TRIMET Aluminium SE

Aluminium wires for **electrical** and **mechanical** applications

trimet
TRIMET Aluminium SE – an independent family-run enterprise for more than 30 years

TRIMET Aluminium SE is an innovative family-run enterprise. The medium-sized company develops, produces, recycles, casts, and sells modern light metal aluminium products with some 2,900 employees at eight production locations.

TRIMET serves and supplies the entire industry-oriented value chain for the aluminium sector with customized products from a single source. With four production plants, two recycling plants, four foundries, a marketing and trading division, and state-of-the-art research and development laboratories, TRIMET offers its customers a broad product portfolio. It ranges from liquid aluminium through aluminium wire, rolling ingots, extrusion billets, and cast alloys to high-quality die-cast components. The medium-sized company is a reliable partner to its customers and a modern and dependable employer for its staff.

We provide you with aluminium in all formats, qualities and alloys. Short- and long-term price and supply models to meet all your aluminium requirements. We are your local partner in a global marketplace – around the clock.

We produce special alloys in our smelters exclusively for you according to your requirements and not commodities.

We recycle your aluminium to be able to offer it back to you in the sizes and qualities you require. We help you bring your recyclables efficiently back into circulation.

We cast sophisticated castings for all applications. From the development, design, model and mould, casting, and finishing right through to the finished casting.

We research and develop new speciality alloys for you, to make your products even better.
TRIMET offers high-quality aluminium wire varieties from in-house production. We always work in accordance with your specifications and requirements regarding the alloy, cross-section, and processing technique.

Delivered on time

Together, the TRIMET plants in Saint-Jean-de-Maurienne and Castelsarrasin supply products predominantly to the energy and automotive industries. These use aluminium wire for various applications, including electrical cables and connecting components. Here as well, TRIMET’s basic principle applies: You tell us what delivery form you require for further processing, and we will ensure that your order arrives in the right format and at the specified time. So we have an extensive range for a customized production with enhanced quality focus, thanks to innovative process control equipment.

TRIMET guarantees aluminium wire
> in reliable top quality
> in variable diameters and cross-sections
> as special alloys developed to suit customer specifications

Saint-Jean-de-Maurienne:
> 180 electrolytic furnaces in 2 production halls
> 9 casting furnaces (each 20–25 t), gas-heated
> 145,000 metric tons of primary aluminium produced annually
> 145,000 metric tons of cast products produced annually
> 430 employees
> Aluminium wire, Rolling and Remelting ingots

Castelsarrasin:
> 1 wire casting plant
> Various packaging, processing, and packaging plants
> 10,000 metric tons of cast products produced annually
> 35 employees
> Aluminium wire

We produce customized aluminium wires for electronic and mechanical applications
ELECTRICAL
Redraw Rod – Continuously Cast and Rolled

Electrical engineering

One of the areas in which TRIMET CCR (Continuously Cast and Rolled) rod is really in its element is electricity. For many years, it has been chosen now by the major cable makers worldwide.

The fields of application for CCR rod are virtually unlimited. They include insulated cables for low and medium voltage distribution networks, conductors for overhead lines, flexible cables for robotics, welding and railway engineering, cables using nickel-plated wire for aeronautical engineering, enameled wire for windings, etc.

Registered brands

<table>
<thead>
<tr>
<th>Family</th>
<th>Alloy</th>
<th>Temper</th>
<th>UTS</th>
<th>IACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>131050</td>
<td>H22, H24, H26</td>
<td>120-160</td>
<td>58.0-60.1</td>
</tr>
<tr>
<td>Al</td>
<td>137050</td>
<td>R6, R8, R10, R11, R12, O, H11, H12, H13, H14</td>
<td>60-130</td>
<td>62.3-61.5</td>
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<tr>
<td>Al</td>
<td>137072</td>
<td>R11</td>
<td>120</td>
<td>35.0</td>
</tr>
<tr>
<td>AlMgSi</td>
<td>610145</td>
<td>F, TS</td>
<td>150-175**</td>
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<tr>
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<td>F, TS</td>
<td>155-195**</td>
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<tr>
<td>AlMgSi</td>
<td>610166</td>
<td>F, TS</td>
<td>170-205**</td>
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</tr>
</tbody>
</table>

** 10 days after quenching (redraw rod)
MECHANICAL
Redraw Rod – Continuously Cast and Rolled
An incomparable range for mechanical engineering

The expertise acquired in TRIMET CCR (Continuously Cast and Rolled) rod based on a substantial program of research and development has resulted in the creation of an outstanding range of aluminium alloys geared to mechanical engineering applications.

From rivets, superfine wire, bolts, screws or forging part, TRIMET CCR redraw rod matches a wide variety of requirements.

Registered brands

Size (Examples)

<table>
<thead>
<tr>
<th>Family</th>
<th>Alloy</th>
<th>Temper</th>
<th>UTS</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1080</td>
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<td>1099</td>
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<tr>
<td>AlCu</td>
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<tr>
<td>AlCu</td>
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<tr>
<td>AlMnFe</td>
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<tr>
<td>AlMg</td>
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<tr>
<td>AlMg</td>
<td>5019</td>
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<tr>
<td>AlMgSi</td>
<td>6101</td>
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</table>

** Registered brands

** 10 days after quenching
WELDING
Redraw Rod – Continuously Cast and Rolled
An incomparable range for welding engineering

The expertise acquired by TRIMET in CCR (Continuously Cast and Rolled) rod based on a substantial program of research and development have gone into the creation of an incomparable range of aluminium alloys geared to welding and brazing applications.

Registered brands

Size

Ø 9.5 mm

<table>
<thead>
<tr>
<th>Family</th>
<th>Alloy</th>
<th>Temper</th>
<th>UTS</th>
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<tr>
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<td>4043A</td>
<td>O, H19</td>
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<tr>
<td>AlSi</td>
<td>4047</td>
<td>4047A</td>
<td>O, H18</td>
</tr>
<tr>
<td>AlMg</td>
<td>5183</td>
<td></td>
<td>O, H18, H19</td>
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<tr>
<td>AlMg</td>
<td>5356</td>
<td></td>
<td>O, H19</td>
</tr>
<tr>
<td>Code</td>
<td>Description</td>
<td></td>
<td></td>
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<tr>
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<tr>
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<tr>
<td>1099</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
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<tr>
<td>2011</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
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<tr>
<td>2017</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
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<tr>
<td>2024</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
<td></td>
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</tr>
<tr>
<td>3103</td>
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<td></td>
</tr>
<tr>
<td>4043</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4043A</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4047</td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4047A</td>
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<td></td>
</tr>
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<tr>
<td>5019</td>
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<td>Redraw Rod – Continuously Cast and Rolled</td>
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<td>610145</td>
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<tr>
<td><strong>ELECTRICAL</strong></td>
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<tr>
<td><strong>MECHANICAL</strong></td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
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<tr>
<td><strong>WELDING</strong></td>
<td>Redraw Rod – Continuously Cast and Rolled</td>
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<td></td>
</tr>
</tbody>
</table>
1080 | 1090 | 1099
Redraw Rod – Continuously Cast and Rolled
Metallurgical aspects of the wiredrawing process.
Work-hardening curves.

Heat treatments:
> Full annealing: 350°C during 3 hours.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E_{50} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1080 H18</td>
<td>160</td>
<td>4</td>
</tr>
<tr>
<td>1090 H18</td>
<td>140</td>
<td>2</td>
</tr>
</tbody>
</table>

Applications
Mainly for metallizing, aluminium capacitor connections, electronics.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>TI</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1080</td>
<td>0.15</td>
<td>0.15</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
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<tr>
<td>1090</td>
<td>0.007</td>
<td>0.07</td>
<td>0.02</td>
<td>0.01</td>
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</tr>
<tr>
<td>1099</td>
<td>0.006</td>
<td>0.006</td>
<td>0.002</td>
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<td>0.004</td>
<td>0.006</td>
<td>0.002</td>
<td>0.002</td>
<td></td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications. Other alloys are also available upon request (ex. 1098, 1188).

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: 1080 type R6 to R12 (see 1370), 1090, 1199 F Temper.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E_{50} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1080 R8</td>
<td>80-95</td>
<td>60-80</td>
<td>15-30</td>
</tr>
<tr>
<td>1199 F</td>
<td>65-90</td>
<td>60-80</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
See technical brochure “137050 Conductal®” part “drawing”.

Applications
Mainly for metallizing, aluminium capacitor connections, electronics.

Pure aluminum wires with different impurity levels – in general less than 1%. Related to their different grades of “cleanliness” they offer an excellent electrical conductivity of up to 63 ICAS. Due to its lowest strength level within all aluminum alloy groups they show very good workability characteristics, including a high corrosion resistance and good weldability.

Material condition (2 tons coils):
For each application, TRIMET can propose composition according customer’s specifications. Other alloys are also available upon request (ex. 1098, 1188).

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E_{50} (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1080 H18</td>
<td>160</td>
<td>4</td>
</tr>
<tr>
<td>1090 H18</td>
<td>140</td>
<td>2</td>
</tr>
</tbody>
</table>

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TRIMET France • Rue Henri Sainte Claire Deville • F-73300 Saint-Jean-de-Maurienne
Telephone +33 4 79201010 • www.trimet.eu

GB - 02.2016

Elements

Each

Total

Piece A A
Redraw Rod – Continuously Cast and Rolled
Alloy 2011 is a free machining alloy which is comparable with many of the favorable free cutting brass alloys. 2011 is the most versatile alloy if good strength and high machining rates are required. It can be machined to very close tolerances, and the quality of the machined surfaces is excellent. The weldability and its general corrosion characteristic are poor. Our alloy with max 0.3 Pb is RoHS compliant.

**Applications**
- Screw machining

**Description**
- Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
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<tr>
<td>Max</td>
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<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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</tr>
</tbody>
</table>

Foot note: 0.20 - 0.6 Bi, 0.20 - 0.6 Pb

For each application, TRIMET can propose composition according customer’s specifications.

