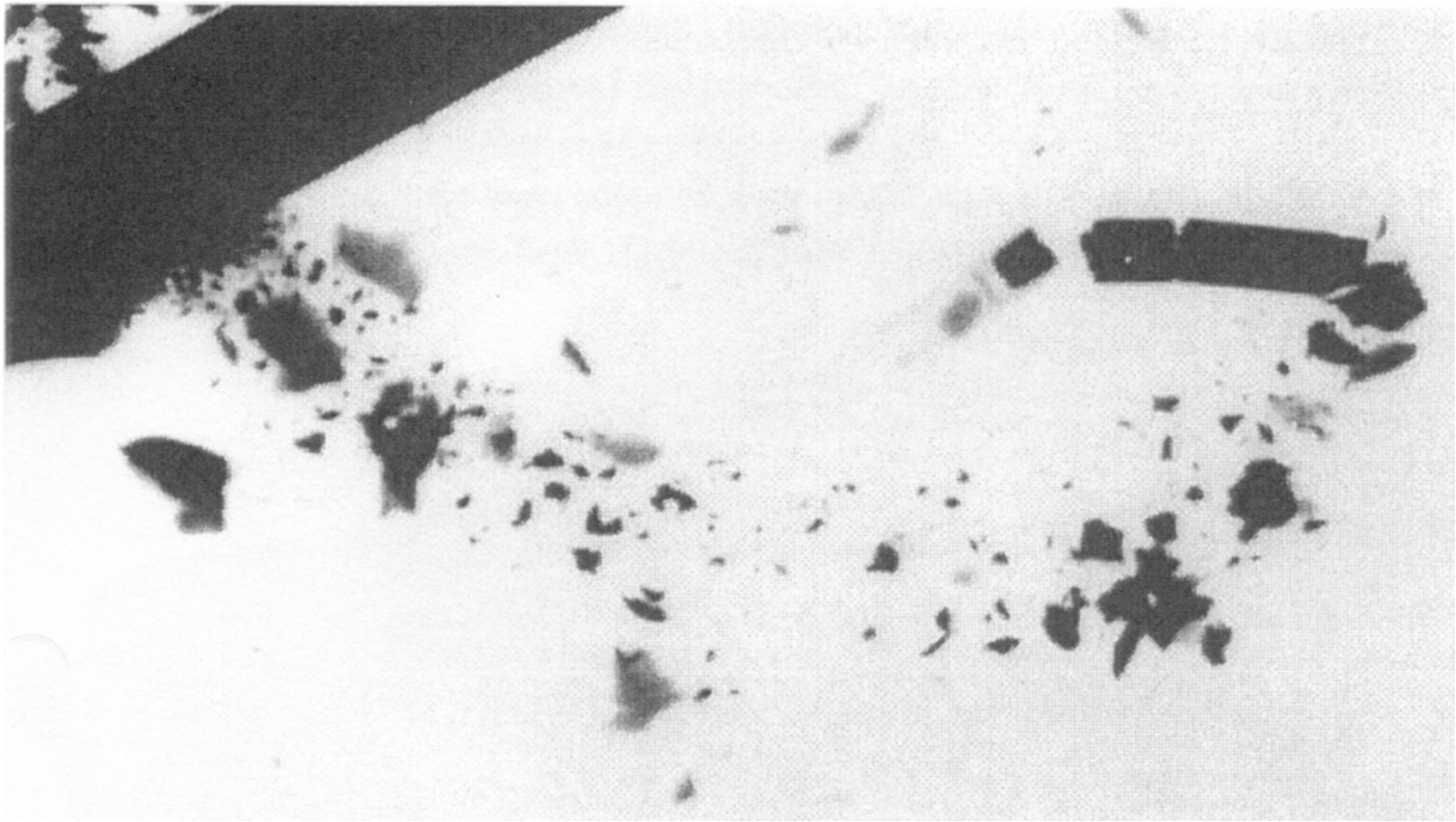


Content of presentation

- Join technique of jacket and core: explosive cladding
- Propellant production and light weight sabot
- Experiments with and results for jacket penetrators
- Conclusions



Limit fragmentation……



Jacketed penetrators obtain higher flexural rigidity with increasing jacket thickness

- Flexural rigidity of a rod $\propto$ E x R^4 (Youngs modulus x radius^4)
- Penetrator mass increase as well $\propto$ $R^{2/3}$ x ρ (radius$^{2/3}$ x mass density)
- Use high Young's modulus, low mass density material for the jacket
- Large radius of low density jacket will reduce penetration capacity of jacketed penetrator
- Commercially available metals (tubes) have been used for jackets

Focus

- Most published work is focussed on the important penetrator depth of penetration (DOP)
- This work is focussed on penetrator condition after perforating spaced/layered thin targets
- Reduced DOP of an intact jacketed penetrator is sometimes preferred over hardly any DOP of a broken penetrator

Under what circumstances can a jacket be useful?

- Thick target plates cause probably too high lateral forces on the penetrator

A jacket could be of advantage in case of:

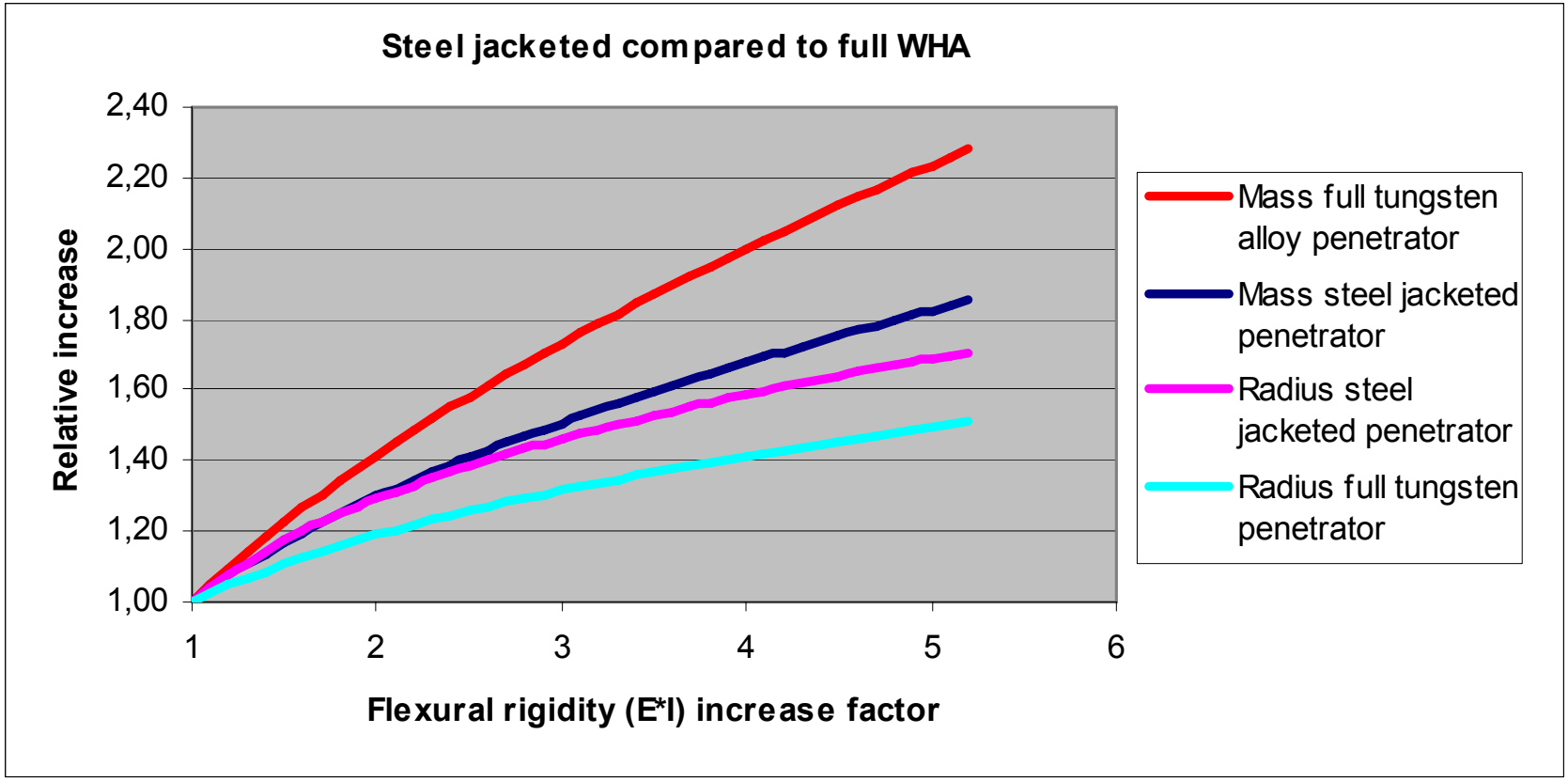
- Spaced target
- Layered target

…..both consisting of relatively thin plates

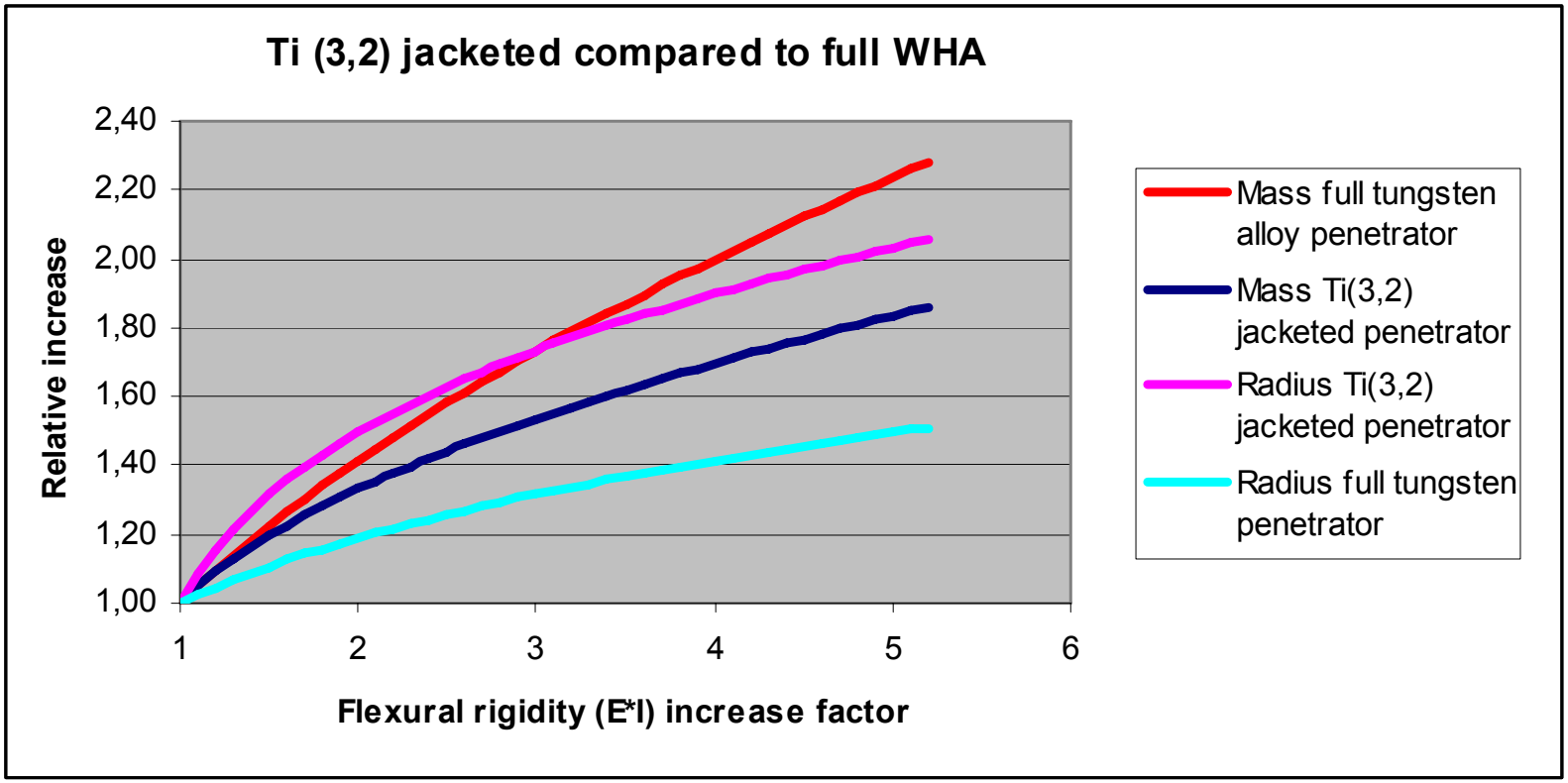
Results of published work

Type of work	D_c/D_j	V_{impact}	*Ref/year*
Computer code	> 0.9	1700 m/s	[2]/1994
Experiment	> 0.8	1800 m/s	[4]/1996
Experiment	> 0.6	2200 m/s	[3]/2001
Experiment	> 0.7	1500 m/s	[5]/2005
Experiment	0.5 – 0.8	1100 – 1300 m/s	this work

