Material Specifications & Recycling for the 2015 Ford F-150

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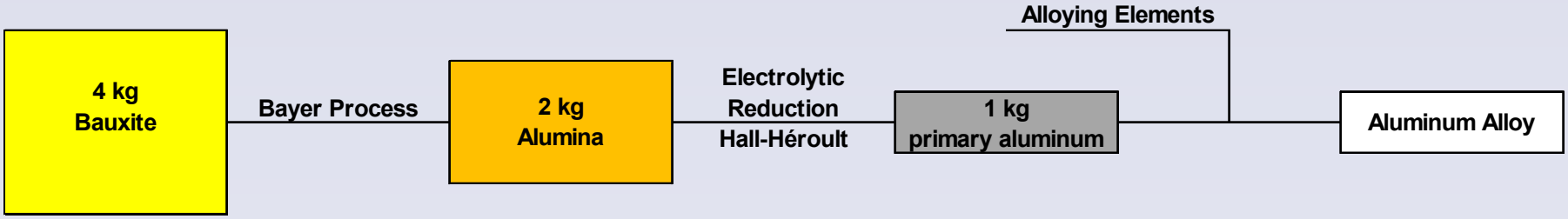
Overview

- Definitions & Introduction
- Concept for the new specifications
- Recycling Implementation
- Conclusions

Making & Recycling aluminum



- **Bauxite is abundant** - aluminum compounds make up ~8% of the Earth's crust
- Top 5 largest deposits in Guinea, Australia, Vietnam, Jamaica and Brazil
- It takes ~47MJ (13kWh) to produce 1 kg of primary aluminum
- **Primary** aluminum is **pure aluminum**
- Aluminum is highly recyclable
- **Secondary** aluminum is **recycled aluminum alloys**

Recycling aluminum

- A shipment of secondary aluminum could be a single or a mixture of aluminum alloys.
- Mixed alloys ⇔ lower value

⇨ *Definitions:*

- **Tolling** ⇔ recycling one alloy into itself. This means sorting non-compatible scrap streams. Maximum value.
- **Recycling** ⇔ recycling a mixture of aluminum alloys into the secondary market as a lower purity product, for example sheet into castings. Lower value.

75 percent of all aluminum produced in the US since the early 1900's is still in use

Drivers for Tolling Aluminum

- Recycling aluminum = only 5-8% of the energy required to extract it new from bauxite.
- Aluminum is expensive
- Aluminum pricing is based on the commodity market ⇔ pricing is volatile

Tolling

- Good for the life cycle energy equation
- Lowers material costs
- Minimizes dependency on primary aluminum ⇔ stabilizes raw material costs

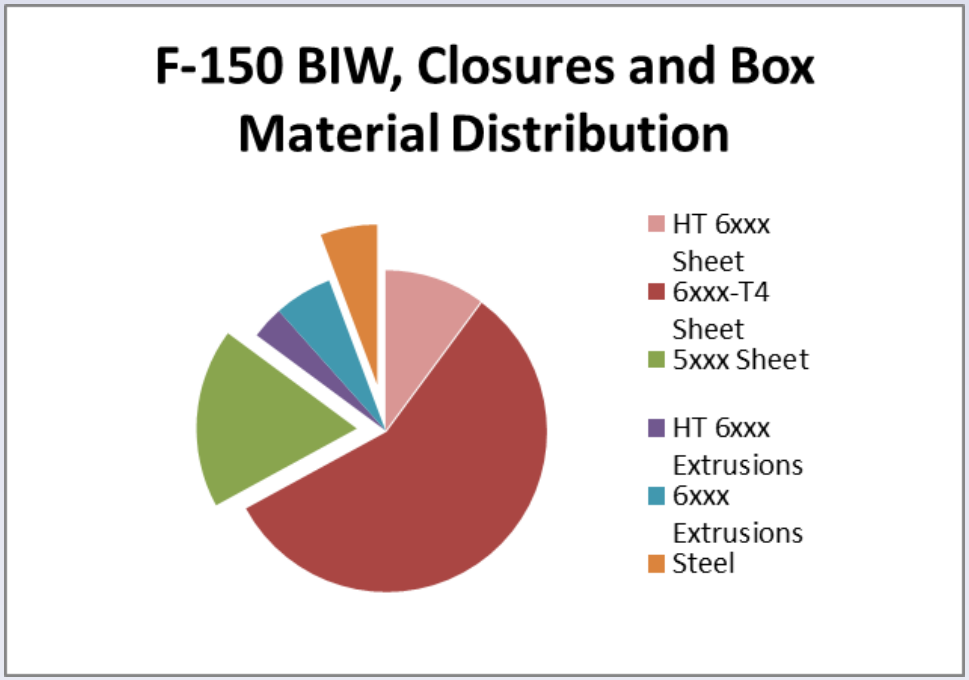
For the F-150 enterprise:

- 87% of the total stamping scrap is tolled back to Novelis and ALCOA.
- Displaced 1/3 of the primary aluminum

Approach for F-150

- Tolling was a base assumption of the project
- Multi-disciplinary team:
  - Product Engineering
  - Materials Engineering
  - Stamping Engineering
  - Advanced Research Engineering
  - Purchasing
- 3 areas of focus:
  - Developing a set of recycling compatible specifications
  - Geographical consolidation of the consumption
  - Engineering a cost effective scrap handling system

F-150 at a Glance



- 2 assembly plants
- > 275,000,000kg/yr
- 3 aluminum sheet suppliers / 4 mills
- 7 alloys
- 11 unique supplier/alloy combinations

Cannot sort each of the 11 unique combinations of alloy & supplier!

