High-Strength Steels and Alloys for the Defense Industry

Enhancing your performance
Your fully integrated partner from melting to the finished part

Process flow

Selected raw materials

- HPS
- Melting
- NiSA

Remelting

- Conversion
  - HPS
  - NiSA
  - PM

- Rolling
- Open die or closed-die forging
- Hot Isostatic Pressing (HIP)

Heat treatment

Premachining

Non-destructive testing

- Machining to net shape

Bars & sheets

Forgings

Powders

HPS
High-Performance Steels:
A range of alloyed steels with tightly controlled characteristics offering optimum value for customers.

NiSA
Nickel-based Superalloys:
A range of alloyed materials with specific resistance to very high temperatures and corrosion, the majority component being nickel.

Ti
Titanium:
Pure or alloyed titanium, combining mechanical properties and corrosion-resistance with light weight.

Al
Aluminum:
Slightly alloyed aluminum, widely used in aircraft structural parts.

PM
Powder metallurgy:
HIP Net Shape parts & Metal Powders (steels, superalloys or titanium) for additive manufacturing.

www.aubertduval.com
Along history in Defense markets. Aubert & Duval has the capability to design, melt, manufacture and market metallurgical products with high mechanical properties in steels, superalloys, aluminum and titanium alloys. As a leading provider of forgings for gun barrels, Aubert & Duval has over 70 years of experience within this business segment and is proudly serving the military community both for new equipment and upgrades.

Qualified Products and Processes

Aubert & Duval is fulfilling the most stringent requirements for artillery applications.

With a long history in supplying materials to missile systems such as anti-ship, air to air, cruise, ground to air, air to ground, tactical and antitank missiles, our products meet the most stringent requirements for critical missile components. As a leading supplier of firearm steels, Aubert & Duval serves the weapon manufacturing sector through both button riffling and hammer forging processes.

<table>
<thead>
<tr>
<th>Form</th>
<th>Fabrication process</th>
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<tbody>
<tr>
<td>Thin tubes</td>
<td>Extruded</td>
</tr>
<tr>
<td>Heavy tubes</td>
<td>Forged / Hot rolled / Hollow forged</td>
</tr>
<tr>
<td>Sheet thickness &lt; 6 mm</td>
<td>Cold rolled</td>
</tr>
<tr>
<td>Plate thickness &gt; 6 mm</td>
<td>Hot rolled</td>
</tr>
<tr>
<td>Bars &lt; Ø 130 mm</td>
<td>Rolled / Forged</td>
</tr>
<tr>
<td>Bars Ø 130 to 200 mm</td>
<td>Forging machine</td>
</tr>
<tr>
<td>Bars &gt; Ø 200 mm</td>
<td>Forged</td>
</tr>
<tr>
<td>Forged parts</td>
<td>Open-die or closed-die forging</td>
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Armored vehicles 4 - 5
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Equipment

- **MELTING**
  Melting furnaces (EAF, AOD, Ladle refining process) up to 60 tons
  Vacuum Induction Melting (VIM) up to 20 tons
  Remelting furnaces (ESR, VAR) up to 30 tons

- **POWDER METALLURGY**
  Atomization (Air, VIM)

- **FORGING**
  Open-die forging presses from 1,500 to 10,000 tons
  Closed-die forging presses from 4,500 to 65,000 tons
  Forging machine

- **ROLLING MILL**
  7-200 mm diameter bars

- **HEAT TREATMENT**
  Solution and ageing furnaces
  Horizontal and vertical quenching equipment

- **TESTING**
  Immersion UT up to 13 tons (28,000 lbs)
  Automated contact UT up to 20 tons
  Material testing laboratories
  ISO 17025

Dedicated brochure for Navy on www.aubertduval.com
As a specialist in upscale metallurgy, Aubert & Duval operates several closed-die facilities, such as its 22,000 MT, 40,000 MT and 65,000 MT hydraulic presses. Closed-die forging is the process of forming complex-shaped parts from a metal semi-product between two engraved tools (dies) by pressing with a closed-die forging press.
Main materials

HPS
- A&D grade:
  - 819B 36NiCrMo16
  - GKH* 33CrMoV12.9
  - NC35MW 35NiCrMoV 14-4
  - NC35M1 39NiCrMoV 15-6
  - CLARM®HBR 30NiCrMoV 14
  - CLARM®HB3 33NiCrMoV 15
  - CLARM® 40NiCrMoV 15
  - HB7 40NiCrMoV 15
  - J-Steel 32NiCrMoV 14-4
  - GK4W 40CrMoV 13-9