**Material condition (2 tons coils):**
- Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
- Usual temper as supplied: H (homogenised) and F.
- Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>170-230</td>
<td>10-25</td>
</tr>
<tr>
<td>H</td>
<td>120-170</td>
<td>15-30</td>
</tr>
</tbody>
</table>

**Process**
- Recommended wiredrawing conditions:
  - Type of wiredrawing machine: non-slip.
  - Maximum reduction* by wiredrawing prior to annealing: 75 to 90%.
  - Reduction* per die: 15 to 30%.
  - Die geometry
    - reduction angle: 16 to 12°
    - bearing length: 0.25 d (d: die diameter).

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2017
Redraw Rod – Continuously Cast and Rolled
Alloys of his group are used where highest strength levels are required. These alloys contain mainly copper and Magnesium. But in order to achieve their strong mechanical properties they need to be solution heat treated. In the soft condition, the lower alloyed derivates offer a very good formability. The general corrosion resistance is poor.

**Applications**
- Die-forgings – Nuts and bolts – Screw machining.

**Description**
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>%</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td></td>
<td>0.20</td>
<td>3.5</td>
<td>0.40</td>
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</tr>
<tr>
<td>Max</td>
<td></td>
<td>0.8</td>
<td>0.7</td>
<td>4.5</td>
<td>1.0</td>
<td>0.8</td>
<td>0.15</td>
<td>0.25</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

A Zr + Ti limit of 0.20 percent maximum may be used for forged products only.

For each application, TRIMET can propose composition according customer’s specifications.

**Material condition (2 tons coils):**
- Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
- Usual temper as supplied: H (homogenised) and F.
- Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>200-260</td>
<td>80-130</td>
<td>10-30</td>
</tr>
<tr>
<td>H</td>
<td>150-220</td>
<td>70-110</td>
<td>18-35</td>
</tr>
</tbody>
</table>

**Process**
Recommended wiredrawing conditions:
- Type of wiredrawing machine: non-slip.
- Maximum reduction* by wiredrawing prior to annealing: 85%.
- Reduction* per die: 15 - 30%.
- Die geometry
  - reduction angle: 16 - 12°
  - bearing length: 0.25 d (d: die diameter).

**Heat treatments:**
- Full annealing (0 temper): 375°-410°, 3 to 4 hours, followed by slow cooling (25°C to 30°C/hour up to 250°C).
- Heat solution treatment prior to quenching (T4 - T3 tempers): 500°C +/- 5°C, 1 hour. Cold water quenching (40°C maximum).
- Natural ageing (T4 Temper): minimum 4 days at 20°C.

**Typical mechanical properties of drawn wire:**

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T4</td>
<td>450</td>
<td>280</td>
<td>20*</td>
</tr>
</tbody>
</table>

Note:
- Under no circumstances should products be stored for extensive periods in a damp or humid atmosphere.
- Lubrification with grease.

*Reduction (%) = \( \frac{S_s}{S_s} \times 100 \) (where "S" is the entry cross-section and "s" the exit cross-section).

**Metallurgical aspects of the wiredrawing process.**

Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2 YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

**Heat treatments:**
- Full annealing (0 temper): 375°-410°, 3 to 4 hours, followed by slow cooling (25°C to 30°C/hour up to 250°C).
- Heat solution treatment prior to quenching (T4 - T3 tempers): 500°C +/- 5°C, 1 hour. Cold water quenching (40°C maximum).
- Natural ageing (T4 Temper): minimum 4 days at 20°C.

**Typical mechanical properties of drawn wire:**

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T4</td>
<td>450</td>
<td>280</td>
<td>20*</td>
</tr>
</tbody>
</table>

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2024
Redraw Rod – Continuously Cast and Rolled
Alloy 2024 has a higher strength than either alloys 2014 and 2017. Due to its high strength level in the T-tempers it is used in aircraft applications and other pretentious applications. It has good machining characteristics, but not as distinguished as 2011. The cold formability in the soft condition is considered fair, although it is one of the most popular alloys for cold heading and thread rolling applications. Corrosion resistance and anodizeability are only fair.

**Applications**
Rivets, Bicycle Nipples, Screws, Balls

**Description**
Chemical composition from Aluminum Association

```
<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Max</td>
<td>3.8</td>
<td>0.30</td>
<td>1.2</td>
<td>0.15</td>
<td>0.25</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Zr + Ti limit of 0.20 percent maximum may be used for forged products only.
```

For each application, TRIMET can propose composition according customer’s specifications.

**Typical Physical Properties 2024**
Density at 20°C 2,77 g/cm³
Melting range (with nominal chemical composition) 502°C - 638°C
Specific Heat at 100°C 875 J/kg - °C
Thermal Linear Expansion Coefficient at 100°C 22.9 * mym/°C
Thermal Conductivity O Temper 190 W/m - °C
Thermal Conductivity T4, T351 Temper 120 W/m - °C
Thermal Conductivity T6, T851 Temper 150 W/m - °C
Electrical Conductivity O Temper 50% IACS
Electrical Conductivity T4, T351 Temper 30% IACS
Electrical Conductivity T6, T851 Temper 40% IACS

**Heat treatments:**
- Full annealing (O temper): 375° - 410°, 3 to 4 hours, followed by slow cooling (25°C to 30°C/hour up to 250°C).
- Solution Heat treatment prior to quenching (T4 - T3 tempers): 490°C +/- 5°C, 1 hour Cold water quenching (40°C maximum).
- Natural ageing (T4 Temper): minimum 4 days at 20°C

**Processing / Work hardening**

![Graph showing typical mechanical properties](image)

* Mechanical values may vary significantly due to natural aging effects

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3103
Redraw Rod – Continuously Cast and Rolled
This alloy has mainly manganese as an alloying element. 3103 has moderate strength level which is approximately 20% stronger than pure aluminum. Especially at elevated temperatures it performs better than the 1000 series alloys. It has a very good resistance to atmospheric corrosion and a very good weldability and is widely used in soldered structures like radiators. The formability is very good.

Applications
Impact extrusion of cartridge cases.
Tube extrusion by the CONFORM process.
Miscellaneous.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>%</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td></td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Max</td>
<td></td>
<td>0.5</td>
<td>0.7</td>
<td>1.0</td>
<td>1.5</td>
<td>0.15</td>
<td>0.20</td>
<td>0.05</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: H (homogenised) and F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>140-190</td>
<td>10-20</td>
</tr>
<tr>
<td>H</td>
<td>95-120</td>
<td>30-40</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
> Type of wiredrawing machine: slip or non-slip.
> Maximum reduction* by wiredrawing prior to annealing: 95 to 98%.
> Reduction* per die: 15 to 30%
> Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

3103
Redraw Rod – Continuously Cast and Rolled

Metallurgical aspects of the wiredrawing process.
> Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:
> Full annealing (0 temper): 350°C to 380°C
  - 3 hours for a drawn wire from F temper rod.
> Part annealing (H2X* tempers): 250/300°C
  - 3 hours for a drawn wire from F temper rod.

Typical mechanical properties of drawn wire (from diameter 9.5 mm F temper):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>115</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>H19</td>
<td>260</td>
<td>200</td>
<td>3</td>
</tr>
</tbody>
</table>

* H2X tempers: H24-H26

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4043 | 4043A
Redraw Rod – Continuously Cast and Rolled
Metallurgical aspects of the wiredrawing process.

Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:

Full annealing (0 temper): 320°C -3 hours.

Typical mechanical properties of drawn wire:

Innovation

TRIMET has developed a range of Welding alloys without added Beryllium (protection of welders): the BE FREE.
4047 | 4047A
Redraw Rod – Continuously Cast and Rolled
Metallurgical aspects of the wiredrawing process.

Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:
> Full annealing (0 temper): 320°C - 3 hours.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>125-170</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Innovation
TRIMET has developed a range of Welding alloys without added Beryllium (protection of welders): the BE FREE.

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Telephone +33 4 79201010 • www.trimet.eu
5005
Redraw Rod – Continuously Cast and Rolled
Metallurgical aspects of the wiredrawing process.

Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:

- **Full annealing (0 temper):** 350°C to 380°C
  - 3 hours. Minimal deformation before annealing: 20%
- **Part annealing (H2X* tempers):** 240/280°C
  - 3 hours.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E_E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>210</td>
<td>100</td>
<td>30</td>
</tr>
<tr>
<td>H19</td>
<td>350</td>
<td>320</td>
<td>6</td>
</tr>
<tr>
<td>H13*</td>
<td>240</td>
<td>180</td>
<td>15</td>
</tr>
</tbody>
</table>

*Reduction (%) = \( \frac{S-s}{S} \times 100 \) (where “S” is the entry cross-section and “s” the exit cross-section).

Applications

Cold heading.

Description

Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements %</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Others Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.30</td>
<td>0.7</td>
<td>0.20</td>
<td>0.20</td>
<td>1.1</td>
<td>0.10</td>
<td>0.25</td>
<td>0.05</td>
</tr>
<tr>
<td>Max</td>
<td></td>
<td>0.90</td>
<td>0.25</td>
<td>0.30</td>
<td>1.30</td>
<td>0.15</td>
<td>0.30</td>
<td>0.15</td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according to customer’s specifications.

Material condition (2 tons coils):

- Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
- Usual temper as supplied: F.
- Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E_E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>130-200</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Process

Recommended wiredrawing conditions:

- Type of wiredrawing machine: slip or non-slip.
- Maximum reduction* by wiredrawing prior to annealing: 85 to 95%.
- Reduction* per die: 15 to 30%
- Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Note:

Recommendations for wiredrawing on a slip machine:

- Proper lubrication (use grease at the first reduction stage)
- Proper wire / die alignment
- A low slip coefficient,
- Sufficient cooling during wiredrawing.

*Reduction (%) = \( \frac{S-s}{S} \times 100 \) (where “S” is the entry cross-section and “s” the exit cross-section).