Steel Grades vs. Aluminum Alloys

Steel sheet has evolved with the auto industry

⇨ *Commodity with a product engineering point of view*

- Focus on mechanical properties
- Chemistry not mentioned in body sheet specs

Aluminum sheet has evolved with the aerospace industry

⇨ *Engineered products*

- Aluminum Association controls alloy registration
- Chemistry as the first differentiator

⇨ **Steel Grades**
Aluminum Alloys

Specifying Approach

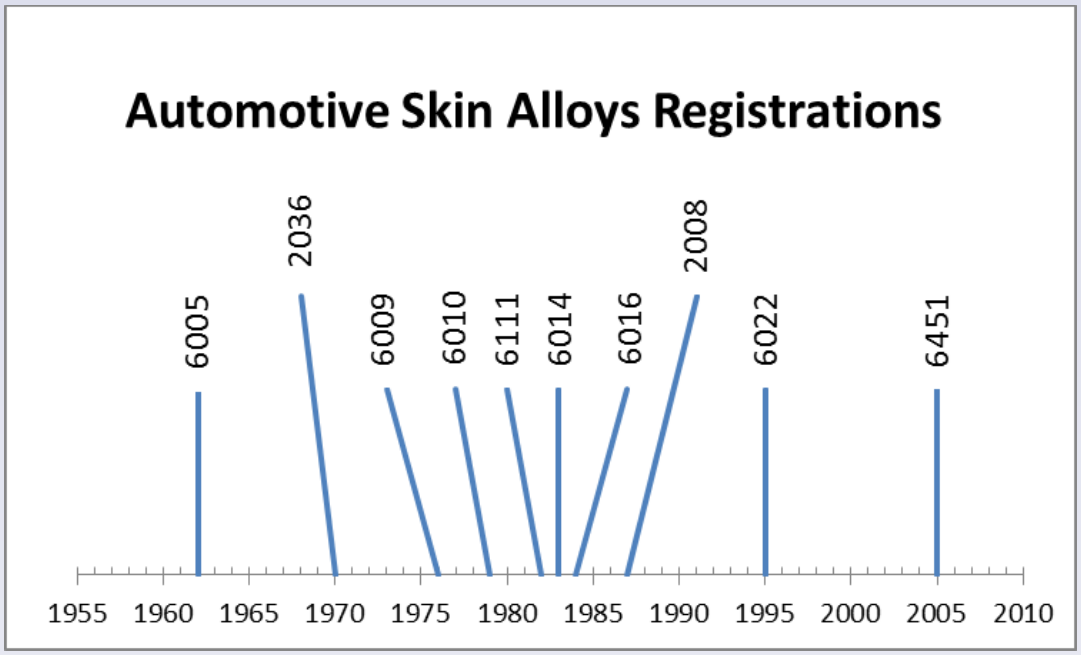
As an automotive OEM, we want to define:

- *Automotive aluminum grades,* not specific alloys
- *Compatible* grades between suppliers
  - Tolling scrap from one to an other without loss of value (multi-suppliers tolling)
- *Contamination tolerant* grades
  - Tolling re-melts tolerate small, accidental mixes
  - Added value end of life recycling

Specifying Chemistry

- 2 automotive sheet alloy families
  - 5xxx – Magnesium
  - 6xxx – Magnesium & Silicon
- 4 major alloying elements
  - Magnesium (Mg)
  - Manganese (Mn)
  - Silicon (Si)
  - Copper (Cu)
- 4 minor alloying elements
  - Zinc (Zn), Nickel (Ni), Chromium (Cr) and Titanium (Ti)

