ALUMINUM EXTRUSION IDENTIFICATION, CLASSIFICATION, AND TRADE LAW SEMINAR

For U.S. CUSTOMS AND BORDER PROTECTION, ICE/HSI, AND OTHER ALUMINUM EXTRUSION-FOCUSED USG OFFICIALS AND CUSTOMHOUSE BROKERS

AUGUST 22 – AUGUST 23, 2017

U.S. Customs and Border Protection Offices
301 E. OCEAN BLVD, SUITE 1400
LONG BEACH, CA 90802

Presented and Sponsored by the
ALUMINUM EXTRUDERS COUNCIL
Represented by
RIO TINTO ALUMINIUM
FRONTIER ALUMINUM CORP.
SIERRA ALUMINUM
SAPA
<table>
<thead>
<tr>
<th>Time</th>
<th>Sect.</th>
<th>Topic</th>
<th>Discussion Presentations Tuesday, August 22, 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30 – 10:00 AM</td>
<td>Overview of the aluminum extrusion industry</td>
<td>Overview of the aluminum extrusion industry – Jeff Henderson, Aluminum Extruders Council</td>
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<tr>
<td></td>
<td>Break</td>
<td>(10 mins.)</td>
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<tr>
<td>10:00 – 10:55 AM</td>
<td>Primary, Remelt, Alloys, Billet</td>
<td>Primary, Remelt, Alloys, Billet – Jerome Fourmann, Rio Tinto Aluminium</td>
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<tr>
<td></td>
<td>Break</td>
<td>(10 mins.)</td>
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<tr>
<td>11:05 – Noon</td>
<td>Extrusion Press and Dies</td>
<td>Extrusion Press and Dies – Mike Rapport, Frontier Aluminum Corp.</td>
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<tr>
<td>Noon – 1:30 PM</td>
<td>Lunch</td>
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<tr>
<td>1:30 – 2:25 PM</td>
<td>Finishing; Paint, Powder, Anodizing</td>
<td>Finishing; Paint, Powder, Anodizing – Shayne Seever, Sierra Aluminum</td>
<td></td>
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<tr>
<td></td>
<td>Break</td>
<td>(10 mins.)</td>
<td></td>
</tr>
<tr>
<td>3:30 – 4:00 PM</td>
<td>Circumvention / Transshipment</td>
<td>Circumvention / Transshipment – Jeff Henderson, Aluminum Extruders Council</td>
<td></td>
</tr>
<tr>
<td>4:00 – 4:50 PM</td>
<td>Legal Presentation; Orders, Enforcement</td>
<td>Legal Presentation; Orders, Enforcement – Wiley Rein Attorneys</td>
<td></td>
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**Wednesday, August 23, 2017**

<table>
<thead>
<tr>
<th>Time</th>
<th>Sect.</th>
<th>Topic</th>
<th>Discussion Presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 – Noon</td>
<td>Tour of Extrusion Facility</td>
<td>Tour of Extrusion Facility – Hosted by Mike Rapport, President Frontier Aluminum Corp.</td>
<td></td>
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<tr>
<td></td>
<td>Frontier Aluminum Corp.</td>
<td>Frontier Aluminum Corp.</td>
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</tr>
<tr>
<td></td>
<td>2480 Railroad Street</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Corona, CA  92880</td>
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*Current as of August 7, 2017*
Aluminum Extrusion Identification, Classification & Trade Law Seminar
Post-Seminar Participant's Survey

Location: Long Beach, CA Date: August 22-23, 2017
Representing: Customs & B.P. ___ ICE/HSI ___ Other USG ___ Customhouse Broker ___ Other ___

Rate the program elements on a scale of 1 (poor) to 5 (excellent):
Overall: ___ Seminar Format: ___ Format Suggestions: ________________________________

Overview of the Aluminum Extrusion Industry
1. Introductory Overview, Market Perspective – Henderson ___

Primary Aluminum, Remelt, Alloys, Billet Topics
2. A. Standards, Specifications, Metallurgy, – Fourmann ___

Extrusion Press/Dies
3. Overview of Key Equipment Components – Rapport ___

Finishing Processes
4. A. Anodizing – Seever ___
   B. Powder/Liquid Paint – Seever ___

Fabrication/Products
5. Profiles/Products – Weber ___

Seminar met my expectations ___

Subject areas of greatest interest to me are _________________________________________

I would like to see greater emphasis on _____________________________________________

I would like the following uncovered topics covered in future seminars ________________

I would like the following topics deemphasized or deleted in future seminars ________

Personal Information (optional, but appreciated):

Name: ____________________________________________________________________
Organization: _______________________________________________________________
Address: ___________________________________________________________________
Phone: _________________________ Email: ________________________________
<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Represents</th>
<th>Expertise</th>
<th>Phone/Fax/email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeff Henderson</td>
<td>Aluminum Extruders</td>
<td>Aluminum Extrusion Industry</td>
<td></td>
<td>847.416.7222 318.348.0425 Cell <a href="mailto:jhenderson@tso.net">jhenderson@tso.net</a></td>
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<tr>
<td>Robert DeFrancesco, Esq.</td>
<td>Wiley Rein LLP</td>
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<td>Trade law (bars, structural, flat rolled, and grating)</td>
<td>202.719.7473 202.719.7049 Fax <a href="mailto:RDeFrancesco@wileyrein.com">RDeFrancesco@wileyrein.com</a></td>
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<td>Wiley Rein LLP</td>
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<td>Trade law (bars, structural, flat rolled, and grating)</td>
<td>202-719-3375 202-719-7049 <a href="mailto:aprice@wileyrein.com">aprice@wileyrein.com</a></td>
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<tr>
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<td>Wiley Rein LLP</td>
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<td>Rio Tinto Aluminium</td>
<td>Primary producers Of aluminum billett</td>
<td></td>
<td>440.460.3320 440.520.4975 Cell <a href="mailto:Jerome.Fourmann@riotinto.com">Jerome.Fourmann@riotinto.com</a></td>
</tr>
<tr>
<td>Mike Rapport.</td>
<td>Frontier Aluminum Corp.</td>
<td>Extrusion Plants</td>
<td></td>
<td>951.735.1770 <a href="mailto:m.rapport@frontier-aluminum.com">m.rapport@frontier-aluminum.com</a></td>
</tr>
<tr>
<td>Shayne Seever</td>
<td>Sierra Aluminum</td>
<td>Extrusion Plants</td>
<td></td>
<td>951.781.7800 951.837.0671 Cell <a href="mailto:sseever@sierraaluminum.com">sseever@sierraaluminum.com</a></td>
</tr>
<tr>
<td>Jason Weber</td>
<td>Sapa</td>
<td>Extrusion Plants</td>
<td></td>
<td>605.321.4387 <a href="mailto:jason.weber@sapagroup.com">jason.weber@sapagroup.com</a></td>
</tr>
</tbody>
</table>
BIOGRAPHIES

(In order of the agenda including industry team members not attending this event)

Jeff Henderson is President of the Aluminum Extruders Council (AEC). In addition to managing the overall activities at AEC, Mr. Henderson is responsible for directing and managing the Fair Trade Committee, which is the U.S. aluminum extrusion industry’s team that successfully petitioned the U.S. government for free and fair trade action against China in 2011. He also manages the AEC’s Industry Promotion effort that has resulted in thousands of inquiries each year to aec.org. Mr. Henderson is also the owner and president of The Sanford Organization (TSO), which is an association management company that runs non-profit organizations. In addition to the AEC, TSO manages the Aluminum Anodizers Council, the National Plasterers Council, and several other trade associations.

Jerome Fourmann is Technical Director, Global Customer Support and Product Development for the aluminum metal group of Rio Tinto. Since joining Rio Tinto in 2000, Jerome has utilized his technical expertise to support customers and the market development of value added product in extrusion and foundry products. He holds a MS degree in Metallurgy and serves on committees at The Aluminum Association, ASTM and AEC; he is based in Cleveland, Ohio. In addition of being a frequent presenter at industry conferences, Jerome has authored several papers and is a contributing editor for the magazine Light Metal Age.