This group of alloys contains increasing levels of the main alloying element magnesium respectively. With the increasing level of magnesium the strength is significantly increased while the formability becomes poor. The general corrosion resistance is excellent, therefore theses alloys are used in maritime environments. Among other aluminum alloys, this series is used for the widest applications including welded structures. The lower alloyed derivates can be easily anodized.

Elements

<table>
<thead>
<tr>
<th>%</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Others Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.5</td>
<td>0.5</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Max</td>
<td>0.6</td>
<td>0.6</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

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Redraw Rod – Continuously Cast and Rolled

5005

This group of alloys contains increasing levels of the main alloying element magnesium respectively. With the increasing level of magnesium the strength is significantly increased while the formability becomes poor. The general corrosion resistance is excellent, therefore theses alloys are used in maritime environments. Among other aluminum alloys, this series is used for the widest applications including welded structures. The lower alloyed derivates can be easily anodized.

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5019
Redraw Rod – Continuously Cast and Rolled
Metallurgical aspects of the wiredrawing process.

Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:

- Full annealing (0 temper): 350°C to 380°C - 3 hours.
- Part annealing (H2X* tempers): 240/280°C - 3 hours.
- Corrosion resistance annealing (tempers H3X**: 230/240°C during 24 hours

This heat treatment is helpful in case of using at high temperature (65°C) in corrosive atmosphere.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E% (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>290</td>
<td>150</td>
<td>30</td>
</tr>
<tr>
<td>H19</td>
<td>475</td>
<td>420</td>
<td>5</td>
</tr>
<tr>
<td>H38</td>
<td>415</td>
<td>345</td>
<td>10</td>
</tr>
<tr>
<td>H13*</td>
<td>325</td>
<td>260</td>
<td>15</td>
</tr>
</tbody>
</table>

+10% reduction * H2X tempers: H24-H26 ** H3X tempers: H38-H36-H34

---

Applications
Cold heading (rivets, nails, miscellaneous).
Zip fasteners, metal screening and wire fencing,
staples, miscellaneous.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.10</td>
<td>0.10</td>
<td>0.6</td>
<td>5.6</td>
<td>0.20</td>
<td>0.20</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>0.40</td>
<td>0.50</td>
<td>1.0</td>
<td>4.5</td>
<td>0.20</td>
<td>0.20</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications. Version 5019A available upon request.

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: H (homogenised) and F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>wire diameter mm</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E% (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>270-320</td>
<td>150-300</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
> Type of wiredrawing machine: slip or non-slip.
> Maximum reduction* by wiredrawing prior to annealing: 75 to 90%.
> Reduction* per die: 15 to 30%
> Die geometry
- reduction angle: 16 to 12°
- bearing length: 0.25 d (d: die diameter).

Note:
Recommendations procedure for wiredrawing on a slip machine:
> First pass with high reduction value (30-40%)
> Full annealing
Ensure:
> correct lubrication (use grease at the first reduction stage)
> correct wire / die alignment
> a low slip coefficient at each reduction stage,
> sufficient cooling during wiredrawing.

*Reduction (%) = S-s x 100 (where “S” is the entry cross-section and “s” the exit cross-section).

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5051
Redraw Rod – Continuously Cast and Rolled
This group of alloys contains increasing levels of the main alloying element magnesium respectively. With the increasing level of magnesium the strength is significantly increased while the formability becomes poor. The general corrosion resistance is excellent, therefore theses alloys are used in maritime environments. Among other aluminum alloys, this series is used for the widest applications including welded structures. The lower alloyed derivates can be easily anodized.

Applications
Wire fencing, miscellaneous.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min</td>
<td>0.40</td>
<td>0.7</td>
<td>0.25</td>
<td>0.20</td>
<td>1.7</td>
<td>2.2</td>
<td>0.10</td>
<td>0.25</td>
<td>0.10</td>
<td>0.05</td>
<td>0.15</td>
</tr>
<tr>
<td>Max</td>
<td>0.40</td>
<td>0.7</td>
<td>0.25</td>
<td>0.20</td>
<td>1.7</td>
<td>2.2</td>
<td>0.10</td>
<td>0.25</td>
<td>0.10</td>
<td>0.05</td>
<td>0.15</td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>170-220</td>
<td>100-150</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
> Type of wiredrawing machine: slip or non-slip.
> Maximum reduction* by wiredrawing prior to annealing: 90 to 98%.
> Reduction* per die: 15 to 30%
> Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Note:
Recommendations for wiredrawing on a slip machine:
Ensure:
> proper lubrication (use grease at the first reduction stage)
> proper wire / die alignment
> a low slip coefficient.
> sufficient cooling during wiredrawing.

*Reduction (%) = 100 \times \frac{s}{S} (where “S” is the entry cross-section and “s” the exit cross-section).

Heat treatments:
> Full annealing (0 temper): 350°C to 380°C - 3 hours.
Minimal deformation before annealing: 20%  
> Part annealing (H2X* tempers): 240/280°C - 3 hours.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>0</td>
<td>190</td>
<td>90</td>
</tr>
<tr>
<td>H19</td>
<td>320</td>
<td>300</td>
<td>6</td>
</tr>
</tbody>
</table>

* H2X tempers: H24-H26

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5052
Redraw Rod – Continuously Cast and Rolled
Aluminium alloy 5052 has very good corrosion resistance to seawater and marine and industrial atmosphere, has a very good weldability and excellent cold formability at an medium strength level. It is a medium strength alloy with a strength slightly higher than 5051 and slightly lower than 5754.

Applications
- Cold heading.
- Zip fasteners.
- Wire fencings, staples, miscellaneous.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.15</td>
<td>0.25</td>
<td>0.10</td>
<td>0.10</td>
<td>2.2</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>0.40</td>
<td>0.25</td>
<td>0.10</td>
<td>0.10</td>
<td>2.8</td>
<td>0.35</td>
<td>0.10</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

Material condition (2 tons coils):
- Material condition (2 tons coils).
- Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
- Usual temper as supplied: F.
- Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>180-230</td>
<td>100-150</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
- Type of wiredrawing machine: slip or non-slip.
- Maximum reduction* by wiredrawing prior to annealing: 85 to 95%.
- Reduction* per die: 15 to 30%
- Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Note:
Recommendations for wiredrawing on a slip machine:
- proper lubrication (use grease at the first reduction stage)
- proper wire / die alignment
- a low slip coefficient.
- sufficient cooling during wiredrawing.

Metallurgical aspects of the wiredrawing process.
> Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2 YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:
> Full annealing (0 temper): 350°C to 380°C - 3 hours.
- Minimal deformation before annealing: 20%
- Part annealing (H2X* tempers): 240/280°C - 3 hours.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H19</td>
<td>350</td>
<td>320</td>
<td>6</td>
</tr>
<tr>
<td>H13</td>
<td>240</td>
<td>180</td>
<td>15</td>
</tr>
</tbody>
</table>

+10% reduction * H2X tempers: H24-H26

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5154
Redraw Rod – Continuously Cast and Rolled
5154
Redraw Rod – Continuously Cast and Rolled

This group of alloys contains increasing levels of the main alloying element magnesium respectively. With the increasing level of magnesium the strength is significantly increased while the formability becomes poor. The general corrosion resistance is excellent, therefore these alloys are used in maritime environments. Among other aluminum alloys, this series is used for the widest applications including welded structures. The lower alloyed derivates can be easily anodized.

Applications
Cold heading.
Wire fencings, staples, miscellaneous.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Max      | 0.25| 0.40| 0.10| 0.10| 3.1| 0.15| 0.20| 0.20| 0.05  

For each application, TRIMET can propose composition according customer’s specifications. Versions 5154A and 5154B are available upon request.

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>210-270</td>
<td>15-30</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
> Type of wiredrawing machine: slip or non-slip.
> Maximum reduction* by wiredrawing prior to annealing: 85 to 95%.
> Reduction* per die: 15 to 30%
> Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Note:
Recommendations for wiredrawing on a slip machine:
Ensure:
> proper lubrication (use grease at the first reduction stage)
> proper wire/die alignment
> a low slip coefficient,
> sufficient cooling during wiredrawing.

Metallurgical aspects of the wiredrawing process.
> Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2%YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:
> Full annealing (0 temper): 350°C to 380°C -3 hours. Minimal deformation before annealing: 20%.
> Part annealing (H2X* tempers): 240/280°C -3 hours.
> Corrosion resistance annealing (tempers H3X**): 230/240°C during 24 hours

This heat treatment is helpful in case of using at high temperature (65°C) in corrosive atmosphere.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>240</td>
<td>115</td>
<td>30</td>
</tr>
<tr>
<td>H19</td>
<td>400</td>
<td>375</td>
<td>5</td>
</tr>
<tr>
<td>H34</td>
<td>290</td>
<td>230</td>
<td>13</td>
</tr>
<tr>
<td>H13</td>
<td>270</td>
<td>210</td>
<td>15</td>
</tr>
</tbody>
</table>

*Reduction (%) = \( \frac{5.5}{S} \times 100 \) (where “S” is the entry cross-section and “s” the exit cross-section).

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5183
Redraw Rod – Continuously Cast and Rolled
This group of welding alloys are the best choice if high mechanical properties in welded structures is required while 5183 has even higher mechanical properties than 5356. They produce welds with higher ductility than those using 4xxx series filler materials but are not as easy to use than the 4xxx series. However, they should not be used with high Si content alloys (i.e. castings) because of excessive magnesium-silicide (Mg2Si) developed in the weld structure and will decrease ductility and increase crack sensitivity.

**Applications**
- Welding wire (MIG, TIG, laser).

**Description**
Chemical composition from Aluminum Association (with reference to EN ISO 18273)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.40</td>
<td>0.40</td>
<td>1.0</td>
<td>1.0</td>
<td>5.2</td>
<td>0.25</td>
<td>0.25</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td>Max</td>
<td>0.40</td>
<td>0.10</td>
<td>1.0</td>
<td>1.0</td>
<td>5.2</td>
<td>0.25</td>
<td>0.25</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

**Material condition (2 tons coils):**
- Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
- Usual temper as supplied: F or H (homogenised).
- Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>280-350</td>
<td>15-30</td>
</tr>
<tr>
<td>H</td>
<td>280-330</td>
<td>20-35</td>
</tr>
</tbody>
</table>

**Process**
**Recommended wiredrawing conditions:**
- Maximum reduction* by wiredrawing prior to annealing: 75 to 85%.
- Die geometry:
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Metallurgical aspects of the wiredrawing process.

