Alcoa Innovation: transforming aluminum into better products!

With its ties with the *Alcoa Technical Center*, Alcoa Innovation is supporting Quebec’s industries in their projects using aluminum.
Four Things I Want You to Know

- Not all aluminum alloys are fusion weldable
- Molten aluminum likes hydrogen
- Aluminum shrinks more than steel during solidification
- Filler alloy selection for aluminum welding is more about matching chemistry with the base metal than strength
Properties of Aluminum That Affect Arc Welding

- High thermal conductivity
- High solidification shrinkage, 6% by volume, which is twice as much as steel
- High melting tenacious surface oxides
- High hydrogen solubility in molten aluminum
Implication of High Thermal Conductivity

- Slightly higher welding currents are required than those used for steel
- Cold weld starts
- Short circuiting arc transfer, commonly used for steel
  Gas Metal Arc Welding is not recommended for aluminum – spray or pulse spray should be used
- Steel welding equipment often does not work well on aluminum
Implication of High Solidification Shrinkage

- Aluminum shrinks 6% by volume, twice as much as steel during solidification.
- Because of shrinkage, aluminum distorts more than steel as a result of welding.
- More care must be taken in terminating welds. Otherwise “crater cracks” result.

Crater-crack revealed with the aid of dye-penetrant.
- Aluminum oxide ($\text{Al}_2\text{O}_3$) is an electrical insulator
- Melts at a temperature 3x of the aluminum it is protecting
- Thick oxides and water stains must be removed before welding
Surface Oxide

- $\text{Al}_2\text{O}_3$ reforms instantaneously
- A thin coating is formed but grows thicker very slowly
- The DC electrode positive current portion of the welding cycle, cathodically removes surface oxides in front and sides of aluminum welds (3 mm wide)
Hydrogen has a high solubility in molten aluminum

Oil, grease, paint must be removed prior to welding with a solvent
Sources of Hydrogen

- Hydrocarbons broken down in the arc
  - Oils and greases
    - Machining lubricants, solvents, oil in shop air
  - Dust, dirt and sand
    - Contaminants trapped within the weld joint
- Water vapor broken down in the arc
  - Condensation on material being welded (Dew Point)
  - Hydrated oxides on filler wire or base material
  - Contaminated welding gas
  - Water cooling leak in welding torch
  - Extremely high humidity
  - Water in shop air
Primary Factors

- Ease of Welding or Freedom from Cracking
- Tensile or Shear Strength of Weld
- Weld Ductility
- Service Temperature
- Corrosion Resistance
- Color Match Between Weld and Base Metal
- Post Weld Heat Treatment

Final determination of the best filler alloy for joining an aluminum alloy should be made only after through analysis of the welds final performance requirements.
Base Alloy Crack Sensitivity

Relative crack sensitivity vs. weld composition for various binary aluminum systems.
Dilution Ratios of Weld Joints

- **Fillet Welds**: 80% filler metal, 20% base metal
- **Single Vee-Groove Weld**: 60% filler metal, 40% base metal
- **Square Groove Weld**: 20% filler metal, 80% base metal
## Filler Alloy Selection Chart

### Chart Details:
- **Title:** Filler Alloy Selection Chart
- **Source:** ALCOA
- **Purpose:** Provides a selection guide for fillers based on specific criteria.

### Chart Columns:
- **Filler Alloy**
- **Heat Treated**
- **Mechanical Properties**
- **Other Properties**

### Chart Rows:
- **Alloy Designation**
- **Heat Treatment**
- **Tensile Strength**
- **Yield Strength**
- **Hardness**
- **Other Comments**

### Chart Notes:
- **Legend:**
  - A key for interpreting the chart is typically provided at the top or bottom of the chart.
- **Guidance:**
  - Instructions or guidelines for using the chart are usually included.

### Chart Layout:
- The chart is structured in a tabular format, with columns and rows for detailed information.
- The chart includes a variety of fonts and colors to highlight different sections.

### Chart Analysis:
- Users can select a filler alloy based on required mechanical properties and other characteristics.
- The chart helps in making informed decisions for material selection in various applications.

### Chart Importance:
- Filler alloys are critical in welding processes, and the selection chart aids in choosing the most suitable alloy for specific projects.