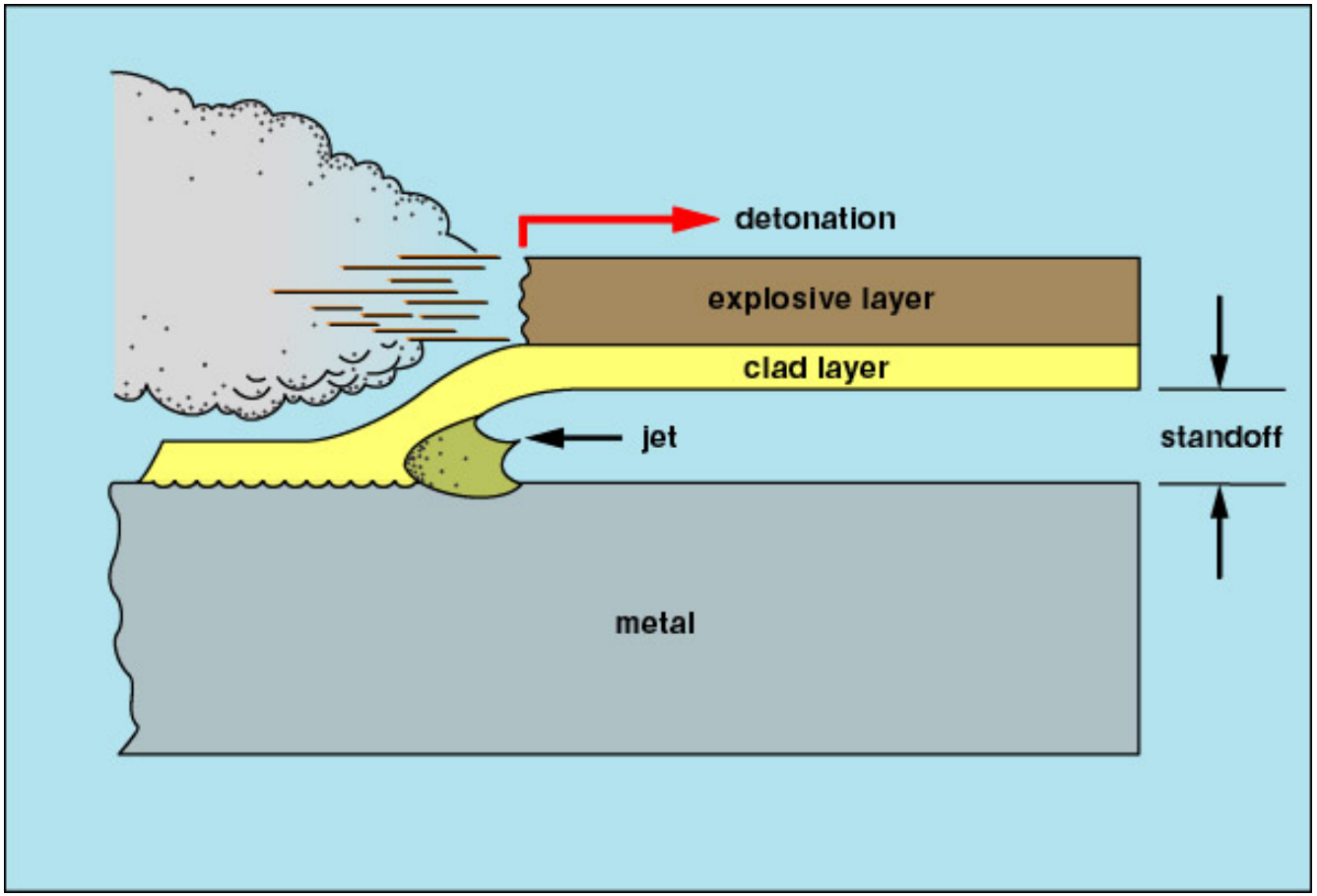
Relative mass and radius increase (1)



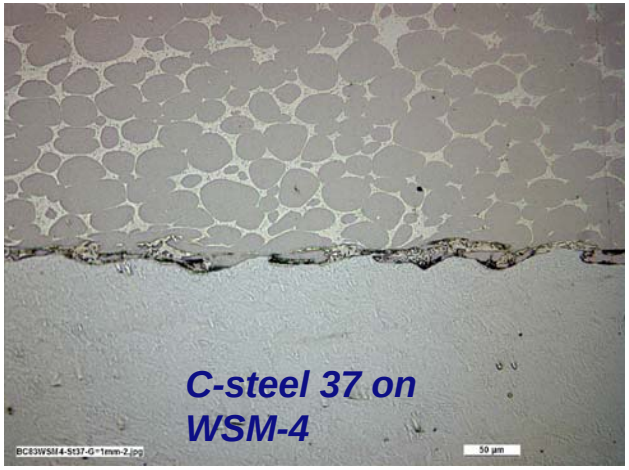
Relative mass and radius increase (2)