Mike Rapport is the President of Frontier Aluminum Corporation. Started as a family business in 1990, Frontier has grown to become a leading independent West Coast aluminum extruder and finishing company. As the sole owner since 2013, Frontier remains on the cutting edge of the aluminum extruding industry. Mr. Rapport has traveled extensively around the “extrusion” world including multiple visits for China, Italy and Spain applying what he has learned from those travels to Frontier. Mr. Rapport was the early warning signal and call to action for the formation of the anti-dumping action against Chinese imports. He is still active today in his efforts to monitor and assist in regulation the burgeoning extrusion juggernaut in China. With 27 years of experience in extrusions, Mr. Rapport is a qualified aluminum extrusion expert on the West Coast.

Shayne Seever is VP of Administration for Sierra Aluminum, a full service manufacturer of standard and custom aluminum extrusions located in Riverside, California. He earned a B.S. in Physics with a minor in Engineering Studies from Carnegie Mellon University and an MBA from the Drucker School of Management at the Claremont Graduate University. Shayne started working in the aluminum extrusion industry when he was 21 year old and has been in it for 21 years. His background has allowed him to evolve into and out of a number of positions within Sierra, depending on what was needed by the company at the time. Over the years he has been involved with building construction and process line installations and upgrades (casting, extrusion, anodizing, and paint), equipment specification, P&L responsibility for the paint and anodizing departments along with oversight of approximately 100 employees, and was a fiduciary for the Sierra Employee Stock Ownership Trust (the legal entity which owns Sierra). His vast experience has allowed Shayne the freedom to be involved in many parts of the business.

Jason Weber is the Director of Business Development for Energy and Industrial Products at Sapa Extrusion North America. With over 20 years of experience in the aluminum extrusion industry Weber and his team are responsible for increasing extruded aluminum content, promoting Sapa’s brand, and developing local and global product strategies within the Energy and Industrial Product segments. Weber is a member of the Aluminum Extruders Council with a seat on the AEC’s Board of Directors and holds a Bachelor of Science degree in Business Administration and Marketing from Minot State University in North Dakota.

Richard F. DiDonna is the director of the U.S. domestic steel industry customs seminar program. In addition, Mr. DiDonna is an International Trade Analyst at the Washington, D.C., law firm of Wiley Rein LLP. Mr. DiDonna assists clients before federal Executive agencies and independent federal agencies on a variety of issues including trade remedies, customs compliance, entry and clearance of goods into the U.S., and other related matters. Licensed as a U.S. Customs Broker since 2010, he has particular experience with issues including tariff classification, free trade
agreements, rules of origin, country of origin marking rules, and post-entry procedures. Mr. DiDonna has also represented clients before the Committee for Statistical Annotation of Tariff Schedules (the “484(f) Committee”) in proposing and securing revisions to the Harmonized Tariff Schedule of the United States (“HTSUS”).

Mr. DiDonna’s representative industry experiences spans a broad spectrum of products including ferrous goods of all types (carbon and alloy long products, carbon and alloy flat-rolled products, tubular goods, semifinished steel inputs, and fabricated structural goods), nonferrous metals including copper and aluminum products, paper products, photovoltaic goods, and various manufactured OEM products.

Mr. DiDonna earned his B.A. in politics and East Asian Studies – focusing on Japan – from Washington and Lee University.

**Alan H. Price** is a partner in the Washington, D.C. law firm of Wiley Rein LLP and serves as the chairman of the firm’s international trade practice. Alan has more than 25 years of experience representing clients in high-profile, complex international trade regulatory matters, including trade litigation involving public and government relations issues. In addition to being chair of the firm’s international trade practice, he heads the firm’s antidumping and countervailing duty practice. He also counsels clients on bilateral and multilateral agreements, trade legislation, customs regulation, Foreign Corrupt Practices Act (“FCPA”) compliance issues, escape clause investigations, and Section 301 cases.

Alan has particularized expertise in the fields of metals – including both ferrous and non-ferrous metals and has represented these industries in high-level proceedings before CBP, the U.S. Department of Commerce, the U.S. International Trade Commission, the U.S. Court of International Trade, the U.S. Court of Appeals for the Federal Circuit, and various international bodies. Alan has served as the president (2012-2014), vice president and president elect (2010-2012) of the Committee to Support U.S. Trade Laws (“CSUSTL”).

Alan obtained his Bachelor of Arts degree with high honors from the State University of New York at Stony Brook, and obtained his J.D. with honors from the George Washington University Law School.

**Robert DeFrancesco** is a partner in Wiley Rein’s International Trade Practice, handles all aspects of trade remedy proceedings. He has particular expertise in both U.S. antidumping and countervailing duty proceedings appearing before the Department of Commerce, the International Trade Commission, the U.S. Trade Representative, the Court of International Trade, and the Court of Appeals for the Federal Circuit. Mr. DeFrancesco has also actively assisted in World Trade Organization matters, providing advice regarding WTO obligations and dispute settlement proceedings for various clients and governments.
Aluminum Extrusions Identification, Classification, and Trade Law Seminar

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Aluminum Extrusion Seminar
U.S. Customs & Border Patrol

Long Beach, CA
August 22, 2017
The Aluminum Extruders Council Represents:

- 124 Members
- 64 U.S. Extrusion Members
- 7 new members in 2017
- 97.7% Renewal Rate
- Vendors, Suppliers, Aluminum Producers
- 84% of Reported U.S. Extrusion Capacity

AEC has been the only association dedicated to the Aluminum Extrusion industry. AEC members have plants in 35 states in the U.S.
What is an aluminum extrusion?

The extrusion process is relatively simple. Use a large hydraulic press to push a heated aluminum billet through a steel die.
What is an aluminum extrusion?

About 40% of all aluminum extrusions are either painted, anodized, or coated in some way. Applications can range from storm doors to luggage racks on vehicles.
What is an aluminum extrusion?

Virtually all extrusions are fabricated in some way after extrusion. This is performed by either the extruder, the customer, or a third party. Extruders continue to grow their businesses in this area as more OEM’s want ‘parts’ versus raw material.
What is an aluminum extrusion?

In some cases, customers ask extruders to kit or assemble their fabricated extrusions.
Extrusion Industry Overview

- There are over 100 extrusion companies in the U.S.
- Most are ‘one-shop’ operations that service customers in their region
- They tend to specialize in the types of extrusions demanded from their regional customers
- The industry has always had at least one large extruder with a few multi-site extruders
- Over the last 30 years, extruders have evolved into a more integrated supplier with their customers
  - More fabrication
  - In house coatings
  - Assembly & fabrication
  - JIT programs
- It wasn’t until the Chinese ramp up in 2009-2010 that imports became a major threat to our industry.
Extrusion Industry Overview

Building & Construction: 36%
Transportation: 34%
Consumer Durables: 5%
Electrical: 6%
Machinery & Equipment: 4%
Distribution: 11%
Exports: 2%
Other: 2%
Distribution: 11%

Total Pounds: 5,502,121

Source: AEC Annual End Use Survey 2016
Extrusion Industry Overview

Source: AEC Annual End Use Survey 2016

Building & Construction Uses

- Primary Doors & Windows: 25%
- Secondary Doors & Windows: 15%
- Store Fronts & Entrance Doors: 11%
- Curtain Walls: 12%
- All Other Building & Construction: 33%
- Bridge, Street & Highway Construction: 1%
- Awnings & Canopies: 2%
- Mobile Homes/Manufactured Housing: 1%
- Construction 1%
Extrusion Industry Overview

Source: AEC Annual End Use Survey 2016

- **Truck & Bus**: 7%
- **Passenger Car & Light Truck**: 31%
- **Travel Trailers & Recreational Vehicles**: 14%
- **Trailers & Semitrailers**: 39%
- **Aircraft & Aerospace**: 5%
- **All Other Transportation**: 4%

