Titanium Current Applications & Future Possibilities for The US Navy

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OUTLINE

• Titanium Alloys & Properties
• Titanium attributes & benefits for sea water service
• Applications over the last 30 years
• Newer applications
• Potential applications
• Summary – is the future bright?
Titanium Alloys & Properties

- No seawater corrosion - EVER
- Range of strengths possible through alloy selection (50 to 115 ksi yield strength)
- Titanium offers excellent strength-to-weight benefit
- Environmentally friendly
- Excellent compatibility with composites
- Little to no maintenance required
- High recycle value or re-use possible
- Excellent fire and shock resistance
Titanium offers an excellent range of alloy strengths – while maintaining corrosion immunity.

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**Titanium Alloys & Properties**

- **Tensile**
- **Yield**
- **Elongation**

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**Typical Properties (ksi or %)**

<table>
<thead>
<tr>
<th>ASTM Grade</th>
<th>Tensile</th>
<th>Yield</th>
<th>Elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>415</td>
<td>275</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>550</td>
<td>138</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>690</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>32</td>
<td>825</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>965</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>120</td>
<td>1100</td>
<td></td>
<td>0</td>
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<tr>
<td>140</td>
<td>1240</td>
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</table>

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**Typical Strength (MPa)**

- **2**
- **12**
- **9**
- **32**
- **23**

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**ASTM Grade**
Titanium’s attributes create excellent benefits for Naval ships

<table>
<thead>
<tr>
<th>ATTRIBUTE</th>
<th>BENEFIT</th>
</tr>
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<tbody>
<tr>
<td>Corrosion Immunity</td>
<td>Reduced Maintenance</td>
</tr>
<tr>
<td></td>
<td>Reduced Manning/Operating Costs</td>
</tr>
<tr>
<td></td>
<td>Life of Ship Durability/No Replacement</td>
</tr>
<tr>
<td>Low Density</td>
<td>Increased Payload Capabilities</td>
</tr>
<tr>
<td></td>
<td>Lower Support Loads</td>
</tr>
<tr>
<td></td>
<td>Reduced Fuel Consumption</td>
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<tr>
<td>High Shock Resistance</td>
<td></td>
</tr>
<tr>
<td>Excellent Ballistic Properties</td>
<td>Ship Survivability</td>
</tr>
<tr>
<td>High Melting Point/Fire Resistance</td>
<td></td>
</tr>
<tr>
<td>Environmentally Friendly</td>
<td>Non-toxic to Marine Life</td>
</tr>
<tr>
<td>Inherent Value</td>
<td>Retains Value for Recycling/Re-Using</td>
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</tbody>
</table>
Titanium’s Unique Benefits

Titanium Piping for Naval Ships Offers Significant Weight Savings

<table>
<thead>
<tr>
<th>Titanium Pipe</th>
<th>Wt. Of 100ft (lbs)</th>
<th>Cu-Ni Pipe</th>
<th>Wt. Of 100ft (lbs)</th>
<th>Weight Savings (lbs)</th>
<th>Weight Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2in Sch 10</td>
<td>152</td>
<td>3in Class 200</td>
<td>394</td>
<td>242</td>
<td>61</td>
</tr>
<tr>
<td>4in Sch 10</td>
<td>323</td>
<td>6in Class 200</td>
<td>1060</td>
<td>737</td>
<td>70</td>
</tr>
<tr>
<td>6in Sch 10</td>
<td>534</td>
<td>8in Class 200</td>
<td>1528</td>
<td>994</td>
<td>65</td>
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<tr>
<td>10in Sch 10</td>
<td>1073</td>
<td>12in Class 200</td>
<td>3805</td>
<td>2732</td>
<td>72</td>
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</tbody>
</table>

Erosion resistance of titanium allows use of smaller bore piping when designed properly.
Mature Naval Applications

Radar Cooler Tube Bundle (Ti-Gr 2)

Sea Water Pump (Ti-Gr 2)
Mature Naval Applications

Titanium fire water piping systems on LPD-17 (Ti-Gr 2)

Over 100K feet of welded pipe and 10,000 fittings/flanges
Mature Naval Applications

Ti-5111 HDR Mast (Virginia Class)
Mature Naval Applications

DDG Exhaust Uptake Liners (Ti-3-2.5)
Current Naval Applications

Ti-5111 Optical Periscope

HDR Mast

Optical Periscope

Photo used with permission of Ti-Fab
Current Naval Applications

Acoustic Sensor Pod for Sub Sea Application (Ti-Grade 2)

Photo used with permission of Ti-Fab
Current Naval Applications

Boat Launch & Recovery System (Ti-Grade 2)
Current Naval Applications

Boat Launch & Recovery System (with Ti-Fab crew)
Potential Naval Applications

**CVN Series**
- Blast Deflectors
- Hanger Doors
- Fasteners
- Elevator Platforms
- Piping
- Armor

**Surface Combatants**
- Topside Structure & Masts
- Piping/Valves
- Armor
- Weather Doors
- Bulkheads

*(Images of CVN 78 and DDG 1000 from Public Domain)*
Potential Naval Applications

Unmanned Underwater Vehicles
- Near net-shape hull castings
- Fasteners

High-Speed Ships (LCS)
- Structural Components
- Castings (Waterjet components - impellers, pump casings, ducts)
Potential Naval Applications

Prototype Cast Titanium & Titanium Alloy for UUV Pressure Hulls

Ti CP-2LO

Ti-5111

Photos taken from prior Navy public presentation
SUMMARY

• Titanium is THE technically correct engineering metal for Naval shipboard seawater service

• Titanium has a >30yr excellent track record of use by the Navy, typically in ship & submarine Ht/Ex and piping systems seeing seawater

• Past applications were limited by high upfront costs – which may have to change with new ship technologies and manning scenarios

• Acquisition costs will be recouped by reduced maintenance and inherent end of service value

• Opportunities exist for titanium to enhance the capabilities of the next generation Navy ships
Firing of 16in Guns from the Battleship USS Iowa (BB 61)
Target Range ~20 miles

Launch of a Tomahawk Cruise Missile from the Destroyer USS Stetham (DDG 63)
Target Range ~800 miles

Thank You for Your Attention