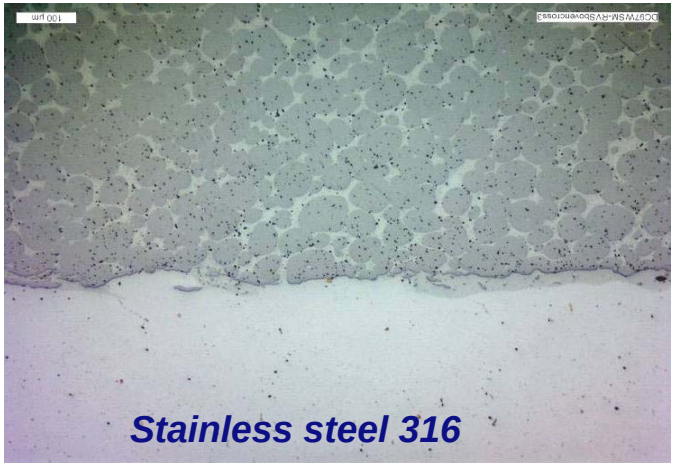


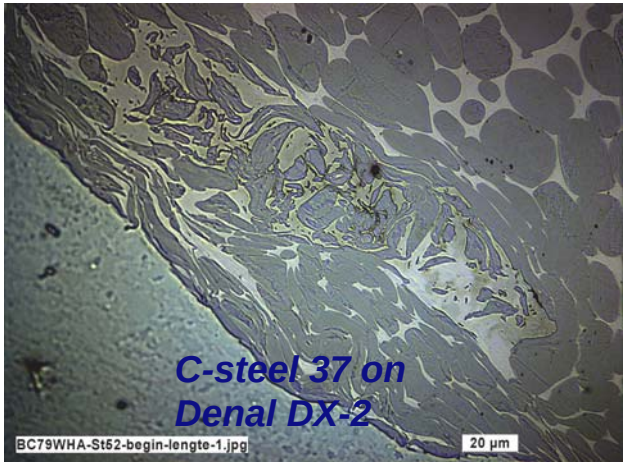
Explosive cladding



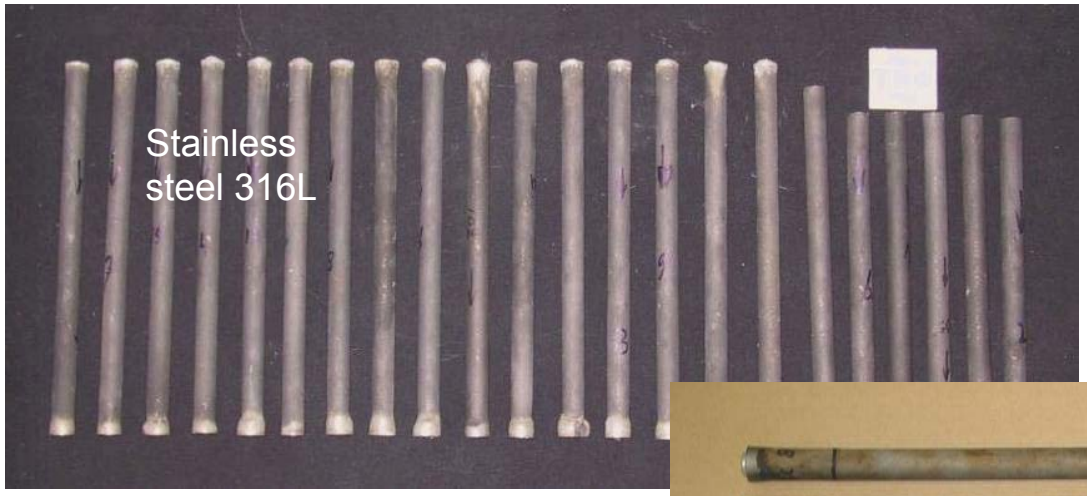
WHA – metal interface







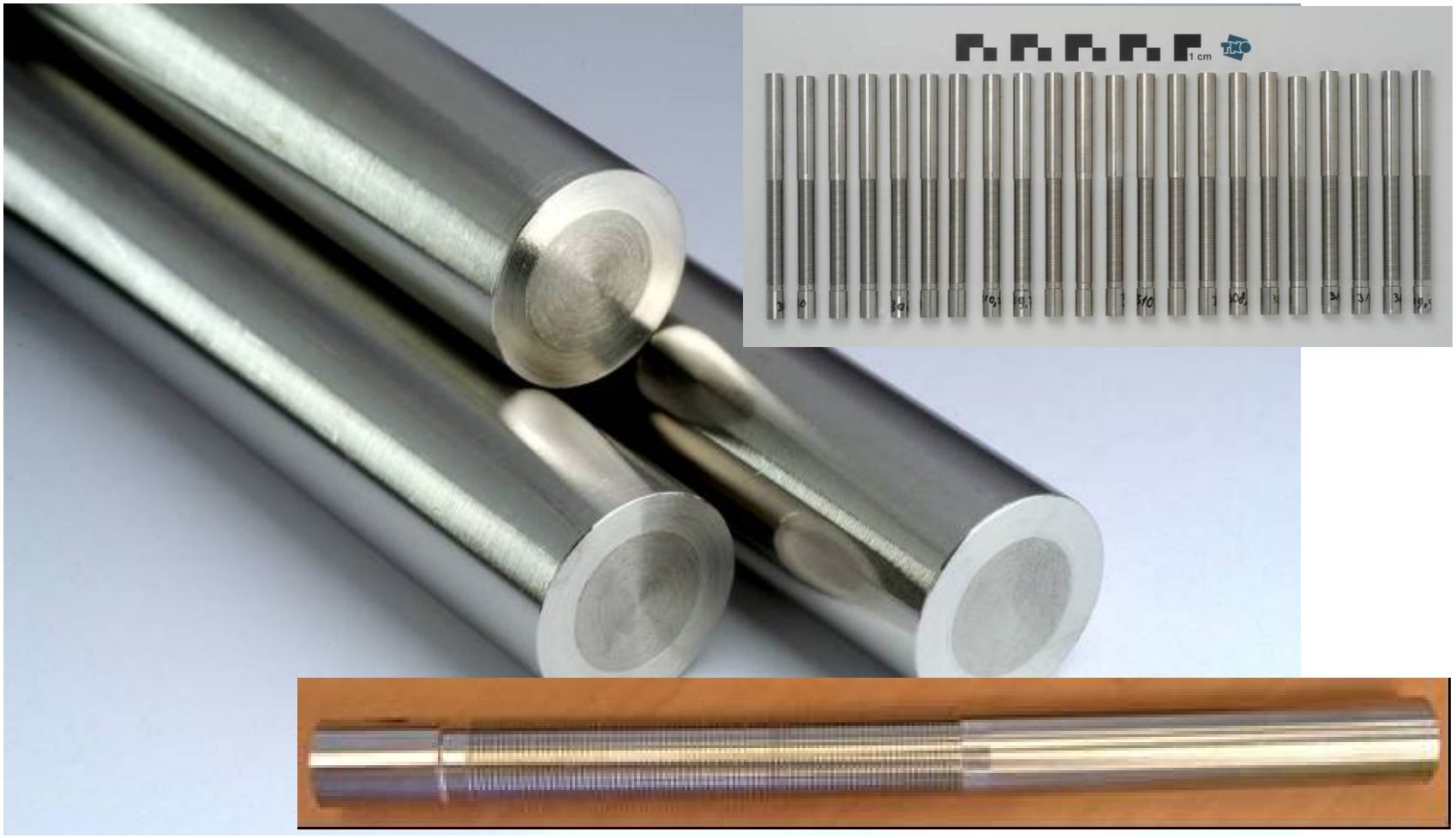
Explosively clad metals on WHA rods



Shear strength data of jacket - core interface

Jacket material	WSM-4 rod diameter (mm)	Jacket thickness (mm)	Shear strength (MPa)
Titanium (3,2)	10	1.2	156
Titanium pure grade 2	15.2	1	159
