Aluminium Car Body Sheet: Alloys and Surface Pretreatments as System Solution

Aluminium-Karosserieblech: Werkstoffe und Oberflächenvorbehandlungen als Systemlösung

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Average Use of Aluminium Per Car
Western Europe

Source: European Aluminium Association
Aluminium Car Body Sheet - Requirements

Increasing use of Aluminium → Increasing requirements

- Formability
- Strength/age hardening
- Recycling
- Surface characteristics
- Tolerances
- Processability/automatisation
- Joining behaviour

+ Cost reduction
Car producers requirements

The requirements are usually specific depending on the application, the customer and his process chain.

Tailor made solutions are offered.
Car body sheet system to satisfy the customers needs: overview on presentation

- **car body sheet alloys**
  - for outer applications
  - for inner applications
- **surface topography**
- **chemical and electrochemical pretreatments**
- **prelubrication**
- **precoatings**
  - primers
  - prelacquers
AlMgSi car body sheet alloys for **outer** applications

- **AA 6016**: standard sheet alloy in Europe
  - Ac-120: mostly used, Ac-121: for improved bendability
  - Ac-122, Ac-140: Cu free alloys for increased strength
- **AA 6111**: standard alloy in N. America

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**Graphs**

- **Graph 1**: Mg content in weight % vs Si content in weight %
  - AA 6111 (+ 0.75% Cu)
  - Ac-120/Ac-121
  - Ac-122, Ac-140
  - AA 6016

- **Graph 2**: O.2% PS, MPa vs bending factor f
Influence of pre-stretching on bending factor of Ac-170 in comparison to Ac-120

bending longitudinal to RD, 1.0-1.2 mm sheet gauge; for flat hem: $f < 0.5$ for 1mm sheet gauge

**Ac-170 for superior bendability**
Increased age hardening response for AlMgSi alloys

- **good formability** in T4 temper
- **maximum increase of 0.2% PS** at < 190°C
  - **Process reliability**
- **saturation of 0.2% PS** at > 180°C
- **high strength after e-coat curing**: 0.2% PS ≥ 200 MPa (including 2% prestretching)
Increased age hardenability of AA 6016: Ac-120 PX and Ac-140 PX

![Graph showing increased age hardenability of AA 6016 with Ac-120 PX and Ac-140 PX. The x-axis represents age hardening temperature (°C x 20 min) ranging from 100 to 240 MPa, and the y-axis represents 0.2% proof strength (MPa) ranging from 100 to 240 MPa. The graph compares Ac-140 PX, Ac-120 PX, and Ac-120.]
Aluminium car body sheet alloys for inner applications

Advantages of Ecodal-608 (AA 6181A):
- increased strength due to age hardenability --> down gauging
- no stretcher strain marks --> suitable for visible inner panels
- same alloy family as outer sheet --> easier process scrap recycling
- formability sufficient for most panels

<table>
<thead>
<tr>
<th>AA</th>
<th>typical composition</th>
<th>typical tensile test data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>weight%</td>
<td>0.2% PS</td>
</tr>
<tr>
<td></td>
<td>Mg</td>
<td>Si</td>
</tr>
<tr>
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<td>3.0</td>
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<tr>
<td>5182</td>
<td>4.5</td>
<td>0.3</td>
</tr>
<tr>
<td>6181A</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>

1) temper: AA 5xxx: 0, AA 6xxx: T4
Ecodal-608 (AA 6181A): age hardenability

- **T4 (AA 6xxx) bzw. 0 (AA 5182)**
- **e-coat curing: 180°C x 30 min**
- **separate age hardening: 204°C x 30 min**
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Surface topography for car body sheet

- Established surface topography in Europe is EDT (Electric discharge texturing), transferred to the strip surface from texturized rolls during the last rolling pass.

3D plot of EDT structure measured by means of white light interference microscopy.
Advantages of EDT topography

- isotropic --> no directional influence on forming behaviour
- lubrication pockets lead to build up of hydrostatic pressure
  - --> low and regular friction coefficient
  - --> better formability than with Millfinish structure
  - --> less pick-up of work piece material on the tool surface
  - --> regular press parameters
- stochastic surface structure
  - --> good lacquer appearance
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- **Surface topography**

- **Chemical and electrochemical pretreatments**

- **Prelubrication**

- **Precoatings**
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Chemical and electrochemical pretreatments

Different types of pretreatments can be applied on the strip surface - depending on the customer requirements:

- degreasing
- pickling
- anodisation
- conversion treatments, e.g.
  - Ti- or Ti/Zr-fluoride based agents, without or with polymer addition
    --> mainly for hem flange bonding
    --> as pretreatment for primer or prelacquer application
  - PT2: silicate based agent: for structural bonding
Influence of strip pretreatment (conversion and dry lubricants) and corrosive exposure on adhesive bond strength

Tensile shear strength of adhesive bonds
alloy: AA 6016; adhesive: BM 1496

- Ti/Zr-fluoride
- Ti/Zr + Alub VS
- Ti/Zr + Alub ZX

- RT storage
- SCAB test, 8 weeks
- VDA 621-415, 10 rounds
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History of prelubricated sheet (Europe)

- 1987: Oil, 1-2 g/m², low viscosity
- 1990: First high volume supply
- 1995: 2nd generation dry lubricant: Alub VS
- 1997: Dry lubricant Alub ZX
- 1998: 3rd generation Alub XX
- 2001: DFL fully compatible with electrocoat bath

Source: C. Bassi, Sierre
Advantages of dry lubricated sheet

- surface protection during transport and storage
- automatic destacking of panels in the press shop
- no oiling operation
- no operators at line entry to remove interleave paper
- improved formability compared to drawing oil
- constant friction conditions during pressing --> robust pressing conditions
- increased stamping rate
- less problems with surface contamination
- compatible with mechanical joining and bonding
- removable with mild alkaline degreasing agents
- e-coat compatible products are available
Combination of conversion + lubrication + PX treatment on the Al strip = combination of the advantages

Saving of process steps: „lean“ production
**Alusuisse Combi Line (ACL), Sierre**

- dry lube
- PX
- chemical treatments
- continuous annealing furnace

**Algroup alusuisse**
primary materials and fabricated products

ETHZ Materials Day, 18.05.2001/M. Bloeck/22/05/01/22
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Precoated sheet: primers

- Sheet with **Bonazinc** primer coating is supplied since several years

Example:
use of Bonazinc primered AA 6016 sheet for a motor hood

- Plant trials are in progress with a new primer: **Granoccoat**
Advantages of primer coated sheet

- surface protection, e.g. during transport and handling
- improved formability (lubrication still required)
- protection against corrosion
- good basis for bonding
- good basis for lacquering, less influence of the Zn-phosphating conditions
- surface appearance of lacquered Al parts compatible with that of steel parts
Primer coated strip - benefit for car producer

- easier processing of Aluminium sheet on equipment optimized for steel
- suitable for use in mixed metal constructions steel/Zn-coated steel/Aluminium

! Limitations
- grinding of the formed panels --> reduction of the corrosion resistance
- not weldable --> bonding and mechanical joining
- recyclability (less value of process scrap)
Prelacquered car body sheet

Status

- Different types of prelacquered materials have been tested in cooperation with several customers
- Despite promising results up to now no introduction into production
Panels produced out of prelacquered sheet: examples

- chemical pretreatment: Ti/Zr-fluoride
- prelacquer as e-coat replacement: polyurethane primer + polyurethane stone-chip resistant coating

fender out of prelacquered AA 6016
front semi-structure out of prelacquered AA 5754
Future potential of prelacquered Al sheet

- **short to medium term**: use of sheets with e-coat replacement, e.g. for repair parts
- **long term**: use of sheet with e-coat and filler replacement or with full lacquer system, e.g. for mixed material car bodies with plastic panels (heat treatments limited to < 100°C)

**Precondition**: adaptation of processing concept and equipment at car producer
Nachterstedt
Annealing and Finishing Line

Treatment steps
- levelling
- continuous annealing followed by air or soft water quench
- electrolytic cleaning/anodising: 0.05 - 0.20 µm
- chemical pretreatment: chemcoater, No Rinse
- precoating: primers or prelacquers, roll coater, followed by curing
- lubrication
- lamination of protective film

- strip width: 1000 - 2300 mm
- strip gauge: 0.6 - 3.2 mm
- line speed, process part: max. 150 m/min, 268 m line length
- line capacity: 100 000 t/year
System solution according to customers needs

Contribution to success of Al sheet in large volume production of car bodies

- alloy
- topology
- lubrication
- chemical surface treatment
- processing
- application technique
- material data
- data on component performance

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Challenges for future developments

- **alloys**
  - further improved formability
  - increased strength to allow down gauging: 1.1 mm --> 0.9 mm --> ?
  - suitable for process with e-coat curing at < 160°C
- **pretreatments:** introduction of new, further improved treatments for structural bonding, e.g. strip anodisation
- **dry lubricants with further improved property profile**
- **introduction of prelacquered sheet**