**Transportation Uses**
Extrusion Industry Overview

Source: AEC Annual End Use Survey 2016

Consumer Durables Uses

- Refrigerators & Freezers: 5%
- Other Major Appliances: 10%
- Furniture: 26%
- Pleasure Boats & Outboard Motors: 23%
- All Other Consumer Durables: 26%
- Sporting & Athletic Goods and Toys: 10%

Source: AEC Annual End Use Survey 2016
Extrusion Industry Overview

Source: AEC Annual End Use Survey 2016

Electrical Uses

- Power Transmission & Distribution: 17%
- Solar, Wind, Alternative Energy: 33%
- Electronics & Communications: 8%
- All Other Electrical: 42%
Extrusion Industry Overview

Source: AEC Annual End Use Survey 2016

- Ladders & Scaffolds: 11%
- All Other Machinery & Equipment: 89%
Thank You
Agenda

1. History of metal over the years…
   - Historical background
   - Aluminum production process

2. Aluminum alloys
   - Wrought Alloys designation
   - Alloy families
   - Alloy selection
   - 5050 vs. 6063 or 6463

3. Extrusion billet making
History of metal used over the years…

- Copper used for 9,000 years
  - Bronze (Copper + Tin) used for 4,000 years

- Iron used for 3,000 years
  - Steel (Iron + Carbon) used for 300 years

- Aluminum used for 131 years
Historical background

- English chemist Sir Humphry Davy found the existence of the metal in 1808.
- First produced in 1825 (in an impure form) by Danish chemist Hans Christian Oersted.
- First Chemical Production in 1855.
- 2 tons of Aluminum were produced in 1869.
Historical background – Ground breaking discovery

- **Electrochemical Production** by Charles Hall (Oberlin, Ohio USA) and Paul Heroult (France) in 1886

- **Bayer Process for Alumina in 1892**
Aluminum production process

The Five Steps in the Aluminum Cycle

1. Mining
2. Refining
3. Smelting
4. Fasting
5. Recycling
Aluminum production process

1. Mining

- 3rd most abundant element in the earth’s crust
- The most abundant metal in nature

![Diagram showing the distribution of elements in the earth's crust. Oxygen is the most abundant at 46%, followed by Silicon at 28%, then Aluminum at 8%, Calcium at 5%, Iron at 4%, Calcium Iron at 4%, and All others at 9%.](image)
Aluminum production process

1. Mining

**Bauxite** is an ore rich in Aluminum Oxide

Mined in Tropical regions of the World.

The production on aluminum consumes 90% of global bauxite mined.

Aerial view of bauxite mining operations, Gove, Australia
Aluminum production process

2. Refining

- **Bauxite** is turned into Aluminum Oxide or “**Alumina**” (Al$_2$O$_3$)
- The Bayer process
Aluminum production process

3. Smelting

“Hall-Heroult process” in which an electrolytic reduction turn Aluminum Oxide (Alumina) into Aluminum (Metal)

\[ 2\text{Al}_2\text{O}_3 + 3\text{C} = 4\text{Al} + 3\text{CO}_2 \]
Aluminum production process
4. Casting

Alloy batching and solidification of the molten aluminum
Mining – Refining – Smelting – Casting - &…
Aluminum production process

5. Recycling

“The most valuable material in the waste stream”

- Over 66 billion cans were recycled last year

Recycling uses 5% of the energy of producing Aluminum from ore

Aluminium Stewardship initiative – a unique aluminum value chain initiative that define and deliver the first standard for responsible aluminum
Aluminum Alloys

Wrought Alloys designation

Alloy families

Alloy selection

5050 vs. 6063 or 6463
Wrought Alloys Designations

WROUGHT ALUMINUM ALLOYS

1948
• Took effect in the US

1954
• Adopted in US

1957
• Became the National Standard

1962
• Adopted and included in ANSI H35.1

1970
• Internationally accepted
Wrought Alloys designation

A designation system of four-digit numerical designations

- *1000 series: Al – dilute alloys Al > 99%
- 2000 series: Al + Cu
- *3000 series: Al + Mn
- 4000 series: Al + Si
- 5000 series: Al + Mg
- *6000 series: Al + Mg + Si
- *7000 series: Al + Zn + Mg/Cu
- 8000 series: Al + Other elements

* Most extrusions are made from these alloy series

Heat treatable alloys, other are non-heat treatable
Wrought Alloys designation

4-Digit Designation system since 1954

XXXX

First digit classifies alloy by principal alloying element or series

Second digit if different from 0 is a modification of a specific alloy

Third and Fourth digits form an arbitrary number to identify a specific alloy in the series
Wrought Alloys designation

<table>
<thead>
<tr>
<th>Xxxx</th>
<th>XXXX</th>
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<tbody>
<tr>
<td>1xxx: indicates the minimum aluminum content is 99.00% or greater</td>
<td>If Zero:</td>
<td>1xxx: minimum aluminum percentage</td>
</tr>
<tr>
<td>2xxx-8xxx: indicates the alloy group determined by the most prevalent alloying element</td>
<td>1xxx: unalloyed aluminum with natural impurity limits</td>
<td>2xxx-8xxx: identify different aluminum families within a group</td>
</tr>
<tr>
<td>Other than Zero:</td>
<td>2xxx-8xxx: original alloy of a family</td>
<td>2xxx-8xxx: modifications of the original alloys</td>
</tr>
<tr>
<td>1xxx: special control of one or more individual impurities or alloying elements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2xxx-8xxx: modifications of the original alloys</td>
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For further information refer to Recommendation Section of the Teal Sheets [http://www.aluminum.org/resources/industry-standards](http://www.aluminum.org/resources/industry-standards)
1xxx – dilute alloys >99% Aluminum

- Where strength is not a primary consideration
- Where high **press productivity** is essential
- Where **formability and corrosion resistance** needs to be high

**Applications**

- Heat exchanger tubing
- Electrical rod and sheathing
- Appliance trim
2xxx – Al + Copper

- Where strength is a primary consideration
- Responds well to natural and artificial aging

Applications

Structural members aerospace & military (2014 / 2024)

Free machining stock (2011)
3xxx – Al + Manganese

- Where a **higher strength than 1xxx series** alloys is required
- **Formability, corrosion resistance, thermal stability**

**Applications**

- Heat exchanger tubing
- Photocopier drums
- Furniture tubing
- Chemical equipment
4xxx – Al + Silicon

Not widely used in extruded form, except:

• 4032

Forging stock for pistons where wear resistance and thermal stability are required

• 4021

ABS brake components, machineable, strength close to AA6061 / AA6082

• Welding Wire, Brazing sheet 4043, 4047

Low melting point, high molten metal fluidity
5xxx – Al + Magnesium

- Where good **corrosion resistance** is needed
- Where good **weldability** and good post-welded strength are required
- Alloys with useful strength (~5% Mg) are difficult to extrude

**Applications**

- Ship superstructures
- Cryogenic applications
- Offshore construction
- Automotive
6xxx – Al + Magnesium + Silicon (Soft)

- **6060 / 6063 / 6360 / 6560**
  - Most popular extrusion alloys
  - Fast extruding, lower strength, anodize well
  - General applications i.e. door and window, heat sinks, architectural, transportation

- **6463 / 6463A**
  - Specialized “6063” type to give bright finish after chemical brightening.
  - i.e. tub and shower, picture frame
6xxx – Al + Magnesium + Silicon (Medium Strength)

- **6061 / 6082 / 6005 / 6005A**
  - Medium strength, transportation, ladders, scaffolding, general engineering, gas cylinders, forging stock, welded construction…
Composition limits of 6xxx series alloys

<table>
<thead>
<tr>
<th>Wt% Magnesium</th>
<th>Wt% Silicon</th>
</tr>
</thead>
<tbody>
<tr>
<td>6061</td>
<td>0.8 - 1.2</td>
</tr>
<tr>
<td>6082</td>
<td>0.6 - 1.0</td>
</tr>
<tr>
<td>6005A</td>
<td>0.4 - 0.8</td>
</tr>
</tbody>
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Common **Medium Strength** 6xxx alloys
Composition limits of 6xxx series alloys

