165 kg of long steel ...

... power your vehicle.
ArcelorMittal Europe produces bars and rods in Duisburg, Gandrange, Hamburg, Sonasid, Sosnowiec, Veriña, Warzawa and Zenica.

This process flow shows the four units dedicated to the production of bars for Automotive market.

We find their steel in the powertrain (engine, transmission), the chassis (steering, suspension), in safety and comfort parts.
ArcelorMittal Duisburg

The wire rod mill offers products on a high-end quality spectrum. The bars & billet mill offers range of products up to 200 mm² or Ø 170 for rerolling or for forging. This is particularly adapted to truck market or off-road vehicles.

Final applications

- Cold heading qualities:
  - steel for cold extrusion, fasteners
- Heat treatable steel grades:
  - components of common rail systems
- Carbon grade: offshore, pre-stressed steel
- Alloyed spring steel: Valve springs, clutch springs
  - tension/compression and axle springs
- Free-cutting steel
  - special shape turned parts
  - shafts and hydraulic systems
- Bainitic steel
  - front axle beams, steering levers & knuckle parts
  - heavy duty: crankshafts

Facilities

- Steel plant:
  Two oxygen converters (TBM process)
  Ladle furnace
  Steel ladle vacuum treatment: circulation degasser (RH) and tank degasser (VD), as per metallurgical need
  Steel conditioning (Argon & Nitrogen stirring)
  1 billet caster
  1 bloom caster with Soft Reduction
- Bar & Billet mill:
  Reversing breakdown and finishing stand
- Inspection and finishing line for bars & billets:
  Conditioning with ultrasonic and surface testing (Therm O’ Matic)
  Annealing devices (up to 9 m length): soft annealing, normalising
  Dimension control
  Surface grinding (including robot)
- Wire rod rolling mill:
  High speed single-strand 28 stands including pre-block
  Thermo-mechanical rolling incl. loop
  104 m long stelmor line
- Wire rod processing (annealing, pickling, phosphating) upon request

Strengths

- Production of crude steel with lowest C content (< 100 ppm) and a defined alloy concentration.
- Refining of metal charges in 150 t converters due to a specific model calculation incl. management of lance status, oxygen flow rate and alloys.
- Ladle metallurgical centre for precise alloying, reduction of solute gases, desulphurisation and adjustment of melting temperature.
- Bloom and billet casters with re-oxidation prevention, mould stirring, MSR.
- Square blooms
- Most modern layout and equipment on a new wire rod mill like thermo-mechanical rolling and special cooling devices for a fine-grained structure.
- Special customer requirements upon request.

Finished products

- Wire rod (mm): 5.5 to 25 (steps of 0.5 mm)
  - Coil length (mm) (max.): 2300
  - Coil weight (t) (max.): 3
    1.5t; 2t; 2.5t upon request

- Bars (mm):
  - 63² to 200² (round corner square)
  - 100 to 170
  - Length: 5-16 meters (3-5 m upon request)
  - Strapping: 6 steel bands
  - Labelling: content upon request
  - Bundle weight (t) (max.): 10
ArcelorMittal Warszawa

Mini-mill with a strong position in mechanical engineering and automotive markets.

Warszawa offers heat-treated bars and peeled bars.

Final applications

- Case hardening steels
  Parts such as camshafts, gearbox shafts, engine parts
- Heat treatable steel grades
  Components of steering system, braking system, axle hubs, front axles
- Cold heading qualities
  Steel for cold extrusion, fasteners, screws, ball pins
- Carbon and micro-alloyed steel grades
  Hot forging / stamping – flanges, conrods
  Cold forming
- Carbon and alloyed spring steel
  Tension/compression and axle springs
- Bearing steel
  Bearing rings, hub bearings

