**QC-10** is among the first aluminum alloys specifically designed for a variety of mold making applications. QC-10 combines the high thermal conductivity of aluminum with higher hardness and strength, more uniform properties through thickness, and greater corrosion resistance than previous aluminum alloys. Available in thicknesses from 1 inch to 32 inches, QC-10 possesses extremely low quench sensitivity which assures mold makers of consistent machining through the entire thickness of the plate. QC-10 is full wrought, tempered, and stress relieved prior to delivery.

QC-10 has been successfully substituted for P-20 in production injection molds making in excess of one million cycles. The tight grain structure allows for outstanding machinability with small chips, outstanding surface finish, very few burrs, and very fast CNC feeds and speeds. QC-10 can also be polished to a very fine finish (SPI A2). Many molds have been constructed of aluminum employing slides and lifters.

**Benefits**

- Lower part cost through reduced cycle time (25% - 40% typical reduction).
- Higher thermal conductivity permits flexibility in water line placement and simplifies cooling system design.
- Up to 10 times faster metal removal rates than P-20.
- Shorter mold build lead times.
- Reduced wear and down time on molding equipment due to the lower weight of QC-10 vs. P-20.
- Better corrosion resistance than other high strength aluminum alloys.
- Eight times higher thermal diffusivity than steel. Material with higher thermal diffusivity rapidly adjusts its temperature to that of its surroundings.
- More uniform temperature distribution throughout the mold and the elimination of hot spots.
- QC-10 is delivered fully heat treated and stress relieved. No further heat treat or stress relief is necessary.

### Typical Mechanical Properties

<table>
<thead>
<tr>
<th>Thickness (in.)</th>
<th>UTS (ksi)</th>
<th>YTS (ksi)</th>
<th>Elongation (%)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>81</td>
<td>78</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>74</td>
<td>14</td>
</tr>
<tr>
<td>6</td>
<td>80</td>
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<td>6</td>
</tr>
<tr>
<td>8</td>
<td>77</td>
<td>71</td>
<td>8</td>
</tr>
<tr>
<td>10</td>
<td>76</td>
<td>70</td>
<td>6</td>
</tr>
<tr>
<td>12</td>
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<td>68</td>
<td>6</td>
</tr>
<tr>
<td>16</td>
<td>74</td>
<td>67</td>
<td>5</td>
</tr>
<tr>
<td>20</td>
<td>74</td>
<td>65</td>
<td>5</td>
</tr>
</tbody>
</table>

### Physical Properties

- **Thermal Conductivity:** 92 Btu/ft/hr/ft°F
- **Surface Hardness:** 170 - 150 HB
- **Coefficient of Thermal Expansion:** $13.7 \times 10^{-6}$ in/in/°F
- **Specific Heat:** 0.210 Btu/lb
- **Poisson’s Ratio:** 0.33
- **Exfoliation Corrosion Rating:** EA
- **Stress Corrosion Cracking Rating:** A
- **Modulus of Elasticity:** $10.4 \times 10^6$ lb/in²
- **Density:** 0.103 lb/in³

continued —
**QC-10 Machining Speeds and Feeds**

<table>
<thead>
<tr>
<th>Milling Speeds and Feeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machining Process</td>
</tr>
<tr>
<td>Roughing</td>
</tr>
<tr>
<td>Roughing</td>
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<tr>
<td>Finishing</td>
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<table>
<thead>
<tr>
<th>Turning Speeds and Feeds</th>
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<tbody>
<tr>
<td>Machining Process</td>
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<tr>
<td>Single Point Turning</td>
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<table>
<thead>
<tr>
<th>Standard Drilling Speeds and Feeds</th>
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</thead>
<tbody>
<tr>
<td>Machining Process</td>
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<tr>
<td>Standard 2 Flute Drilling</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Gun Drilling Speeds and Feeds</th>
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</thead>
<tbody>
<tr>
<td>Machining Process</td>
</tr>
<tr>
<td>Standard 2 Flute Drilling</td>
</tr>
</tbody>
</table>

**Machining Recommendations**

QC-10 machines 8 to 10 times faster than P-20 steel. The machine time savings result in lower mold costs and faster mold delivery times. Also, since QC-10 machines more easily, your cutting tools last longer.

**EDM Guidelines**

**Wire EDM**
- Recommended wire — 0.010 coated brass wire.
- Machine settings — same as for copper.

**Conventional EDM**

QC-10 can be machined utilizing conventional EDM practices. The following recommendations are only guidelines and will vary, depending on the specific machining requirements and the different makes and models of EDM equipment.

- Pure copper electrodes are recommended using positive polarity. If an electrode with one square inch of surface area is used, a starting voltage of 100 volts is recommended with 9 milliseconds on and 10 milliseconds off, at a feed rate of 15 inches per minute.
- A 50% duty cycle is recommended as a starting guideline, modified as dictated by finish requirements.
Mirror Polishing

- Surface: milling
- Paper grain: 400 grit
- Paper grain: 1000 - 1200 grit
- Medium size diamond grain: 6 mm
- Thin diamond grain: 1 mm
- Extra thin diamond grain: 0.25 mm
- Hyper thin diamond grain: 0.1 mm
- Chrome polish

Repair Welding

Welding QC-10 aluminum is no more difficult than welding a piece of steel. What needs to be understood is that welding characteristics and proper procedures must be followed and performed correctly to ensure a successful weld.

QC-10 mold surfaces are repairable in several ways:

- GTAW (Gas Tungsten Arc Welding)
- Removal of the damaged area by machining and inserting a new section of QC-10 using the “freeze plug” method.
- In extreme cases the entire mold surface can be re-cut, providing there is enough material to ensure the mold’s integrity.