Aluminum Alloys
- Aluminum:
  - 2000
  - 5000
  - 7000

Titanium Alloys
- Titanium:
  - T40
  - Ti64

Artillery parts
- Hatch Cover: forging part for protective equipment for armoured vehicle
- Turret shield: Forging Turret Mantlet for protective equipment Main Battle tank (MBT)
- Gun barrels
  (More pages 6-7)
- Breech ring
Choose the best designed grade for your application

Heavy and medium gun barrels

Heavy gun barrels

Corresponding data sheets are available on request.
ubert & Duval meets the defense industry’s material requirements for artillery forgings, drawing on extensive, worldwide experience in artillery systems.

The CLARM® steel grades are the most advanced steels for large calibers gun barrels: CLARM®HBR, CLARM®HB3, and CLARM®HB7 steel grades meet all the critical metallurgical requests of the most advanced arm systems. CLARM family steel grades provide to artillery components manufacturers a wide range of mechanical properties with yield strengths from 1000 to 1400 MPa, combined with exceptional level of toughness (Charpy Energy values or K1c).

- Field towed guns: 105 - 122 - 155 mm
- Tank guns: 60 - 90 - 100 - 105 - 120 - 125 - 140 mm
- Self-propelled howitzers: 105 - 120 - 155 mm
- Naval guns: 40 - 57 - 76 - 127 - 155 mm
- Mortars: 60 - 81 - 120 - 160 mm
- Breech rings, breech blocks and muzzle brakes

![Graph](image)

Open-die and rotary forgings
Final product format can be: blooms, round bars, square bars, plates, disks, mandrels, blocks, shafts, flanges, tubes or hollow forgings, etc.
High Performance Steels

Main materials for mechanisms

**HPS**

- FADH 14NICRMO13-4
- FDG 20NICRMO13-4
- FND 15NIMOSICR10
- FDMA 30NICRMO16
- 819B 36NICRMO16
- 819AW E35NICRMO16
- MARVAL18 X2NICOMO18-8-5

**Gun barrels**

Aubert & Duval offers for this application three martensitic grades achieving the best high strength / toughness compromise on the market: ARMAD®, GKH® (CrMoV martensitic grades), and APX4 (martensitic stainless grade). For barrels submitted to a transverse load during firing, a specific care has been placed on transverse properties of bars. Aubert & Duval grades (ARMAD®, GKH® and APX4) present a highly isotropic structure given to the material stable properties when longitudinal and transverse directions are compared. (see photos below)

**Mechanism parts**

For firing pins, extractors, ejectors, breeches...

All main parts in gun mechanisms are submitted to shock, intensive wear and are expected to exhibit the highest fatigue performances possible.
ubert & Duval keeps innovating best steel solutions dedicated to Army and Law Enforcement safeguarding.

Our R&D guide lines remain:
- Best safety even in worst usage condition
- Highest accuracy during intensive shooting
- Best operational performance

<table>
<thead>
<tr>
<th></th>
<th>APX4</th>
<th>GKH*</th>
<th>ARMAD*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Martensitic stainless</td>
<td>Martensitic CrMoV</td>
<td>Martensitic CrMoV</td>
</tr>
<tr>
<td>EN designation</td>
<td>X4CrNiMo16-5-1</td>
<td>33CrMoV12-2</td>
<td>32CrMoV12-10</td>
</tr>
<tr>
<td>HRC as delivered</td>
<td>28/34</td>
<td>28/34</td>
<td>28/34</td>
</tr>
<tr>
<td>HRC after final hardening</td>
<td>38/42</td>
<td>38/42</td>
<td>38/46</td>
</tr>
<tr>
<td>UTS (MPa)</td>
<td>900/1050</td>
<td>930/1080</td>
<td>1200/1250</td>
</tr>
<tr>
<td>YS 0.3 (MPa)</td>
<td>≥ 700</td>
<td>≥ 750</td>
<td>&gt; 950</td>
</tr>
<tr>
<td>ASd (%)</td>
<td>≥ 16</td>
<td>≥ 15</td>
<td>&gt; 16</td>
</tr>
<tr>
<td>KV (RT)</td>
<td>≥ 120</td>
<td>≥ 140</td>
<td>&gt; 160</td>
</tr>
<tr>
<td>KV (hgfh)</td>
<td>≥ 90</td>
<td>≥ 130</td>
<td>&gt; 130</td>
</tr>
</tbody>
</table>