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**Example Scenario:**
- A user needs to select a filler alloy for a specific mechanical requirement. By consulting the chart, they can find the alloy that meets the necessary tensile strength and hardness levels, ensuring optimal performance in their application.
# Filler Alloy Selection for Base Alloy Combination

<table>
<thead>
<tr>
<th>Base Alloys</th>
<th>5052</th>
<th>5083</th>
<th>5086</th>
<th>5454</th>
<th>6005, 6063, 6101, 6151, 6201, 6351</th>
<th>5061</th>
<th>5070</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler</td>
<td>W</td>
<td>S</td>
<td>D</td>
<td>C</td>
<td>T</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>6061</td>
<td>4043</td>
<td>A D C A</td>
<td>A D C A</td>
<td>A D C A</td>
<td>A D C A</td>
<td>A D C A</td>
<td>4043</td>
</tr>
<tr>
<td>6070</td>
<td>4145</td>
<td>A B C A</td>
<td>A B C A</td>
<td>A B C A</td>
<td>A B C A</td>
<td>A B C A</td>
<td>4145</td>
</tr>
<tr>
<td>5183</td>
<td>4643*</td>
<td>A B C A</td>
<td>A B C A</td>
<td>A B C A</td>
<td>A B C A</td>
<td>A B C A</td>
<td>4643*</td>
</tr>
</tbody>
</table>

### How to Use:

1. Select base alloys to be joined (one from the side blue column, the other from the top blue row).
2. Find the block where the column and row intersect.
3. This block contains horizontal row(s) of letters (A, B, C, or D) representative of the alloy directly across from them in the filler alloy box at the end of each row. The letters in each line give the A-to-D rating of the characteristics listed at the top of each column-W, S, D, C, T, and M (see Legend at right for explanation of each letter).
4. Analyze the weld characteristics afforded by each filler alloy. You will find that you can "trade off" one characteristic for another, until you find the filler that best meets your needs.

### Legend

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>Ease of welding (relative freedom from weld cracking)</td>
</tr>
<tr>
<td>S</td>
<td>Strength of welded joint (&quot;as-welded&quot; condition). (Rating applies particularly to fillet welds. All rods and electrodes rated will develop presently specified minimum strengths for butt welds).</td>
</tr>
<tr>
<td>D</td>
<td>Ductility. (Rating is based upon the free bend elongation of the weld.)</td>
</tr>
<tr>
<td>C</td>
<td>Corrosion resistance in continuous or alternate immersion in fresh or salt water.</td>
</tr>
<tr>
<td>T</td>
<td>Recommended for service at sustained temperatures above 150 °F (65.5 °C).</td>
</tr>
<tr>
<td>M</td>
<td>Color match after anodizing</td>
</tr>
</tbody>
</table>

*A, B, C and D are relative ratings in decreased order or merit. The ratings have relative meaning only within a given block.*
Heat-Affected Zones (HAZ)

All aluminum alloys are affected by temperature and time at temperature

The HAZ is most often weaker than the parent material

The engineer must think about the HAZ when designing a structure
Welding is a local annealing operation
Recrystallization and grain growth occur in the HAZ
No matter what the starting temper, the HAZ will have “0” temper properties
Nothing can be done to restore properties after welding

*Important*
For welded structures design to “0” temper properties, not strain-hardened properties
Typical Properties of Aluminum Groove Welds on Non-Heat Treatable Alloys