Wt% Magnesium

Wt% Silicon

Common Soft 6xxx alloys
7xxx – Al + Zinc-Magnesium

• Where **strength >6xxx** is required, along with extrudability, ease of quenching and weldability. Stress corrosion has to be managed

• Can be processed on standard presses

**Applications**

Bumpers systems

Automotive

Transportation

Military bridging

Heat Treatable
7xxx – Al + Zinc-Magnesium-Copper

- Where **high strength and toughness** are required
- Available Complex process route, low extrudability - not compatible with standard operations

**Applications**

- Major structural members - Aerospace
- Military application
- Medical cylinders

Heat Treatable
8xxx – Other aluminum alloys

• Other alloying elements: Li, Fe, Zr…

Applications

Al-Li: high stiffness, low density → Aerospace structural components

Al-Fe: electrical wire, where higher strength than AA1350 is required, i.e. building wire

Al-Zr: electrical wire, where good thermal stability is required. GATSR & ZATSR overhead cables
Alloy selection – Mechanical Properties

Non Heat Treatable

Heat Treatable

YS mild steel

Strength (MPa)
Alloy selection – Extrudability (speed)

Extrudability falls with increasing flow stress and lower melting point.
Alloy selection – Alloy vs. Process

Non Age Hardenable
- 1xxx
- 3xxx
- 5xxx

Formal solution treat
- 2xxx
- 7xxx
  (Al-Zn-Mg-Cu)

Solution treat in Press
- 6xxx
- 7xxx
  (Al-Zn-Mg)

Age Hardenable

Specialised Process
Difficult to cast

Some extruders specialize in these products
Possible on most commercial presses
Alloy selection – Extrusion as a Heat Treatment

- Melting starts (solidus)
- Mg and Si in solution (solvus)

Temperature (°C)

Time (mins)

- Gas fired furnace 20°C/min
- Induction furnace 250°C/min
- Quench

Extrusion
Alloy selection – 6XXX Compositions vs. Properties
Chemical composition 5050 vs. 6063 or 6463

AA6063 and 6463 have the same Mg and Si composition

<table>
<thead>
<tr>
<th>Wt% Silicon</th>
<th>Wt% Magnesium</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2 – 0.6</td>
<td>0.45 – 0.9</td>
</tr>
<tr>
<td>0.30 max</td>
<td>0.50 - 1.1</td>
</tr>
<tr>
<td>0.40 max</td>
<td>1.1 – 1.8</td>
</tr>
</tbody>
</table>

5050
Si 0.40 max
Mg 1.1 – 1.8

5005
Si 0.30 max
Mg 0.50 - 1.1

6063 / 6463
Si 0.20 – 0.6
Mg 0.45 – 0.9

Alloy certification
Analysis
In the field
Large samples
Precision
Accuracy

Yes
Quantitative
No
No
< 1%
< 5%

No
Semi-quantitative
Yes
Yes
< 20%
< 20%
Mechanical Properties 5050 vs. 6063 or 6463

Industry standards

Table 2

<table>
<thead>
<tr>
<th>Temper</th>
<th>Specified Section or Wall Thickness, in.</th>
<th>Area, in.²</th>
<th>Tensile Strength, ksi</th>
<th>Yield Strength (0.2% offset), ksi</th>
<th>Elongation in 2 in. or 4 x Diameter, min., %</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>up through 0.3500</td>
<td>up through 20</td>
<td>17.0</td>
<td>9.0</td>
<td>12</td>
</tr>
<tr>
<td>T5</td>
<td>up through 0.5000</td>
<td>up through 20</td>
<td>22.0</td>
<td>16.0</td>
<td>8</td>
</tr>
<tr>
<td>T6</td>
<td>up through 0.124</td>
<td>up through 20</td>
<td>30.0</td>
<td>25.0</td>
<td>8</td>
</tr>
</tbody>
</table>

Alloy 6463

<table>
<thead>
<tr>
<th>Temper</th>
<th>Specified Section or Wall Thickness, in.</th>
<th>Area, in.²</th>
<th>Tensile Strength, ksi</th>
<th>Yield Strength (0.2% offset), ksi</th>
<th>Elongation in 2 in. or 4 x Diameter, min., %</th>
</tr>
</thead>
<tbody>
<tr>
<td>T5</td>
<td>up through 0.5000</td>
<td>all</td>
<td>22.0</td>
<td>16.0</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>0.501–1.000</td>
<td>all</td>
<td>21.0</td>
<td>15.0</td>
<td>8</td>
</tr>
<tr>
<td>T6, T62</td>
<td>up through 0.124</td>
<td>all</td>
<td>30.0</td>
<td>25.0</td>
<td>8</td>
</tr>
</tbody>
</table>

The AA limits for properties are only published for sheet and plate products, not extrusions
Mechanical Properties 5050 vs. 6063 or 6463
Natural ageing

ALL 6XXX alloys naturally age at room temperature after extrusion, 5050 does not

Hardness proportional to log time
Mechanical Properties 5050 vs. 6063 or 6463

Except “6063 Ref”, all other 5050 samples do not naturally age over time
Barcol™ is a simple, rapid and non-destructive method to measure extrusion hardness.

**Mechanical Properties 5050 vs. 6063 or 6463**

- L_D hardness: ~220 – 255
- HB (Brinell): ~32 - 43
Extrusion billet making
Billet casthouse layout

Alloy batching

Metal treatment

Casting table

Homogenization - Heat
Billet casting table

*From Wagstaff Website
Thank you for your attention!

Aluminum alloy

Jerome Fourmann – Long Beach, CA - August 22, 2017
Major Extrusion Press Components:

Dealing with Defects, Failures, Repairs and Replacements

Presented By

Loewy Lombard Wean Youngstown HydroPress BLH

Designers and Manufacturers of Heavy Machinery and Components for the Metals Industry Worldwide

We Build Things. Better.
Major Extrusion Press Components:

Main Cylinder
- Integral cylinder / rear platen (1 piece)
- Separate inserted cylinder
- Separate rear platen

Main Ram

Crosshead

Piercer (if equipped)
- Piercer Cylinder
- Piercer Ram
- Piercer Crosshead

Tie Rods

Container Housing

Front Platen
Common Materials in Use

- Cast Iron (Chilled)
- Cast Ductile Iron
- Cast Steel
- Fabricated Plate, Bar and Structural Steel
- Fabricated/Forged Combination
- Forged Steel
Main Cylinder

Integral cylinder / rear platen (1 piece)
- Cast steel
- Fabricated Steel / Forging combination
- Multi-piece Forging / Welded
- Solid Forging

Separate cylinder
- Cast Steel
- Multi-piece Forging / Welded
- Solid Forging

Separate rear platen
- Cast Steel
- Fabricated Steel
- Fabricated Steel / Forging combination
- Solid Forging
Main Ram

Cast Iron
- Chilled casting process
- Forged / Welded Multi-piece
- Flame hardened
- Quench and Temper HT
- Welded Surface Overlay

Solid Forged
- Flame hardened
- Quench and Temper HT
- Welded Surface Overlay
Crosshead

- Cast Steel
- Fabricated Steel
- Fabricated Steel / Forging Combination
- Solid Forging
Tie Rods

Rolled Steel
Forged Steel
Forged/Rolled Flat Bar

Tie Rod Nuts:
Rolled Steel
Forged Steel

- Solid
- Split
- Tensioning (Supernut)
Container Housing

- Cast Steel
- Fabricated Steel
- Forged / Fabricated Steel
- Solid Forged
Front Platen

- Cast Steel
- Fabricated Steel
- Forged / Fabricated Steel
- Solid Forged
Common Defects by Material Type

Cast Irons and Cast Steel:

- Stress / Fatigue cracking
- Brinelling / Coining
- Latent casting defects
  - *Shrinkage*
  - *Sand pockets*
  - *Inclusions/Voids*
Common Defects by Material Type

**Fabricated Plate and Structural Steel:**
- Fatigue cracking
- Brinelling / Coining
- Stress Cracking
- Material Defects
- Weld Failures
Common Defects by Material Type