C-steel-37	14.9	1.3	65

Stainless steel 316L clad on WSM-4 rod



Penetrators having screw thread on the jacket instead in the jacket

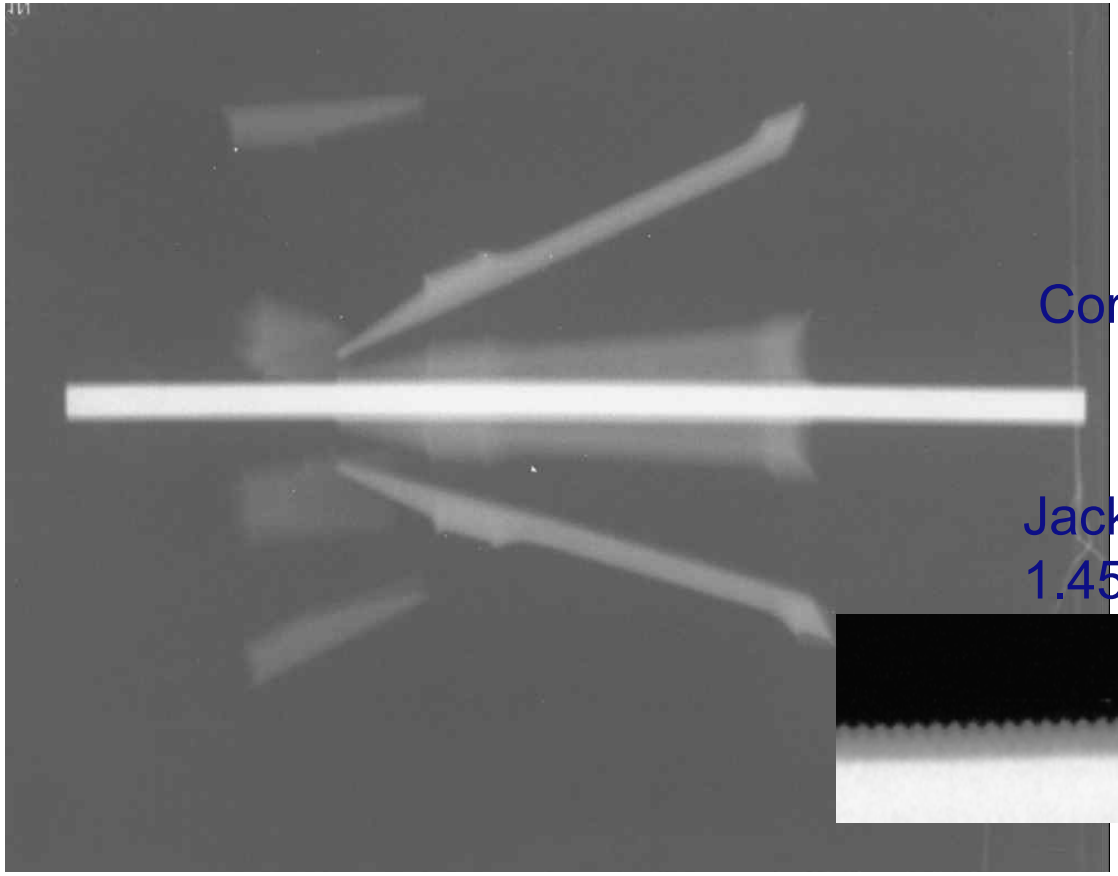
Penetrators, sabot and propellant casing

Light weight sabot

Propellant production facility: extruder

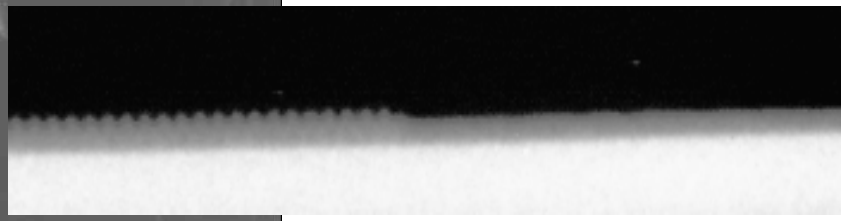
Experimental arrangement

Pure Titanium (grade 2) jacketed penetrator prior to impact (thin jackets)

