Trends and recent developments in outer skin aluminium alloys

Constellium P&ARP

AluMag®
Europe ■ India ■ Americas ■ Asia
THE MARKET DEVELOPER

ROADSHOW 2014

Markus Gehrig

Packaging and Automotive Rolled Products
Zip Rhénane Nord RD52
68600 Biesheim, France
T : +33 (0)389 724578

Constellium

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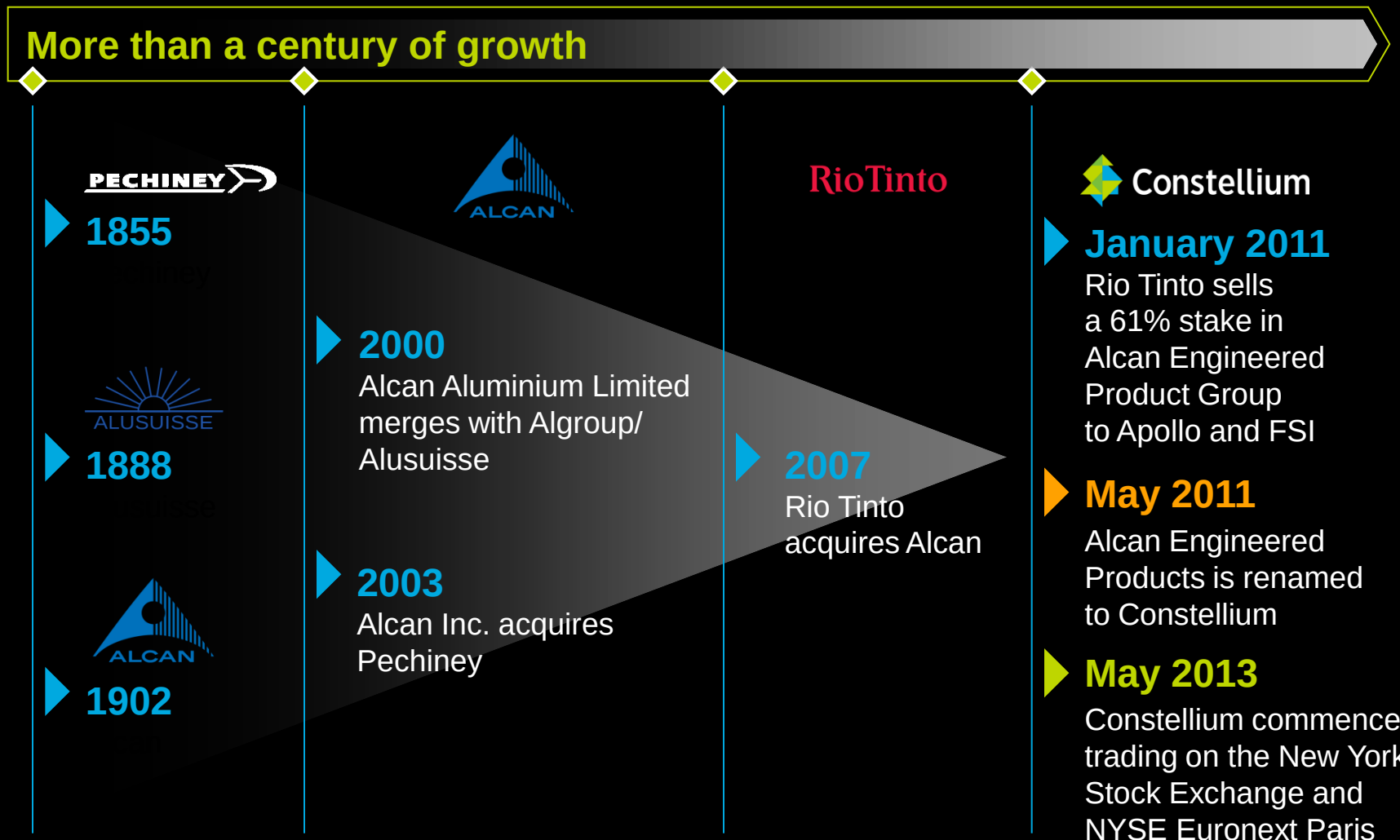
- Introduction
- Trends for skin alloy development
- Surfalex® **HF**
- Surfalex® **HS**
- Summary

Constellium

From Pechiney, Alusuisse, and Alcan to Constellium: A long and rich experience in Aluminium



Our customers: market leaders in their industries

Aerospace	AIRBUS AN EADS COMPANY, BOMBARDIER, EMBRAER, EADS, KAI, BOEING, DASSAULT AVIATION, SPACEX, LOCKHEED MARTIN
Packaging	REXAM, CROWN Brand-Building Packaging™, amcor, ArdaghGroup, CP CAN-PACK S.A., Ball
Automotive	Audi, GM, BMW, PSA PEUGEOT CITROËN, DAIMLER, Mercedes-Benz, BENTELER, PORSCHE, Valeo

Constellium is amongst the Key BiW suppliers for premium as well as volume oriented OEM

TOP CUSTOMERS

German Premium

- Mercedes Benz
- Audi
- BMW
- Porsche

European Volume

- Peugeot
- Citroen
- Renault
- Opel

US

- Tesla

Constellium expands capacity to meet booming demand

2014-2016: Increase production capacity of body-in-white (BiW) coils & sheets to follow OEM's