<table>
<thead>
<tr>
<th>Base Metal</th>
<th>Filler Alloy</th>
<th>Minimum Expected Welded Ultimate Tensile Strength in MPa (ksi)</th>
<th>Minimum Expected Welded Yield Strength in MPa (ksi)</th>
<th>Typical As-Welded Elongation (% in 50.8 mm / 2 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1060</td>
<td>1188</td>
<td>55 (8)</td>
<td>17 (2.5)</td>
<td>29</td>
</tr>
<tr>
<td>1100</td>
<td>1100</td>
<td>76 (11)</td>
<td>25 (3.5)</td>
<td>29</td>
</tr>
<tr>
<td>1350</td>
<td>1188</td>
<td>55 (8)</td>
<td>17 (2.5)</td>
<td>29</td>
</tr>
<tr>
<td>3003</td>
<td>1100</td>
<td>96 (14)</td>
<td>35 (5)</td>
<td>24</td>
</tr>
<tr>
<td>5005</td>
<td>5356</td>
<td>96 (14)</td>
<td>35 (5)</td>
<td>15</td>
</tr>
<tr>
<td>5050</td>
<td>5356</td>
<td>124 (18)</td>
<td>40 (6)</td>
<td>18</td>
</tr>
<tr>
<td>5052</td>
<td>5356</td>
<td>172 (25)</td>
<td>65 (9.5)</td>
<td>19</td>
</tr>
<tr>
<td>5083</td>
<td>5183</td>
<td>276 (40)</td>
<td>115 (18)</td>
<td>16</td>
</tr>
<tr>
<td>5086</td>
<td>5356</td>
<td>241 (35)</td>
<td>95 (14)</td>
<td>17</td>
</tr>
<tr>
<td>5154</td>
<td>5654</td>
<td>207 (30)</td>
<td>75 (11)</td>
<td>17</td>
</tr>
<tr>
<td>5454</td>
<td>5554</td>
<td>214 (31)</td>
<td>85 (12)</td>
<td>17</td>
</tr>
<tr>
<td>5456</td>
<td>5556</td>
<td>289 (42)</td>
<td>125 (19)</td>
<td>14</td>
</tr>
</tbody>
</table>

Ref: Table 11.1 Welding Aluminum Theory and Practice, Fourth Edition
Aluminum Association 2002
Properties of Heat-Affected Zones (HAZ) in Arc Welded 6xxx Heat-Treatable Alloys

- Depending on the alloy, re-solution and/or over aging take place in the HAZ of heat-treatable alloys.
- The HAZ is always weaker than the parent material.
- When any heat-treatable alloy is fusion welded in the –T6 temper, the strength of the weld/HAZ will be 60%-70% of the –T6 properties.
Hardness profiles across heat-affected zone in welded 3 mm thick 6061-T6 sheet
## Typical Properties of Aluminum Groove Welds on Heat Treatable Alloys

### Table 1

<table>
<thead>
<tr>
<th>Base Metal</th>
<th>Filler Alloy</th>
<th>Typical As-Welded Ultimate Tensile Strength in MPa (ksi)</th>
<th>Typical As-Welded Yield Strength(^5) in MPa (ksi)</th>
<th>Typical As-Welded Elongation(^6) (%)</th>
<th>Typical Post-Weld Heat-Treated Ultimate Tensile Strength in MPa (ksi)</th>
<th>Typical Post-Weld Heat-Treated Yield Strength(^5) in MPa (ksi)</th>
<th>Typical Post-Weld Heat-Treated Elongation(^6) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-T6, T651</td>
<td>4043</td>
<td>234 (34)</td>
<td>193 (28)</td>
<td>4</td>
<td>344 (50)(^1)</td>
<td>--</td>
<td>2(^1)</td>
</tr>
<tr>
<td>2219-T31, T37</td>
<td>2319</td>
<td>241 (35)</td>
<td>179 (26)</td>
<td>3</td>
<td>276 (40)(^2)</td>
<td>227 (33)(^2)</td>
<td>2(^2)</td>
</tr>
<tr>
<td>2219-T81, T87</td>
<td>2319</td>
<td>241 (35)</td>
<td>179 (26)</td>
<td>3</td>
<td>379 (55)(^1)</td>
<td>262 (38)(^1)</td>
<td>7(^1)</td>
</tr>
<tr>
<td>2519-T87</td>
<td>2319</td>
<td>255 (37)</td>
<td>227 (33)</td>
<td>4</td>
<td>386 (56)(^1)</td>
<td>--</td>
<td>5.5(^1)</td>
</tr>
<tr>
<td>6061-T4, T451</td>
<td>4043</td>
<td>186 (27)</td>
<td>124 (18)</td>
<td>8</td>
<td>241 (35)(^2)</td>
<td>165 (24)(^2)</td>
<td>3(^2)</td>
</tr>
<tr>
<td>6061-T6, T651</td>
<td>4043</td>
<td>186 (27)</td>
<td>124 (18)</td>
<td>8</td>
<td>303 (44)(^1,4)</td>
<td>276 (40)(^1,4)</td>
<td>5(^1,4)</td>
</tr>
<tr>
<td>6061-T6, T651</td>
<td>5356</td>
<td>207 (30)</td>
<td>131 (19)</td>
<td>11</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>6063-T4</td>
<td>4043</td>
<td>138 (20)</td>
<td>68 (10)</td>
<td>12</td>
<td>207 (30)</td>
<td>--</td>
<td>13(^1)</td>
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<tr>
<td>6063-T6</td>
<td>4043</td>
<td>138 (20)</td>
<td>83 (12)</td>
<td>8</td>
<td>207 (30)(^1)</td>
<td>--</td>
<td>13(^1)</td>
</tr>
<tr>
<td>6063-T6</td>
<td>5356</td>
<td>138 (20)</td>
<td>83 (12)</td>
<td>12</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>7005-T53</td>
<td>5556</td>
<td>303 (44)(^3)</td>
<td>172 (25)(^3)</td>
<td>10(^3)</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>7039-T63</td>
<td>5183</td>
<td>323 (47)</td>
<td>220 (32)</td>
<td>10</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>356.0 Casting</td>
<td>4043</td>
<td>151 (22)</td>
<td>103 (15)</td>
<td>2</td>
<td>261 (38)(^1,4)</td>
<td>220 (32)(^1,4)</td>
<td>--</td>
</tr>
</tbody>
</table>