**Forged Construction:**
- Fatigue cracking
- Brinelling / Coining
- Stress Cracking
- Weld Failures
- Material Defects
Common Defects / Failure Locations

**Integral Rear Platen / Main Cylinder**

- Internal rear radius of cylinder bottle
- Main body of cylinder
- Inside corners
- Bolt holes for prefill
- Vent port
- Drain Port
- Underneath tie rod nuts (cracks/coining)
- Inside near main bushing shoulder
- All structural welds
- Intersection of the cylinder and rear platen
- Any welds added for mounting accessories
- Near all drilled holes or penetrations
Common Defects / Failure Locations

*Inserted Main Cylinder*

- Internal rear radius of cylinder bottle
- Main body of cylinder
- Cylinder shoulder
- Bolt holes for prefill
- Vent port
- Drain Port
- Inside near main bushing shoulder
- All structural welds
- Any welds added for mounting accessories
- Near all drilled holes or penetrations
Common Defects / Failure Locations

Rear Platen

- Cylinder retention shoulder
- All structural welds
- Any welds added for mounting accessories
- Near all drilled holes or penetrations
Common Defects / Failure Locations

Main Ram

- Scoring / Scratching along length of Ram
- “Hourglass” wear pattern
- Near all drilled holes or penetrations
Common Defects / Failure Locations

Crosshead

- Behind pressure plate / Stem area
- Base of pullback cylinder connection
- All structural welds
- Any welds added for mounting accessories
- Near all drilled holes or penetrations
Common Defects / Failure Locations

**Tie Rods**

- Root of threads
- Thread relief area
- Inside corners or steps
- Holes or lathe centers on ends
- Any welds added for mounting accessories
Common Defects / Failure Locations

Container Housing

- Container keyways
- Base of connection to container shift cylinders
- All sharp or inside corners
- All structural welds
- Any welds added for mounting accessories
- Near all drilled holes or penetrations
Common Defects / Failure Locations

**Front Platen**

- Behind pressure plate
- Underneath tie rod nuts (cracks/coining)
- Near “mouse ears” on discharge side
- All sharp or inside corners
- All structural welds
- Any welds added for mounting accessories
- Near all drilled holes or penetrations
Common Defects / Failure Causes

- Press Misalignment
  Components are loaded off center
  Binding
- Overloading press
- Unequal pullback or container shift cylinders
- Inadequate preload on tie rods
- Design flaws
  Stress Concentrations
  Poor weld locations
  Drain / Vent design and location
- Manufacturing defects
  Weld flaws (penetration, inclusion, HAZ)
  Tool marks, rough finishes
  Unblended radii
- Press accident
- Drilling, welding on press in critical areas
- Weakened / cracked adjacent component
Course of Action once damage is found

Determine extent of damage:
- Do not panic, may be old defect
- May never propagate
- May crack and stop
- Crack may be located in non critical area
- Clean, Excavate / Explore crack
- Scribe ends of crack and date
- Relieve ends gently
- Arrange for NDT services
- Check loaded / unloaded
- Monitor hourly, daily, weekly
- Record progression
- Confirm max press loading
- Consider reducing press tonnage
- Check hydraulic system safeties
- Locate drawings of component
- Get costs / lead time for replacement
Course of Action once damage is found

Repair options:

Welding
- Field welding must be done carefully
- Small local welding vs. major repair
- Poor weld repair breeds more cracks
- Welding success is material dependent
- Preparation is very important
- Bridging may be appropriate
- Pre and post heating required
- Stress relieving
- Distortion can occur
- Disassembly will probably be required
- Field machining may be required
- Weld repairs considered temporary
- Can be expensive
- 3-7 days downtime depending on scope
Course of Action once damage is found

Repair options:

Metal Stitching
- Specialized service
- Works with different materials
- Distortion is minimized
- Disassembly may not be required
- Field machining may not be required
- Stitch repairs considered less temporary
- Can be expensive
- Potentially less downtime than welding
Course of Action once damage is found

Repair options:

Mechanical Reinforcement/Repair

- Engineered repair
- Bridging, strapping
- Studs perpendicular to crack
- Banding around cylinder
- External clamping
- Sometimes used with welding
- Works with different materials
- Distortion is minimized
- Disassembly may not be required
- Field machining may be required
- Most repairs considered temporary
- Can be less expensive
- Potentially less downtime than welding
Specifying / Procuring new Components

Design Considerations:

- Engineered Replacement vs. duplicate
  - Finite Element and Fatigue analysis
  - Service factor
- Understand reason for failure and modify design
- Manufacturing methods
  - Certified weld procedures and personnel
  - NDT inspections at specified intervals
  - Thermally stress relieve all fabrications
  - No welding after stress relief
  - Attach accessory mounts during manufacturing
  - No chain or tool marks
# Common Material Comparison

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
<th>Life Expectancy</th>
<th>Ease of Welding</th>
<th>Machinability</th>
<th>Flexibility in design</th>
<th>Domestic Availability</th>
<th>Field repairable</th>
<th>NDT Inspection Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabricated Low Carbon Steel</td>
<td>$</td>
<td>Mid-High</td>
<td>Easy</td>
<td>Easy</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Yes</td>
<td>Easy</td>
</tr>
<tr>
<td>Forged Low Carbon Steel</td>
<td>$$</td>
<td>Very High</td>
<td>Easy</td>
<td>Easy</td>
<td>Very Good</td>
<td>Good</td>
<td>Yes</td>
<td>Easy</td>
</tr>
<tr>
<td>Forged Alloy Steel</td>
<td>$$$</td>
<td>Very High</td>
<td>Difficult</td>
<td>Moderately Difficult</td>
<td>Limited by size</td>
<td>Limited</td>
<td>Easy</td>
<td></td>
</tr>
<tr>
<td>Cast Steel</td>
<td>$</td>
<td>Mid-High</td>
<td>Difficult</td>
<td>Moderately Difficult</td>
<td>Very Good</td>
<td>Very Limited</td>
<td>Difficult</td>
<td>Very Difficult</td>
</tr>
</tbody>
</table>
Specifying / Procuring new Components

Design Considerations (cont’d):

- **Material Selections**
  - Forged vs. Fabricated vs. Casting
  - Alloys
  - Material quality very important (NDT inspected)
  - Cost vs. life expectancy
- **Time to upgrade?**
  - Higher tonnage, longer billet,
  - 4 corner guiding, flat ways, etc
- Consider used or reconditioned
- Lead time for new can be 6 months or more
Major Press Components:
Dealing with Defects, Failures and Replacements

Thank You!

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Salem, Ohio USA
www.butechbliss.com 330-337-0000
ALUMINUM EXTRUSION IDENTIFICATION, CLASSIFICATION, AND TRADE LAW SEMINAR

Aluminum Extrusions: Tooling and Dies
FEEDERS

Feeders come in many shapes, sizes and forms. A feeder can be built into the die known as a pocket die, or as a separate unit known as a feeder plate. It has an orifice that controls the flow of aluminum to the die. There are many advantages in using feeders.

WELD BILLETS TOGETHER

Once the first billet is pushed through the die stack and the extruded aluminum is past the pressure ring, the chance of the aluminum plugging up somewhere in the die stack is virtually eliminated because each billet thereafter will weld together in the feeder plate with the previous billet.
CONTROL CONTOUR

Certain dies that have thin-walled shapes and/or special tolerances need a feeder plate to control the contour. The feeder plate alone may not always be the answer. Sometimes, in conjunction with the feeder, a contoured pocket in the die plate, which allows additional control of metal flow, is needed.