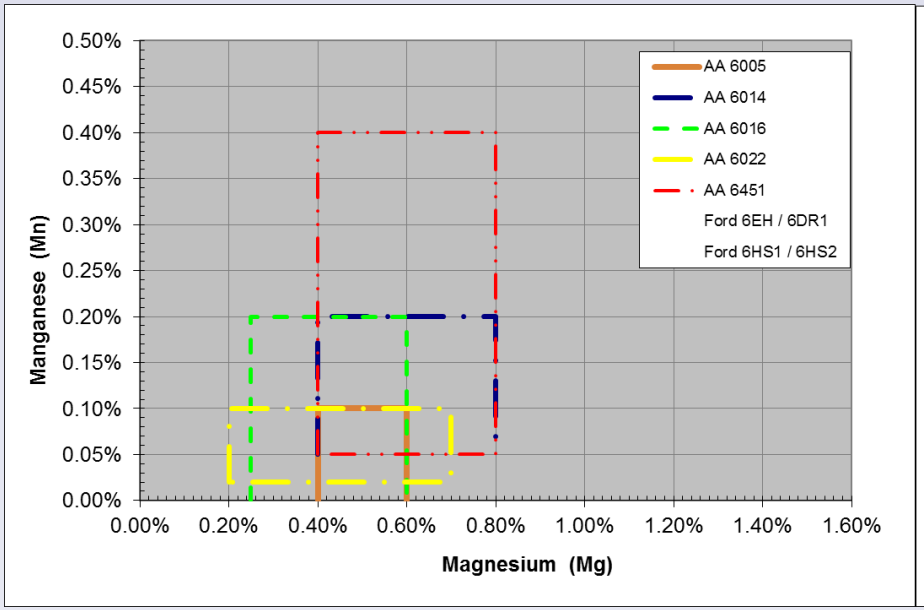
Skin Alloys

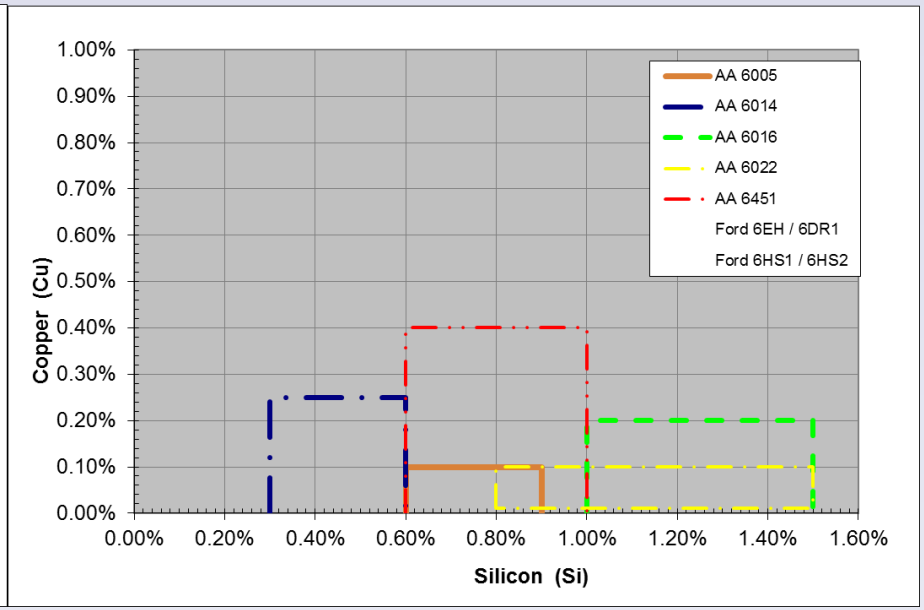


5 alloys still in use:

- 6005
- 6014
- 6016
- 6022
- 6451

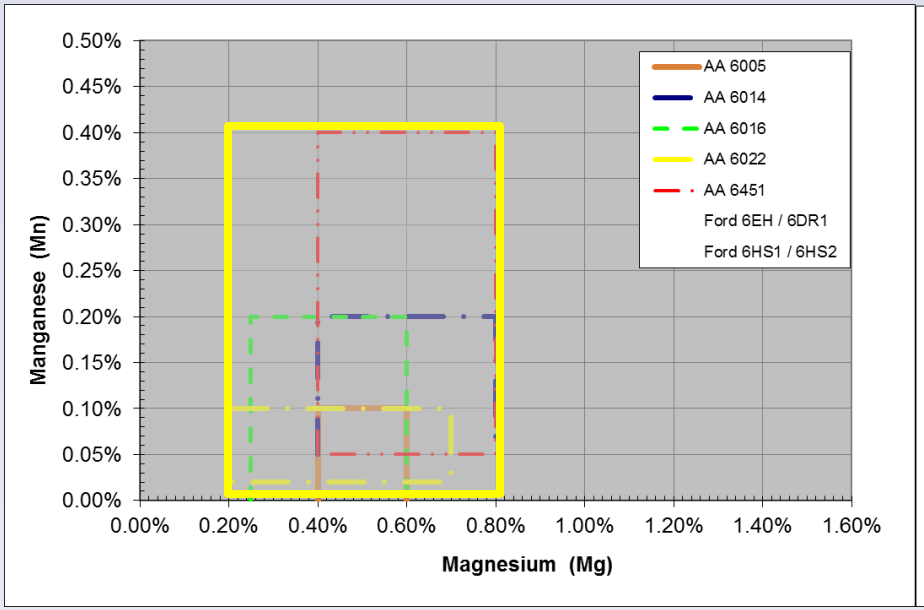
Skin Alloys Major Chemistry

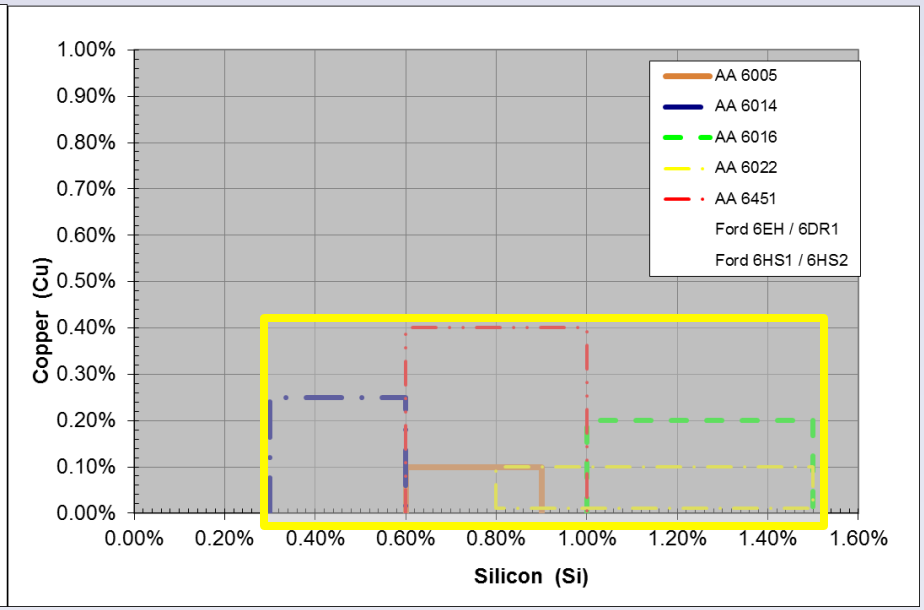




- Some overlaps, but no evident compatibility
- Expected, since they were developed independently as ***Engineered Products***