- **Neuf-Brisach (France) => + 120 000 T**
- **Singen (Germany) => + 20 000 T**

2014-2017: Build greenfield finishing capacity in the US through a JV with UACJ

- Combined capacity **>100 000 T**

➢ 200´000 T

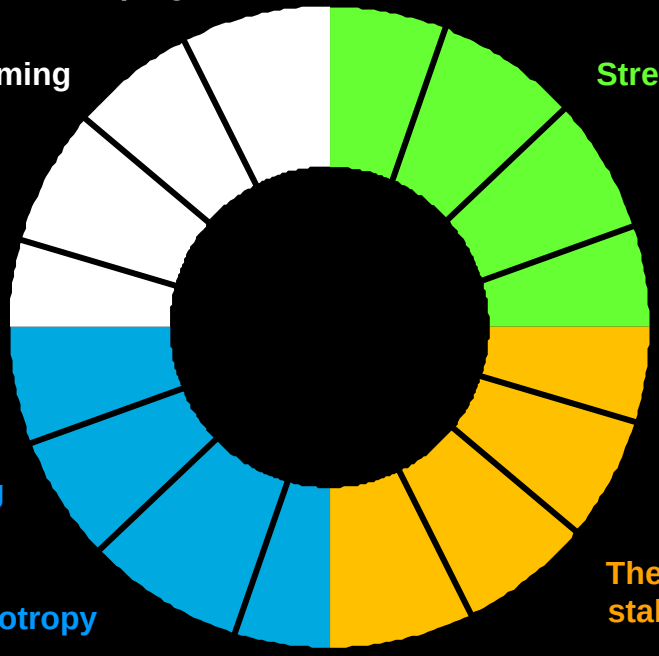
"*Constellium to invest up to €200 million to add significant Body-in-White production capacity in Europe to meet anticipated automotive market growth*" Amsterdam, 15 January, 2014

"*Constellium and UACJ announce plan to create Joint Venture in the United States to produce Body-in-White aluminium sheet for the automotive industry*" New York, January 23, 2014

A key trend for developments: No compromise

No compromise with
Aesthetics!

No compromise with
Light-weighting!



No compromise with
Design!

No compromise with
Safety!

Our portfolio today: our original products and our last generation of alloys

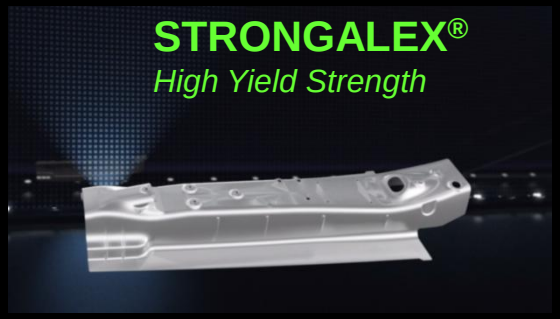
DR100/120/130

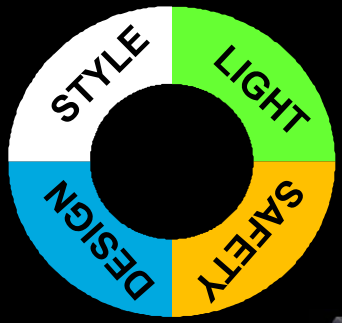
SURFALEX®
Perfect surface with excellent hemming

SURFALEX ® HF
Perfect surface with High Formability.

SURFALEX ® HS
Perfect surface with High Strength.

