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.

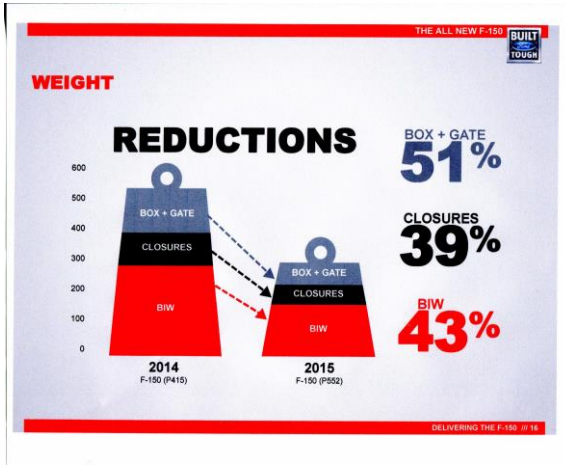
- **10% vehicle mass reduction – "achievable"**

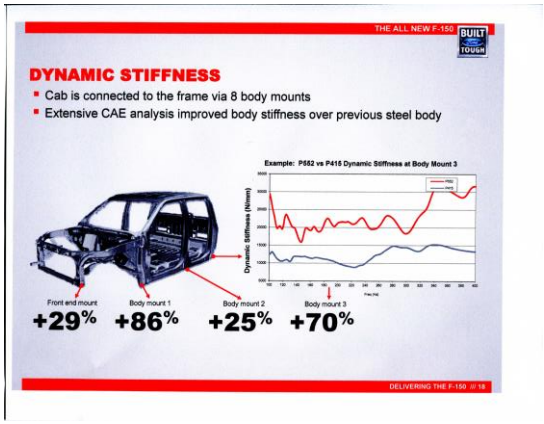
  6.5% FE improvement (+ 2.7 MPG)