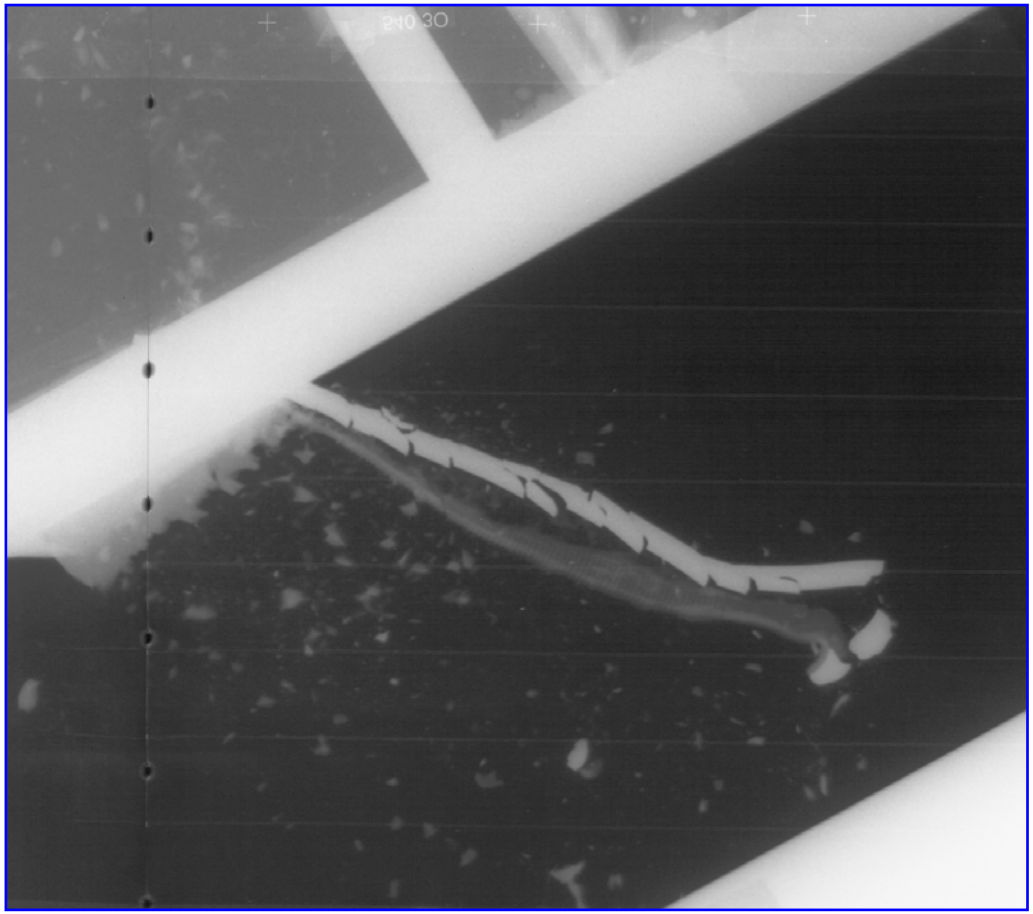


Core diameter: 6.3 mm

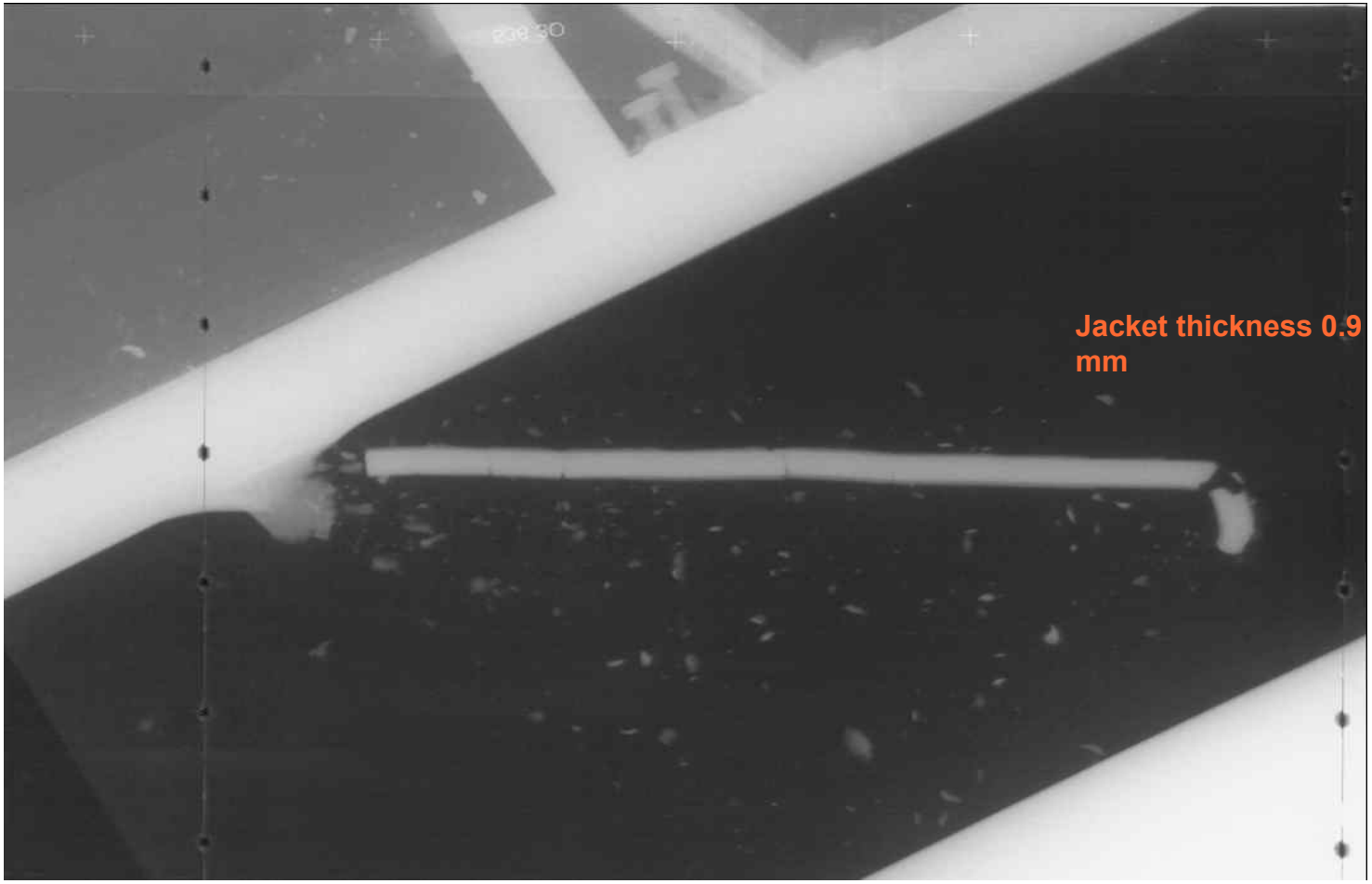
Jacket thickness
1.45 mm



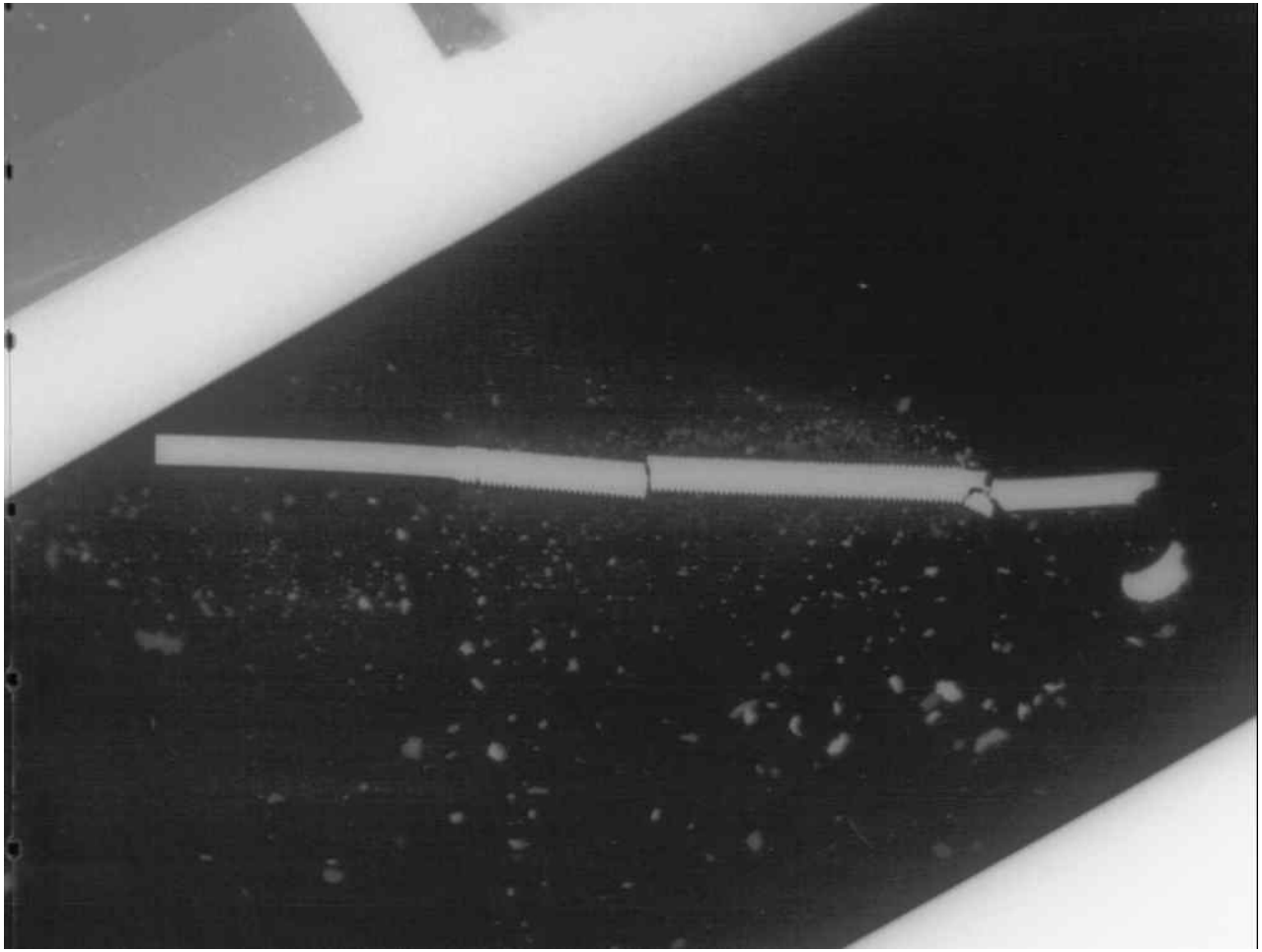