6016 X/DRX/RSX





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FORMALEX®
Forming optimized

FORMALEX® PLUS
Extra formability for complex shapes

SECURALEX®
Crash crushable alloy for structural parts

SECURALEX® HS
High Strength Crash Crushable

SECURALEX®P5/P6
Pedestrian Safety alloy

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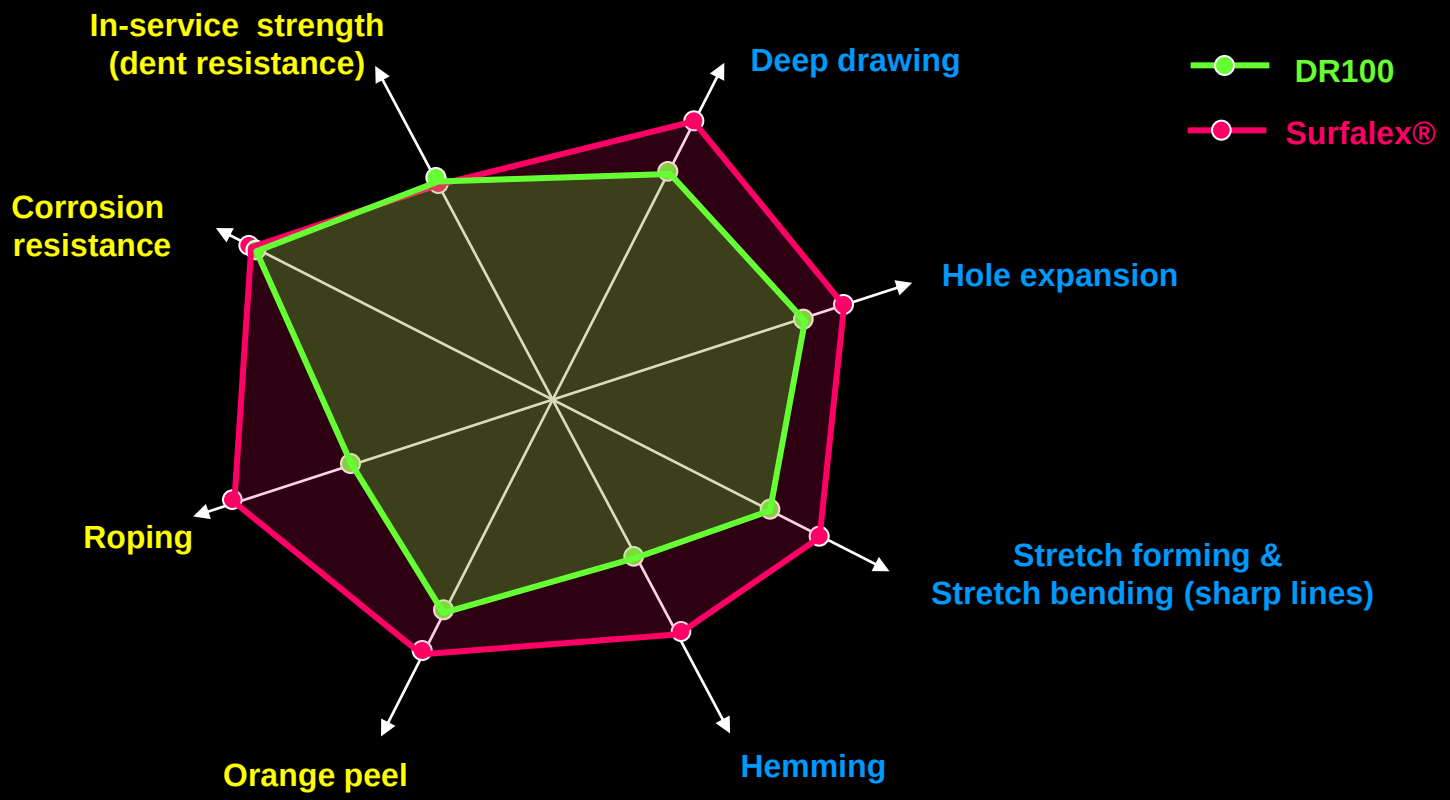
Outer skin alloys requirements

Constellium development strategy is towards overall improvement of the balance of properties, not just improving one property at the expense of another.

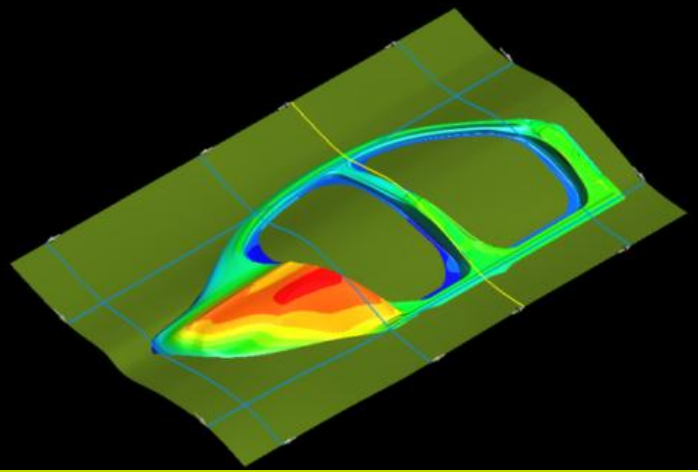


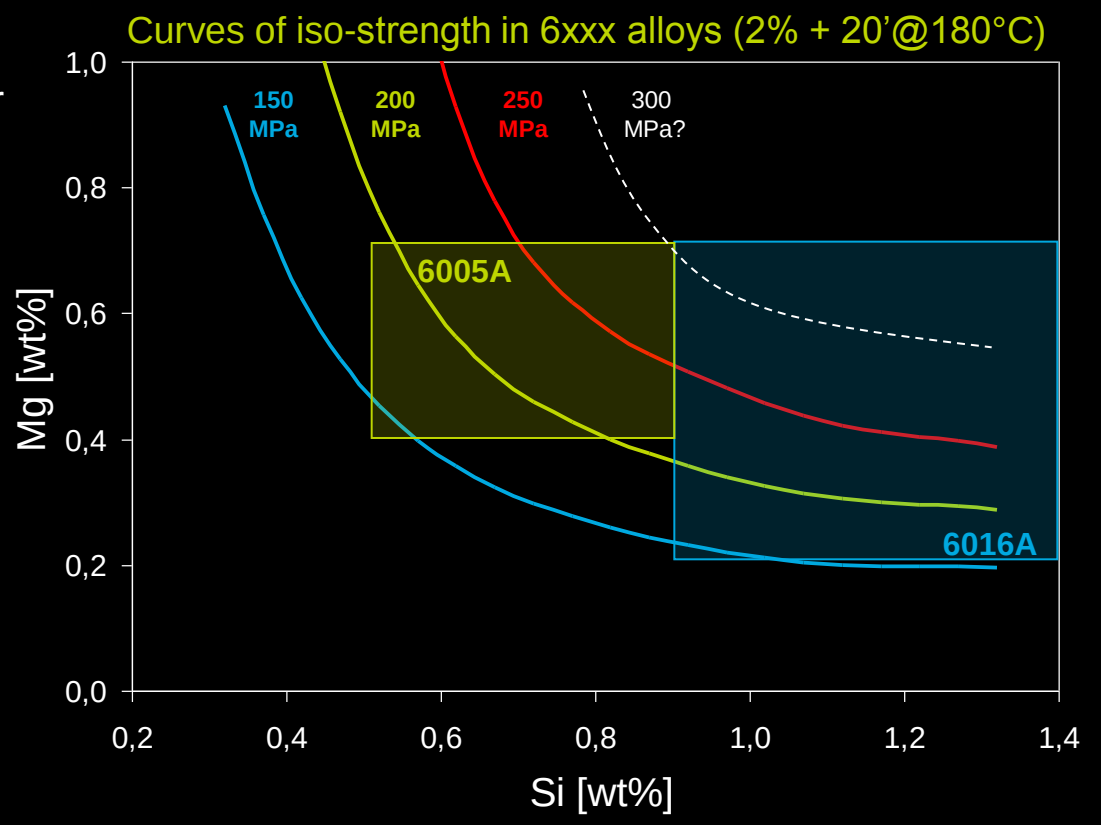
In-service performance **Ability to form the part**