**Work-hardening curves.**

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

![Work-hardening curves](image)

**Heat treatments:**
- Full annealing (0 temper): 360°C - 3 hours.

**Typical mechanical properties of drawn wire:**

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>310</td>
<td>150</td>
<td>30</td>
</tr>
<tr>
<td>H18</td>
<td>460</td>
<td>420</td>
<td>6</td>
</tr>
<tr>
<td>H19</td>
<td>500</td>
<td>450</td>
<td>4</td>
</tr>
</tbody>
</table>

**Innovation**
TRIMET has developed a range of Welding alloys without added Beryllium (protection of welders): the BE FREE.

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5356
Redraw Rod – Continuously Cast and Rolled
This group of welding alloys are the best choice if high mechanical properties in welded structures is required while 5183 has even higher mechanical properties than 5356. They produce welds with higher ductility than those using 4xxx series filler materials but are not as easy to use than the 4xxx series. However, they should not be used with high Si content alloys (i.e. castings) because of excessive magnesium-silicide (Mg2Si) developed in the weld structure and will decrease ductility and increase crack sensitivity.

Applications
Welding wire (MIG, TIG, laser).

Description
Chemical composition from Aluminum Association (with reference to EN ISO 18273)

<table>
<thead>
<tr>
<th>Element</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.25</td>
<td>0.40</td>
<td>0.10</td>
<td>0.20</td>
<td>5.5</td>
<td>0.20</td>
<td>0.10</td>
<td>0.20</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>0.30</td>
<td>0.45</td>
<td>0.15</td>
<td>0.25</td>
<td>6.0</td>
<td>0.25</td>
<td>0.15</td>
<td>0.25</td>
<td>0.20</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E100 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>270-320</td>
<td>120-160</td>
<td>18-30</td>
</tr>
<tr>
<td>H</td>
<td>260-310</td>
<td>110-140</td>
<td>20-35</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
> Maximum reduction by wiredrawing prior to annealing: 75 to 85%.
> Reduction per die: 15 to 30%
> Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Metallurgical aspects of the wiredrawing process.
> Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:
> Full annealing (0 temper): 360°C - 3 hours.
> Partial annealing: 240°/280°C - 3 hours.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>300</td>
<td>140</td>
<td>30</td>
</tr>
<tr>
<td>H19</td>
<td>480</td>
<td>420</td>
<td>3</td>
</tr>
</tbody>
</table>

Innovation
TRIMET has developed a range of Welding alloys without added Beryllium (protection of welders): the BE FREE.

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5754
Redraw Rod – Continuously Cast and Rolled
Alloy 5754 has a very good general corrosion resistance and thus is one of the most preferable alloys for applications in maritime and seawater conditions and industrially polluted atmospheres. Its strength is medium / medium-high and it has a very good formability in the lower strength Hxx conditions.

Applications
Cold heading.
Staples, sundry.

Description
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.40</td>
<td>0.10</td>
<td>0.50</td>
<td>2.6</td>
<td>3.6</td>
<td>0.10</td>
<td>0.20</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>0.40</td>
<td>0.10</td>
<td>0.50</td>
<td>2.6</td>
<td>3.6</td>
<td>0.10</td>
<td>0.20</td>
<td>0.15</td>
<td>0.05</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

Foot note: 0.10% - 0.6% Mn + Cr

For each application, TRIMET can propose composition according customer’s specifications.

Material condition (2 tons coils):
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: H (homogenised) and F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>210-260</td>
<td>15-30</td>
</tr>
<tr>
<td>H</td>
<td>215-250</td>
<td>20-35</td>
</tr>
</tbody>
</table>

Process
Recommended wiredrawing conditions:
> Type of wiredrawing machine: slip or non-slip.
> Maximum reduction* by wiredrawing prior to annealing: 85 to 95%.
> Reduction* per die: 15 to 30% 
> Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

Note:
Recommendations procedure for wiredrawing on a slip machine:
Ensure:
> proper lubrication (use grease at the first reduction stage)
> proper wire / die alignment
> a low slip coefficient,
> sufficient cooling during wiredrawing.

*Reduction (%) = \( \frac{S-s}{S} \times 100 \) (where “S” is the entry cross-section and “s” the exit cross-section).

Metallurgical aspects of the wiredrawing process.
> Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2% YS could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

Heat treatments:
> Full annealing (0 temper): 350°C to 380°C
  - 3 hours.
> Minimal deformation before annealing: 20%
> Part annealing (H2X* tempers): 240/280°C
  - 3 hours.
> Corrosion resistance annealing
  (tempers H3X**:): 230/240°C during 24 hours

This heat treatment is helpful in case of using at high temperature (65°C) in corrosive atmosphere.

Typical mechanical properties of drawn wire:

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>230</td>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>H19</td>
<td>390</td>
<td>360</td>
<td>5</td>
</tr>
<tr>
<td>H34</td>
<td>270</td>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td>H13+</td>
<td>260</td>
<td>200</td>
<td>15</td>
</tr>
</tbody>
</table>

*+10% reduction * H2X tempers: H24-H26 ** H3X tempers: H38-H36-H34

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6056
Redraw Rod – Continuously Cast and Rolled
Alloy 6056 is an extremely versatile material for applications which require with high strength in the T-tempers. It has 25%-30% higher strength and hardness compared with 6082-T6 supplementary with a higher stability at elevated temperatures up to 150°C. Its good formability in the H1x-conditions comparable to 6082 recommends this alloy for cold heading and cold impact extrusion processes.

Heat treatments:
> Full annealing (O temper): 400° - 420°, 3 to 4 hours, moderate cooling recommended (30°C-60°/hour up to 250°C).
> Solution Heat treatment prior to quenching (T4 - T3 Temper): 545°C +/- 4°C, 1 hour Cold water quenching (50°C maximum).
> Natural ageing (T4 Temper): minimum 4 days at 20°C
> Artificial ageing (T6x Temper): Various temperatures and times between 160°-200°C (i.e. 8h/180°)

Applications
Screws, Nuts and bolts, Fittings

Description
Chemical composition 6056 DIN EN 573-3

<table>
<thead>
<tr>
<th>Elements</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>0.7</td>
</tr>
<tr>
<td>Fe</td>
<td>0.50</td>
</tr>
<tr>
<td>Cu</td>
<td>0.40</td>
</tr>
<tr>
<td>Mn</td>
<td>0.6</td>
</tr>
<tr>
<td>Mg</td>
<td>0.10</td>
</tr>
<tr>
<td>Cr</td>
<td>1.3</td>
</tr>
<tr>
<td>Zn</td>
<td>1.0</td>
</tr>
<tr>
<td>Ti</td>
<td>0.25</td>
</tr>
<tr>
<td>Zr</td>
<td>0.7</td>
</tr>
<tr>
<td>Ti+Zr</td>
<td>0.2</td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

Typical Physical Properties 6056
Density at 20°C 2.71 g/cm³
Solidus Temperatur (with nominal chemical composition) 550°C
Specific Heat at 100°C 885 J/kg °C
Thermal Linear Expansion Coefficient at 100°C 23.4 * mm/m°C
Thermal Conductivity T6 150 W/m °C
Electrical Conductivity O Temper 40% IACS
Electrical Conductivity T6 35% IACS

Typical mechanical properties 6056

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E50 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>180</td>
<td>90</td>
<td>24</td>
</tr>
<tr>
<td>T4</td>
<td>340</td>
<td>270</td>
<td>16</td>
</tr>
<tr>
<td>T6</td>
<td>420</td>
<td>370</td>
<td>10</td>
</tr>
<tr>
<td>T9</td>
<td>450</td>
<td>400</td>
<td>6</td>
</tr>
</tbody>
</table>

* Mechanical values may vary significantly due to natural aging effects
6082
Redraw Rod – Continuously Cast and Rolled
This alloy is mainly selected where welding or brazing is required together with a high corrosion resistance in all tempers at medium strength level. The formability in H- and O-Tempers is excellent and fairly acceptable in the T4 temper. In comparison to the special designated machining alloys it is more difficult to use. The appearance after anodizing is superior in comparison to other machining alloys.

**Applications**
Cold heading, knitting needles.
Die-forgings.

**Description**
Chemical composition from Aluminum Association

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.7</td>
<td>0.4</td>
<td>0.4</td>
<td>0.6</td>
<td>0.4</td>
<td>1.2</td>
<td>1.0</td>
<td>1.2</td>
<td>0.05</td>
</tr>
<tr>
<td>Max</td>
<td>1.3</td>
<td>0.5</td>
<td>0.1</td>
<td>1.0</td>
<td>0.25</td>
<td>0.20</td>
<td>0.10</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

For each application, TRIMET can propose composition according customer’s specifications.

**Material condition (2 tons coils):**
> Usual diameter: 9.5 mm; diameters from 7.5 to 26.5 mm available upon request.
> Usual temper as supplied: H (homogenised) and F.
> Mechanical properties (figures given as a rough guide):

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>E90 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>130-220</td>
<td>10-30</td>
</tr>
<tr>
<td>H</td>
<td>100-150</td>
<td>15-30</td>
</tr>
</tbody>
</table>

**Process**
Recommended wiredrawing conditions:
> Type of wiredrawing machine: slip or non-slip.
> Maximum reduction* by wiredrawing prior to annealing: 93%.
> Reduction* per die: 15 to 30%
> Die geometry
  - reduction angle: 16 to 12°
  - bearing length: 0.25 d (d: die diameter).