Pure Titanium (grade 2) jacketed penetrator (Denal DX2) after impact of layered steel/rubber/steel target



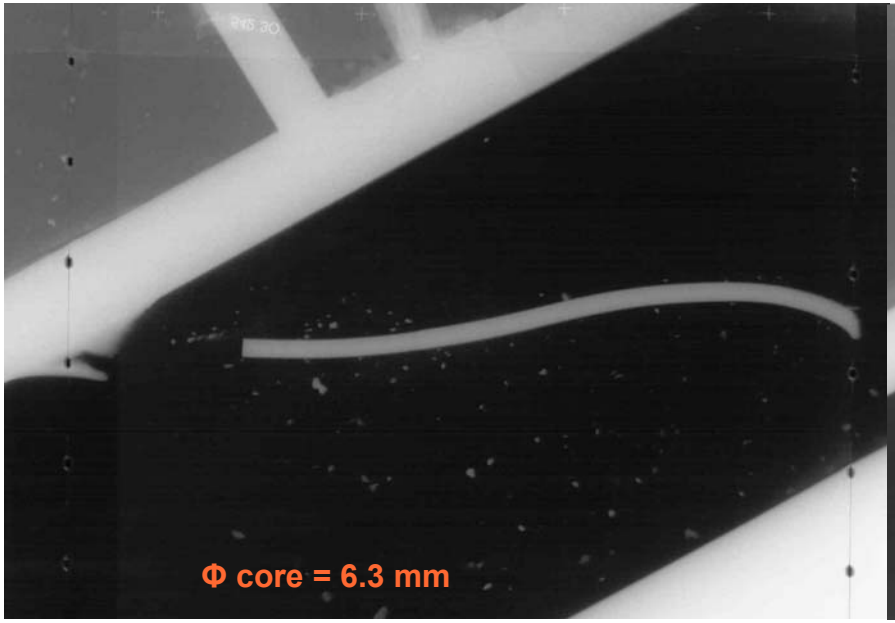
C-steel-37 jacketed penetrator (core: Denal DX 2)