Facilities

- Steel plant:
  Electric arc furnace with eccentric bottom tapping
  Ladle furnace
  Vacuum degassing
  4 strand billet caster
- Bar & Billet mill:
  18 stands in continuous system roll line
- Inspection and finishing line:
  Straightening machines
  Milling and chamfering devices
  Surface control (Circograph, Circoflux)
  Ultrasonic control device
  Antimixing control - spectrotect devices, packaging, marking
- Bar processing:
  Heat treatment: softening, normalising, isothermal, annealing
  Spheroidising, stress relieving treatments, quenching and tempering (Q+T)
  Peeling

Strengths

- Production of wide range of steel grades
- Flexibility of mini-mill
- Steel with controlled/regulated sulphur content
- Micro alloys steel with Nb, V, B
- Steel with “restricted hardenability”
  (2/3 of band, 1/3 of band, controlled narrow Jominy band)
- Full downstream capability: heat treatment and peeling on bars

Finished products

- Bars (mm): 20 - 80
- Length (m): 3.5 - 12
- Strapping: min. 3 steel bands
- Labelling: customer specifications (min. 2)
- Bundle weight (t) (max.): 10
ArcelorMittal Gandrange

Strongly positioned in the field of bars and rods in coils products

Products for Automotive, Energy and Mechanical Engineering markets (forging, cold heading, bright drawing...).

Final applications
- Carbon and micro-alloyed steel grades
  - Hot forging / stamping
  - Cold forming
- Cold heading qualities
  - Steel for cold extrusion; fasteners
- Free-cutting steel girdes
  - Special shape turned parts
  - Shafts and hydraulic systems
- Heat treatable steel grades
  - Components of Common Rail systems
- Carbon and alloyed spring steel
  - Tension/ compression and axle springs, torsion bars

Facilities
- Bar & Wire rod rolling mill:
  - Furnace with tight temperature control
  - Sizing block
  - On-line dimensional control
  - On-line surface control
  - Garrett coiling for wire rod
- Inspection and finishing line for bars:
  - Multi-roll straightener
  - Sawing and chamfering devices (45° or 60° from 0.2 up to 4mm)
  - Surface control (Circoflux)
  - Ultrasonic control device
- Bar processing upon request:
  - Peeling
- Wire rod processing (annealing, pickling, phosphating) upon request

Strengths
- Possibility to source steel from both BOF and EAF routes
- A wide range of grades and dimensions on Bars and Wire Rods
- State of the art Sizing Block and Bar Conditioning
- Mini-mill flexibility in order to meet customer needs
- Tolerances according EN10060 A to P, tighter tolerances upon request

Finished products
- Wire rod (mm):
  - 15 - 52 (steps of 0.1 mm)
  - 14.3 - 42.5 (hexagons)
- Bars (mm):
  - 15 - 103 (steps of 0.1 mm)
  - 14.3 - 70.4 (hexagons)
- Coil length (mm) (max.): 1500
- Standard coil weight (t) (max.): 2.5
- other coil weights available upon request.
- Length (m): 5 - 16
- Strapping: 4 - 8 steel bands
- Labelling: 2 per bundle
- Bundle weight (t) (max.): 1.5 - 8
ArcelorMittal Revigny

Main French Bars supplier for bright drawn, peeled and grinded bars for Automotive and Mechanical Engineering markets.

Final applications

- Steels for general engineering
  - head rest support – stabiliser bar – green good applications
- Free-cutting steels
  - components for camshaft – injector pieces
  - temperature sensors
  - ABS parts – hydraulic couplings
- Case hardening steels
  - Air conditioning parts
- Steels for quenching and tempering
  - components for shock absorber struts – gearbox fork

Strengths

- Production of wide range of diameters
- Tight quality control
- Various upstream supply routes – wide range of product choice
- High supply flexibility due to tight relation with the rolling mills of ArcelorMittal Duisburg & Gandrange
- 2 Service Centres in France & Germany

Facilities

- Cold drawing
- Peeling
- Grinding
- Inspection
  - Eddy current control (Circograph – Defectomat)
  - Ultra-sonic testing