1. Post-weld solution heat treated and aged
2. Post-weld aged only
3. Allowed to naturally age 2-4 weeks
4. For thickness greater than 0.500 inch (12.7 mm) filler alloy 4643 is suggested when post-weld solution heat treating and aging
5. 0.2% offset in a 2.0 inch (5.08 mm) gauge length
6. Elongation measured over a 2.0 inch (5.08 mm) gauge length

* Post-weld thermal treatments not recommended due to increased sensitivity to stress corrosion cracking

Ref: Table 11.2 Welding Aluminum Theory and Practice, Fourth Edition
Aluminum Association 2002
Material Storage

- Aluminum Metal Storage
  - Storage indoors out of the weather is best
  - Keep in shipping package

- Outside Storage
  - Plates should be stored out of packaging and spaced to allow air circulation
Metal Cutting – Mechanical

**Grinding - Air or Electric**

- Use non-loading grinding wheels specific for aluminum
- Beware of grinding wheels that may contain a hydrocarbon or wax in the wheel – this could cause weld porosity
Metal Cutting – Mechanical

Gouging / Beveling

- Air or Electric Rotary
- Air Chisel
Metal Cutting – Mechanical

**Filing**

**Rotary Cutter**

Coarse non loading cutting tools will minimize aluminum build up within the tool
Lubrication for Cutting

- Releases metal cuttings
- Keeps blade/tool cool and sharp

Lubricants must be removed prior to welding
Metal Cutting – Thermal

<table>
<thead>
<tr>
<th>Laser Cutting</th>
<th>Plasma Arc Cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$ or Nd: YAG</td>
<td>Cuts foil to 150 mm</td>
</tr>
<tr>
<td>Cuts foil to 6 mm</td>
<td>Easily mechanized</td>
</tr>
<tr>
<td>High power</td>
<td>Good for shape cutting</td>
</tr>
<tr>
<td>High cost</td>
<td></td>
</tr>
<tr>
<td>High volume</td>
<td></td>
</tr>
</tbody>
</table>

Some mechanical clean-up may be necessary to remove micro-cracking in cut edge of heat treatable (2xxx, 6xxx, 7xxx) alloys.
Metal Cutting – Thermal

Micro Cracking in Plasma-Arc Cut Edge in **heat treatable** (2xxx, 6xxx, 7xxx) alloys, 3 mm of material should be mechanically removed from laser and plasma cut edges of heat treatable edges that will be welded. Not a requirement for 5xxx alloys.
Surface Preparation

**Degreasing**
- Remove oils, greases, paints etc
- Done by wiping, spraying or dipping in suitable, safe solvent

**Deoxidizing**
- Welding arc will break up mill finish surface oxide
- Heavy oxides and water stains will need to mechanically or chemically removed
Surface Preparation - Degreasing

