PLANSEE

# HIGH PERFORMANCE
# HEAVY ALLOY MATERIALS

PLANSEE

Plansee Tungsten Alloys is the world leader in the development and production of powder metallurgically processed high performance tungsten alloy components.

As a centre of excellence within the global Plansee Group, we are committed to delivering outstanding product solutions based on extensive know-how in materials, technology and applications. The combination of innovation, process control and quality policy makes us a reliable partner for the most demanding industries.

Plansee Tungsten Alloys commits its unique blend of expertise and experience to your service. Advanced competencies in machining, heat treamtent and swaging allow us to produce highly complex finished products with special material characteristics. Our R&D center is fully integrated within our production and guarantees maximum flexibility and efficiency. Together we are capable of responding to the individual needs of our customers and meeting their ever increasing requirements. By developing industrial partnerships we set new standards for the future and ensure cutting-edge solutions will be developed in an openminded approach based on partnership.

Our mission is to remain one step ahead in the development of the highest quality materials and to offer our customers real competitive advantages. We work very closely with our customers and take customer service, rapid response and quality very seriously. Certifications like the ISO9001/2000 and the Aeronautic standard AS 9100 testify our state of the art performance.

La marque de CIME BOCUZE SAS:
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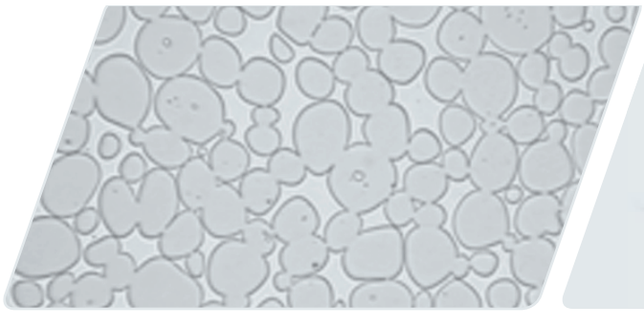
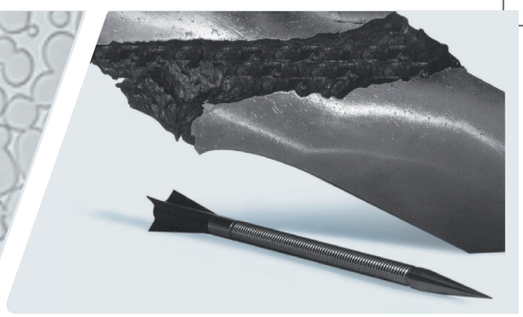


Typical microstructure L a ~ 19 µm - C a/a ~ 18%



40 CTA penetrator

# Kinetic energy penetrators

Plansee Tungsten Alloys has developed the advanced range of alloys DENAL® 2035 ideally suited for KE ammunition penetrators.

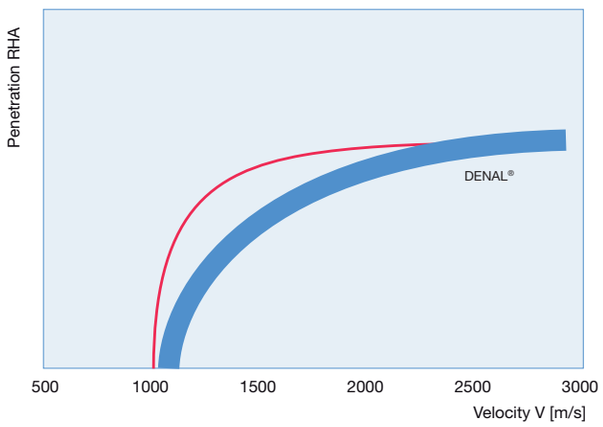
## Penetration performance against modern armour plates depends on:

- the impact velocity of the penetrator and
- its length/diameter ratio.