*Reduction (%) = \( \frac{S - s}{S} \times 100 \) (where “S” is the entry cross-section and “s” the exit cross-section).

**Metallurgical aspects of the wiredrawing process.**

> Work-hardening curves.

The work-hardening curves shown below have been constructed for a wiredrawing process carried out one reduction stage at a time. In the normal industrial wiredrawing process, the figures for UTS and 0.2 Yield could be lower by 10 to 40 MPa, depending on the process conditions and the diameter of the drawn wire.

**Heat treatments:**
> Heat solution treatment prior to quenching: 565°C +/- 5°C - 1 hour
> Critical rate of quenching (500 to 200°C): >5°C/sec (cold water)
> Artificial ageing for T6 temper (immediately after solution treatment and quenching): 175°C +/-5°C - 8 hours
> Full annealing (0 temper): 360°C to 400°C - 3 hours

**Typical mechanical properties of drawn wire:**

<table>
<thead>
<tr>
<th>Temper</th>
<th>UTS (MPa)</th>
<th>0.2% YS (MPa)</th>
<th>E90 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>130</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>T4</td>
<td>250</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>T6</td>
<td>350</td>
<td>280</td>
<td>15</td>
</tr>
</tbody>
</table>

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131050
Redraw Rod – Continuously Cast and Rolled
The CCR (Continuous Casting and Rolling) 131050 ALUFLEX® Rod is an Aluminium-Iron-Magnesium alloy used in the manufacture of fine gauge wire for flexible cables for aeronautical engineering, cables for automotive engineering, braids and screens for cables.

### Description

**Specified composition**

As tabulated below:

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>V</th>
<th>Ti</th>
<th>B</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.50</td>
<td>0.08</td>
<td>0.01</td>
<td>0.02</td>
<td>0.007</td>
<td>0.02</td>
<td>0.015</td>
<td>0.09</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>0.80</td>
<td>0.035</td>
<td>0.25</td>
<td>0.035</td>
<td>0.007</td>
<td>0.02</td>
<td>0.015</td>
<td>0.03</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Works production tolerances with respect to composition are in fact closer than tabulated above.

### Production process

From primary liquid metal by Continuous Casting and Rolling (PROPERZI or SECIM processes).

A special “Fine-gauge wire” production procedure is employed to obtain a redraw rod of excellent metallurgical quality, ensuring very high drawability down to very small diameters (down to 0.12 mm) to yield wire which performs well in terms of:

- > stranding to form flexible cables.
- > annealing and insulation of the wires and the subsequent assembly of the same.

### Material condition

- > Diameter
  - 9.5 mm
  - Tolerance on diameter is ± 4 %.

### Mechanical and electrical properties:

- > 131050 ALUFLEX® redraw rod is supplied in the as-rolled condition (Temper F).

Usual properties in F temper are as tabulated below:

<table>
<thead>
<tr>
<th>MECHANICAL PROPERTIES</th>
<th>ELECTRICAL PROPERTIES TO 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultimate tensile strength (UTS) MPa (1)</td>
<td>Resistivity (mΩ cm)</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>IACS (mS/mm²)</td>
</tr>
<tr>
<td>Range</td>
<td>120–160</td>
</tr>
<tr>
<td>Typical</td>
<td>140</td>
</tr>
</tbody>
</table>

### Physical properties

- Density: 2.708 kg/m³
- Modulus of elasticity: 69.000 MPa
- Thermal conductivity at 20°C: 220 W/m°C
- Coefficient of linear expansion over the range 20 to 100°C: 23 x 10⁻⁶ °C⁻¹
- Temperature correction factor for resistivity: 4.0 x 10⁻³ °C⁻¹
- Specific heat: 960 J/kg°C

### Wiredrawing / Cablemaking

#### Metallurgical considerations

The end-uses of alloy 131050 will normally call for wire of temper H22, H24 or H26 (1/4 hard to 3/4 hard), combining good mechanical strength and sufficient ductility for downstream assembly/insulation operations and actual cable duty.

The metallurgical factors which come into play during wiredrawing and cablemaking are, basically:

- > the work-hardening of the wire brought about by the wiredrawing operation;
- > the softening brought about by recovery and/or recrystallization heat treatments.

### Work hardening curves

When alloy 131050 is subjected to an industrial wiredrawing sequence, the mechanical properties of the drawn wire so obtained will be determined by:

- > the reduction in cross-section brought about by wiredrawing;
- > any annealing treatments carried out on the original redraw rod or at some intermediate stage in wiredrawing;
- > the type of wiredrawing machine employed (slip or non-slip).
Figure 1 illustrates how ultimate tensile strength and elongation vary with diameter down to 0.5 mm for:

> Redraw rod, diameter 9.5 mm, Temper F
> Redraw rod, diameter 9.5 mm, Temper O
> Redraw rod, diameter 9.5 mm, Temper F, with inter-stage annealing at diameter 2.5 mm.

Heat treatment practice

> Annealing of redraw rod (dia. 9.5 mm).
As normally used, 131050 ALUFLEX® rod does not require annealing.

> Inter-stage annealing during wiredrawing
(2 to 2.5 mm).
For certain applications, and depending on wiredrawing practice and final wire diameter (very small diameters of less than 0.5 mm), it may be advantageous to include a complete recrystallization/softening treatment at some intermediate stage.

Operating conditions in the static heat treatment oven could in this event be, say:

> Temperature: 300° C
> Treatment time: 4 hours (at temperature).

N. B.: The advantages of inter-stage annealing are:

> Improved drawability at very small diameters.
> Improved stranding characteristics of wire for flexible cables, if stranding precedes the final heat treatment.
> More uniform final mechanical properties after final heat treatment.
> Improved final electrical properties after final heat treatment.

As against this, it has an adverse effect on the mechanical properties (UTS and \( E_{200} \)) of the end-product.

> Annealing at final diameter.

For fine-gauge wire, the final annealing treatment can be carried out either in the static oven on reels of drawn wire, or continuously as the wire leaves drawing machines fitted with electric annealing systems suitable for aluminium.

**Annealing in the static oven.**

The final heat treatment conditions need to be matched to:

> the annealing oven,
> the load to be treated,
> the desired level of mechanical properties (UTS - \( E_{200} \)) for the wire,
> the manufacturing sequence adopted, with particular reference to whether or not inter-stage annealing is employed.

As an example, values of:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTS</td>
<td>145 MPa</td>
</tr>
<tr>
<td>( E_{200} )</td>
<td>10 %</td>
</tr>
<tr>
<td>( p )</td>
<td>2.90 ( \mu )Ω cm</td>
</tr>
</tbody>
</table>

can be achieved by heat treatment in the oven with:

> a temperature: 245° C
> and a treatment time (at temperature) of 3 hours.
For a 0.5 mm diameter wire drawn without inter-
stage annealing from 9.5 mm redraw rod in 131050
alloy-Temper F. - Figure 2 below illustrates the
effects of static annealing conditions on the final
mechanical properties exhibited by the wire.

Final mechanical and electrical properties

Depending on the application and manufacturing
facilities available, various manufacturing sequenc-
es may be adopted to obtain different typical com-
binations of mechanical and electrical properties.
These are illustrated in the table below for a wire
of dia. 0.5 mm having an elongation at break of
10%.

<table>
<thead>
<tr>
<th>MANUFACTURING SEQUENCE</th>
<th>MECHANICAL AND ELECTRICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rm</td>
</tr>
<tr>
<td></td>
<td>MPa</td>
</tr>
<tr>
<td>Without intermediate</td>
<td>145</td>
</tr>
<tr>
<td>annealing</td>
<td></td>
</tr>
<tr>
<td>With intermediate</td>
<td>130</td>
</tr>
<tr>
<td>annealing</td>
<td></td>
</tr>
</tbody>
</table>

Utilisation of Redraw Rod / Manufacturing practice

In view of the fact that 131050 is intended for
fine-gauge wire production and applications, users
should exercise the very greatest care at the vari-
ous stages of the wiredrawing operation, since any
damage to the rod, undue rubbing or faults could
be conducive to breakage at small diameters in no
way attributable to the quality of the product sup-
plied.

> Storage of redraw rod
> Unwinding
> Wiredrawing
See Data for 137050

Generally speaking, the user should follow the rec-
ommendations for 137050. Recommendations of
particular importance when drawing fine-gauge
wire from 131050 include the use of:
> diamond dies,
> a mineral oil of viscosity appropriate to small
and very small diameters.

Applications

131050 ALUFLEX® wires the characteristics de-
manded for use in flexible cables:
> good mechanical properties
  (breaking load and elongation)
> good resistance to alternated breaking
> good resistance to corrosion and good
temperature stability
> good electrical conductivity

Applications are as following:
> manufacture of flexible cables of every type for
  use in welding, automotive industry (1), home
  electrical appliances, railways, aircraft construc-
tion, shipbuilding.
> manufacture of cables for aeronautical engi-
  neering: direct nickel plated ALUFLEX®.

(1) Battery cables.
137050
Redraw Rod – Continuously Cast and Rolled
137050
Redraw Rod – Continuously Cast and Rolled

The CCR (Continuous Casting and Rolling) 137050 CONDUCTAL® conforms to EN 1715.

Description
Specified composition
The composition guaranteed by TRIMET is as tabulated below:

<table>
<thead>
<tr>
<th>Elements</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ga</th>
<th>Ti+V</th>
<th>B</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
<td>0.1</td>
<td>0.07</td>
<td>0.010</td>
<td>0.005</td>
<td>0.010</td>
<td>0.003</td>
<td>0.03</td>
<td>0.005</td>
<td>0.005</td>
<td>0.004</td>
<td>0.02</td>
<td>1.10</td>
</tr>
<tr>
<td>Max</td>
<td>0.2</td>
<td>0.07</td>
<td>0.010</td>
<td>0.005</td>
<td>0.010</td>
<td>0.003</td>
<td>0.03</td>
<td>0.005</td>
<td>0.005</td>
<td>0.004</td>
<td>0.02</td>
<td>1.60</td>
</tr>
</tbody>
</table>

Its composition complies with the European standard EN573-3 and the ALUMINUM ASSOCIATION standards for Alloys 1350 and 1370.