Solvent Wipe

Alkaline Bath
Surface Preparation

**Deoxidizing**
- Breaks up oxide layer
- Use only clean SS brushes
- Should follow degreasing
- Use light pressure

**Chemical Deox**

**Wire Brush**
Interpass Operations

Back Gouging

- Removes un-fused metal from weld root prior to welding other side
- Provides edge preparation

Wire Brush

- Clean Stainless Steel – Used only on aluminum
- Removes Smut / Oxide
Weld Smut or Soot

- More common with Gas Metal Arc Welding
- Hot metal vapor condensed on base metal surface
- Not harmful
- Generally easily removed
GMAW Process Description

- The arc is established and maintained between a consumable electrode / filler wire and parts being welded.
- The welding electrode is energized with the welding current as it passes through the contact tip.
- The arc is established and supported by the ionization of inert shielding gas (e.g., argon), continuously discharged onto the welding region (arc and molten pool).
- The inert gas, besides supporting the welding arc also shields the molten pool as it solidifies.
Attributes of GMAW

- Can be used manually and automatically
- Suitable for welding most joint types
- Applicable to joining various thicknesses ($\geq 1.5$mm) and thickness combinations
- Relatively productive (0.5–2 meters/minute) when mechanized
- Due to its relatively high welding speed of travel and decreased heat input per linear length, the process is more prone to formation of weld porosity than GTAW
- Can be used in any position
- Although it can be used for weld repair, the process is not as “fine” to control as GTA welding
GMAW Welding Equipment Recommendations

Manual Welding

■ Power Supply
  ▪ Direct Current (DC), minimum 350 Amp capacity, designed for aluminum welding with pulse welding capability

■ Wire Feeder
  ▪ Push – pull capability designed for aluminum welding

■ Torch
  ▪ Water cooled compatible with wire feeder and rated for expected output current and duty cycle – 7.5+ meter length advantages

Machine Welding

■ Power Supply
  ▪ Direct Current (DC), minimum 450 Amp capacity, designed for aluminum welding with pulse welding capability

■ Wire Feeder
  ▪ Push or push– pull capability designed for aluminum welding

■ Torch
  ▪ Water cooled compatible with wire feeder and rated for expected output current and duty cycle – shorter length the better
Advantages of Gas Metal Arc Welding (GMAW)

- Can be used manually and automatically
- Suitable for welding most joint types
- Applicable to joining various thicknesses – $\geq 1.5$ mm (1/16”)
  thickness combinations
- High deposition rates
- Relatively productive – 0.5-2 meters/min (20–80 inches/min ) when mechanized
- Can be used in any position (in spray transfer)
Push Feeders

- Work well for steel because the electrode is relatively stiff
- Work well for 1.6 mm (0.062”) diameter electrodes and 5xxx 1.2 mm (0.047”) electrode if gun length is 3 meters (10 feet) or less
- Will not reliably feed smaller diameter electrodes
Push-Pull Wire Feed Systems

- Combine a push motor at the spool with a pull motor in the torch
- Reliably feed all wires up to 15 meters (50 feet)
- Available for semi-automatic (manual) and automatic (robotic) applications
- System is a little more complicated
- Torch is a little bigger and bulkier
GMA Welding System

- GMAW is most often utilized with Direct Current Electrode Positive (DCEP) current with:
  - Constant Voltage (CV) or Constant Current (CC) welding power supplies

Wire Feeder

Note: This wire feeder has a door to protect the opened spool
GMAW Modes of Metal Transfer

- Due to the high thermal conductivity of aluminum: Axial Spray and Pulsed Spray modes of metal transfer are most suitable for welding aluminum.

- **Axial Spray** – occurs at currents above transition current
  - Small droplets are propelled across arc
  - Minimum currents for spray transfer of aluminum electrode
    - 1.6 mm electrode – 180 amps
    - 1.2 mm electrode – 135 amps

- **Pulsed Spray** – pulse current between a high peak and low background – transfer occurs at peak current that is above spray transition current.
Argon, Helium or a mixture of Argon and Helium are the only recommended shielding gases for welding aluminum.

Blends containing Oxygen or Carbon Dioxide are not recommended.

Pure Argon is recommendation for material up to 9.5 mm (3/8”) thick.

