DRIVING INNOVATION WITH AUTOMOTIVE ALUMINUM

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DISCUSSION OUTLINE

- Why Automotive Aluminum?
- 50 Years of Growth
- Aluminum Materials
- Advances in Automotive Aluminum
- Corrosion
- Repair Industry Issues
THE ALUMINUM ADVANTAGE
ALUMINUM ADVANTAGES

What Automotive Customers Need...

- **Weight Reduction**
  (Multi-Material Vehicles)
- **Fuel Economy/CO2 (CAFE)**
- **Performance:**
  - Safety, 0-60, handling, ride, NVH, braking, etc.
  - Payload, towing capacity
- **Cost Effective**

- **Aluminum Products**
  - Body Sheet
  - Extrusions
  - Structural castings

- **Properties**
  - Strong
  - Tough
  - Energy absorbing
  - Corrosion resistant
  - Formable
ALUMINUM AUTO BODY SHEET AND EXTRUSIONS

- 1.0 lb. of aluminum replaces 1.7 lbs. of MS/HS/AHSS
  - Body: - 40% mass (BIW, Closures)
  - Curb mass: -12%
  - Jaguar, F-150, Aachen, FEV/EDAG ...

- Secondary mass reductions
  - Up to 0.5 lbs.

- 10% vehicle mass reduction – “achievable”
  - 6.5% FE improvement (+ 2.7 MPG)

- Cost advantage over other fuel economy technologies
  - Diesel, hybrid, electric, …
FORD F-150 ACCOMPLISHMENTS
50 YEARS OF GROWTH
2015 DUCKER WORLDWIDE AUTOMAKER SURVEY

- 40 year growth trend continues
- Highest growth = 2015
  - First high-volume automotive body and structures – F-150 pickup truck all-aluminum body
  - Sheet and extrusions – body, closures
- Continued growth
  - Non-body applications: castings and extrusions
50 YEARS OF ALUMINUM GROWTH

Source: Ducker Worldwide

Pounds Per Vehicle (PPV)


- Wheels
- Heads
- Blocks
- Bumpers
- Hoods
- Heat Exchangers
- Sheet Extrusions

DOORS & BODY-IN-WHITE

500 lbs.

394 lbs.

50 lbs.

Source: Ducker
50 YEARS OF ALUMINUM GROWTH

Aluminum Component 2015 Share by Weight

- Bumpers: 1%
- Body & Closures: 11%
- Blocks: 12%
- Suspension: 2%
- Steering: 4%
- Brakes: 2%
- Wheels: 16%
- Heat Transfer: 10%
- Transmission & Driveline: 19%
- Other Engine: 9%
- Heads: 12%
- All other: 2%

- 11% Body & Closures
- 73% Castings
- 33% Engine

Average 394 Lb. per Vehicle
6.9 Billion Pounds
AUTOMOTIVE MATERIAL MIX SHIFT - LIGHTER

### 2015
- Mild Steel: 17%
- HS Steel: 14%
- FR AHSS: 5%
- All Other Steel: 16%
- Iron: 8%
- All Other Al: 8%
- Al Str Castings: 1%
- Copper: 1%
- Other Metals: 3%
- Non Metallics: 23%

**Total:** 3700 lbs.

### 2025
- Mild Steel: 12%
- HSLA: 7%
- AHSS: 11%
- Other Steel: 16%
- Iron: 8%
- Rolled Al: 4%
- Cast Al: 8%
- AL Str Castings: 1%
- Ext Al: 1%
- Other Metals: 3%
- Non Metallics: 25%

**Total:** 3427 lbs.
ALUMINUM BODY COMPONENTS

- Body in White
- Bumper Beams
- Shock Towers
- Door and other closure inners
- Fenders
- Deck
- Door outer
- Hood
ALUMINUM-INTENSIVE VEHICLES TODAY

© Ford
© Audi
© Jaguar
© Jaguar
© Tesla
© Land Rover

DRIVEALUMINUM.ORG
ALUMINUM DRIVES CREATION OF NEW SEGMENT: ULTRA-LUXURY SUV

Bentley Bentayga

Maserati Levante

Lamborghini Urus

Rolls Royce Cullinan
MULTI-MATERIAL VEHICLES: THE NEW NORMAL

© Cadillac
CT6

© Chrysler
Pacifica

© BMW
7-Series

© Mercedes-Benz
S-Class

© BMW
i3

© Chevrolet
Malibu
AUTOMOTIVE ALUMINUM MATERIALS
All aluminum materials are **NOT** the same
Can not easily identify specific material in the field
Repair practices varies by material

**Automotive alloy selection**
- Strength
- Ductility
- Corrosion resistance
- Cost (material, processing)
- Energy absorption
Different Automotive Aluminum Materials

Product form
- sheet, extrusion, casting

Alloys
- composition, mechanical properties, strengthening process

Tempers (strengthening)
- mechanical properties, formability

Heat Treatable:
- F, T4, T4PB: High Formability
- T6: Maximum Strength (+50% over T4 Typ.)