Strength: Need for higher strength

- Constellium development strategy to develop best-in-class alloys at two strength levels =
  - Medium strength (around 200-220 MPa after paint bake)
  - High strength (around 240-260 MPa after paint bake)

- Possibly one additional level (lower strength) in future, driven by need for forming without design compromise for very difficult parts (e.g. full body side panels)





Formability: Strong need for better press formability

- Constellium development strategy is to design alloys that give better performance in real part stamping rather than incremental improvement in specific strain modes.

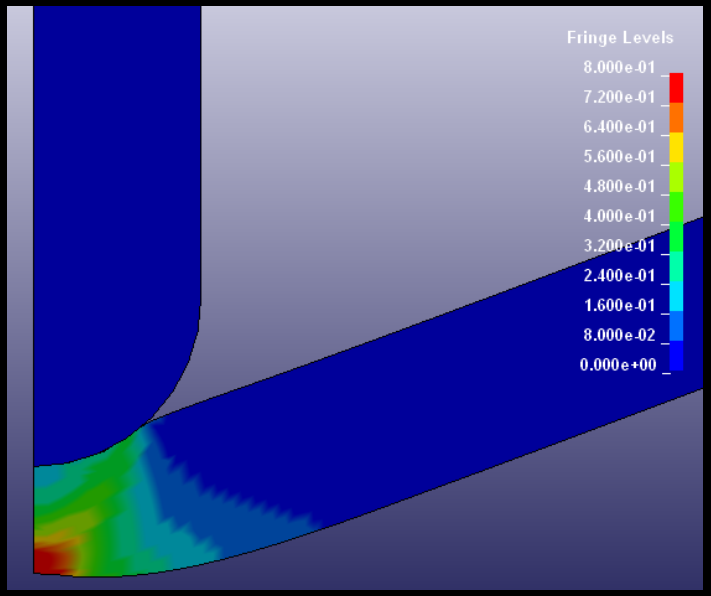
- We use numerical simulation of stamping (Autoform) to define the material needs for different real parts. First we design virtual alloys that allows a given part to be formed, then we work on chemical composition and process route to get these mechanical properties

- Several traditional target material properties (n_5, r_{10}, Δr, A_{80} etc) are not good indicators of the ability to form real, complex part in 6xxx-series aluminium alloys.

- Key development target for us is enhanced **work hardening at medium strains**.

Formability: Current design require sharp lines

- Request from most OEMs for skin alloys that allow for very sharp lines = character-lines
- Sharp line on the part = small **external** radius (internal tool radius + ~sheet thickness)