- **Cost advantage over other fuel economy technologies**

  Diesel, hybrid, electric, …

FORD F-150 ACCOMPLISHMENTS



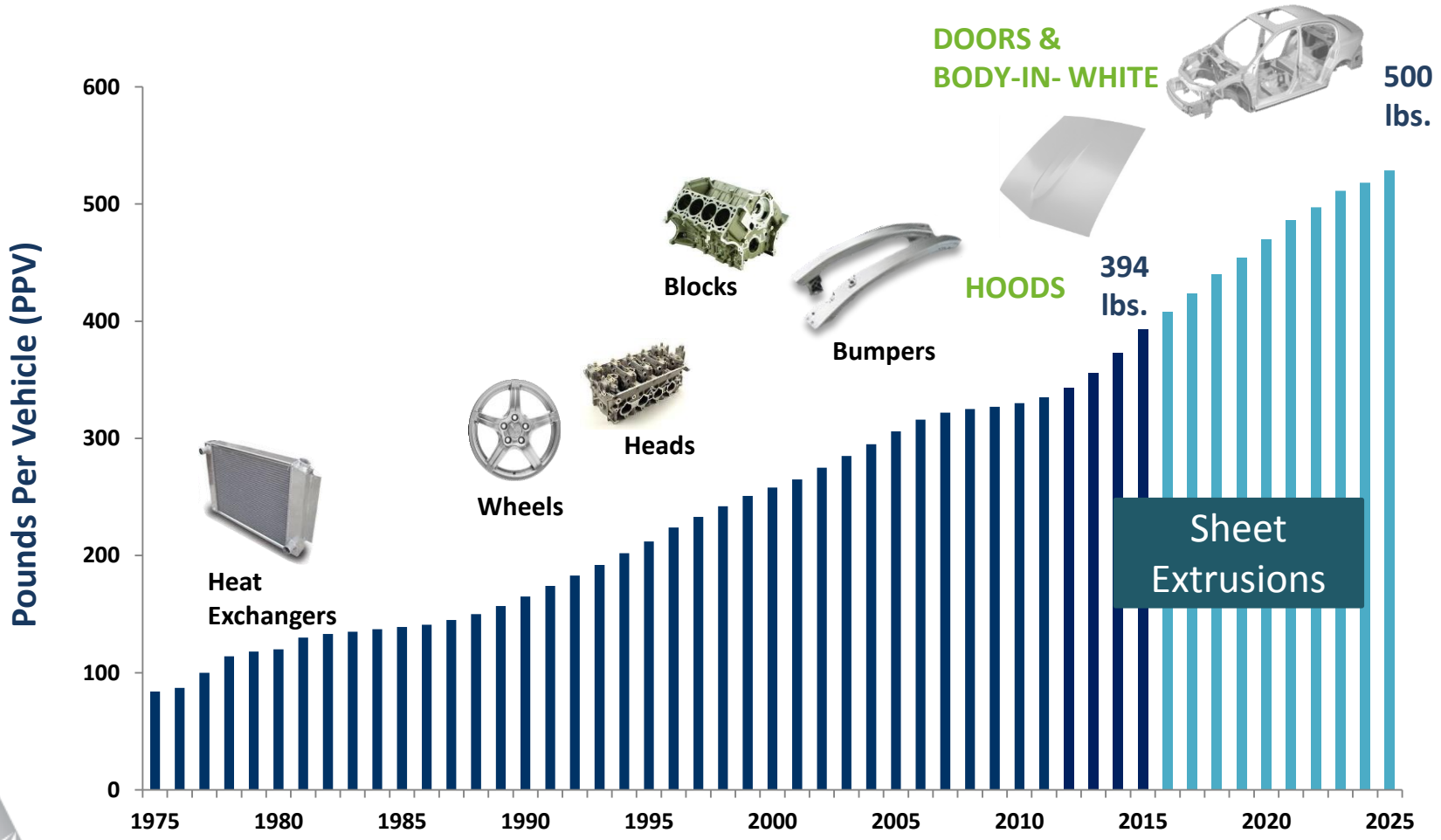


50 YEARS OF GROWTH

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



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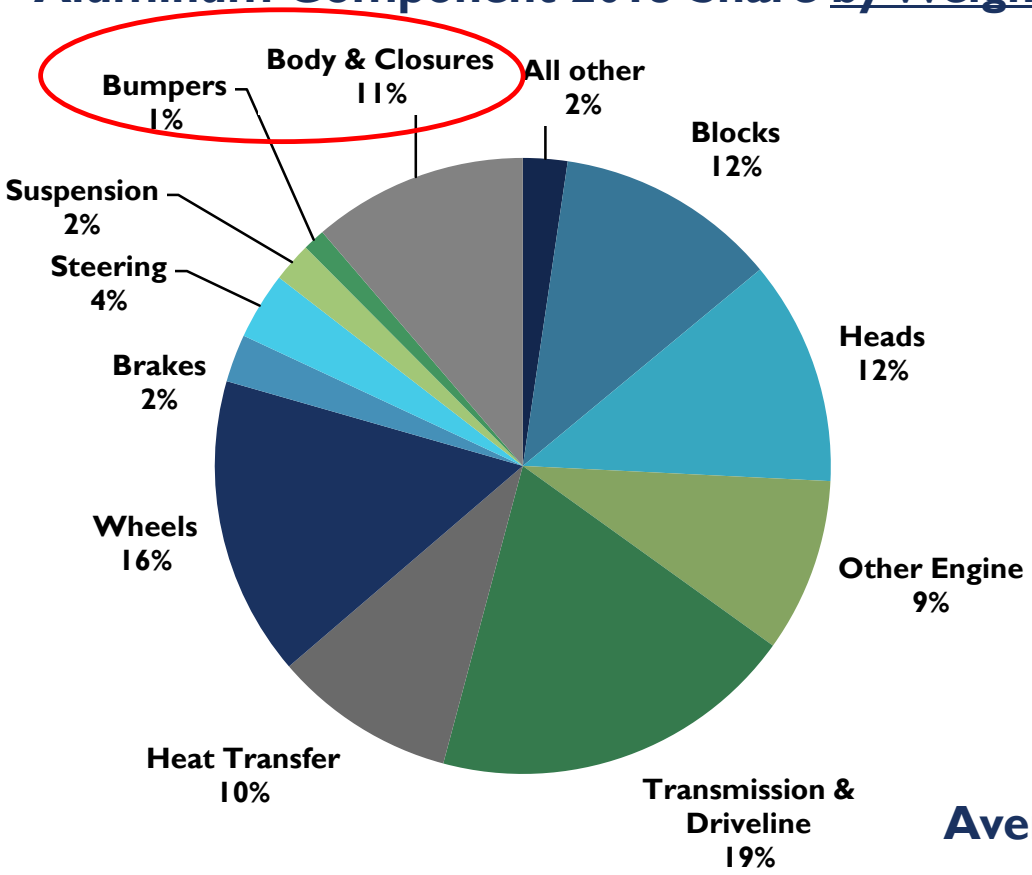
Source: Ducker

