The classic Aluminum Mode CAM
## Aluminum types

<table>
<thead>
<tr>
<th>Type</th>
<th>Composition</th>
<th>Tensile Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1xxx</td>
<td>&gt; 99 % aluminum</td>
<td>70…190</td>
</tr>
<tr>
<td>2xxx</td>
<td>Copper</td>
<td>190…570</td>
</tr>
<tr>
<td>3xxx</td>
<td>Mangan</td>
<td>100…350</td>
</tr>
<tr>
<td>4xxx</td>
<td>Silicium</td>
<td>170…380</td>
</tr>
<tr>
<td>5xxx</td>
<td>Magnesium</td>
<td>100…450</td>
</tr>
<tr>
<td>6xxx</td>
<td>Magnesium und</td>
<td>100…450</td>
</tr>
<tr>
<td>7xxx</td>
<td>Silicium</td>
<td>220…700</td>
</tr>
</tbody>
</table>
• **CAM – Classic Alu Mode**
  Software package to weld aluminum material.

• **IQR**
  Adaptive welding package for steel materials running from mild steel to UHSS (Ultra High Strength Steel)

• **CCR – Secondary Constant Current Regulation**
  Up to 7 seconds regulated current possible.
The Tool: MFDC inverter GeniusHWI

- Flexible configuration through software from factory.
- Later update possible at customers site.
- Suitable to run CAM and adaptive IQR welding for steel one unit.
- All major field bus systems available as EthernetIP or Devicenet.
- Available in wide power range from 80 to 600 KVA.
The CAM - overview
### Aluminium Parameter

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ALU</td>
<td>1000 ms</td>
<td>0.00 kA</td>
<td>0 ms</td>
<td>0 ms</td>
<td>15.00 kA</td>
<td>100 ms</td>
<td>85 kN/m</td>
<td>0 ms</td>
<td>0 ms</td>
<td>35.00 kA</td>
<td>140 ms</td>
<td>0 ms</td>
<td>6.00 kA</td>
<td>0 ms</td>
<td>0 ms</td>
<td>300 ms</td>
</tr>
</tbody>
</table>

**Force Before**: 500.0 daN
**Force Current Phase**: 300.0 daN
**Force After**: 500.0 daN
**Force Equalization Time**: 30 ms

**Regulation Mode**: ALU
**Program State**: Free
**Continue After Time Elapsed**: nan

**Real Values**:
- Cooling Time: 0.000 s
- Condensation Time: 0.000 s

---

**Aluminum Weld Cycle**

![Aluminum Weld Cycle Graph](image)

---

**CAM in XPegasus (HMI)**

---

**Module Group**: HWH
**Module Name**: 2012_10_17_DWH

---

**Show Main Times Only**: 

---

**OK**

---

**Close**
**Help**
Electrode geometry

- Small concave shape prevents electrodes to penetrate sheets.
- Penetration is related to the soft material and high current.
- Electrode material: Cu – Cr- Zr and electrodes with aluminum alloy.

For aluminum

Undressed caps

Small concave shape

High concave shape

For steel
Electrode forces related to its shape

Typ A

Typ B

Typ C

Typ D

Typ E

Typ F

<table>
<thead>
<tr>
<th>$d_1$</th>
<th>$d_2$</th>
<th>$d_3$</th>
<th>$l_1$</th>
<th>$l_2$</th>
<th>$\varepsilon$</th>
<th>$R_1$</th>
<th>$R_2$</th>
<th>$\alpha$</th>
<th>$F_{\text{max}}$ (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>6</td>
<td>10</td>
<td>18</td>
<td>3</td>
<td>83</td>
<td>8</td>
<td>32</td>
<td>5</td>
<td>2,5</td>
</tr>
<tr>
<td>16</td>
<td>6</td>
<td>12</td>
<td>20</td>
<td>9,5</td>
<td>4</td>
<td>40</td>
<td>6</td>
<td>15°</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>15</td>
<td>22</td>
<td>11,5</td>
<td>5</td>
<td>50</td>
<td>8</td>
<td>22°</td>
<td>6,3</td>
</tr>
</tbody>
</table>
During welding resistance spot welding of aluminum high electrode forces are required.

- The material expands very much with fast raising temperatures.
- A fast cooling of the expanded material leads to bad recrystallizations of the aluminum.
- The high force compresses the weld lens.
- Under this pressure recrystallizations is improved.
- Low electrode concave shape keeps remaining wall thickness high.
- Due to the high forces electrodes shall have larger diameter.
Overview

For resistance welding aluminum of the group 5000 to 6000 is suitable.

5xxx
• Difficult on high environmental temperatures.
• Simple to weld.
• Strength: 100 to 450 \( \frac{N}{mm^2} \).

6xxx
• No problems at high environmental temperatures.
• Heat related cracks may occur.
• Strength: 100 to 450 \( \frac{N}{mm^2} \).
## Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clamping of the material before welding</td>
<td>High force</td>
</tr>
<tr>
<td>Resistance raise while welding</td>
<td>Small force</td>
</tr>
<tr>
<td>Non-optimal recrystallization due to expanded lens</td>
<td>High force</td>
</tr>
<tr>
<td>Extreme expulsion due to oxide layers</td>
<td>Current profile to avoid expulsion</td>
</tr>
</tbody>
</table>
## Comparison in welding

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Steel</th>
<th>Aluminum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joining type</td>
<td>Melting process</td>
<td>Melting process</td>
</tr>
<tr>
<td>Typ. Weld current</td>
<td>12 kA</td>
<td>36 kA</td>
</tr>
<tr>
<td>Typ. gun force</td>
<td>3000 N</td>
<td>6000 N</td>
</tr>
<tr>
<td>Electrode type</td>
<td>Concave</td>
<td>flat</td>
</tr>
<tr>
<td>Typ. Inverter pwr</td>
<td>80 KVA</td>
<td>1600 KVA</td>
</tr>
<tr>
<td>Welding mode</td>
<td>Adaptive IQR or constant current</td>
<td>CAM</td>
</tr>
<tr>
<td>Mass production</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Tip dress cycle</td>
<td>high</td>
<td>Typ. 30-50 spots</td>
</tr>
</tbody>
</table>
References (examples)

• **CAM**: Audi, Mercedes (Voestalpine in USA, China, South Africa and China), VW

• **IQR**: VW global, Hyundai global, Kia, Audi, Skoda, Gestamp, Magna Europe, Ford Motor Europe, Camaco NE

• **Industrial**: Stihl USA, Magneti Marelli USA, Miele, Continental, TRW, Autoliv, Takata, ZF (shock absorbers)

• **Tiers**: Magna Europe, Kirchhoff, Gestamp, ISE Alabama, Ajin USA, Sungwoo Hitech, PWO Canada
**Support structure USA**

- **Alliance Engineered Solutions, Troy MI**
  Sales contact automotive USA

- **Stegner Controls, Auburn Hills MI**
  Test resistance welding lab, panel building according UL, installation, training facilities, import handling.

- **Huys Industries, Toronto (Canada)**
  Industrial sales and service, equipment repair.

- **Coldwater Machine, Coldwater OH**
  Friction Welding full service supplier USA
Thank you very much.