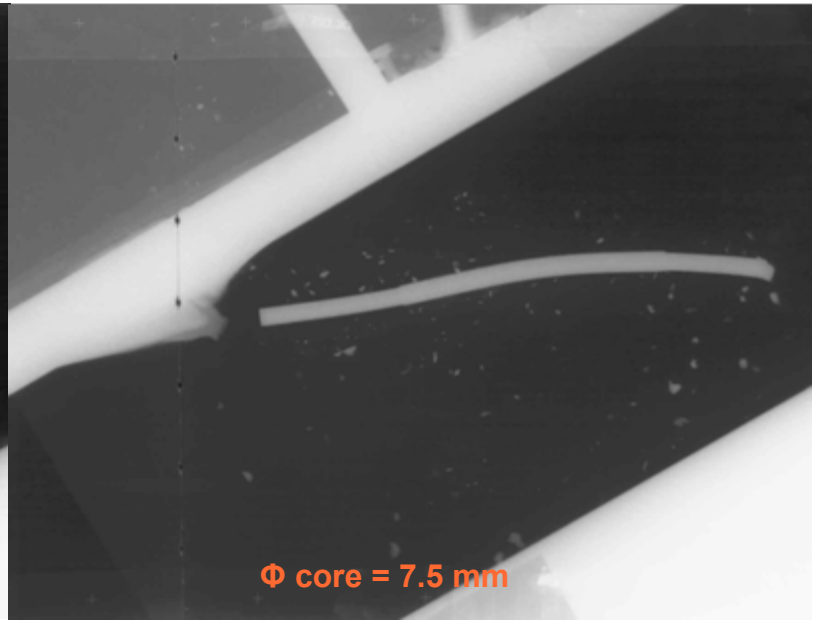


Denal DX 2 penetrator without a jacket

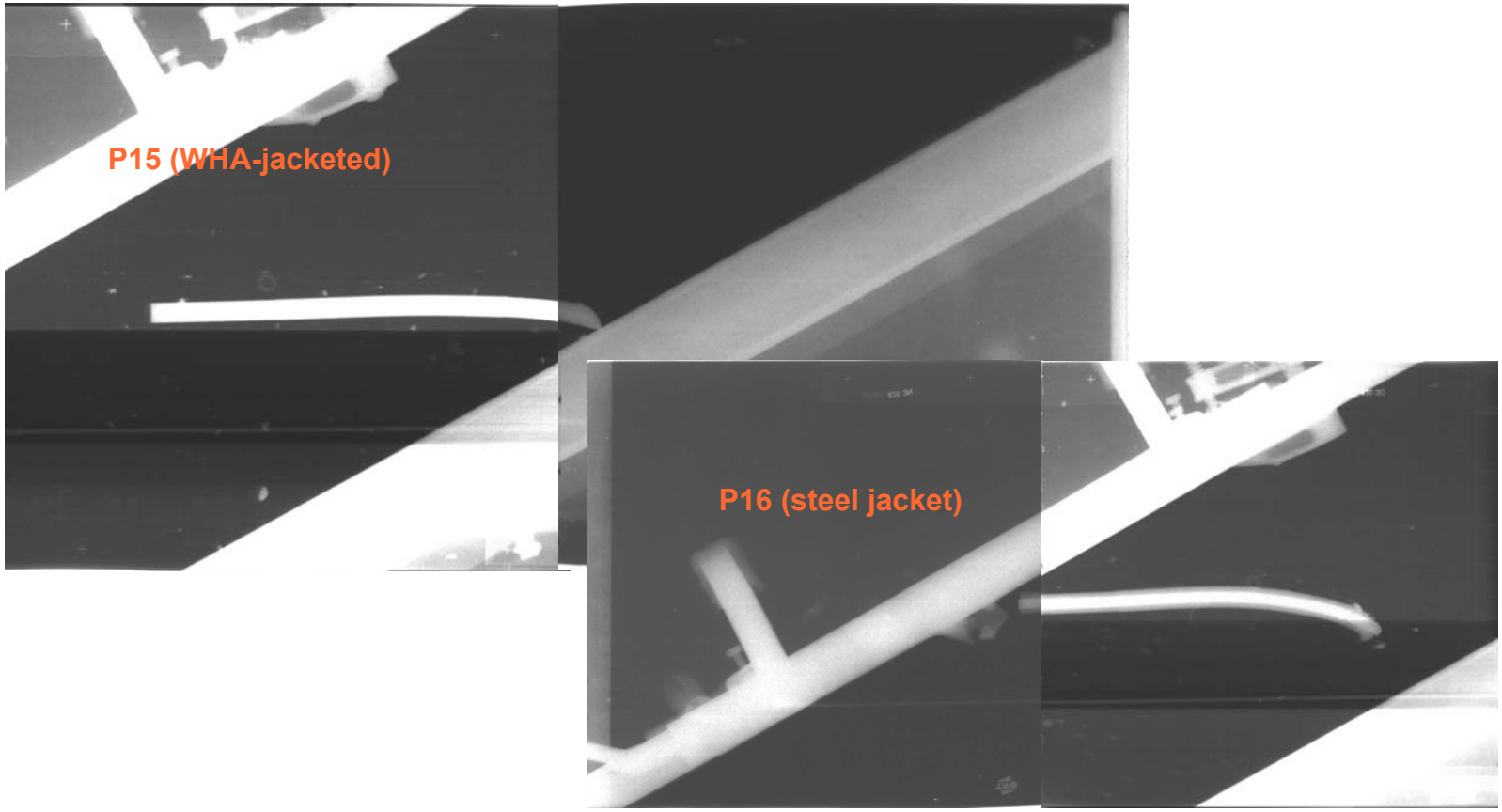


WSM-4 and WSM-4 “jacket”





Thick jackets: WHA “jackets” compared to steel jacketed (core: WSM-4)



DOP reduction

Penetrator	Jacket material	DOP (mm)
423/P15 μ = 0.64	WHA	118
425/P16P μ = 0.5	Steel-37	68

Steel jacketed penetrator

Penetration of stainless steel jacketed penetrator into RHA

Conclusions:

- Jackets can be clad on WHA rods and withstand acceleration forces for muzzle velocities up 1300 m/s (and very likely higher)
- At moderate velocities 1100 -1300 m/s:
  - Jackets can be of advantage:
    - against thin layered targets
    - in case projectile mass is a limiting factor for a firing system;
- Thicker jackets ($\mu \approx 0.5$) jackets reduce “DOP” in semi-infinite RHA-target
- At higher impact velocities, thicker jackets may give advantages as well