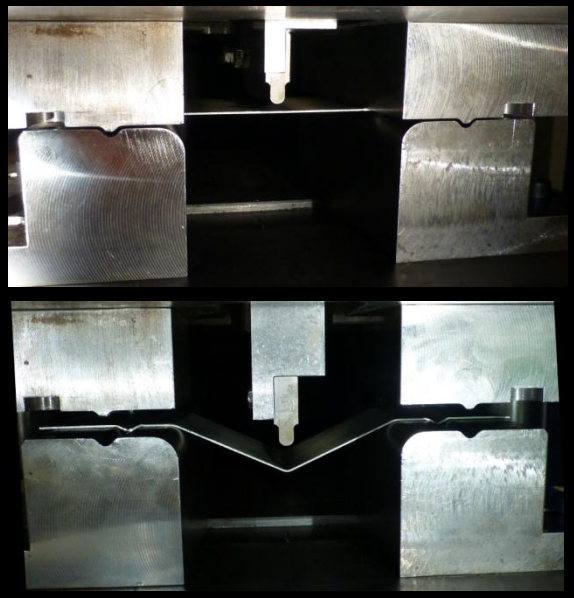


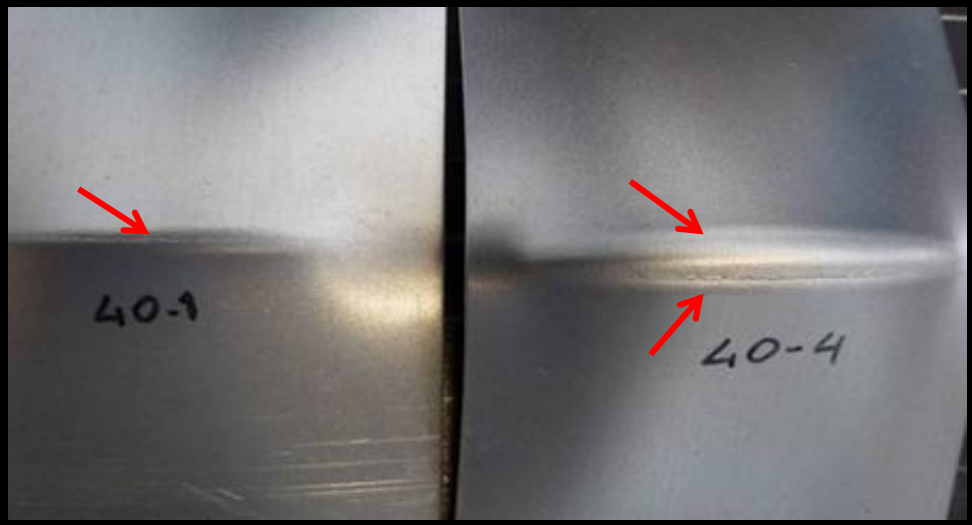
2D LS-Dyna model of sheet stretch-bending over sharp inner radius

Formability: Current design require sharp lines

- We test the alloys ability to form sharp lines on laboratory scale using stretch-bending

- Failure mode is cracking on the bend when using small inner radii (r/t < 3) and necking the edge of the punch nose when using larger inner radii





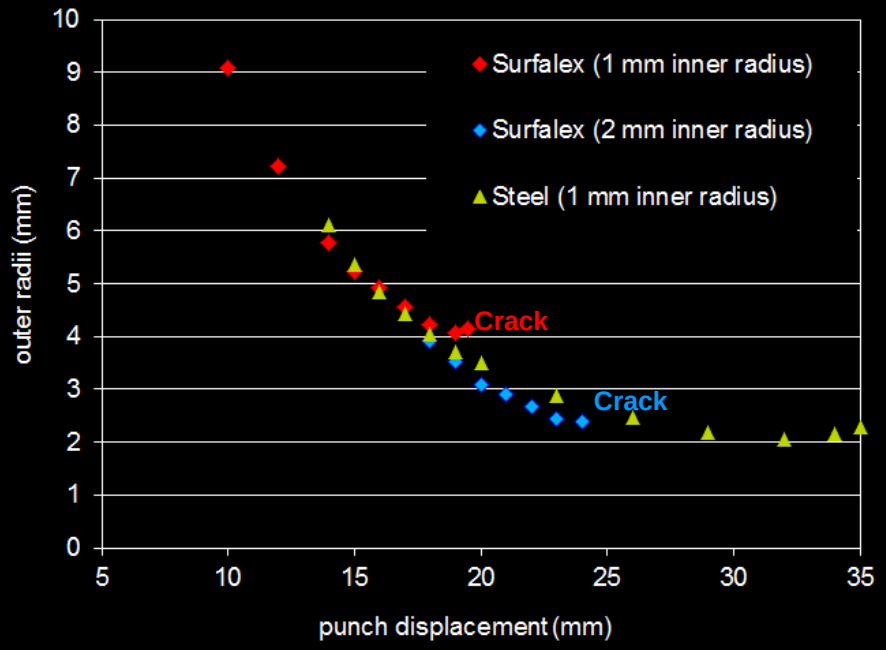
Stretch bent samples over 1 mm (left) and 4 mm (right) tool radius.

Formability: Current design require sharp lines

- Independent of the material (different aluminium alloys or steel grades) the outer radius is determined by geometric restrictions (tool inner radius & the sheet thickness) at a given depth of stretch forming

- Sharpest outer radius is achieved with alloys that allow deep stretching without failure when using sharp inner tools.

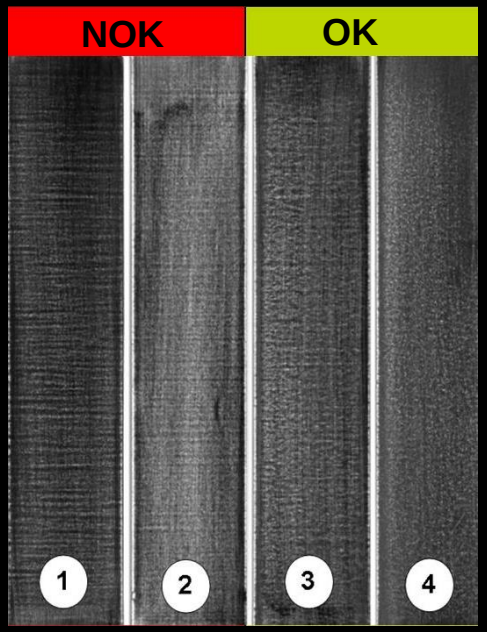
- Best results for aluminium are achieved with medium strength alloys with optimized bendability and optimized tool inner radius.