Skin Alloys Major Chemistry – Option 1

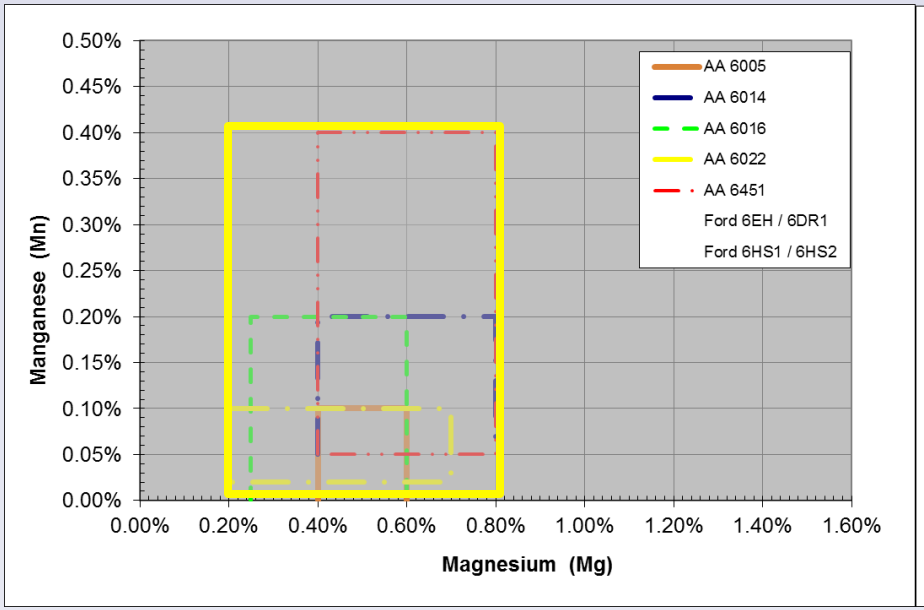


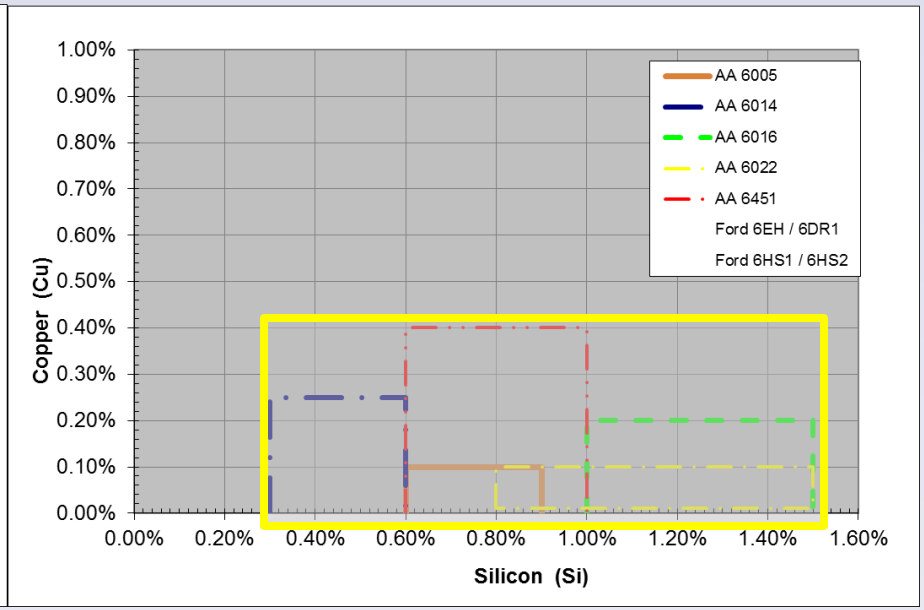


Option 1:

Set the chemistry boundaries to encompass all of the candidate alloys

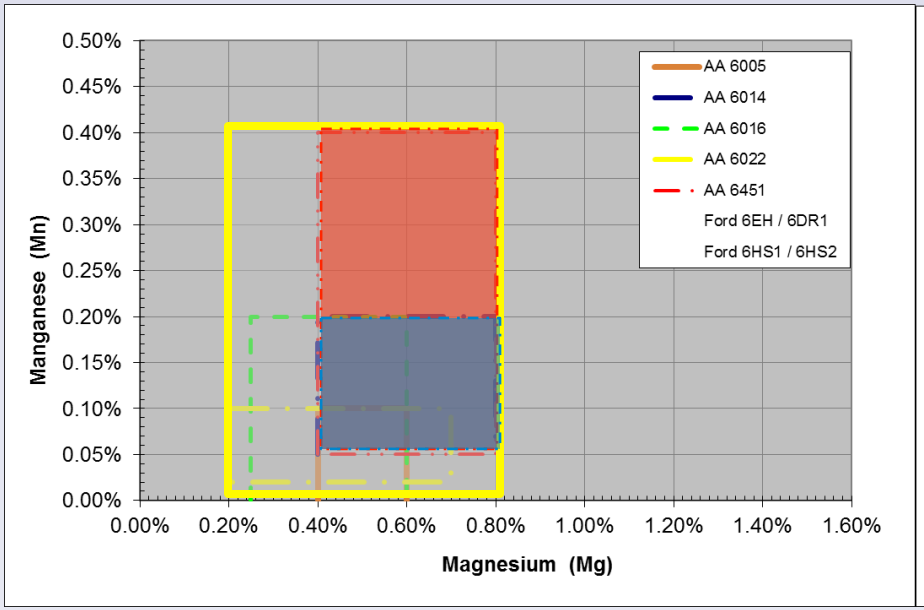
Skin Alloys Major Chemistry – Option 1

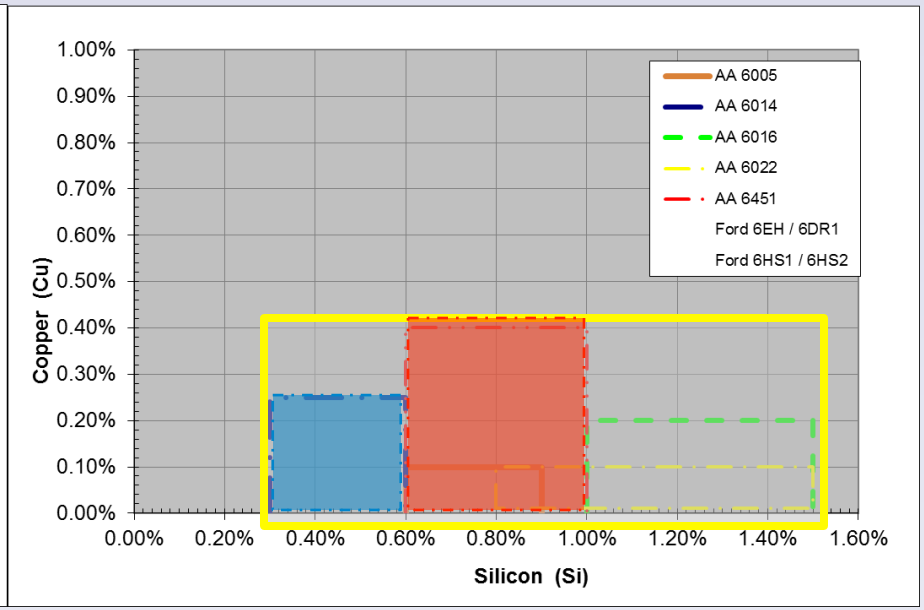




- All of these alloys are available today, and they all make acceptable metal for closures ⇔ maybe chemistry is not that important
- OK from a product designer point of view
- Offers great flexibility for sourcing metal from many different suppliers