Finished products

- Bright bars (mm): 5 - 80 (special shape on request)  
  5.5 - 75 (hexagons)
- Peeled bars (mm): 20 - 100
- Grinded bars (mm): 6 - 50

- Length (m): 3 - 8
- Strapping: 3 - 6 steel bands
- Labelling: 1 – 2 per bundle

Bundle weight (t) (max.): 2
### Improved Machinability Steels

Improved Machinability Steel grades have small amounts of additional alloying elements to improve machinability. Alloying elements are added during secondary steelmaking specifically to modify the steel inclusion population. Some elements form controlled inclusions to promote chip formation and break-up during subsequent machining, while others melt locally at the tool / work piece interface acting as a lubricant and reducing tool wear. Possible additions include Sulphur, Lead, Tellurium, Bismuth and Selenium.

#### Specifications

<table>
<thead>
<tr>
<th>Grade designation</th>
<th>Duisburg (as rolled)</th>
<th>Gandrange (as rolled or peeled)</th>
<th>Warsaw (as rolled, peeled or heat-treated)</th>
<th>Revigny (as drawn or peeled)</th>
<th>Comments</th>
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### Quenched and Tempered Steels Alloysed Steels

Quenched and Tempered Steel grades have greater hardenability than structural carbon steels Q&T C22, C60. The grades contain specific amounts of alloying elements to favour transformation of austenite into martensite during the quenching process. After forging, the work piece is quenched in water, polymer or oil to increase the hardness even in thick sections (through-hardening). The tempering process allows to obtain the best compromise between strength, ductility and toughness.

#### Specifications

<table>
<thead>
<tr>
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<th>Revigny (as drawn or peeled)</th>
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</table>
Product offer (non-exhaustive)

### Bainitic Steels

Bainitic Steels are designed for applications requiring a good compromise between Tensile Strength and Ductility, and offer the added benefit of eliminating the final Quench and Tempering process usually performed to achieve high properties. Controlled cooling after forging steers the Austenite transformation into the Bainitic region. The fine tuning of alloying elements will enable to reach the desired level of strength, taking into account the customer process and the size of the part.

<table>
<thead>
<tr>
<th>Grade designation</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Revigny</th>
<th>Comments</th>
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<tbody>
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<td>SOLAM® B1100</td>
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<td>UTS &gt; 1100 MPa - Truck Axle Beam, Steering Knuckle, Steering Arm</td>
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<td>SOLAM® B1150 IH</td>
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<td>UTS &gt; 1150 MPa - Crankshaft (Induction Hardened)</td>
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<td>SOLAM® B1200</td>
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<td>UTS &gt; 1200 MPa Common rail, Axle Beam, Steering Lever</td>
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<td>UTS &gt; 1200 MPa - Injectors, Injection Nozzles</td>
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</table>

### Cold Heading Steels / Cold Forging Steels

These steels are designed to fulfill the most demanding customer specifications. So, the formability, ductility and strength required for producing by cold deformation the most complex parts is offered by a wide range of low carbon, alloyed, micro-alloyed and boron grades produced according to international standards. Closely controlled manufacturing practices ensure their good internal soundness and their defect-free surface. For specific grades for cold heading, a close control of the chemical composition and post-rolling cooling allow the achievement of requested mechanical properties of the parts even by cold heading without final heat treatment. Finishing on bars are proposed: annealing, spheroidising and peeling.

<table>
<thead>
<tr>
<th>Grade designation</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Revigny</th>
<th>Comments</th>
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<tr>
<td>FREEFORM® Dual 800</td>
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<td>UTS 1000-1200 Mpa - Wheel Spindle, Ball Joint, Fastener</td>
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<td>Screw</td>
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- ● Industrial in all dimensions
- ○ In development (part trial or produced)
- □ In-house development

* Sulphur levels on request
Product offer (non-exhaustive)

Spring Steels

Spring Steels are Medium or High Carbon Steels with very high Yield Strength. This property allows the part formed with these grades to return to their original shape after significant bending or twisting. The principal alloying elements to achieve the high yield strength are Silicon and Manganese. For the very demanding applications, the grades are processed with high cleanliness level; hence, a very good fatigue behaviour.