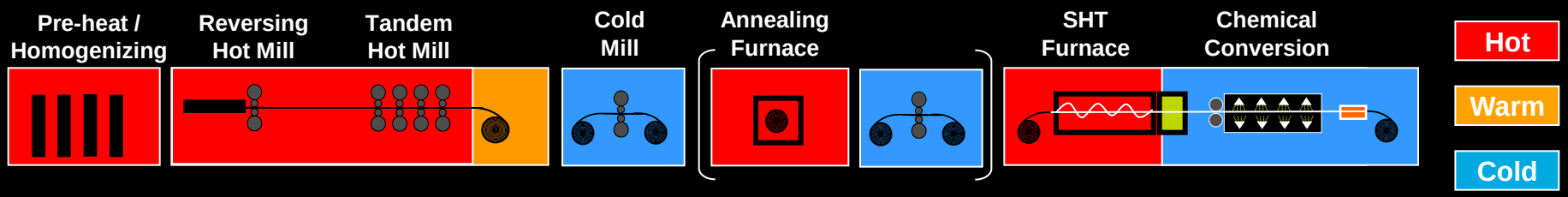


Outer radius as function of punch displacement for 1 mm gauge sheet materials

Surface aspect: Trend towards perfect surface

- Trend towards thinner paints mean less tolerance for surface disturbance and/or roping lines after forming.
- Non-uniformity in the surface during forming operations in 6xxx alloys is caused by preferential crystallographic orientation of grains / colonies of grains.
- Can be controlled by appropriate hot / cold rolling schedules.
- Improving the surface aspect is not normally a trade-off against other properties.





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Constellium

Surfalex® HF

- Surfalex® HF is developed for **improved stamping formability of complex parts** at medium in-service strength level.
- No compromise has been made with other key properties.
- The alloy composition is within the norm of AA6016

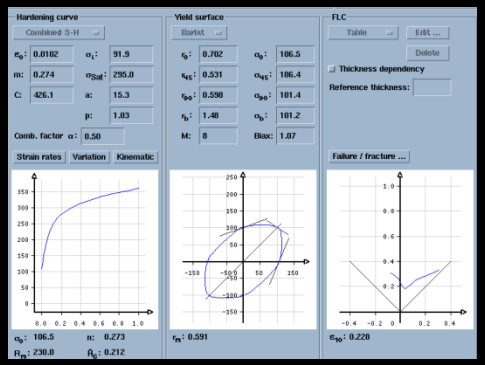
Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Ni
1,0 – 1,5	<0,30	<0,20	<0,20	0,30 – 0,60	<0,10	<0,10	<0,10	0,10

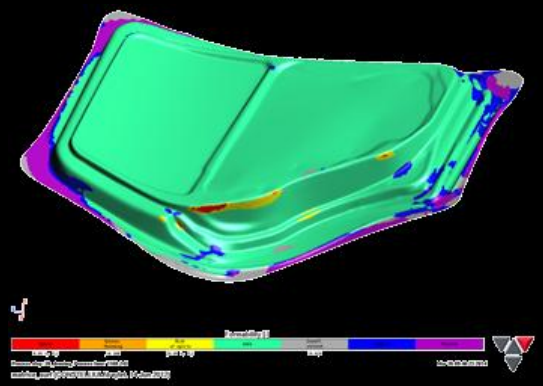
- Available dimensions and conditions:
  - Width: max. 1820 mm as standard
  - Thickness: 0.7 – 1.5 mm
  - Surface: EDT or Mill Finish, with / without conversion coating.
  - Lubrication: stamping oils, protection oils or hot-melt dry lubricants
  - Cut to length: rectangular, trapezoidal and curve cuts

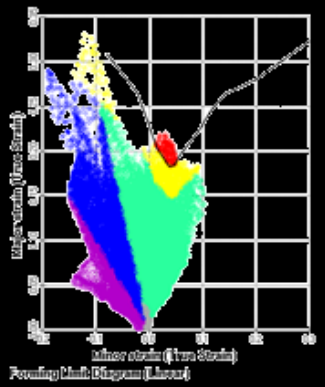
Surfalex® HF: Formability

- Surfalex® HF gives clear formability improvement both in simulation and in prototype stamping trials of complex parts.