Note: The data tabulated is guaranteed to within the analytical precisions indicated.

Production process
The redraw rod is produced from primary liquid metal by continuous casting and rolling (PROPERZI or SECIM processes).

The procedure followed in the foundry ensures excellent metal quality and, inter alia, excellent drawability.

Packaging
2 tonnes coils.

Material condition
> Diameter
Normally 9.5 mm.
Other diameters can be supplied on request, namely: 7.5, 12.2, 15.2, 18.5 mm. Development is in progress for bigger diameters.
> Mechanical and electrical properties

137050 CCR rod is produced in five standard tempers or grades:

Aluminum Association designation
R6 annealed by suitable heat treatment 0
R8 “as rolled” grades H11
R10 “as rolled” grades H12
R11 “as rolled” grades H13
R12 “as rolled” grades H14

The table below sets out:
> maximum/minimum tensile strengths and maximum resistivity for each grade.

<table>
<thead>
<tr>
<th>Temper</th>
<th>Min (MPa)</th>
<th>Max (MPa)</th>
<th>Typical (MPa)</th>
<th>Resistivity (μΩ·m)</th>
<th>Conductivity (mS/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R6</td>
<td>60</td>
<td>75</td>
<td>70</td>
<td>2.725</td>
<td>62.3</td>
</tr>
<tr>
<td>R8</td>
<td>80</td>
<td>95</td>
<td>85</td>
<td>2.785</td>
<td>61.9</td>
</tr>
<tr>
<td>R10</td>
<td>95</td>
<td>110</td>
<td>100</td>
<td>2.801</td>
<td>61.5</td>
</tr>
<tr>
<td>R11</td>
<td>105</td>
<td>120</td>
<td>110</td>
<td>2.801</td>
<td>61.5</td>
</tr>
<tr>
<td>R12</td>
<td>115</td>
<td>130</td>
<td>120</td>
<td>2.801</td>
<td>61.5</td>
</tr>
</tbody>
</table>

(1) MPa = 0.1 N/mm² = 98.068 psi
(2) see conversion table in appendix 1.

Physical properties
Melting point 659 °C
Density 2.703 kg/m³
Modulus of elasticity 69,000 MPa
Coefficient of linear expansion over the range 20 to 100°C 23 x 10-6 °C-1
Temperature correction factor for resistivity
> annealed condition 4.07 x 10-3 °C-1
> work hardened condition 4.03 x 10-3 °C-1
Thermal conductivity at 20°C 222 W/m°C
Specific heat 920 J/kg°C
Wiredrawing

Metallurgical considerations

The factors which come into play when redraw rod 137050 is drawn down to wire for cablemaking are, basically:

the work hardening brought about by the wiredrawing operation and affecting both mechanical and electrical properties:
> it increases mechanical strength (ultimate tensile strength and yield strength),
> it reduces plasticity (elongation and flexibility),
> it slightly increases resistivity;

heat treatments, if any, to bring about softening (recovery and recrystallisation).

Work hardening

At the stage of industrial wiredrawing, the mechanical and electrical properties of the drawn wire will be conditioned mainly by:
> the properties of the original redraw rod,
> the total reduction in cross-section brought about by the wiredrawing operation,
> the type of wiredrawing machine employed.

Slip type drawing machines

Figure 1 and 2 illustrate, for each temper of rod of diameter 7.5, 9.5 and 12.2 mm, how ultimate tensile strength and resistivity vary with the diameter of the drawn wire.

Non-slip machines

Where non-slip machines are employed, the wire heats up less on drawing and will therefore display slightly higher tensile strength (by 5 to 15 MPa) and resistivity (by 0.01 to 0.02 μΩ cm).

Heat treatment practice

Figure 3 (below) illustrates typical variations in ultimate tensile strength, elongation and resistivity with heat treatment temperature for wire drawn down to 3 mm and annealed for four hours in a batch furnace.
Utilisation and Fabrication Practice

Storing the redraw rod (Recommandations)
It is recommended that coils be unwrapped as soon as received and stored indoors in a dry place so as to obviate any corrosion which could render the rod unsuitable for drawing.

Should the coils be slightly, moist when received, because of condensation, they must be allowed to dry out for several days before drawing. In winter, preheating of the coils (in a stream of warm air) can assist pick-up of lubricant in the initial stages of drawing.

Wiredrawing
Unless otherwise specified, the data set out below refer to the reduction of redraw rod to diameters of 5 to 1.5 mm and do not cover any subsequent reduction operations designed to obtain fine and very fine gauge wire of diameter 0.8 mm or less.

137050 CCR rod exhibits excellent drawability and can be drawn on any of the present-day designs of industrial wiredrawing machines, whether of the slip or non-slip types.

Best results will be obtained if the following recommendations are adhered to:
> Slip rate (slip drawing machines): the maker’s instructions should be scrupulously adhered to in order to keep wire slip on the capstans within the correct limits.
> Elongation per block \( \frac{S-s \times 100}{S} \)
> 20 to 45% (reduction \( \frac{S-s}{S} = 16.5 \) to 31%)
- see conversion table in Appendix 2)
  for the production of standard diameters of power cable (5 to 1.5 mm), higher elongations being restricted to the initial stages of the drawing operation;
> 13 to 20% for subsequent reduction of wire of diameters below 1.5 mm.

Elongation in the first die should not be too small (less than 20 %) since this would embrittle the wire surface (the degree of work hardening being greater near the surface than at the core) and adversely affect pick-up of lubricant.

> Drawing speed: up to 40 meters per second leaving the machine for wire of diameter 2.0 mm. If speeds exceed 30 meters per second, elongation should preferably be limited to less than 33% for the initial reduction stages and less than 26% for the final stages.
> Dies:
  - tungsten carbide for diameters above 1.5 mm,
  - carbide, diamond for finishing or for diameters below 1.5 mm.

The geometry of tungsten carbide dies can vary between fairlywide limits:
> entry angle: 40 to 90°,
> reduction angle: 16 to 25° - preferably 16 to 18° for diameters of less than 5 mm,
> bearing length: one-quarter to one-half of diameter for diameters between 9.5 and 12 mm,
> exit angle: 60 to 90°.
The very greatest care must be taken with the polishing of dies to be employed to draw aluminium. Particular attention should be given to careful radiusing of all edges and replacing dies before wear becomes significant. Perfect alignment of the wire in the dies is also a must.

> Lubrication:
  - non-slip machines: mineral oils or greases,
  - slip-machines: mineral oils.
Lubrication with grease for the first reduction stage is always advisable.

Important:
Wherever possible, it is preferable not to employ the same machine to draw both copper and aluminium because of the risk of contamination of the mineral oil by the emulsion employed in copper drawing. In fact, even small amounts of water (less than 0.5 %) have a distinctly adverse effect on the lubricating properties, in addition to which any contamination of the drawn wire by particles of copper could impair corrosion resistance.
Oxidized redraw rod: should any accidental oxidation of the redraw rod have occurred as a result of faulty protection during shipment, the use of a special grease is recommended for the first reduction stage, together with dies of large working angle (22-24°) and short bearing length to avoid scoring or scratching.

Appendix 1
ELECTRICAL RESISTIVITY / CONDUCTIVITY
Conversion table:

<table>
<thead>
<tr>
<th>Resistivity µΩcm²/cm</th>
<th>Conductivity* IACS</th>
<th>Resistivity µΩcm²/cm</th>
<th>Conductivity* IACS</th>
<th>Resistivity µΩcm²/cm</th>
<th>Conductivity* IACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.700</td>
<td>63.68</td>
<td>37.04</td>
<td>2.900</td>
<td>59.45</td>
<td>34.48</td>
</tr>
<tr>
<td>2.705</td>
<td>63.74</td>
<td>36.97</td>
<td>2.905</td>
<td>59.35</td>
<td>34.42</td>
</tr>
<tr>
<td>2.710</td>
<td>63.80</td>
<td>36.90</td>
<td>2.910</td>
<td>59.25</td>
<td>34.36</td>
</tr>
<tr>
<td>2.715</td>
<td>63.86</td>
<td>36.83</td>
<td>2.915</td>
<td>59.15</td>
<td>34.31</td>
</tr>
<tr>
<td>2.720</td>
<td>63.92</td>
<td>36.76</td>
<td>2.920</td>
<td>59.04</td>
<td>34.25</td>
</tr>
<tr>
<td>2.725</td>
<td>63.98</td>
<td>36.70</td>
<td>2.925</td>
<td>58.94</td>
<td>34.19</td>
</tr>
<tr>
<td>2.730</td>
<td>64.04</td>
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Appendix 2
ELONGATION (E%) / REDUCTION OF DRAWING (R%)

<table>
<thead>
<tr>
<th>E %</th>
<th>R %</th>
<th>d D</th>
<th>D d</th>
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</thead>
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<td>0.817</td>
<td>1.226</td>
</tr>
<tr>
<td>45</td>
<td>31.0</td>
<td>0.831</td>
<td>1.204</td>
</tr>
<tr>
<td>40</td>
<td>28.5</td>
<td>0.845</td>
<td>1.183</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>35</td>
<td>25.9</td>
<td>0.861</td>
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<td>34</td>
<td>25.4</td>
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<td>1.113</td>
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<td>1.109</td>
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<td>17.4</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>13.0</td>
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</table>

Elongation
\[ E\% = \frac{s_s}{s} \times 100 = \left(\frac{D - d}{D}\right) \times 100 \]

Reduction (per area)
\[ R\% = \frac{s_s}{s} \times 100 = 1 - \frac{D}{d} \times 100 \]

WHERE
<table>
<thead>
<tr>
<th>ENTERING DIE</th>
<th>LIVING DIE</th>
</tr>
</thead>
<tbody>
<tr>
<td>cross-section</td>
<td>s</td>
</tr>
<tr>
<td>length</td>
<td>l</td>
</tr>
<tr>
<td>diameter</td>
<td>D</td>
</tr>
<tr>
<td>d</td>
<td></td>
</tr>
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137072
Redraw Rod – Continuously Cast and Rolled
The CCR (Continuous casting and Rolling) 137072 is employed in the manufacture of wires and cables for transport and distribution of electricity. The advantage of this product lies in its ability to sustain higher temperature and thus higher ampacity. The maximum continuous temperature of use is 150°C and the maximum temperature for pics < 10h is 180°C.

