Leading the Way in the Production of Plasma Atomized Spherical Metal Powders

ISO 9001:2008 AS 9100C

10 yr.+ servicing major customers

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AP&C: Large Scale Production of Spherical Titanium Powders

Superior Features
- Low oxygen content
- High purity
- Crucible and ceramic free melting
- Excellent flowability
- High apparent and tap densities
- Highly spherical with very few satellites
- Virtually no gas entrapped porosities
- Batch to batch consistency

Superior Services
- Segregated reactors for main products
- Tailored size distributions
- Expert knowledge of Ti alloy powders
- Certified quality system (AS9100C and ISO 9001:2008)
- Complete powder certification
- Traceability from ingot to powder
- Flexible packaging solutions

Core expertise in
- Plasma atomization technology
- Titanium and Ti alloys
- Nickel superalloys
- High melting point metals
- Reactive metals

End Markets
- Aerospace
- Biomedical
- Industrial
- Oil & gas
- Research

Spherical Powders Designed for
- Additive Manufacturing (3D printing)
- Metal Injection Moulding (MIM)
- Cold and Hot Isostatic Pressing (CIP and HIP)
- Coatings

AP&C has 10 years + of experience working with major biomedical and aerospace OEM. This close relationship has allowed AP&C to constantly meet the changing requirements of these industries through continuous improvement and product development.

AP&C’s mission is to facilitate the use of titanium and other high melting point alloys in high end powder metallurgy (PM) processes like additive manufacturing. To do so, AP&C continually invests in R&D to optimize its proprietary plasma atomization process in order to provide high quality products at competitive prices.

By early 2016, AP&C will operate 5 reactors (3 reactors in 2015)

For all your powder needs in Ti and other high melting point alloys, go directly to the best spherical powder source and contact AP&C.
The Plasma Atomization Process

AP&C’s proprietary plasma atomization process uses plasma torches to melt and atomize the metal wire feedstock which is sourced from 100% virgin/multiple melted material. The melting wire never comes into contact with any solid surface and thus the process prevents contamination, ensuring a high purity product. The reactor is purged to a low level vacuum prior to each production batch and the powder is then produced in a high purity argon atmosphere to ensure the lowest oxygen content.

Using a wire feedstock allows an accurate feeding rate and therefore provides excellent control over the powder size distribution and batch to batch consistency. The wire chemical composition is maintained allowing for better control of the powder chemistry.

AP&C’s plasma atomization process superheats the metal. The following cooling stage rapidly solidifies the melt into highly spherical powder. A low concentration of suspended particles is maintained in the reactor chamber in order to prevent the formation of satellites. Because of this low level of satellite particles, AP&C spherical powders exhibit an excellent flowability rating.

The as-produced powder size distribution ranges from 0 to 250 microns with the vast majority between 0 to 106 microns or 0 to 75 microns depending on configuration. Powder is then sieved to meet the particular requirements of each customer. Before packaging and shipping, each lot is blended for homogeneity, tested and certified.

Standard Spherical Powder Products
- CP-Ti grade 1
- Ti-6Al-4V grade 5 and 23 (ELI)
- Nickel superalloy (IN 718)

Custom Spherical Powder Products
- Ti alloys
- Ti-6Al-2Sn-4Zr-2Mo
- Ti-5Al-5V-5Mo-3Cr
- Ti-5Al-2.5Sn (grade 6)
- Nickel-titanium
- etc.

Characterization Available
- Size distribution by sieving (ASTM B214)
- Size distribution by laser diffraction (ASTM B822)
- Flowability (ASTM B213 and ASTM B964)
- Apparent density (ASTM B212)
- Tap density (ASTM B527)
- Chemical composition (ASTM E1409, E1447, E1941, E2371 etc.)*

*Powder chemical composition analysis is outsourced to a certified independent laboratory.
### Typical Physical Properties