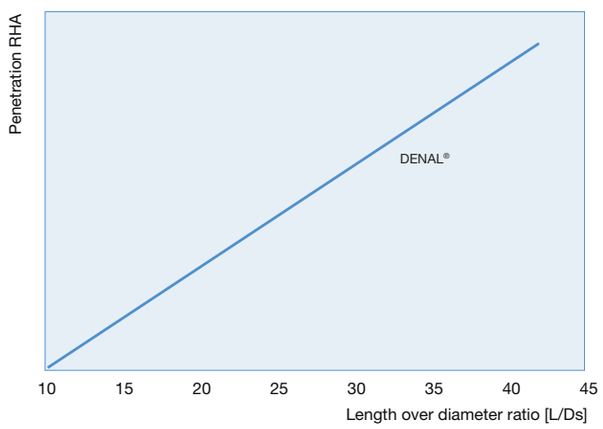
## Present research and development will lead in near future to:

- velocities of 1600 to 2500 ms-1
- L/D ratios of 25 to 35
- accelerations of 90.000 to 100.000 g, particularly in the field of medium calibre

The main characteristics of the DENAL® 2035 materials are summarized in the table below and are ideally suited to large and medium calibre ammunition specifications.



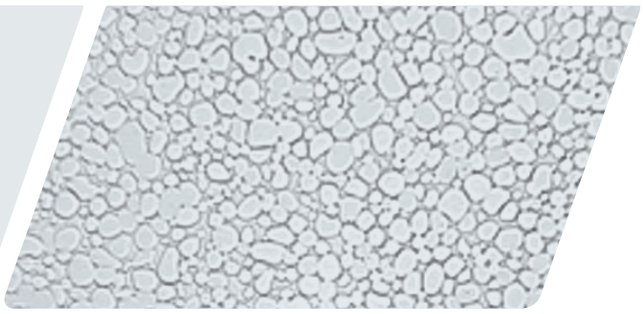

General effect of velocity (V) on penetration of homogeneous armour




General effect of L/D ratio on penetration of homogeneous armour

| MATERIAL | DENSITY | Y 0.2 YIELD STRENGTH [MPa] Av. / Min. | UTS Tensile strength [MPa] Av. / Min. | A% Elongation [%] Av. / Min. | K (5x5) Charpy test [J/cm²] Av. / Min. | K (10x10) Charpy test [J/cm²] Av. / Min. |
|---|---|---|---|---|---|---|
| **DX2HCMF** | 17.6 | 1090 / 1050 | 1150 / 1100 | 10 / 8 | 30 / 10 | 30 / 10 |
| **DENAL 920 60 20** | 17.6 | 1250 / 1180 | 1250 / 1180 | 14 / 9 | 100 / 60 | 130 / 65 |
| **DENAL 920 159 20** | 17.6 | 1460 / 1400 | 1460 / 1400 | 11 / 8 | 150 / 100 | 200 / 110 |
| **DENAL 910 179 20** | 17.5 | 1640 / 1600 | 1640 / 1600 | 10 / 7 | 100 / 60 | 130 / 65 |

SGSC microstructure L a ~ 8 µm - C a/a ~ 15%



Cores for medium calibres KE ammunition

# DENAL® - new generation

## Green ammo

In order to take new environmental recommendations into consideration, Plansee Tungsten Alloys has developed a new DENAL® cobalt-free material

Our Research & Development Centre took up the challenge of developing environmentally-friendly DENAL® materials, adapted to the demands of KE penetrators and preserving their properties and performance to a very high degree. The following material properties can be obtained on request.

Our Co-free materials were successfully fire tested for medium and large caliber APFSDS ammunition.

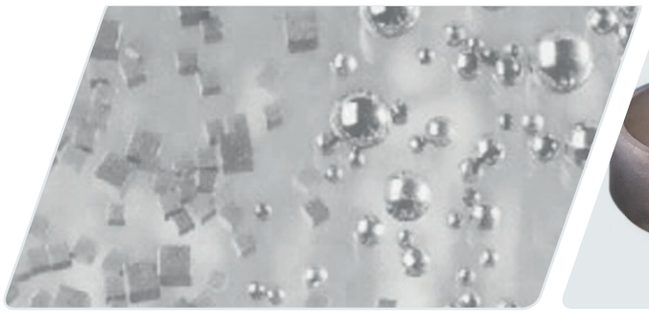
| Material | Density | Y 0.2<br>Yield STstrength<br>[MPa]<br>Av. / Min. | UTS<br>Tensile strength<br>[MPa]<br>Av. / Min. | A%<br>Elongation<br>[%]<br>Av. / Min. | K (5x5)<br>Charpy test<br>[J/cm²]<br>Av. / Min. |
|---|---|---|---|---|---|
| **Denal 917 108 XXX (1)** | 17.55 | 1280 / 1220 | 1315 / 1255 | 12 / 8.5 | 170 / 105 |
| **Denal 917 108 XXX (2)** | 17.55 | 1410 / 1350 | 1435 / 1375 | 11 / 7 | 150 / 70 |
| **Denal 917 108 XXX (3)** | 17.55 | 1510 / 1450 | 1525 / 1465 | 8 / 5 | 60 / 30 |