The CCR AT1 conforms to IEC 62004

**Description**

**Specified composition**

The composition guaranteed by TRIMET is as tabulated below:

<table>
<thead>
<tr>
<th>Elements</th>
<th>%</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>O</th>
<th>Zn</th>
<th>Ti</th>
<th>Ga</th>
<th>Zr</th>
<th>Ti+V</th>
<th>B</th>
<th>Others</th>
<th>Each</th>
<th>Total</th>
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<tbody>
<tr>
<td>Min</td>
<td></td>
<td>0.05</td>
<td>0.18</td>
<td>0.02</td>
<td>0.03</td>
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<td>0.005</td>
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<td></td>
</tr>
<tr>
<td>Max</td>
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<td>0.15</td>
<td>0.18</td>
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<td>0.05</td>
<td>0.07</td>
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<td>0.02</td>
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<td>0.005</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

Note: The data tabulated is guaranteed to within the analytical precisions indicated.

**Production process**

The redraw rod is produced from primary liquid metal by continuous casting and rolling (PROPERZI or SECIM processes).

The procedure followed in the foundry ensures excellent metal quality and, inter alia, excellent drawability.

**Packaging**

2 tonnes coils.

**Material condition**

> Diameter

Normally 9.5 mm.

> Mechanical and electrical properties

137072 is usually supplied in the partially work-hardened condition R11:

UTS: 105 to 120 MPa

Elongation > 10%

<table>
<thead>
<tr>
<th>Temper</th>
<th>Min</th>
<th>Max</th>
<th>Typical</th>
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<tbody>
<tr>
<td>UTS</td>
<td>105</td>
<td>120</td>
<td>110</td>
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**Electrical properties to 20°C**

<table>
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<th>Resitivity</th>
<th>Conductivity</th>
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</tr>
</thead>
<tbody>
<tr>
<td>max. mΩ cm</td>
<td>min. mS/mm²</td>
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</tr>
<tr>
<td>2.860</td>
<td>35.0</td>
<td>60.3</td>
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</table>

(1) MPa = 0.1 hbar = 0,102 kg/mm² = 145 psi

(2) see conversion table in appendix 1.

**Physical properties at high temperature of drawn 3.29mm wire**

**After 5h at 200°C:**

IACS = 60.5 +/- 0.3

UTS > 96% of Initial UTS

**After 400h at 180°C:**

IACS = 61.1 +/- 0.3

UTS > 94% of Initial UTS

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610145 | 610155 | 610166
Redraw Rod – Continuously Cast and Rolled
The CCR (Continuous Casting and Rolling) ALMELEC® rods are aluminium-magnesium-silicon alloys developed specially by TRIMET for the manufacture of conductors for overhead transmission and distribution lines (AAAC type) and the manufacture of the neutral catenary of bundled cables.

A suitable combination of thermal and mechanical treatments confers twice the mechanical strength of conductor-grade aluminium (137050) with a loss of only 10 to 15% in terms of electrical conductivity.

The 3 grades are able to meet all current requirements and relevant specifications.

**Description**

**Specified composition**

3 products grades are currently manufactured, namely: 610145, 610155 and 610166 to standards of composition which comply with the European standard EN-573-3 and the ALUMINUM ASSOCIATION specifications for alloy 6101.

<table>
<thead>
<tr>
<th>Elements</th>
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<th>Max</th>
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</thead>
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<tr>
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<td>Fe</td>
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<td>0.32</td>
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<tr>
<td>Cu</td>
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<td>0.01</td>
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<tr>
<td>Mn</td>
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<tr>
<td>Mg</td>
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<tr>
<td>Cr</td>
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<tr>
<td>Zn</td>
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<td>0.09</td>
</tr>
<tr>
<td>V</td>
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<td>0.10</td>
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<tr>
<td>Ti</td>
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<td>0.10</td>
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<tr>
<td>Others</td>
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<tr>
<td>Total</td>
<td>0.40</td>
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Works production tolerances on composition are in fact closer than tabulated above.

**Packaging**

Coils of 1800 kg.

**Production process**

The redraw rod is produced from primary liquid metal by continuous casting and rolling (PROPERZI or SECIM processes). The procedure employed in the foundry ensures excellent metal quality, hence, excellent drawability and cable-stranding characteristics.

**Material condition**

> Diameter
The usual diameter is 9.5 mm.
Other diameters (7.5 - 12mm) can however be supplied to order.

> Temper
The rod is supplied in one of two tempers:
F: i.e. as-rolled, provided the cable manufacturer possesses suitable heat treatment and quenching facilities.
TS: ie heat treated, quenched and dried if such facilities are not available (T4 temper).

Quenching ensures high mechanical strength in the end-product after final artificial ageing. The purpose of drying is to avoid the risk of any undue oxidation of the rod in the centre of the coil.

**IMPORTANT**

As a general rule, the redraw rod should preferably be drawn within 4 to 6 months of quenching in view of the slight hardening which results from natural ageing.

The sooner the wiredrawing operation is carried out, the easier it is.

**Mechanical and electrical properties**

> Rod supplied in temper F: TRIMET offers no guarantee as to tensile strength.
> Rod supplied in temper TS (T4 temper): quenching procedure employed by TRIMET for ALMELEC redraw rod in this temper ensures uniform characteristics throughout coils weighing from 1.500 to 1.800 kg, according to rod diameter. This characteristics meet the European standard EN1715-2: Aluminium and aluminium alloys. Drawing stock. Part 2-Specific requirement for electrical applications.
This being so, mechanical and electrical properties as measured on the redraw rod cannot be employed for production control purposes and are given here merely for the sake of illustration.

### Physical properties

- **Density**: 2.700 kg/m³
- **Modulus of elasticity**: 69,000 MPa
- **Thermal conductivity at 20°C**: 220 W/m°C
- **Coefficient of linear expansion over the range 20 to 100°C**: 23 x 10⁻⁶ °C⁻¹
- **Temperature correction factor for resistivity**: 3.6 x 10⁻³ °C⁻¹
- **Specific heat**: 960 J/kg°C

### Wiredrawing

#### Metallurgical aspects

The conversion of the quenched ALMELEC® redraw rod to the final wire or cable involves the following series of operations:

- **> wiredrawing to the final diameter**,  
- **> artificial ageing treatment**,  
- **> stranding.**

The properties of the drawn wire are checked after the artificial ageing process.

This ageing/recovery treatment is required in order to achieve a satisfactory combination of mechanical and electrical properties and in particular a level of electrical resistivity satisfactory to the applicable standards for overhead conductors.

#### Effect of wiredrawing on properties – Work hardening curves

The wiredrawing operation increases mechanical strength by virtue of work hardening: the smaller the diameter of the drawn wire, the higher its ultimate tensile strength. In addition, wire drawn on a non-slip machine will exhibit higher tensile strength than that drawn on a slip machine because of a greater degree of heating in the latter case.

### The effect on properties of the final artificial ageing treatment

Following curves illustrate variations in tensile strength and resistivity with treatment time at various treatment temperatures. For example, in the case of treatment at 160 °C:

- **> Tensile strength** increases by 10 to 50 MPa over the first hour (i.e. actually spent at the treatment temperature) and then falls by 3 to 4 MPa per hour on average.
- **> Resistivity** falls by approximately 0.1 µΩ cm over the first hour (actually spent at temperature), then, ever more slowly, by approximately 0.15 µΩ cm over the next 5 hours (making a total fall of approximately 0.25 µΩ cm over 6 hours at 160 °C).
In sum, therefore, after initially improving both tensile strength and electrical conductivity (over the first hour), the artificial ageing treatment then slowly, over the next few hours, improves conductivity at the cost of a gradual lowering of tensile strength.

The artificial ageing treatment time therefore has to be limited to the minimum needed to yield the electrical conductivity specified by the relevant standards, plus a sufficient margin of safety. The treatment time required shortens with increase in treatment temperature.

Also, assuming the same treatment temperature, a given resistivity will be obtained in a much shorter time:

> with 610155 than with 610166 (in approximately two-fifths of the time),
> with wire drawn on a slip machine than with wire drawn on a non-slip machine (approximately three-fifths).

In practice, however, since precipitation phenomena and changes in properties induced by artificial ageing will both be faster by higher treatment temperatures, it can be easily understood that temperature gradients in the treatment oven and the thermal inertia of the mass of metal comprising the coil will both negatively influence the uniformity of properties and make it more difficult to control accurately the treatment process at 170°C than at 160°C. It is therefore strongly recommended that the lowest possible treatment temperature and longest possible treatment time be employed.

**Mechanical and electrical properties after drawing and artificial ageing**

For any given resistivity, the mechanical strength of drawn and artificially aged will increase with:

> the concentrations of the alloying elements magnesium and silicon,
> the degree of work-hardening (ratio of diameters of rod and wire).

The table below sets out typical mechanical properties for wires drawn down to various diameters from ALMELEC® redraw rod Grade 610155, dia. 9.5 mm, and Grade 610166, dia. 9.5 mm and 12 mm, respectively.

Resistivity in each case was 3.20 µΩ cm.