Skin Alloys Major Chemistry – Option 1



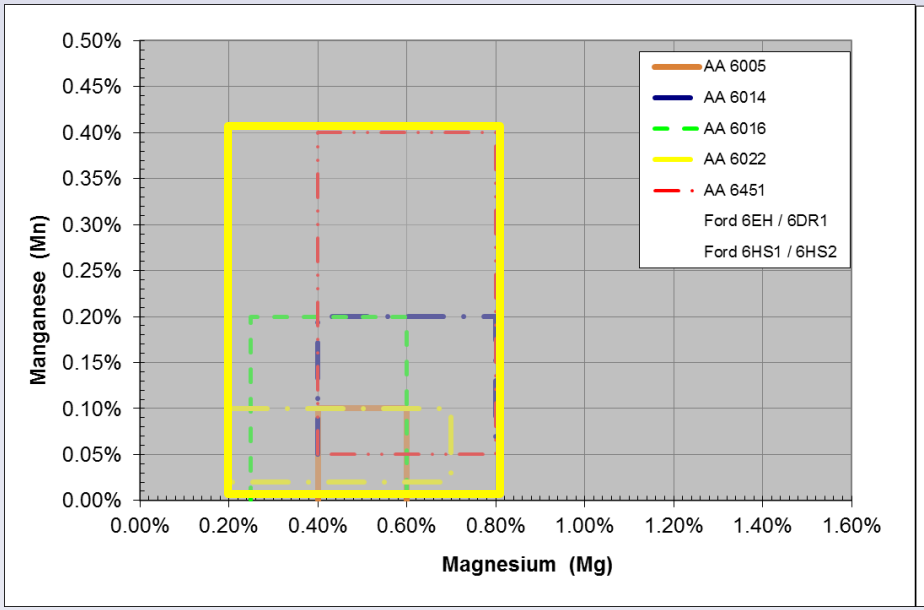


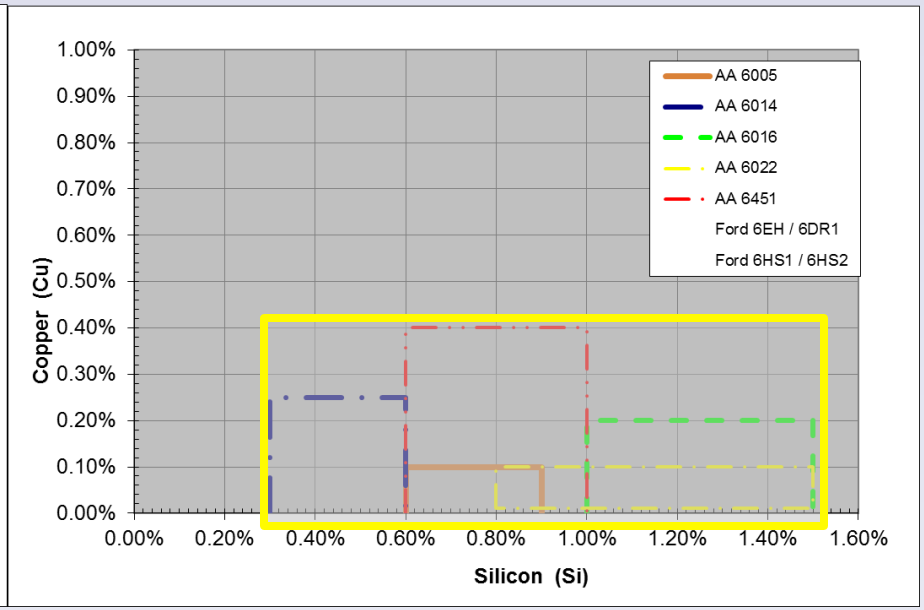
Example:

(A) produces **6451** - OK for Mg/Mn/Cu, but concerns for Si

(B) produces **6014** – too lean for (B) to ever accept any tolled metal in a mixed supply condition

Skin Alloys Major Chemistry – Option 1





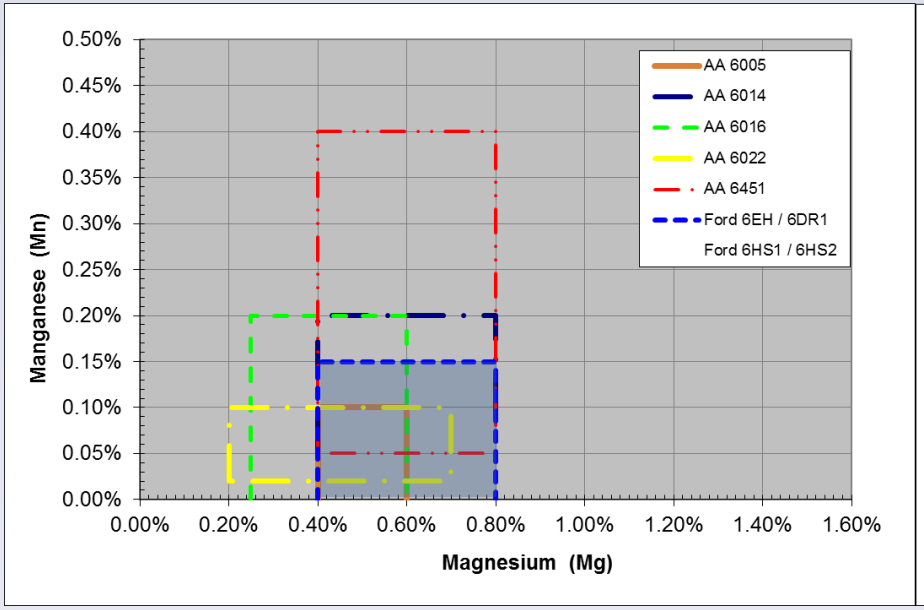
So… alloy (x) from supplier (A) cannot be comingled with alloy (y) from supplier (B) and the resultant scrap tolled back to either supplier…

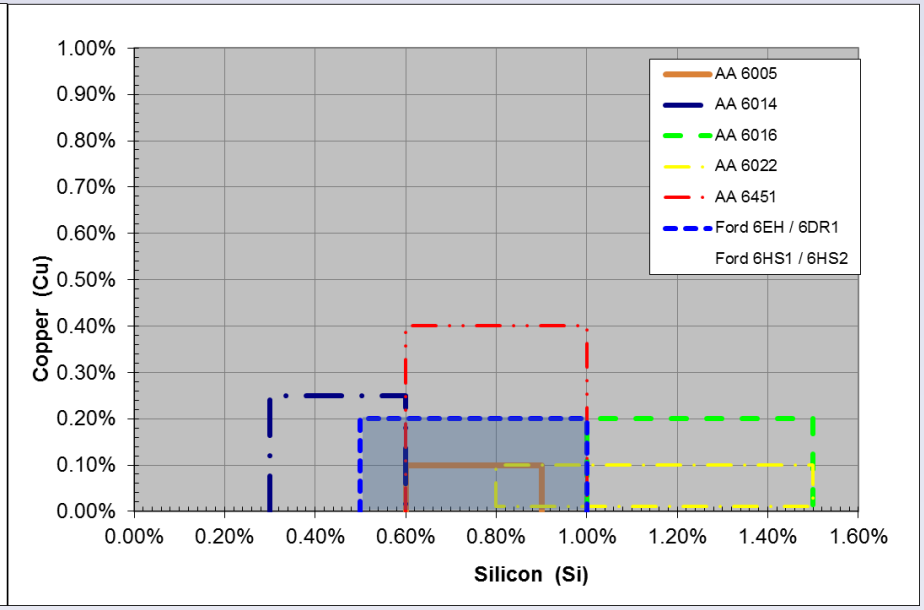
Chemistry Reality Check

- Chemistry does matter
- Similar mechanical properties and age hardening response behavior actually require similar chemistries
- In practice, the chemistry ranges for each alloy are much tighter than the AA registration

→ Real possibility to tighten the chemistry limits to enable alloy comingling and multi-supplier tolling