Specifications

<table>
<thead>
<tr>
<th>Grade designation</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Revigny</th>
<th>Comments</th>
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<td>●</td>
<td></td>
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</tr>
<tr>
<td>52SiCrNi5</td>
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<tr>
<td>51Cr7</td>
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<tr>
<td>54SiCr6</td>
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<td>54SiCrV6</td>
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<tr>
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<td>●</td>
<td>●</td>
<td></td>
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</tr>
<tr>
<td>60SiCr8</td>
<td>●</td>
<td>●</td>
<td>●</td>
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</tr>
</tbody>
</table>

Case Hardening Steels

Case Hardening Steels are used for parts requiring high surface wear resistance but retaining a soft core that absorbs stresses without cracking. After forging, the outer layer is carburised (diffusion of carbon) and/or carbo-nitrided and then locally hardened by quenching. The grades are Low-Carbon steels with addition of suitable alloying elements. These additions typically include Chrome and Manganese, but also Nickel and Molybdenum can be involved to increase the through-hardening for larger cross-sections. A special characteristic of this kind of grade is the Jominy curve, which needs to be well controlled.

Specifications

<table>
<thead>
<tr>
<th>Grade designation*</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Revigny</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>20Mn5</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<tr>
<td>16MnCr5</td>
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<td>16MnCr5S5Pb</td>
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<tr>
<td>25MoCr4</td>
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<tr>
<td>17Cr3</td>
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<td>15CrNi6</td>
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<td>16CrNi4</td>
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<td>14NiCr14</td>
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<td>18NiCrMo6</td>
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<td>14NiCrMo13</td>
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<td>17CrNiMo6</td>
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<td>●</td>
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</tr>
</tbody>
</table>

These grades are usually adapted for Axles / Shafts / Pinions / Gears

The Bars can be delivered with special annealing treatments on request
# Product offer (non-exhaustive)

## Micro-Alloyed Steels

Micro-Alloyed Steel grades allow to produce parts with higher strength obtained as forged. Typical additions include Niobium, Vanadium and Titanium. These additions increase yield strength by precipitation hardening, and also offer finer grain structures. These 2 effects increase the strength of the forged parts compared to conventional Carbon steels.

<table>
<thead>
<tr>
<th>Grade designation*</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10MnV6</td>
<td>•</td>
<td>•</td>
<td>•</td>
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<tr>
<td>17MnV5</td>
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<td>22MnV6</td>
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<td></td>
</tr>
<tr>
<td>27MnSiV6</td>
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<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>30MnSiV6</td>
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<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>49MnV3</td>
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<td>•</td>
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<td></td>
</tr>
<tr>
<td>38MnSiV5–6</td>
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<td>•</td>
<td>•</td>
<td>UTS &gt; 850 MPa - Crankshaft, Pistons</td>
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<tr>
<td>44MnSiV6</td>
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<td>•</td>
<td>•</td>
<td>UTS &gt; 900 MPa - Rocker Arms</td>
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<tr>
<td>C70S6</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>UTS &gt; 900 MPa - Splittable Connecting Rod</td>
</tr>
</tbody>
</table>

Micro-Alloyed Steels allow to produce parts with higher strength obtained as forged. Typical additions include Niobium, Vanadium and Titanium. These additions increase yield strength by precipitation hardening, and also offer finer grain structures. These 2 effects increase the strength of the forged parts compared to conventional Carbon steels.

## Bearing Steels

Bearing Steels are High-Carbon grades with very high mechanical properties achieved by quench and tempering combined with a very high wear resistance. Depending on the type of applications, different levels of cleanliness will be required to avoid inclusions that initiate fatigue during rolling contact.