50 YEARS OF ALUMINUM GROWTH

Aluminum Component 2015 Share by Weight



11% Body & Closures

73% Castings

33% Engine

Average 394 Lb. per Vehicle
6.9 Billion Pounds

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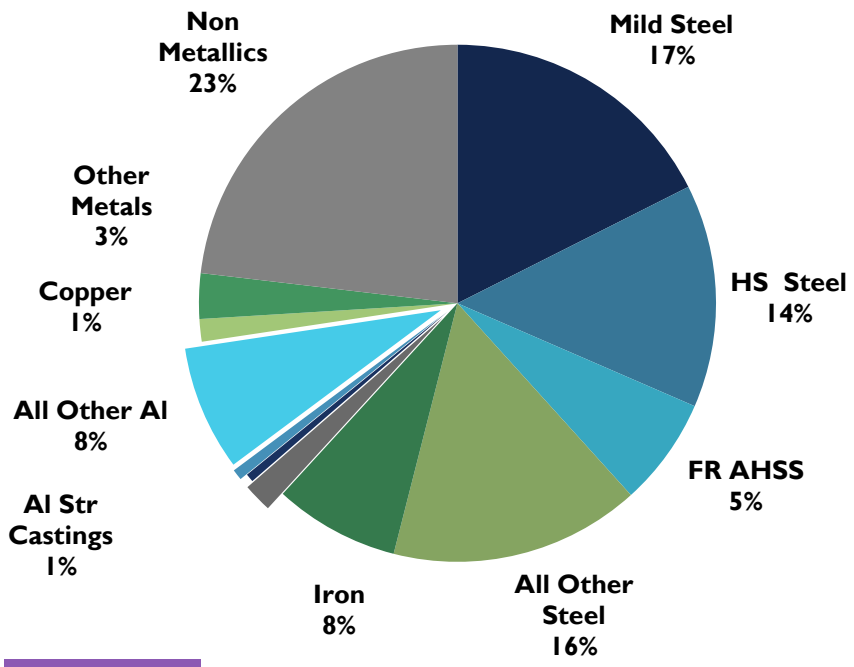
AUTOMOTIVE MATERIAL MIX SHIFT - LIGHTER

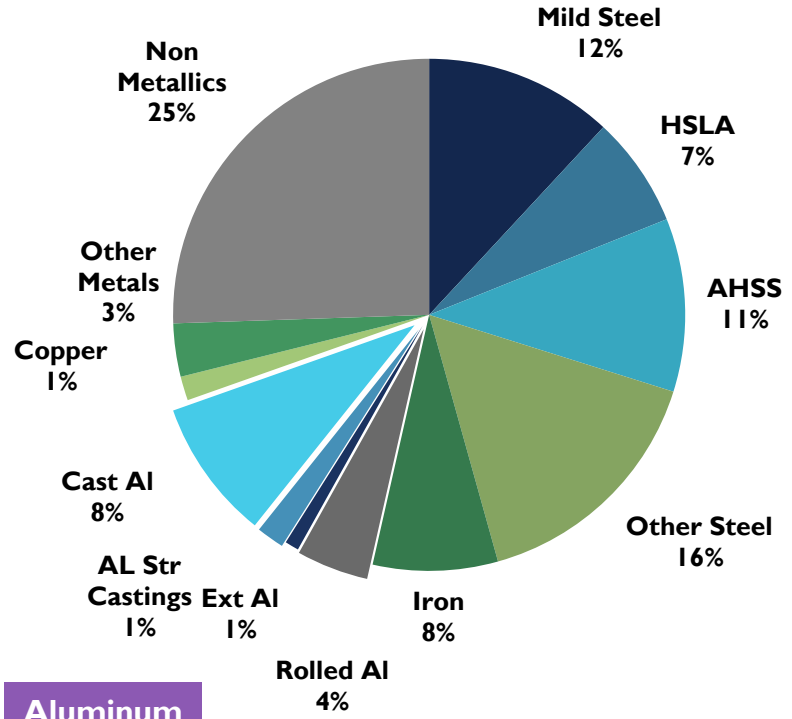
2015



Aluminum 10%

3700 lbs.

2025



Aluminum 13%

3427 lbs.