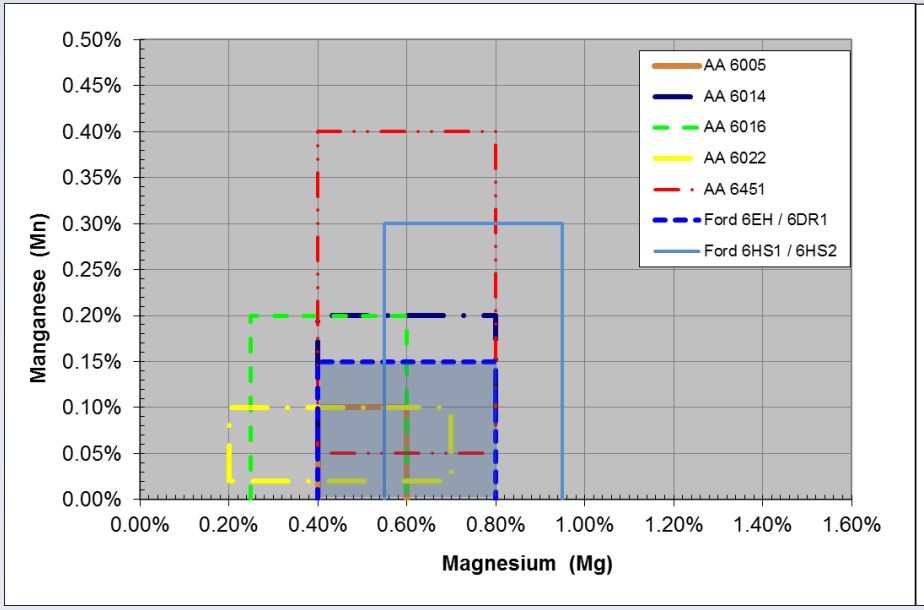
Skin Alloys Major Chemistry – Option 2

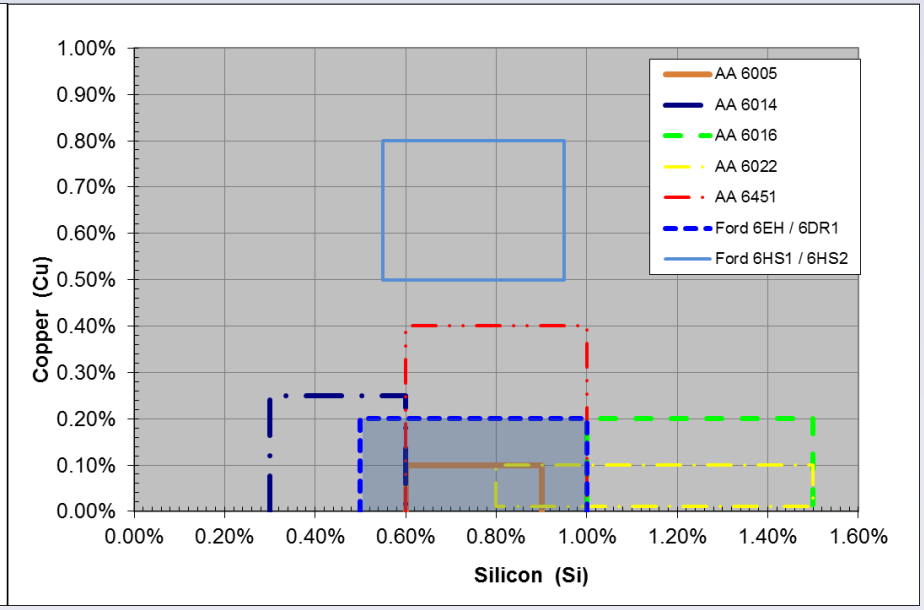




- Much tighter chemistry
- Overlaps, with evident compatibility
- The concept of aluminum grades is possible