SPREAD ALUMINUM

When the circle size of a shape is larger than 85% of the inside diameter of the container, a feeder plate should be used to spread the aluminum to the needed areas. The feeder plate should be designed with a relief angle up to, but not exceed, 30 degrees.
POCKET DIES

The most popular form of a feeder is the pocket die. Also known as a weld pocket or cavity feed. The pocket depth can vary from as little as .250” deep to as much as .750” deep. Any deeper than .750” normally would be a feeder plate. The lighter the shape (thinner walls), less depth; the heavier the shape (thicker walls), deeper depth. When walls are light, sometimes it helps to put a second pocket much closer to the shape, to help control the contour. The pocket die is user friendly. It is very easy to open up the pocket on a mill if flow corrections need to be made to the pocket.
SAMPLE #2 (ORIGINAL)
DIE: 9 x 1.50 w/ .500’ PKT
SAMPLE #5 (ORIGINAL)
DIE: 12 x 5.50

RECESS ENTRY
100° DP W/30°
SAMPLE #6 (ORIGINAL)
DIE: 10 x 5.50

RECESS ENTRY
25° DP W/RADIUS
Thank You
ALUMINUM EXTRUSION IDENTIFICATION, CLASSIFICATION, AND TRADE LAW SEMINAR
Efficiency Through Process Control

• A Process is a Process
• Man, Machine, Material, Method, Metrics
  – Skills, Cross Training, Cont. Ed., Associate Accountability
  – Equipment, Tooling, Robust PM/TPM, Housekeeping
  – Material Certification & Tractability, Supplier Accountability
  – Critical variables, control plans, standard work
  – What gets measured gets managed!!
• Continuous Improvement with LSS & QRM
• Understand your constraints and capacities
• Process Tanks
  – Cleaning
  – Etch (Acid Etch)
  – Desmut
  – Three Anodizing Tanks
  – Hot / Cold Seal
  – One Two-Step Tank
• Class I & II
• Two-Step Anodizing (AAMA 608 Certified)
  – Champagne thru Black colors
• Velo (Clear) Anodizing (AAMA 607 Certified)
• 35’ Maximum Piece Length
• Vertical Wet Paint Line
• Five Stage Cleaning and Chrome Phosphate Pretreatment System
• Four Booth Ransburg Electrostatic Painting System with Matrix Recipe Management and Thermal Oxidizer to Control VOC Emissions
• 24’ 2” Maximum Length
   Regular Paint (AAMA 2603 Certified)
   High Performance Paint (AAMA 2604/2605 Certified)
   Valspar, PPG, AkzoNobel, AAMA Approved Paint Applicator
• Automated Thermal Bar System
  – Polyamide 6/6 Nylon Strip Reinforced with Glass Fibers in three dimensions.
    • Standard & Special Strips
      – Two Tone System
      – 26’ Maximum Length
• Pour and Debridge System (AAMA TIR A8)
  – Automated Line
  – Skip Debridge Capability
  – 32’ Maximum Length
  – AZO-Brade Capability
Paint – People and Process Issues

- Increasing colors → Change Over Efficiency
- Powder/Wet Paint → Same Shared Equipment
- HP/Regular Paint → Group Similar Products

...These issues have to be balanced in your Pull System
Vertical Paint Line
Horizontal power and free conveyor
Liquid Mix Room
Liquid Rotary Atomizers
Powder Booth
Quality Tools

Dry Film Gauge

Tooke Gauge

Adhesion Test

Color Match
Anodizing – Labor Coordination

- Daily Production Plan (To Optimize Tank Utilization)
  - 2Step, Clear, 15min, 30min, 60min coatings
  - Seal Types
- Float working crews between Racking and Unracking depending on the parts
- Use of 2-Way Radios is helpful to coordinate quick labor changes based on production demands
Anodizing – Racking Best Practices

• Rack to maximize process tank utilization
  – Mix
  – Rail Density
  – Style (Pin, Clamp, Twist, Stack)
  – Consistency (order to order)
  – Part Spacing & Orientation
  – Rack Maintenance & Consistent Electrical Conductivity
Anodizing – Crane & Process Control

Crane Operations
- Waste Time (secs/rail)
- Active Time (%)
- Tank Drag Out/In
- Anodize Build (amp/sqft)
  - 12 – 24 amps/sqft

Tank and Process Control
- Caustic Etch
- Acid Etch
- Desmut Sulfuric
- Anodize Sulfuric Concentration
- Anodize Aluminum Concentration

Anodizing Video
Click to Play
Anodizing – Manufacturing Best Practices

- Anodize/Color Capacity & Tank Utilization
- Rack & Rail Loading Densities
- Power and Utility bill management
- Power contracts and management strategies
Anodizing – Environmental & Chemical Issues

- Chemistry & Temperature Control
- Cross Contamination Issues
- Chemical Control Strategies
- Environmental Considerations
THANK YOU
Making Extruded Aluminum Solutions More Cost Effective
Making Extruded Aluminum Solutions More Cost Effective

Presented by:

Mark Telander
Inside Sales Representative
Alexandria Industries

Sponsors:
About AEC

- **The industry association for North American extruders**
- ~60 extruder members, accounting for ~75% of extrusion produced in North America
- **Focused on:**
  - User education
  - Member excellence
  - Fair trade

- **Fifty years of pushing boundaries**
- AEC member, with extrusion operations in Minnesota & Indiana
- A leading supplier of precision custom extrusions & fabricated components
This presentation provides an overview of aluminum extrusion—how to utilize alloys, design features, and secondary processes—to create cost-effective extruded aluminum solutions.

- Introduction
- Extrusion Process & Economics
- Creating Cost Effective Solutions
  - Alloys
  - Profile Design
  - Tolerances
  - Secondary Processes
- Tips for Sourcing Extrusions
- Additional Resources
With aluminum extrusions, designers are able to join the outstanding characteristics of aluminum with the unique attributes of the extrusion process to create compelling product solutions.

**Aluminum**
- Lightweight
- Strong
- High strength-to-weight ratio
- Resilient
- Corrosion resistant
- Heat conductive
- Reflective
- Electrically conductive
- Non-magnetic
- Non-sparking
- Non-combustible
- Cold strength
- Fully recyclable

**Extrusion**
- Tailored performance – put metal where it is needed
- Suitable for complex, integral shapes, produced to close tolerances
- Attractive, wide range of finishes
- Virtually seamless
- Easy to fabricate
- Joinable by various methods
- Suitable for easy-assembly designs
- Produced with uniform quality
- Cost effective
- Short production lead-times
**Introduction**

*Aluminum extrusion* offers you the ability to create the shapes to meet design challenges from large ...
Introduction

... to small

Radiation “shutter”

Onyx on-camera LED light professional videography

Housing, Apple watch, sport edition
Extrusion Process & Economics
Extrusion Process & Economics

Feedstock: Heated aluminum alloy "billet"

Source: Rio Tinto Alcan

Extrusion Cost Structure

- Other
- Dies
- Facility
- Labor
- Metal*

*may vary with alloy

Steel die and supporting tooling

Desired final "profile" or shape
Creating Cost Effective Solutions

- Alloys
- Profile Design
- Tolerances
- Secondary Processes
Select the appropriate alloy

- Review alternative alloys to determine best alloy for the application / end use
- Understand the differences when prototyping or testing with material that is easier to obtain, e.g. 6061 bar stock
- The alloy may have a big effect the extrudability of a profile (i.e. processing cost), and may impact surface finish and tolerances
Alloy extrusions can be produced in different alloys and processed to different tempers to achieve desired mechanical properties.

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Major Alloying Elements and Alloy Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 Series</td>
<td><strong>Minimum 99% Aluminum</strong>&lt;br&gt;High corrosion resistance. Excellent finish-ability. Easily joined by all methods. Low strength, poor machinability. Excellent workability. <strong>High electrical conductivity.</strong></td>
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<td><strong>Manganese</strong>&lt;br&gt;Low to medium strength. Good corrosion resistance. Poor machinability. Good workability.</td>
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<tr>
<td>4000 Series</td>
<td><strong>Silicon</strong>&lt;br&gt;Not available as extruded products</td>
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<tr>
<td>5000 Series</td>
<td><strong>Magnesium</strong>&lt;br&gt;Low to moderate strength. Excellent marine corrosion resistance. Very good weldability.</td>
</tr>
<tr>
<td>7000 Series</td>
<td><strong>Zinc</strong>&lt;br&gt;Very high strength. Poor corrosion resistance. Good machinability. Heat treatable.</td>
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</table>

<table>
<thead>
<tr>
<th>Typical Extrusion Tempers</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Extruded and air cooled</td>
</tr>
<tr>
<td>O</td>
<td>Fully annealed</td>
</tr>
<tr>
<td>H112</td>
<td>Strain-hardened; used for nonheat-treatable alloys</td>
</tr>
<tr>
<td>T1</td>
<td>Cooled from an elevated temperature/naturally aged</td>
</tr>
<tr>
<td>T4</td>
<td>Solution heat-treated and naturally aged</td>
</tr>
<tr>
<td>T5</td>
<td>Cooled from an elevated temperature/artificially aged</td>
</tr>
<tr>
<td>T6</td>
<td>Solution heat-treated and artificially aged</td>
</tr>
</tbody>
</table>

**Alloys / Tempers**

**Typical Extrusion Tempers**

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Firearms, Aerospace

Broadest applicability

F
O
H112
T1
T4
T5
T6
Extrudability – conversion cost – will vary with chemistry.