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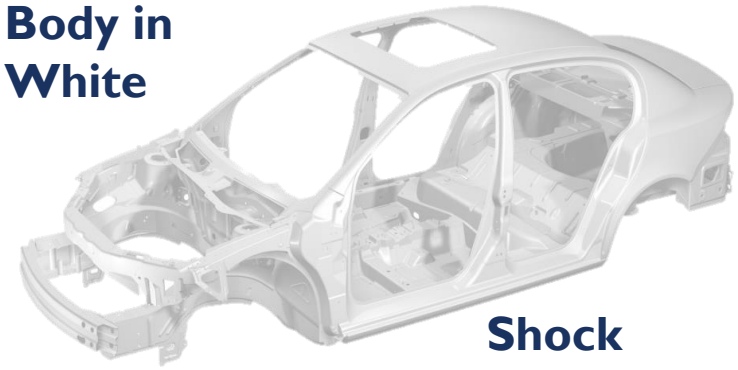
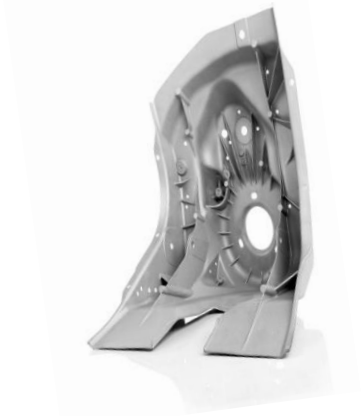
ALUMINUM BODY COMPONENTS

Body in White



Bumper Beams

Shock Towers



Fenders

Deck

Door outer

Door outer

Hood

Door and other closure inners

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ALUMINUM-INTENSIVE VEHICLES TODAY

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ALUMINUM DRIVES CREATION OF NEW SEGMENT: ULTRA-LUXURY SUV

Bentley Bentayga

Lamborghini Urus

Maserati Levante

Rolls Royce Cullinan

MULTI-MATERIAL VEHICLES: THE NEW NORMAL

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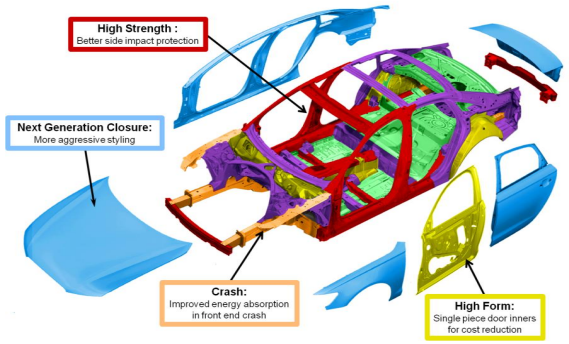
AUTOMOTIVE ALUMINUM MATERIALS

ALUMINUM AUTO BODY 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



ALUMINUM AUTO BODY MATERIALS

- **Different Automotive Aluminum Materials**

Product form

sheet, extrusion, casting

Alloys

composition, mechanical properties, strengthening process

Tempers (strengthening)

mechanical properties, formability

Heat Treatable: Typically: body exterior, loaded structure

F, T4, T4PB, : High Formability

T6: Maximum Strength (+50% over T4 Typ.)

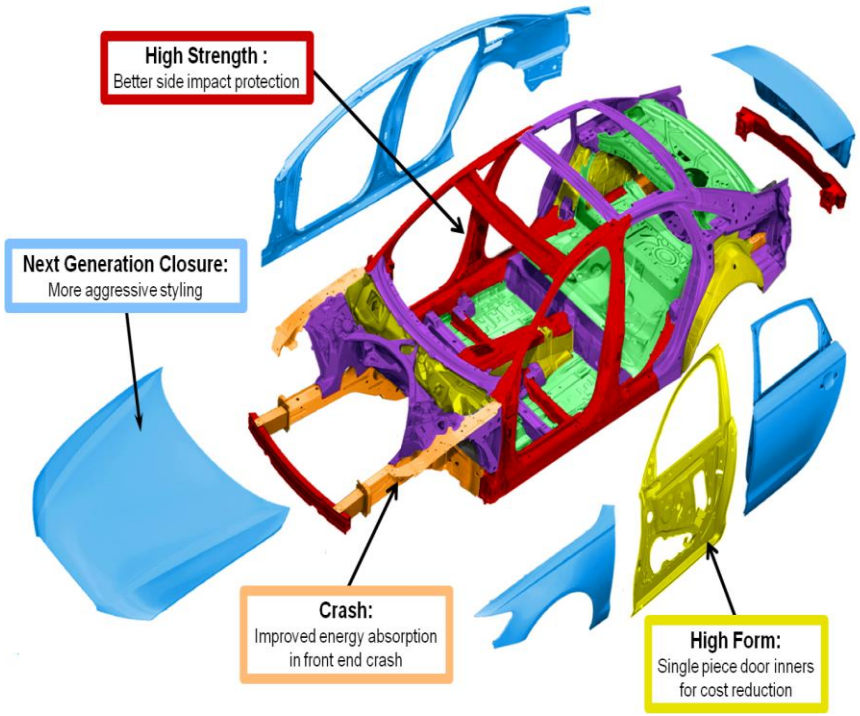
Non-heat treatable: Typically: under-body structure