Skin Alloys Major Chemistry – Final Touches



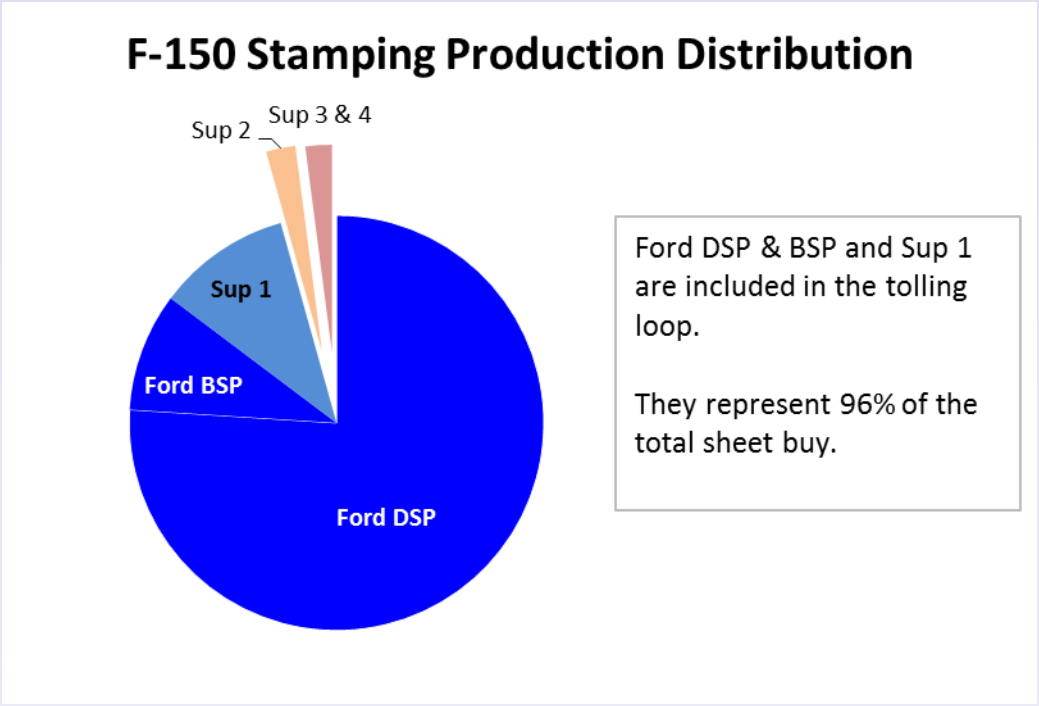


- Standardize the secondary alloying elements across all grades
- Extend the concept to create contamination tolerant grades

Ford Specifications for F-150

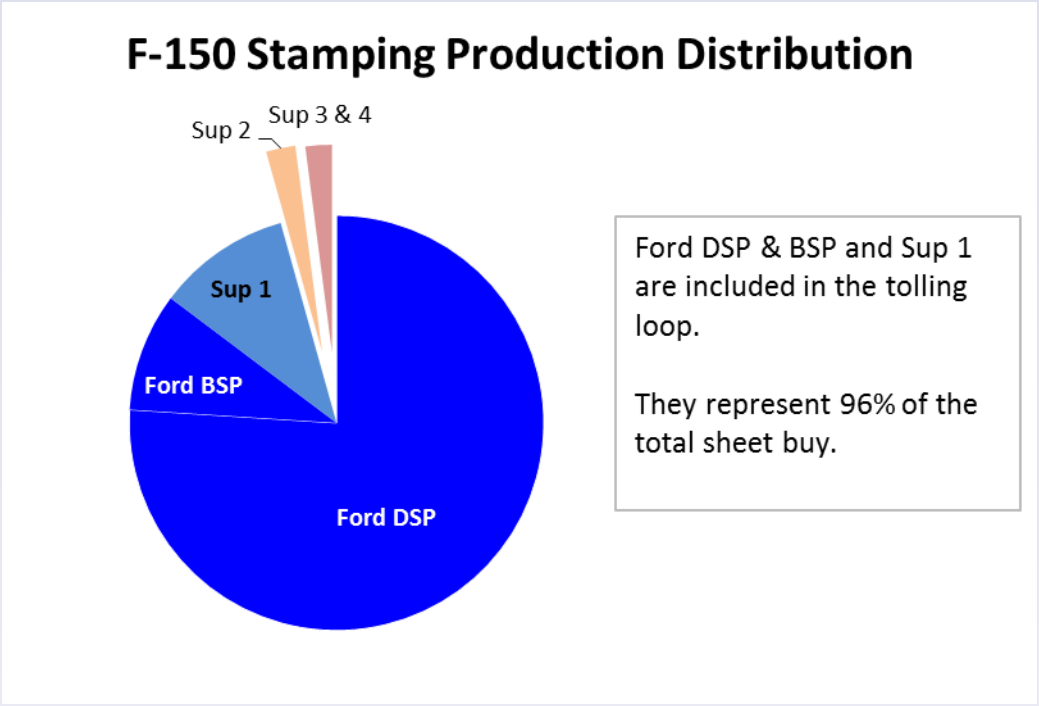
- Define 10 application based grades
  - 6HS1/6HS2/6HS3 (6xxx high strength) for structural applications
  - 6EH/6DR1/6DR2 (6xxx Extra Hemming, Dent Resistant) for skins
  - 5HF/5ST (5xxx High Formability and Structure)
  - 6ST1/6ST2 (6xxx structure) for special structural applications
- Define 4 scrap streams
  - “Low Cu”, “High Cu”, “Low Mg”, “High Mg”

Geographical Consolidation



- Consolidated all of F-150 stamping production into 2 Ford Plants and 2 Tier-1 suppliers
- DSP is an all aluminum plant
- 2 additional small specialty suppliers

Geographical Consolidation



- Mill #1 gets all of BSP's 2 scrap streams
- Mill #2 gets all of Supplier-1's 2 scrap streams
- DSP handles 4 scrap streams and balances scrap distribution to deliveries

Scrap Handling

- Selected a pneumatic conveying system with programmable switches instead of a traditional conveyor system.
- Each press line feeds directly to a series of in-line switches that direct the scrap to its destination.
- The system can be retro-fitted as an addition to a conventional scrap handling system, allowing mixed metal stamping plants.
- A dedicated fleet of specialized trailers handles both the coil deliveries and the return of the scrap between the aluminum mills and Ford, minimizing one way trips.

DSP Scrap Handling – East Side

- 3 way separation (“High Cu”, “Low Cu” & “Low Mg”)
- Each cyclone can handle up to 7 stamping lines running simultaneously
- Max output is around 27mT/hour per cyclone
- Trailer loads vary as a function of gage, 11-20mT

Conclusions

- F-150 is supported by a new family of aluminum sheet specifications focused on recyclability
- 10 grades
- 4 scrap streams
- Tolling between multiple aluminum mills enabled by tighter chemistry definitions

Acknowledgements

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