<table>
<thead>
<tr>
<th>TYPICAL ULTIMATE TENSILE STRENGTHS OF DRAWN AND ARTIFICIALLY AGED WIRE MPa*</th>
<th>Diameter of drawn wire mm</th>
<th>610155 - diameter 9.5mm</th>
<th>610166 - diameter 9.5mm</th>
<th>610166 - diameter 12mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>320</td>
<td>335</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>330</td>
<td>345</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>335</td>
<td>350</td>
<td>355</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>340</td>
<td>355</td>
<td>355</td>
<td></td>
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<tr>
<td>2</td>
<td>340</td>
<td>355</td>
<td>355</td>
<td></td>
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</table>

* MPa = 0.1 N/µm² = 0.102 kg/mm² = 145 psi
Wiredrawing

ALMELEC® is normally drawn at speed of 10 to 25 meters per second, depending on exit diameters, and using approximately 20 to 50% more power than needed for conductor-grade aluminium (137050).
Its drawability is of course inferior to that of 137050, particularly since it contains higher concentrations of alloying elements.
Recommended wiredrawing process conditions are as follows:

Slip or non-slip-machines
> Elongation per block (S-s x 100) less than 33% and close to 26%.
  - capstan diameter 400 mm minimum,
  - slip rate (slip machines) 1 to 3%.
Slip machines designed for elongations of 33% per block or fitted with small diameter capstans are to be classed as “difficult”, with particular reference to ALMELEC® 610166 but can frequently be employed to satisfactory effect.

Highly polished carbide or compax diamond dies:
> reduction angle 12 to 16°
> bearing length as short as possible and in no case exceeding one-quarter of diameter
> entry angle 100°

Unduly great reduction angles, in excess of 18°, are to be avoided because of the risk of cup-and-cone fracture. Particular attention should be given to careful radiusing of all edges and replacing dies before wear becomes significant.

Lubrification
> non-slip machines: mineral oils or greases,
> slip-machines: mineral oils.

Wherever possible, it is preferable not to employ the same machine to draw both copper and ALMELEC® because of the risk of contamination of the mineral oil by the emulsion employed in copper drawing. In fact, even small amounts of water (less than 0.5%) have a distinctly adverse effect on the lubricating properties, in addition to which any contamination of the drawn wire by particles of copper could impair corrosion resistance.

Lubrification with grease for the first reduction stage is always advisable.

Shelf life of quenched redraw rod
We recommended an interval of not more than 4 to 6 months between quenching and wiredrawing.

Artificial ageing

Treatment temperatures and times
These require to be optimised by reference to the equipment employed and to the following basic principles:

> Temperature 155 to 170 °C
  preferably: 150 to 155 °C for 610145
  155 to 160 °C for 610155
  160 to 165 °C for 610166

> Normally speaking, temperature differences through the coil should not exceed 5 °C (slightly more, if acceptance standards are not severe)

> Treatment time: 2 1/2 to 7 hours as determined by the alloy, temperature and equipment employed. Treatment time will be distinctly shorter for wire drawn on slip-machines than for drawn on non-slip machines (in the ration of approximately three to five).

Choice of oven
Forced-draught ovens should be employed and the charge well spaced out to ensure that the treatment temperature is reached at approximately the same time at every part of the charge.

The method of heating is not important. Only the quality of ventilation has to be watched to ensure uniformity of temperature throughout the charge.

Applications

The main use of ALMELEC® redraw rod is in the manufacture of bare cables (AAAC) for overhead power transmission and distribution lines.

A related application is the manufacture of the normally insulated carrier wire in preassembled stranded power distribution cables (in which the carrier wire also acts as the neutral).

Other application is the manufacture of wire for optical fiber cables (OPGW).
Other application for ALMELEC® redrew rod include various uses for mechanical purposes.

**New developments : ALMELEC® HC**

TRIMET has developed a new high conductivity ALMELEC® based on alloy 610155.

The aim is to improve the compromise between mechanical resistance and resistivity for typical applications.

**Standards relating to ALMELEC® wire (as drawn and heat treated)**

<table>
<thead>
<tr>
<th>Country</th>
<th>Standard</th>
<th>Type</th>
<th>Nominal conductivity</th>
<th>Nominal diameter &gt; mm</th>
<th>Minimal traction resistance MPa</th>
<th>Minimal elongation before rupture on 250mm %</th>
<th>Maximal resistivity each µΩcm</th>
<th>Mean of a lot µΩcm</th>
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</thead>
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<td>EUROPE (CENELEC)</td>
<td>EN 50183</td>
<td>AL 2</td>
<td>52.5</td>
<td>1.5</td>
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<td>325</td>
<td>3</td>
<td>3.284</td>
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<td></td>
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<td>AL 3</td>
<td>53</td>
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<td>3</td>
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<td>3.35</td>
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ELECTRICAL
Redraw Rod – Continuously Cast and Rolled
The fields of application for CCR* rod are virtually unlimited. They include insulated cables for low and medium voltage distribution networks, conductors for overhead lines, flexible cables for robotics, welding and railway engineering, cables using nickel-plated wire for aeronautical engineering, enameled wire for windings, etc.

Lightweight, easy to use, high electrical conductivity, corrosion resistance, lending itself well to surface treatments (nickel plating, anodizing, etc), are all some of the desirable features that make CCR* rod a particularly effective and economic material.

Day after day, TRIMET CCR* rod, already catering for the bulk of electrical applications, demonstrates its versatility and ability to meet new needs and requirements.

The CCR* 137050 CONDUCTAL® (equivalent to EC Grade) is extensively employed in the manufacture of insulated wires and cables for transport and distribution of electricity and the manufacture of bare conductors for overhead power transmission and distribution lines (of the AAC, ACSR, …).

The CCR* 610145, 610155, 610166 ALMELEC® rods are aluminium, magnesium and silicon alloys developed specially by TRIMET for the manufacture of bare conductors for overhead transmission and distribution lines (of the AAAC type) and the manufacture of the neutral catenary of bundled cables.

A suitable combination of thermal and mechanical treatments confers twice the mechanical strength of conductor-grade aluminium (137050) with a loss of only 10 to 15% in terms of electrical conductivity.

The CCR* 131050 ALUFLEX® rod is an Aluminium-Iron-Magnesium alloy used in the manufacture of fine gauge wire for:
> flexible cables for aeronautical engineering
> cables for automotive engineering
> braids and screens for cables.

Our products are delivered in 2 tonnes coils. Standard diameter of our wire rod is 9.5 mm with other possibilities upon request.
MECHANICAL
Redraw Rod – Continuously Cast and Rolled
MECHANICAL
Redraw Rod – Continuously Cast and Rolled
An incomparable range for mechanical engineering

The expertise acquired in CCR (Continuously Cast and Rolled) rod based on a substantial program of research and development has resulted in the creation of an outstanding range of aluminium alloys geared to mechanical engineering applications.

From rivets, superfine wire, bolts, screws or forging part, TRIMET CCR redraw rod matches a wide variety of requirements.

TRIMET CCR rod product range includes all the 1000 to 6000 series alloys, for numerous applications.

Our products are delivered in 2 tonnes coils. Standard diameter of our wire rod is 9.5 mm with other possibilities upon request.

Main alloying elements according Aluminum Association:

<table>
<thead>
<tr>
<th>Hardening by:</th>
<th>Alloy series</th>
<th>Main alloying elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold forming</td>
<td>1000</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>3000</td>
<td>Mn 0.5 to 1.5%</td>
</tr>
<tr>
<td></td>
<td>5000</td>
<td>Mg 0.5 to 5%</td>
</tr>
<tr>
<td>Age hardening</td>
<td>2000</td>
<td>Cu 2 to 6%</td>
</tr>
<tr>
<td>(+Cold forming)</td>
<td>6000</td>
<td>Mg &amp; Si 0.5 to 1.5%</td>
</tr>
</tbody>
</table>

Mechanical properties of MECAL® alloys (INDICATIVE data):

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WELDING
Redraw Rod – Continuously Cast and Rolled
Since more than ten years, this know-how has been extended to casting of welding or arc spray alloys.

TRIMET has developed this BE FREE® range of welding alloys without added beryllium (protection of welders).

Our products are delivered in 2 tones coils. Standard diameter of our wire rod is 9.5 mm with other possibilities upon request.

Main welding alloys with alloying elements according Aluminum Association:

<table>
<thead>
<tr>
<th>Hardening by:</th>
<th>Alloy series</th>
<th>Main alloying elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold forming</td>
<td>1XXX</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>4043</td>
<td>4043A</td>
</tr>
<tr>
<td></td>
<td>4047</td>
<td>4047A</td>
</tr>
<tr>
<td>Age hardening (+ Cold forming)</td>
<td>5356</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5183</td>
<td></td>
</tr>
</tbody>
</table>

INDICATIVE choice for welding alloys according to base material. Please refer to welding wire supplier.

Most common welding alloys are:
> Serie 1000: 1080
> Serie 4000: 4043 | 4043A, 4047 | 4047A
> Serie 5000: 5356, 5183

| Serie 1000 3000 | 1XXX | 1XXX |
| 5005 5050       | 1XXX | 1XXX |
| 5052 5454 5754  | 4XXX | 4XXX | 5XXX (1) |
| 5083 5086       | 4XXX | 4XXX | 5XXX 5XXX |
| Serie 6000      | 4XXX | 4XXX | 5XXX 4XXX |
| Alloys          | Serie 1000 3000 | 5005 5050 | 5052 5454 5754 | 5083 5086 | Serie 6000 |

(1) Attention has to be paid to intercrystalline corrosion of welded part.

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Coils Packaging specifications
Saint-Jean-de-Maurienne

Typical diameter
Coil

A. Height (coil only):
850 mm

B. Outer diameter:
1,200 mm for 1.8 t
1,400 mm for 2.0 t

C. Inner diameter:
540 mm

Typical diameter
Wooden pallet
All Size in mm ±5
**Coils Packaging specifications**

**Castelsarrasin**

**Typical diameter**

**Coil**

**A. Height (coil only):**
860 mm

**B. Outer diameter:**
- 1,400 mm for 2.0 t
- 1,440 mm for 2.2 t
- 1,500 mm for 2.4 t

**C. Inner diameter:**
740 mm

**Typical diameter**

**Wooden pallet**

All Size in mm ±5
Your contact person

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