Material properties can be customized according to specific requirements

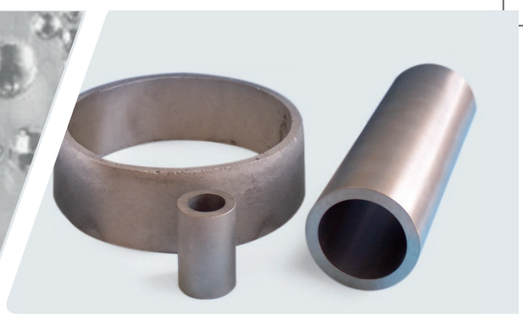
## Customized solutions

Our internal R&D team works continually on the improvement of products and processes. Several different alloys are currently adapted to customer requirements, implementing the best compromise between material properties and industrial efficiency. Following this path, R&D services developed customized solutions such as high UTS/high ductility in laboratory scale.

Our technological approach aims to satisfy our customers. Please contact us for any specific requirement.



Typical microstructure L a ~ 19 µm - C a/a ~ 18%



40 CTA penetrator

# Fragmentation

## Pellets

Plansee Tungsten Alloys has built up a wealth of experience in the production of pre-formed fragments. The dimensional and weight accuracy combined with very good crush test behaviour make our DENAL® materials widely used in many PFF (Pre-Formed Fragments) ammunitions, for example naval (i.e.: 40 and 76 mm), artillery (i.e.: 105 mm) and missile warheads.

| Material | Density | Y 0.2 Yield STstrength [MPa] min. | UTS Tensile strength [MPa] min. | A% Elongation [%] min. | AMS-T2014 ASTM B777 Class |
|---|---|---|---|---|---|
| **Denal DX1** | 17 | 650 | 850 | 18 | 1 |
| **Denal DX2** | 17.6 | 650 | 900 | 18 | 2 |
| **Denal DX3** | 18 | 700 | 900 | 12 | 3 |

Material properties can be customized according to specific requirements

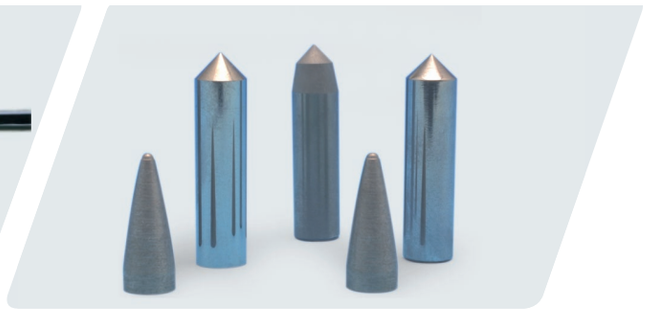
## Casing

In order to meet the ever more demanding ammunition and missile requirements, Plansee Tungsten Alloys developed new ma-te-rials with a very high level of ductility for fragmentation casing. The fragments are generated by dynamically loading a pattern of weakening lines. When the fragments hit the target the high level of the shock resistance of the material keeps fragment whole, thus increasing penetration efficiency.