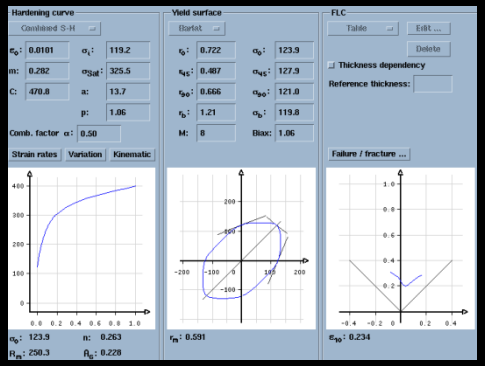
Surfalex®

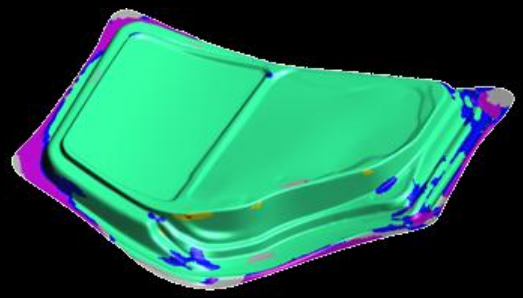


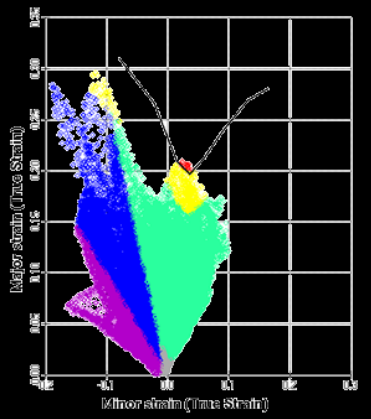




Surfalex® HF





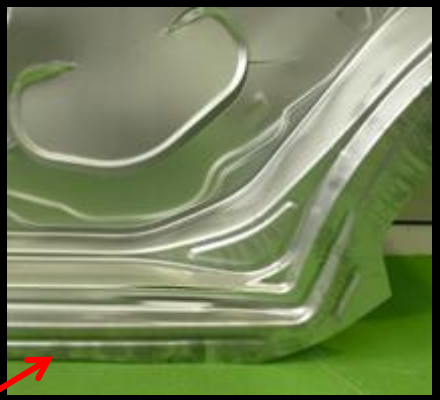


Surfalex® HF: Formability

- Constellium internal stamping trials using difficult door inner tooling

Surfalex®

Surfalex® HF



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Constellium

Surfalex® HS

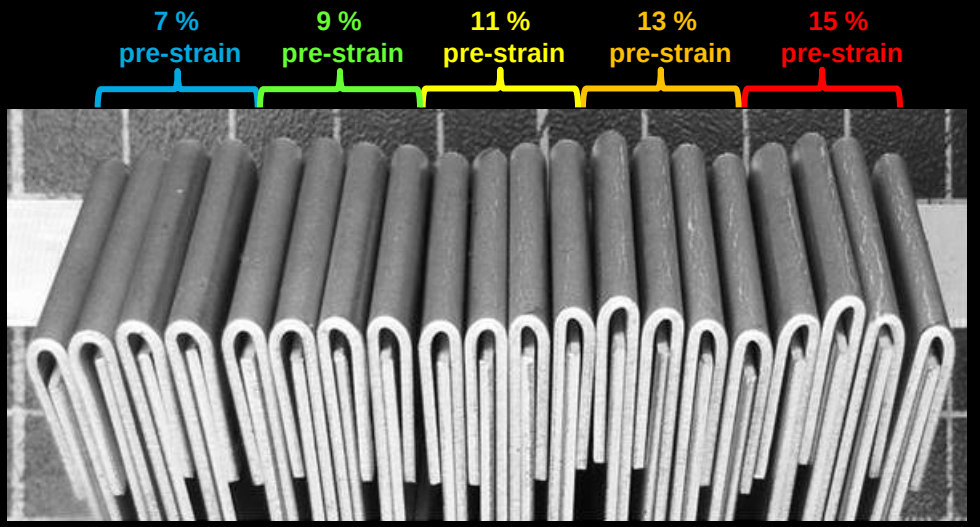
- Surfalex® HS is developed for higher in-service strength, allowing for downgauging, while maintaining very good hemming performance.
- The alloy composition is within the norm of AA6005A

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Ni
0,5 – 0,9	<0,35	<0,20	<0,20	0,50 – 0,70	<0,10	<0,10	<0,10	0,10

- Available dimensions and conditions:
  - Width: max. 1920 mm as standard
  - Thickness: 0.7 – 1,5 mm
  - Surface: EDT or Mill Finish, with / without conversion coating.
  - Lubrication: stamping oils, protection oils or hot-melt dry lubricants
  - Cut to length: rectangular, trapezoidal and curve cuts

Surfalex® HS: Hemming

Surfalex® HS allows flat hemming at more than 10% pre-strain with no cracks or orange peel



Reference: Surfalex® allows flat hemming at more than 15% pre-strain with no cracks or orange peel

Surfalex® family: Typical mechanical properties

- All Surfalex® product have the same excellent surface quality, roping performance and corrosion resistance.

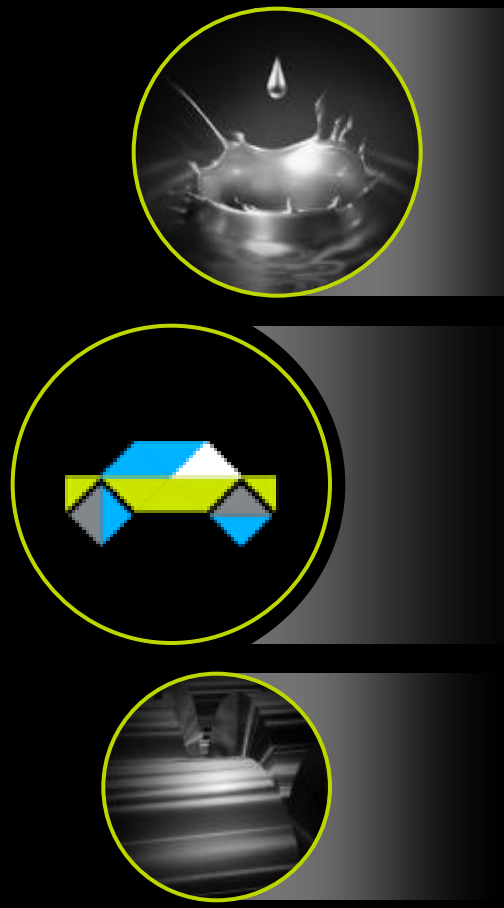
	As supplied (T4) TD						After PB*	
	Rp0.2	UTS	A80%	n_5	r_{10}	VDA bend	Rp0.2	UTS
Surfalex®	95 – 120	180 - 210	25	0,29	0,63	>145°	**~210**	~280
Surfalex® HF	95 - 120	180 - 210	27	0,29	0,67	>145°	**~210**	~280
Surfalex® HS	110 - 140	220 - 250	25	0.27	0.67	>145°	**~240**	~300

* 2% + 20'@185°C

NB: these properties are not the best descriptors of the real performance of the alloys.