<table>
<thead>
<tr>
<th>Grade designation*</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Revigny</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>100Cr6</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Mechanical Application / Tooling</td>
</tr>
<tr>
<td>100Cr7</td>
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<td>•</td>
<td>•</td>
<td>Bearing Ring</td>
</tr>
<tr>
<td>100CrMo6</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Bearing Ring</td>
</tr>
<tr>
<td>100CrMo7</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Bearing Ring</td>
</tr>
<tr>
<td>C56E2</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Hub bearing</td>
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<tr>
<td>C70</td>
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<td>•</td>
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<td>Hub bearing</td>
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</tbody>
</table>

Bearing Steels are High-Carbon grades with very high mechanical properties achieved by quench and tempering combined with a very high wear resistance. Depending on the type of applications, different levels of cleanliness will be required to avoid inclusions that initiate fatigue during rolling contact.

## Carbon Steels

Carbon Steel grades are the combination of 3 families: Low, Medium and High Carbon. Low Carbon steels: Carbon range between 0.1 to 0.25%. One of the most common type of steels used for general purposes and are inherently easier to cold-form and handle (draw, bend, etc.) due to their soft and ductile nature.

Medium Carbon steels: approximately 0.30 to 0.59% Carbon content. Can be heat treated to have a good balance of ductility and strength. These steels are typically used in large parts, forgings, machined and automotive.

High Carbon steels: above 0.60% of Carbon content. High Tensile and Yield strengths. Used for applications in which high strength, hardness and wear resistance are necessary, such as wear parts, gear wheels, chains, brackets.

<table>
<thead>
<tr>
<th>Grade designation*</th>
<th>Duisburg</th>
<th>Gandrange</th>
<th>Warsaw</th>
<th>Revigny</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>C10 to C25</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>Camshaft, Injectors, Joint Casing</td>
</tr>
<tr>
<td>C30 to C60</td>
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<td>•</td>
<td>•</td>
<td>•</td>
<td>Drive shafts, Tripod Tulp</td>
</tr>
<tr>
<td>C68 to C92</td>
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<td>•</td>
<td>•</td>
<td>•</td>
<td>* * Sulphur levels on request</td>
</tr>
</tbody>
</table>

* Industrial in all dimensions
* In development (part trial or produced)
* In-house development
Product & process development

Global R&D
Over 1,400 full-time researchers in 12 Labs, spending in 2017 amounting to $278 million of which 33% is dedicated to Auto.

Missions
- Pro-active approach of future needs in automotive industry
- Innovative solutions taking advantage of Flat & Long synergies
- Development of products, steel solutions and processes from their pre-design phase through their implementation and lifetime at our customers and at our plants
- Assistance to plants for complex technical issues

Activities
- Broad, comprehensive portfolios and programmes addressing business needs
- Expanding Worldwide network of research sites in Europe & America
- Partnerships with focused engineering schools & universities research sites

4 steps to go from customer needs to industrialisation

Listen to customers
- Market & customer needs & expectations OEM, tier 1, tier 2
- Define final steel properties

Solution conception
- Define chemistry & process
- Data base, know how, modelling...
- => Customer contact

Solution validation
- Cast, roll or forge laboratory ingots
- Small scale trials
  - Trials with customer (partnership)
- Laboratory investigations
- Fine-tuning of chemistry & process
  - => Customer contact

Industrialisation
- Industrial heat
- Product homologation
- Serial production

ArcelorMittal’s product development approach is based on long term co-development agreements. From Global Research & Development Centres at group level to European plants, our experts are committed to invent new steel products and to improve steel processing and engineering. Our research and development teams provide also support to our customers to establish a sound knowledge on the key expectations from our products, such as cleanliness, structure homogeneity, mechanical characteristics, machinability, corrosion resistance, etc.

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