**Extrudability index**

<table>
<thead>
<tr>
<th>Alloys</th>
<th>Extrudability</th>
</tr>
</thead>
<tbody>
<tr>
<td>7075</td>
<td>90</td>
</tr>
<tr>
<td>7020</td>
<td>80</td>
</tr>
<tr>
<td>6082*</td>
<td>70</td>
</tr>
<tr>
<td>6005A*</td>
<td>60</td>
</tr>
<tr>
<td>6060/63*</td>
<td>50</td>
</tr>
<tr>
<td>3003</td>
<td>40</td>
</tr>
<tr>
<td>Al 99.5</td>
<td>30</td>
</tr>
</tbody>
</table>

* T6, except 6005A @ T61  **typical properties

Source: Rio Tinto Alcan
Any one alloy can have a variety of formulae e.g.: 6XXX alloy series

Typical Applications
- Auto Intrusion Beams
- Bumper Beams
- Auto Chassis/Structural
- Solar racking systems
- Trim components
- Heat sinks
- Electronics housings
- Window/Façade systems

Increasing strength
<table>
<thead>
<tr>
<th>Alloy</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>6005A</td>
<td>Mechanical properties similar to 6061. Used in structural applications.</td>
</tr>
<tr>
<td>6060</td>
<td>Has better extrudability than 6063. The minimum mechanical properties (with the exception of minimum welded properties), response to finishing processes, and corrosion resistance are similar to 6063.</td>
</tr>
<tr>
<td>6063</td>
<td>The most popular extrusion alloy. Takes a good surface finish, is corrosion-resistant, and can be heat-treated for strength.</td>
</tr>
<tr>
<td>6101</td>
<td>High strength bus conductors; good extrudability, weldability, braze-ability, good resistance to stress corrosion cracking with average machinability.</td>
</tr>
<tr>
<td>6105</td>
<td>Good medium to high strength with average machinability and good corrosion resistance.</td>
</tr>
<tr>
<td>6262</td>
<td>Best machining of all extrusion alloys. Good corrosion resistance.</td>
</tr>
<tr>
<td>6351</td>
<td>Mechanical properties similar to 6061. Used in structural applications. Will take considerable forming in T4. Good corrosion resistance. Used in transportation and general structures.</td>
</tr>
<tr>
<td>6463</td>
<td>Designed to accept a bright finish through anodizing or polishing. Decorative trim applications; machinable and heat-treatable.</td>
</tr>
<tr>
<td>6082</td>
<td>Highest strength of 6000 series. Excellent corrosion resistance and machinable.</td>
</tr>
</tbody>
</table>
## Alloys – Extrudability

<table>
<thead>
<tr>
<th></th>
<th>Yield Strength (min)</th>
<th>Surface Quality</th>
<th>Bending</th>
<th>Machining (based on chips, finish)</th>
<th>Joining</th>
<th>Extrudability/Processing/Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>6060/63</td>
<td>25 ksi</td>
<td>Excellent finish &amp; corrosion resistance</td>
<td>Good in T6, VG in T1/T4</td>
<td>C</td>
<td>B</td>
<td>100 - Superior extrudability, easy quench</td>
</tr>
<tr>
<td>6005A</td>
<td>38 ksi</td>
<td>Superior corrosion resistance</td>
<td>Good in T6, VG in T1/T4</td>
<td>C : continuous chip, good finish</td>
<td>C</td>
<td>95 - Superior extrudability &amp; quench vs. 6061/6082</td>
</tr>
<tr>
<td>6061</td>
<td>38 ksi</td>
<td>Good corrosion resistance</td>
<td>Manageable in T6511, VG in T1/T4</td>
<td>C</td>
<td>B</td>
<td>80 - Good extrudability, quench demanding</td>
</tr>
<tr>
<td>6082</td>
<td>38 ksi</td>
<td>Good corrosion resistance</td>
<td>Manageable in T6511</td>
<td>C</td>
<td>B</td>
<td>80 – Good extrudability, very quench demanding</td>
</tr>
<tr>
<td>7005</td>
<td>44 ksi</td>
<td>Zn precludes good anodize Stress corrosion</td>
<td>Acceptable in T53</td>
<td>B : curled chip, good-exc. finish</td>
<td>D</td>
<td>50 - ½ speed; quench, special ageing</td>
</tr>
</tbody>
</table>

Source: Rio Tinto Alcan
Geometry can offset lower alloy strength
Profile Design – Manufacturability

- Geometry
- Features
- Functionality

(Dark bands are markers to illustrate material flow.)

Think about the material flow through a multi-hole hollow die like this!
Profile Design – Geometry

General Preferable Design Practices

Uniformity

Not this!  This!

Not this!  This!

Symmetry

Not this!  This!

Smooth Transitions

Not this!  This!

Not this!  This!

Enhance Visual Surfaces

Not this!  This!
Extrusion Die Tongue Ratios

**Difficult Design**
- Uneven mass on tongue will bend and break steel tongue in the extrusion die.

**Better Design**
- Even mass creates even pressure on steel tongue and prevents die breakage.

Steel tongue in extrusion die:
- Tongue ratio 8:1
- \[ \frac{1.200}{0.150} = 8 \]
  - (depth of slot is 8 times the width)
Extrusion Die Tongues

Note: Most extruders can make even “not recommended” profile designs work, but costs may be higher due to lower yields and slower run times!
Profile Design – Features

Screw slots are more often simple to incorporate in the profile and can eliminate a more expensive hollow die, which extrudes more slowly and increases cost.

Self tapping screw  Thread cutting screw

60°

This!

Not this!
This housing for a lighting fixture incorporates slots for the electronic components, short fins for heat dissipation, and screw bosses to secure the end cap on each end to enclose the lighting unit.
Sometimes a “complex hollow die” will yield a superior solution!
Design specific features into your extrusion to:

- Enhance joining to other extrusions or other materials
- Facilitate assembly
- Provide added functionality, e.g. heat dissipation
- Enhance aesthetics, etc.
Real-World Application – Design Features
Understand Tolerances

- Critical-to-function vs. non-critical
- CPK requirements
- Capability requirements – PPAP
- Geometric Dimensioning & Tolerancing (GD&T)
- Method of inspection
- Effects of chemical finishing
- Effects of thermal expansion
Design – Tolerances

• Design dimensions for functionality
  – Designate critical features and tolerances
• Apply appropriate tolerances to non-critical or non-functional features
  – Avoid titleblock
  – Consider GD&T
• Understand method of inspection used
  – Correlation between customer and vendor
  – Accuracy of method of inspection
  – Inspect in restrained or non-restrained state
Tolerance Tables
(The Aluminum Association’s Aluminum Standards & Data)

Source: The Aluminum Association
Which are the critical dimensions? These?