Benefits for firearm Producer/designer
- Uses higher deformation yields of cold hammering and preserve more material compared with other grades
- Saves production costs by cold hammering both chamber and gun barrel limiting misalignment between chamber and gun barrel.
- Uses fatigue/strength upgrading opportunities of GKH® and ARMAD® to design lighter barrels.
- Ensures stable process and limit troubles during manufacturing
- Ensures perfect straightness during the cold hammering / swaging operation
- Core properties not impacted by nitriding/ nitrocarburizing
- Exceptional safety margin regarding torture tests

Benefits for firearm user
- Keeps perfect straightness during intensive firing and retains accuracy and safety
- Has longer fatigue lifetime, limiting bore ovalization, which causes a lack of accuracy
- Uses a lighter weapon

Customer benefits directly coming from our metallurgical expertise

Services & Capabilities
- In house fully integrated production process
- NADCAP Heat Treatment
- Approved by major NATO gun manufacturers
- Logistics service provider
- Dedicated products for all manufacturing processes: drilling, machining, cold forming (hammer forging, swaging)
- ISO 9001, EN 9100, ISO 14001
- Full Authorized Economic Operator (AEO)
A long history in missile materials. Aubert & Duval has a long history in supplying material to missile systems such as:

- Ballistic
  - Cruise missile
  - Anti-ship
  - Anti-tank
- Surface-to-air
  - Anti-aircraft
  - Anti-ballistic
- Air-to-air

**Applications**

- Pinions and gears for transmissions
  - FAD/FADH
  - V300
  - GKH/GK3
  - 819B
  - V300
- Torsion Bars
  - LXM5
- Energy recovery systems
  - F66S
  - F65
  - GK3
  - NC25M

**Applications Grades EN designation**

- FAD/FADH 16NiCrMo13
- F65 34CrMo4
- GK3 30CrMo12
- NC25M 28NiCrMo11

**Materials**

- Rolled & forged bars
- Pinions and gears for transmissions
- Torsion Bars
- Energy recovery systems

**UTS (MPa)**

- TA6V 500
- 819B 819AW 1400 819B 1700 819AW 1800 4340 1900 300M 2150

**Superalloys**

- NiSA NICKEL-BASED SUPERALLOYS
- HPS HIGH PERFORMANCE STEELS
- ALUMINUM

**Warhead Casing**

- MARVAL18 (MARAGING 250)
- X15U5W (15-5PH)
- MARVAL X12
- MARVAL13X
- MARVALX12H
- SCV APX4-MARVALX12
- X17U4, X15U5W

**Aluminum Alloys**

- 500 1000 1400 1700 1800 1900 300M 4340 2150

**Surface-to-air**

- • Cruise missile
- • Anti-ship
- • Anti-ballistic

**Air-to-air**

- • Anti-aircraft
- • Anti-ballistic

**Ballistic**

- • Cruise missile
- • Anti-ship
- • Anti-tank

**Warhead Casing**

- 819B / 819AW (36NiCrMo16)
ubert & Duval meets the most stringent requirements in terms of grade composition, micro-structural material integrity, dimensional tolerances and quality control. All our products comply with ASTM standards.

Structures & engines

- Engine pylon parts
- Wing box parts
- Main fittings
- Transmission box parts
- LPT disks
- Turbine shafts
- Rotor parts

Powder metallurgy

Additive Manufacturing and HIP parts

<table>
<thead>
<tr>
<th>Ni-Base</th>
<th>Ni 625, Ni 718, HX</th>
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<tbody>
<tr>
<td>Co-Base</td>
<td>CoCr</td>
</tr>
<tr>
<td>Ti-Base</td>
<td>Ti6Al4V, Ti6Al4V ELI</td>
</tr>
<tr>
<td>Steels</td>
<td>316L, 17-4PH, ASP®, etc...</td>
</tr>
</tbody>
</table>
The information and the data presented herein are typical or average values and are not a guarantee of maximum or minimum values. Applications specifically suggested for material described herein are made solely for the purpose of illustration to enable the reader to make his own evaluation and are not intended as warranties, either express or implied, of fitness for these or other purposes. Aubert & Duval’s liability shall not extend, under any circumstances, to the choice of the Product and its consequences.