<table>
<thead>
<tr>
<th>Size range</th>
<th>0-25 μm</th>
<th>0-45 μm</th>
<th>15-45 μm</th>
<th>45-106 μm</th>
<th>45-250 μm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology</td>
<td>spherical</td>
<td>spherical</td>
<td>spherical</td>
<td>spherical</td>
<td>spherical</td>
</tr>
<tr>
<td>Size distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d10</td>
<td>8 μm</td>
<td>14 μm</td>
<td>20 μm</td>
<td>50 μm</td>
<td>60 μm</td>
</tr>
<tr>
<td>d50</td>
<td>15 μm</td>
<td>32 μm</td>
<td>34 μm</td>
<td>70 μm</td>
<td>144 μm</td>
</tr>
<tr>
<td>d90</td>
<td>24 μm</td>
<td>47 μm</td>
<td>46 μm</td>
<td>105 μm</td>
<td>225 μm</td>
</tr>
<tr>
<td>Flowability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTM B213(1)</td>
<td>x</td>
<td>x</td>
<td>30 s</td>
<td>23 s</td>
<td>23 s</td>
</tr>
<tr>
<td>ASTM B964(2)</td>
<td>x</td>
<td>x</td>
<td>10 s</td>
<td>4 s</td>
<td>4 s</td>
</tr>
<tr>
<td>Apparent density</td>
<td>NA</td>
<td>NA</td>
<td>2.50 g/cm³</td>
<td>2.55 g/cm³</td>
<td>2.70 g/cm³</td>
</tr>
<tr>
<td>Tap density</td>
<td></td>
<td></td>
<td>2.8 g/cm³</td>
<td>2.9 g/cm³</td>
<td>3.0 g/cm³</td>
</tr>
</tbody>
</table>

(1) Flowability tested using the Hall flowmeter.
(2) Flowability tested using the Carney flowmeter.

### Typical Chemical Composition

<table>
<thead>
<tr>
<th></th>
<th>CP-Ti grade 1</th>
<th>Ti-6Al-4V grade 5</th>
<th>Ti-6Al-4V grade 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum (Al)</td>
<td>-</td>
<td>5.50 - 6.75</td>
<td>5.50 - 6.50</td>
</tr>
<tr>
<td>Vanadium (V)</td>
<td>-</td>
<td>3.50 - 4.50</td>
<td>3.50 - 4.50</td>
</tr>
<tr>
<td>Oxygen (O)</td>
<td>0.07 - 0.18</td>
<td>0.11 - 0.20</td>
<td>0.07 - 0.13</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>&lt; 0.20</td>
<td>&lt; 0.25</td>
<td>&lt; 0.25</td>
</tr>
<tr>
<td>Carbon (C)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Nitrogen (N)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Hydrogen (H)</td>
<td>0.010</td>
<td>0.010</td>
<td>0.010</td>
</tr>
<tr>
<td>Tin (Sn)</td>
<td>-</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>-</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>-</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>-</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Zirconium (Zr)</td>
<td>-</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Yttrium (Y)</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Sn + Mo + Cu + Mn</td>
<td>-</td>
<td>&lt; 0.20</td>
<td>&lt; 0.20</td>
</tr>
<tr>
<td>Other elements, each</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
<td>&lt; 0.10</td>
</tr>
<tr>
<td>Other elements, total</td>
<td>&lt; 0.40</td>
<td>&lt; 0.40</td>
<td>&lt; 0.40</td>
</tr>
<tr>
<td>Titanium (Ti)</td>
<td>balance</td>
<td>balance</td>
<td>balance</td>
</tr>
</tbody>
</table>

### Standard size distributions for CP-Ti and Ti-6Al-4V:
- 0-25 and 0-45 microns (MIM or coatings)
- 15-45 and 25-45 microns (laser additive manufacturing or coatings)
- 45-106 microns (electron beam additive manufacturing)
- 45-150, 45-250 and 0-250 microns (CIP and HIP)

### Our fine spherical powders are of the highest quality to meet the demands of the biomedical and aerospace industries.

AP&C standard size distributions have a ± 5% margin of error and are tested according to ASTM B214 standard. All AP&C Titanium and Titanium alloy powders conform to the chemistry of ASTM B348 and ASTM F1580 standards. Chemistry of AP&C CP-Ti grade 1 powders can also conform to ASTM F67 standard. Chemistry of AP&C Ti-6Al-4V grade 23 powders can also conform to ASTM F2924, ASTM F136 and AMS 4956 standards. Chemistry of AP&C Ti-6Al-4V grade 5 powders can also conform to ASTM F3001, AMS 4998 and AMS 4928 standards. Particle size distribution strongly influence the oxygen content.