## Typical material properties for casing

| Material | Density Av. | Y 0.2 Yield STstrength [MPa] Av. | UTS Tensile strength [MPa] Av. | A% Elongation [%] Av. | K Charpy test [J/cm²] Av. |
|---|---|---|---|---|---|
| **Denal 900-120-25** | 17.2 | 700 | 1000 | 35 | 300 |
| **Denal 920-120-25** | 17.6 | 720 | 1030 | 29 | 150 |

Material properties can be customized according to specific requirements

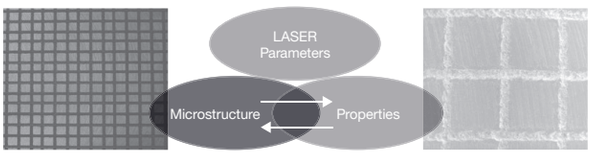
Tungsten carbide cores for AP ammunition

Typical dimensions which can be produced go from 20 mm to 150 mm outside diameter and from 16 mm to 130 mm internal diameter and up to 120 mm for the length.

### The pattern of fragmentation

The pattern of fragmentation is designed according to the customer need (dynamical breaking up).

The weakening lines can be made by machining or laser beam interaction.




# Tungsten carbide cores for small calibre ammunition

Plansee Tungsten Alloys is a center of excellence for Small AP (Armour Piercing) calibre and medium calibre cores made from tungsten carbide for 5.56 mm to 25 mm calibres.

### Typical characteristics

| Grade | | | | Characteristics | | |
|---|---|---|---|---|---|---|
| Tungsten carbide | Cobalt | Iron | Free carbon | Density | Hardness | Bend strength |
| 90% | 10% | max. 0.35% | max. 0.03% | 14.5 | 89 HRA | min. 17kN |

Material properties can be customized according to specific requirements

# Balancing weights for aeronautics

Due to their high densities DENSIMET® and INERMET® are particularly suitable for balancing rotating systems such as in propellers or helicopter blades, rudders, avionics, radar systems and targeting pods. Because of its non magnetic properties, INERMET® is especially used in avionics systems. Thanks to a blend of innovation, process monitoring and strict quality inspections our products meet the most demanding of requirements. Plansee balancing weights are qualified as FSP (Flight Safety parts) requiring approved and consistent production processes which fulfil the highest standards in terms of traceability and repeatability. Plansee Tungsten Alloys is rewarded with Aeronautic standard AS 9100.

### Product range and typical chemical composition of Densimet® and Inermet® standard alloys

| Material | Abbreviation | Chemical composition [%] | | Nominal density | ASM-T-21014 Class |
|---|---|---|---|---|---|
| | | W | Rest | | |
| **Weakly ferromagnetic** | | | | | |
| **DENSIMET® 170** | D170 | 90 | Ni, Fe | 17,0 | 1 |
| **DENSIMET® 176 / W** | D176 / DW | 92,5 | Ni, Fe | 17,6 | 2 |
| **DENSIMET® 180** | D180 | 95 | Ni, Fe | 18,0 | 3 |
| **DENSIMET® 185** | D185 | 97 | Ni, Fe | 18,5 | 4 |
| **Paramagnetic** | | | | | |
| **INERMET® 170** | IT170 | 90 | Ni,Cu | 17,0 | 1 |
| **INERMET® 176** | IT176 | 92,5 | Ni,Cu | 17,6 | 2 |

Material properties can be customized according to specific requirements

# Jet vanes and nozzles in tungsten copper

Plansee Tungsten Alloys produces Tungsten Copper infiltrated materials characterised by a low content of Copper impregnated in a pure tungsten skeleton. These grades are ideally suited for jet vanes and nozzles in missiles.

| Material | Chemical composition [%] | | Final density | Porosity |
|---|---|---|---|---|
| | Cu content (%) | W | | |
| **Cutene 108 WI** | > 7.5 | balance | > 17.0 | < 3.5 |
| **Cutene 109 WI** | > 8.4 | balance | > 16.9 | < 3.5 |

Material properties can be customized according to specific requirements
Typical dimensions go up to 400 x 400 x 100 mm

## Close to the customer – our global network

Plansee manufactures and markets its products worldwide. Production sites in Europe, USA, Japan, India, China, Korea and a global network of sales subsidiaries and sales partners, enable outstanding customer service and product quality delivered by local teams. Stronger than any alliance and more diversified than single producers, Plansee is the most reliable source for high performance components made of refractory metals.

For more information and local contacts please visit our website:

**www.plansee.com**