Cleaning

- Use a carbide de-burring tool to clean. (The purpose is to remove all contaminants instead of pushing them into the softer aluminum surface.)
- Use acetone or MEK cleaning solution to remove oily residue using a clean lint-free cloth.
- Use a stainless steel brush ONLY.
- The use of aluminum cleaner is okay. (This is a mild etching solution to remove contaminants.)
- If you clean and don’t immediately weld after removing the oxide layer, re-clean the piece with acetone or MEK cleaner prior to welding.

Surface Preparation

Aluminum Weld Piece — Aluminum will combine with oxygen to form an aluminum oxide layer. This layer will form instantly as the aluminum surface is ground or machined. The aluminum oxide layer while very thin can also be very porous. The oxide layer will readily trap moisture, oil, grease and other materials adding to the potential for hydrogen pickup. The aluminum oxide layer provides excellent corrosion resistance; however this layer must be removed before welding as it prevents fusion due to its higher melting point (3,700°F) whereas aluminum melts at 1,050°F. The weld arc gas molecules, the fore hand (push) technique, mechanical cleaning, wire brushing, solvents, and chemical etching are used for the oxide removal. When uncleaned aluminum is welded, the aluminum under the aluminum oxide coating will melt but the aluminum oxide coating will stay solid and act as a membrane. When this membrane is finally penetrated, the melted membrane will mix with the melted aluminum and contaminate the weld area.

Aluminum Filler Wire — Using Alcoa’s QC-10 filler wire will reduce crack potential and gives excellent adhesion properties and color match. It is very important to clean the filler wire of all contaminants and oxidation. Just as the mold surface has the invisible oxide layer, so does the QC-10 filler wire. This needs to be removed prior to the welding process. Using a Scotch-Brite pad and following with acetone or MEK cleaner is an excellent method for cleaning the filler wire. Welding wire stored loosely might appear clean but the oxide layer and oils must be removed. It is important to store filler wire in a closed dry place. Please pay attention to the oxide layer removal and pre-cleaning of the weld rod. The welded parts/mold must be clean of all oxides, oil residue, moisture, steel particles and other contaminants. If not cleaned properly, the contaminants will float to the surface and contaminate the weld.

GTAW (TIG) Welding

For most economical and quality welds, TIG welding is recommended for aluminum injection molds. A good TIG weld produces a regular ripple finish and, on both sides of the seam, there is a narrow de-oxidized zone.

TIG Welding Equipment Set Up

1. Welding gas — use only 99.995% (N4.5) and up pure welding/shielding gas.
2. Only zirconated tungsten electrodes with a diameter of 2.4mm are to be used.
3. Water cooled systems are preferred for current ranges of 100A and above.
4. Check the diffuser screen periodically on the TIG gun to ensure an even gas flow. (The diffuser screen could be contaminated with tungsten particles and would cause a insufficient gas shielding, resulting in a contaminated weld.)
5. Ensure that the ceramic cup is large enough and WITHOUT cracks in order to ensure proper gas shielding during welding. (Micro cracking will generate a venturi effect and result in a dirty weld (smut).)
6. The end of the tungsten electrode must be ground, reducing the tip diameter to 2/3 of the overall diameter and then pre weld on a TEST piece of aluminum to remove any loose tungsten splatter before welding on the QC-10 work piece.

7. Use 75% helium/25% argon as a shielding gas. Use for aluminum due to high heat conductivity of aluminum.

8. Shielding gas flow depends on the amperage, usually 15 to 25 L/min. of shielding gas.

After each welding pass, you MUST clean the slight smut from the next pass area with a stainless steel brush in order to prepare for the next pass.

You MUST preheat the tungsten of the torch by creating an arc on a test piece before you attempt the next welding pass on your work piece. This should only take about 3 seconds. Without this, the tungsten will embed tungsten particles into the weld piece thus contaminating the weld.

Coatings

Many coatings can be successfully applied to make aluminum more suitable for a variety of applications. A key consideration for selecting a coating is a low application temperature. The application temperature should be below 200°F

- **Nickel Boron**
  This coating produces an extremely low coefficient of friction which provides superior lubricity and release properties and a excellent level of abrasion and wear resistance. This electroless nickel phosphorus coating incorporates boron nitride particles in a co-deposited nickel matrix.

- **Nickel & PTFE**
  This coating significantly improves release and provides excellent lubricity. Due to the co-deposition of PTFE and nickel, self-lubricating properties work well in grease-free conditions. Autocatalytic application ensures a uniform deposit in even the most complex details.

- **Diamond Chrome**
  This super hard diamond chrome composite provides excellent lubricating characteristics as well as superior abrasion and wear resistance. Diamond chrome can be applied up to .002 inches thick and at very low temperatures; this does not compromise the shape or size.

- **Hard Chrome**
  This process improves lubricity and release over the base material due to the hardness of the deposit. The coating also offers superior hardness and excellent abrasion and wear resistance properties. Hard chrome plating is widely used in many industries worldwide, including the mold making industry, where there is a need for durability and wear resistance.

- **Electroless Nickel Plating**
  This high phosphorous electroless nickel coating provides superior corrosion and oxidation protection. The process also provides moderate abrasion and wear resistance and lubricity and release properties. This thin, uniform coating provides corrosion and oxidation protection for automated equipment, clean room and medical applications.

- **Hard Anodizing**
  Hard anodizing can give hardness equivalent to a tool steel of 65 Rockwell C. Therefore, machining should be carried out prior to treatment to reduce tool wear. Hard anodizing is particularly useful for slides, wear guides, guide bushings and ejector pins since it reduces friction. Note: this treatment will cause dimensional changes in the piece.

For more information or immediate applications assistance, contact:

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