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

HIGH STRENGTH ALUMINUM GRADES

"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

ALUMINUM ENERGY ABSORPTION

"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

ALUMINUM COLLISION REPAIR AND CORROSION

ALUMINUM AUTOMOTIVE BODY REPAIR

Aluminum Repair Considerations

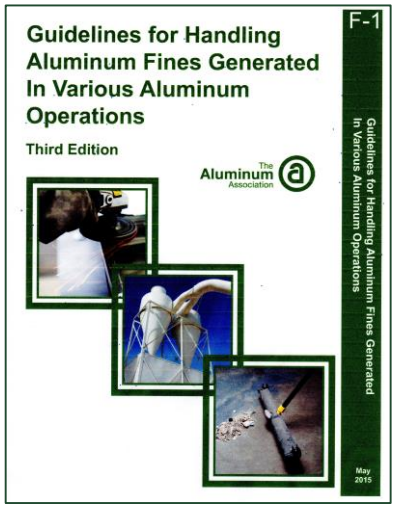
- **Shop Safety**
  - **Dust Management (Combustion)**
- **Corrosion**
- **I-CAR / Aluminum Association Joint**
  - **Studies**
    - **Industry open issues / concerns**
  - **Information**
    - **Develop “Best Practices” Bulletins**

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

Re : Nat Fire Protection Assoc. Std. No. 484

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



ALUMINUM – NATURAL CORROSION RESISTANCE

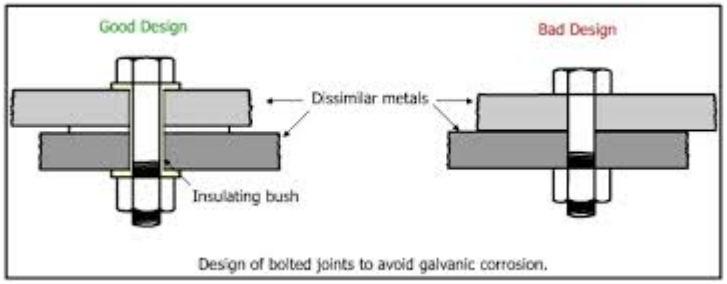
- **Natural Oxide Film (The Key Attribute)**
  - Forms instantaneously
    - increasing thickness over time
  - Transparent
  - Tenacious
  - Hard
  - Chemically stable in "normal" environments (pH 4.5-8.0)
    - exposed raw metal does not corrode
      - engine, transmission, suspension

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

- **Corrosion Typically <u>Cosmetic</u>**
  - Un-painted - White powder on surface

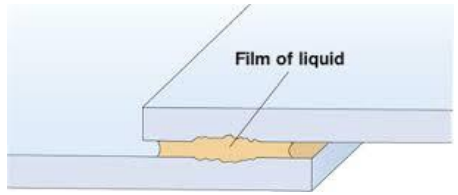
GALVANIC CORROSION - ALUMINUM

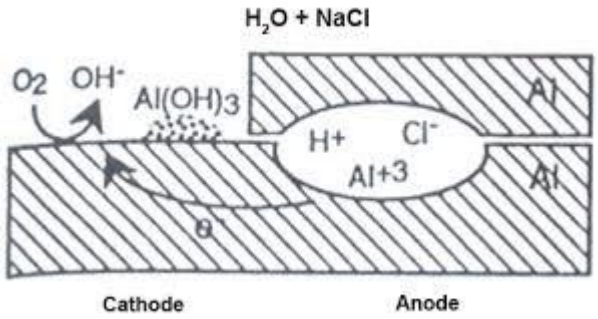
- **Galvanic Corrosion - Conditions**
  - **Dis-similar Metals (or Materials)**
  - **and**
  - **Electrical Contact**
  - **and**
  - **Electrolyte (NaCl)**
- **Corrosion Rate – typically "very slow"**
- **Prevention**
  - **Protective coatings**
    - **fasteners – common coatings**
    - **sheet or extrusion**
  - **Seal interface crevice (exclude electrolyte)**
    - **flexible sealer**