Summary

- Key trend for skin alloy developments = no compromise of design freedom when converting from steel to aluminium.
- For outer skin aluminium alloys the key driver for development is therefore improved stamping press formability without compromising surface appearance, corrosion resistance or in-service strength.
- Today we offer two new products to the Surfalex® family of leading skin alloys.



- THANK YOU VERY MUCH
- VIELEN DANKE FUR IHRE AUFMERSAMKEIT
- MERCI BEAUCOUP POUR VOTRE ATTENTION

Back-up:
Recent inners & structural alloys developments

Constellium P&ARP

AluMag®
Europe • India • Americas • Asia
THE MARKET DEVELOPER

ROADSHOW 2014

Constellium

Our portfolio today: our original products and our last generation of alloys

DR100/120/130

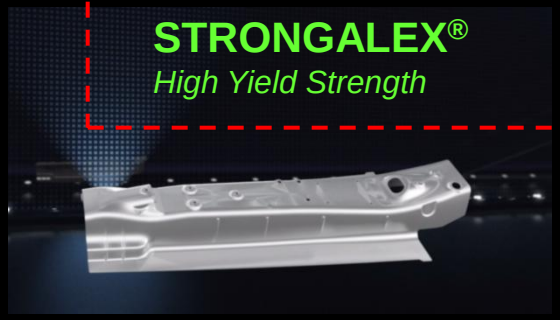
SURFALEX®
Perfect surface with excellent hemming

SURFALEX ® HF
Perfect surface with High Formability.

SURFALEX ® HS
Perfect surface with High Strength.

6016 X/DRX/RSX

STRONGALEX®
High Yield Strength



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FORMALEX®
Forming optimized

FORMALEX® PLUS
Extra formability for complex shapes

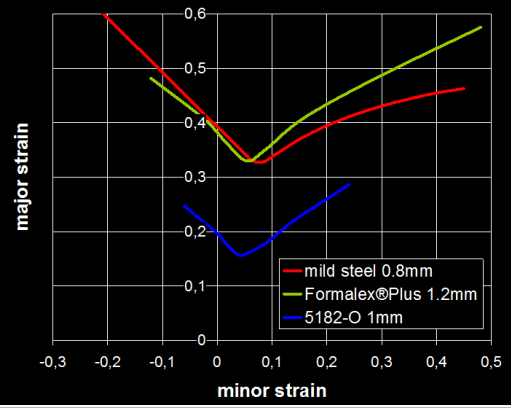
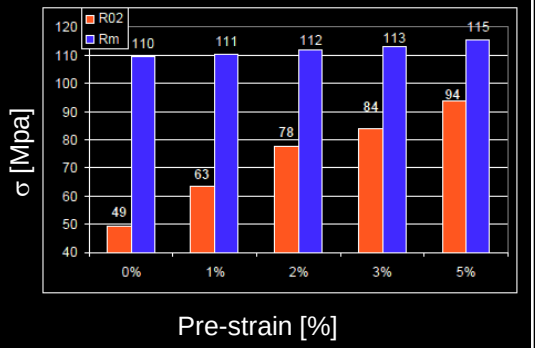
SECURALEX®
Crash crushable alloy for structural parts

SECURALEX® HS
High Strength Crash Crushable

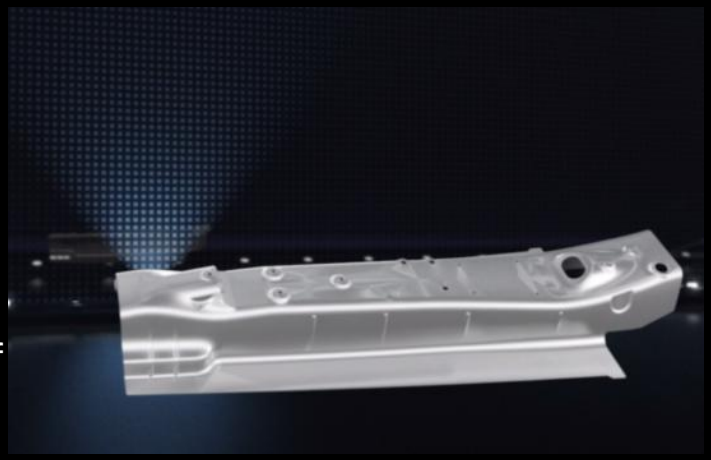
SECURALEX®P5/P6
Pedestrian Safety alloy

FORMALEX®PLUS

- FORMALEX®PLUS has the same forming possibities than midl steel: no compromise with design

Formability	Mechanical Properties	Filliform Corrosion
		
Formability similar to mild steel: siemilar geometries achieavabl	In the lower range of aluminium alloys, but may be tuned according to needs with limited impact on formability	No filliform corrosion sensitivity with dedicated Constellium surface preparation

STRONGALEX®



- STRONGALEX® is a structural alloy, compatible with conventional cold forming and resistant to any type of corrosion
- It allows significative lightweighting versus conventional 5xxx solutions

5182 O in service		
TYS	UTS	A%
~140	~270	~24%

STRONGALEX® afterPB (2%+ 20'@185°C)		
TYS	UTS	A%
>250	>300	~17%

SECURALEX®HS

- SECURALEX®HS has been designed as a higher strength crash alloy with excellent crashability

SECURALEX® after PB (2%+ 20'@185°C)		
TYS	UTS	Axial Crash
180	235	No cracks

SECURALEX®HS after PB (20'@185°C)		
TYS	**UTS**	**Axial Crash**
>220	**>270**	**Very few cracks, < 5 mm**