Non-heat treatable:
- Typically: under-body structure

HXX: Work hardening
ADVANCES IN AUTOMOTIVE ALUMINUM
ADVANCED ALLOYS MEET AUTOMOTIVE NEEDS

- Continuous Product Improvement
  - High Strength
  - Energy Absorption
  - Advanced Formability
  - Value
  - Sustainability

Graphic: Alcoa R&D

DRIVEALUMINUM.ORG
“High Strength” Alloy/Temper Variants

Applications – body structure, bumper

Sheet:

Variants: 6022, 6111, 6451, 7021

UTS: 400 + MPa

Extrusions:

Variants: 6082, 7003, 7046

UTS: 400+ MPa
“Crush Grade” Alloy/Temper Variants

Excellent energy absorption

Applications – body structure, bumper, frame rails, crash cans

Sheet:
- Variants: 6022, 5454, 5754
- UTS: 300 + MPa

Extrusions:
- Variants: 6005, 6061, 6082, 7046
- UTS: 300 + MPa

Aluminum: Highest energy absorption automotive material, pound for pound

Sheet

Extrusions

Kaiser

sapa:
ALUMINUM COLLISION REPAIR AND CORROSION
Aluminum Repair Considerations

- **Shop Safety**
  - Dust Management (Combustion)

- **Corrosion**

- **I-CAR / Aluminum Association Joint Studies**
  - Industry open issues / concerns
  - Information
  - Develop “Best Practices” Bulletins
ALUMINUM DUST MANAGEMENT

- **Fines**
  - Dust or powder
  - Grinding, sanding, polishing

- **Can be combustible when:**
  - Small particles < 500 micron
  - Suspended in air
  - Concentration
  - Ignition source
  - Incidences are rare

- **Control**
  - Dust collection system
  - Electrically grounded
  - Spark resistant
  - No smoking

Re: Nat Fire Protection Assoc. Std. No. 484
ALUMINUM – NATURAL CORROSION RESISTANCE

- **Natural Oxide Film (The Key Attribute)**
  - Forms instantaneously
  - increasing thickness over time
  - Transparent
  - Tenacious
  - Hard
  - Chemically stable in “normal” environments (pH 4.5-8.0)
    - exposed raw metal does not corrode engine, transmission, suspension

- **Corrosion can Occur if Damaged**
  - Scratch
  - Stone chip
  - Mechanical abrasion
  - Sanding, Grinding
  - Chemical attack (Ph: <4, >8)

- **Corrosion Typically Cosmetic**
  - Un-painted - White powder on surface
Galvanic Corrosion - Conditions

Dis-similar Metals (or Materials) and

Electrical Contact and

Electrolyte (NaCl)

Corrosion Rate – typically “very slow”

Prevention

Protective coatings

fasteners – common coatings

sheet or extrusion

Seal interface crevice (exclude electrolyte)

flexible sealer
Crevice Corrosion

Chemical action between surfaces

Required conditions

Crevice - fraying surfaces and
Electrolyte (NaCl)

Locations

lap joints
spot welded joints
or, surface mud accumulation
(similar to steel, less aggressive in aluminum)

Prevention

Protective coatings
sheet or extrusion
Seal interface crevice – exclude electrolyte
Flexible sealer
**Filiform Corrosion – Aluminum**

- **Filiform Corrosion** *(Form of crevice corrosion)*
  - Chemical attack under coatings

- **Required conditions**
  - Damaged coating *(scratches, stone chips, sheet edges)*
  - Electrolyte intrusion *(NaCl)*
  - *(similar to steel, less aggressive in aluminum)*

- **Corrosion Rate**
  - Accelerated by surface marks from grinding, sanding

- **Prevention (or Mitigation)**
  - Surface - Alloy selection *(mitigation)*
  - Surface conversion treatments
  - Coating durability
  - Edge - Seal crevices
Laboratory Test: ASTM G85-A2 (Acidified Salt Fog)
5% NaCl
pH 2.8-3.0 acetic acid
120 F.
500 Hrs. (6 Hr. cycle)
:45 - spray
2:00 - dry
3:15 - soak

Vehicle Test Results

Impact: grinding, sanding, factory coatings
SUMMARY
Multi-material vehicle designs – the new norm
  Aluminum and steel – Co-exist, important auto materials

Aluminum 2025 - OEM production
  Closures - 24 % by 2025
  Body - 12 % by 2025

Aluminum Repair – Different not Difficult
  Training – OEM, I-Car, ...
  Equipment
  Many different aluminum grades
  OEM repair procedures should be followed

Keep Shops SAFE!
  No Dust incidences
THANK YOU