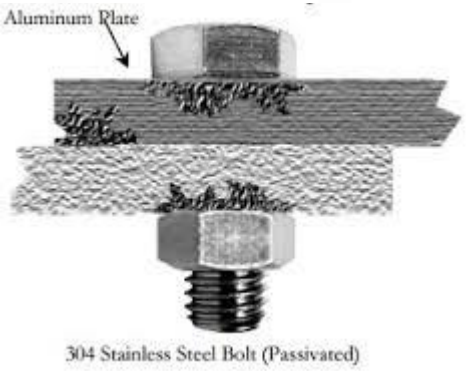


CREVICE CORROSION - ALUMINUM

- **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

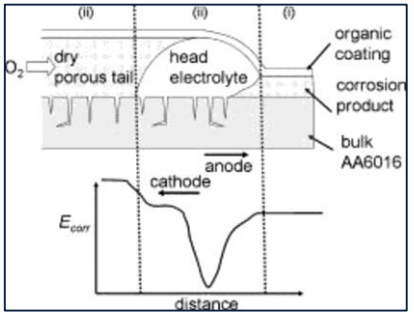


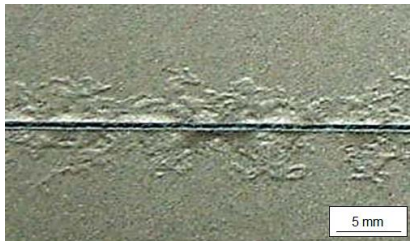


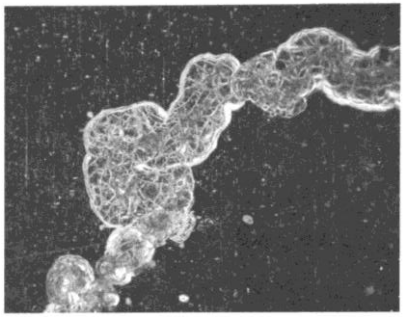


FILIFORM CORROSION – ALUMINUM

- **Filiform Corrosion (*Form of crevice corrosion*)**
  - Chemical attack under coatings
- **Required conditions**
  - Damaged coating (scratches, stone chips, sheet edges)
    - and
  - 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



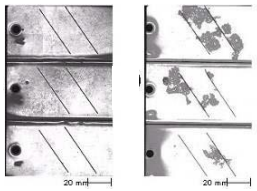




FILIFORM CORROSION – GRINDING, SANDING

Vehicle Test Results

Aluminum 6111 T4:

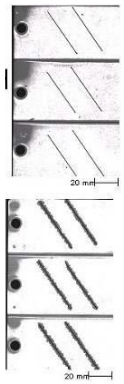


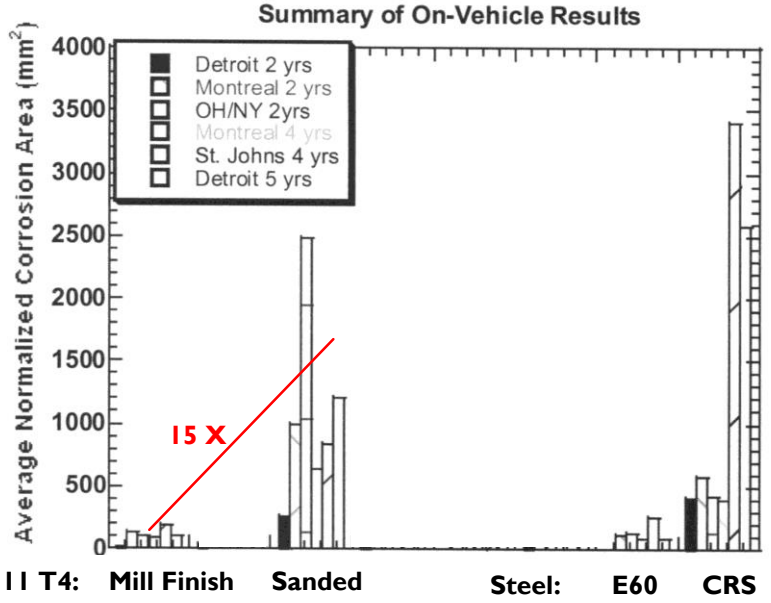
Mill Finish Sanded

Steel:

E60

CRS





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**

Impact: grinding, sanding, factory coatings

SUMMARY

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

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