For thicker materials Helium can be added to make up 50% to 75% of the shielding gas. Helium:
- Is a better thermal conductor and produces a hotter arc
- Produces a wider weld
- Increases Penetration
- Decreases the arc cleaning action
- Requires higher shielding gas flow
- Costs more
Gas Metal Arc Welding Aluminum – Technique

- The wire feeder should be connected to the direct current electrode positive (DCEP) portion of the power supply for welding aluminum.
- The contact tip should be flush to 3 mm (1/8”) recessed and centered inside the gas cup.
- Always weld with the GMAW gun pointed in the direction of travel – “push” never “drag”.
- Hold a 12-15 mm (1/2”–5/8”) cup to work distance – longer distances will result in inadequate gas shielding.
- When welding vertically, always weld vertical up (bottom to top), not vertical down (top to bottom) – vertical down welding is more likely to entrap hydrogen within the weld resulting in porosity.
Gas Metal Arc Welding Aluminum – Technique

- Don’t use a wide weave – use stringer passes
  - In-line oscillation is acceptable and creates regular weld ripples

- Fill in the weld terminations or craters
  - Start and stop the weld a couple times to add filler to compensate for crater shrinkage
  - Taper down current using a crater fill function in the welding power supply or rapidly speed up traverse
  - Stop on a run-out tab
Gas Tungsten Arc Welding
Gas Tungsten Arc Welding - GTAW

- Commonly referred to as TIG (Tungsten Inert Gas) Welding
- GTAW process developed earlier than GMAW
- Requires a constant current power source – same as that used for SMAW or “Stick welding”
- Utilizes a non-consumable tungsten electrode
- Requires an external inert shielding gas
- Most commonly applied to weld thin gauges to about ¼” thick
GTAW Equipment

**AC Power Source**
- Constant current power supply
- High frequency power generator
- Remote amperage control or contact closure

**Inert Shielding Gas**
- Argon, Helium or a mixture of the two
- Gas purity is important

**Welding Torch**
- Material thickness and required current determine size needed – water cooled recommended

**Tungsten Electrode**
- Type and Size are dependent on polarity and current being used – for aluminum the pure and zirconia are generally used
Attributes of GTAW

- Yields excellent weld quality
- Can be used manually and automatically
- Relatively slow and less productive than GMAW
- Suitable for welding most joint types
- Due to its close control over the welding arc and heat, the process can be used to weld a wide range of joint designs and thicknesses
Attributes of GTAW

- Lends itself to automation with mechanized straight-tracks and robotic welding systems. However, when addition of filler wire is required, the process is more “challenging” to automate and control than Gas Metal Arc Welding (GMAW).
- Can be used to weld in all positions
- Less prone to formation of weld porosity than GMAW
- Due to its “fine” control over the arc and welding heat, and the “placid” behavior of the molten pool, the process is extremely useful for weld repair
Shielding Gases

- Argon
- Helium
- Argon/Helium Mix

**Argon Advantages:**
- Produces smoother, quieter arc
- Greater cleaning action on AC
- More abundant & lower cost
- Lower flow rates can be used
- Better resistance to cross drafts

**Helium Advantages:**
- Hotter arc than with argon (1.7 times)
- He & Ar/He mixtures are recommended for:
  - Thick sections
  - Materials having high thermal conductivity
  - Higher welding speeds
As much as possible store parts undercover, clean and dry

Ensure surface cleanliness and thin surface oxides at edges to be welded by:

- Cleaning with solvent followed by mechanical abrasion of surfaces by light brushing with stainless steel brush

Store welding electrode / filler in the original unopened package in an area that does not have wide temperature variations

Welding electrode that is in use should be covered during use and at the end of work shift or when not in use, removed and placed in a cabinet to avoid contamination and/or condensation

Avoid welding in environments that contain airborne moisture, oily mist, dust and sand

Avoid welding with a strong draft that can blow away inert shielding cover.
Four Things I Want You to Know

- Not all aluminum alloys are fusion weldable
- Molten aluminum likes hydrogen
- Aluminum shrinks more than steel during solidification
- Filler alloy selection for aluminum welding is more about matching chemistry with the base metal than strength
Advancing each generation.

ALCOA