- Wall Thickness
- Base of Gap Dimensions
Or these? Hollow/Gap Dimensions – Column 4-9?
## Design – Tolerances

### Parameters that will affect variation / tolerances:

<table>
<thead>
<tr>
<th></th>
<th>Design Dependent</th>
<th>Extruder Dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alloy</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Exit temperature</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Extrusion speed</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Die shape and type</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Cooling time</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Amount of post-stretch</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Multiple die copies</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Multiple holes in die</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Press size</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Method of inspection</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
Extrusions can be machined, formed and assembled with a wide variety of familiar technologies. Yet some processes – particularly bending and welding – benefit from prior extrusion fabrication experience.
Fabrication

- Sawing
- Punching / piercing / drilling
- Bending
- Stretch-forming
- Welding
- Milling
- Tumbling
Real-World Application – Fabrication

- Sawing
- Punching/piercing/drilling
- Bending
- Welding
- Milling
- Tumbling
Fabrication – Machining

• CNC and Robotics
• Lineal Advance Machines
Fabrication – Bending

- Stretch Bending
- CNC Bending
- Roll Bending
Real-World Application – Bending

Bending Technologies

- Stretch bent, over a form
- Both T4 and T5 conditions
- Complex bends are feasible

Source: Almag
Secondary Processes – Finishing

- Anodizing
- Powder Coating
- Painting
- Plating
- Mechanical
Get the most out of your aluminum extruded components.

The combination of alloy, design features, tolerances, and any needed secondary processes, allows you to:

- Optimize component performance
- Reduce part counts, and enhance utility
- Develop creative designs that can simplify and or eliminate secondary processes and assembly steps
- Easily cut, machine, finish, bend, weld, fabricate and assemble components
Tips for Sourcing Extrusions

• Get your extruder involved early in the design stage
• Ensure you have realistic cost expectations
• Leverage extruder experience for small changes that can yield significant savings
• Look for an extruder that offers other manufacturing services and vertical market experience
Additional Resources

For more Information and Training visit the Aluminum Extruders Council website [www.aec.org](http://www.aec.org).

- Find an Extruder search
- Extrusion Applications
- Extrusion Design Resources
- Sustainability Info
- And more!

About AEC:
The Aluminum Extruders Council (AEC) is an international trade association dedicated to advancing the effective use of aluminum extrusion in North America. AEC is committed to bringing comprehensive information about extrusion's characteristics, applications, environmental benefits, design and technology to users, product designers, engineers and the academic community. Further, AEC is focused on enhancing the ability of its members to meet the emerging demands of the market through sharing knowledge and best practices.

AEC Buyers’ Guide ([www.AECguide.org](http://www.AECguide.org))

Joining
The rapid increase in automotive aluminum content – and in multi-material solutions – has led to a dynamic evolution in material joining technology. In response, a comprehensive Aluminum Joining Manual, has recently been developed.

The manual addresses:
• Adhesive Bonding
• Beam Welding
• Brazing
• Mechanical Joining
• Resistance Welding
• Fusion
• Combined Joining
• Joining Dissimilar Materials

To access, go to: www.aec.org/JoiningManual
The Aluminum Association

Aluminum Design Manual
– 2010 Edition
(www.aluminum.org)

Aluminum Standards and Data
• Nominal and specified chemical compositions of alloys
• Typical mechanical and physical properties
• Mechanical property limits
• Definitions, and dimensional tolerances for semi-fabricated products
Thanks to Our Presenting Sponsors…

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EXCO
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Magneo Corporation
Marx GmbH & Co. KG
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M-D Building Products
Metal Exchange Corporation
Metra Aluminum Inc.
MI Metals Inc.
Mid South Extrusion Die Co.
Mid-States Aluminum Corp.
Nanshan America Co.
National Aluminum Ltd.
Ohio Valley Aluminum Co. LLC
OMAV S.p.A.
Penn Aluminum International Inc.
Pennex Aluminum Company
Postle Extrusion
PPG Industries Inc.
Presezzi Extrusion North America
PRICEWalgren
Pries Enterprises Inc.
Profile Custom Extrusion Co.
Reliant Aluminum Products LLC
Republic Chemical Co., Inc.
Richardson Metals
Rio Tinto – Aluminium Product Group
R.L. Best Company
Rusal America Corp.
Sapa Extrusions
SAT S.p.A.
Service Center Metals
Sierra Aluminium
Shoals Extrusion, LLC
Silver City Aluminum Corp.
SMS Technical Services LLC
Southeastern Extrusion & Tool, Inc.
Spectra Aluminum Products Ltd.
Spectrum Metal Finishing Inc.
Superior Extrusion Inc.
Taber Extrusions LLC
TCI Powder Coatings
Technofom Bautec North America
Tecnoglass S.A.
Telkamp Systems Inc.
Thumb Tool & Engineering
Tower Extrusions, LLC
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Turla S.r.L.
Ube Machinery Inc.
Valspar Corporation
Vedanta Limited
Vitex Extrusion
Wagstaff Inc.
WEFA Cedar Inc.
Werner Co.
Western Extrusions Corp.
Whitehall Industries
YKK AP America Inc.
Youngstown Tool & Die Co. Inc.

To find an extruder: go to www.aec.org/FindExtruder
Questions?

Joining us for your questions:

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The Aluminum Association (AA), Aluminum Extruders Council (AEC), the authors and contributors of this overview provide information and resources about aluminum products and aluminum-related technology as a service to interested parties. Such information is generally intended for users with a technical background and may be inappropriate for use by lay persons.

This presentation does NOT attempt to thoroughly discuss all load types, materials, profiles, design requirements, etc.

The purpose is to provide an overview of topics/issues to consider when utilizing aluminum extrusions for designs.

Full understanding and adherence to the Aluminum Design Manual (Aluminum Association 2010) and all documents referenced by it is required for proper design.

In all cases, users should not rely on this information without consulting original source material and/or undertaking a thorough scientific analysis with respect to their particular circumstances. Information presented here does not replace the independent judgment of the user or of the user’s company and/or employer.

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Key Trade Issues

- Circumvention
- Transshipment
Key Trade Issues

✓ Circumvention

5050 Alloy – Several extruders reported issues with this scheme. It impacted shower door applications, railings, fencing, drawn tube products, and various B & C applications.

Mislabeling – Several reports that fabricated extrusions are being labelled as ‘machine parts’

The mislabeling reports generally come when a part or sub-assembly is not being declared a fabricated extrusion. Instead it is labeled as a door threshold, or fan housing, etc. These parts may have been directly identified by Commerce.

Is the part in question really just a fabricated extrusion, or is it a final, finished product?
Key Trade Issues

✓ Transshipment

Vietnam – There is growing alarm at the increase in Vietnamese exports to the U.S. It is unlikely that all of this metal has actually been extruded in Vietnam. Elkhart, IN has been especially impacted in recent months.

Chinese Brokers are sending ‘spam email’ out to possible buyers offering ‘creative trade solutions’ that will enable U.S. buyers to evade duties.

Malaysia remains at the top of the list when it comes to transshipments. There have already been two cases and convictions of transshipments through Malaysia.

Generally, extrusion presses in Vietnam and Malaysia are not particularly sophisticated. There are also size limitations concerning a shape, i.e., the circle size of the shape is too wide for any presses in Vietnam.

Is the finish on that extrusion even produced in Malaysia? Certain applications may or may not be available in these countries, i.e., wet paint vs. powder.

Is it likely that the extrusion being declared could even be extruded in a third country?
AEC wants to help!

The Aluminum Extruders Council wants to help in suspected cases of transshipment or circumvention, etc.

My Direct Line is 847-416-7222. Call me, and if I can’t answer your question, I can find someone that can.

More Seminars! As we move forward, we may want to drill down into certain applications to give staff an even greater understanding of extrusion applications.

Thank you all for your time and support!
Aluminum Extrusion Tour of Frontier Aluminum
2480 Railroad Street
Corona, CA  92880
Tuesday, August 23, 2017
Departing USCBP Offices (Long Beach) - 8:00 am; Returning – noon

Name: __________________________________________

Organization: ____________________________________

Phone Number: ____________________________________

Email Address: ____________________________________

Coat Size (small, medium, large, extra-large (err on sizing up)): __________________

Please reply to Richard DiDonna (rdidonna@wileyrein.com) by August 14, 2017. Information will be kept confidential and shared only with responsible individuals at Frontier Aluminum.