About Stress Engineering Services

- Independent Engineering Consultant
- Multi-Industry Clientele

Oil & Gas  Medical  Consumer Products
About Stress Engineering Services

continued

• Oil & Gas Industry

• Services Offered…

  ▪ Engineering

  ▪ Testing

  ▪ Failure Analysis
Use of Titanium in the Oilfield

• Industry Conditions:
  ▪ Deepwater 3,000 – 10,000 ft.
  ▪ Deepwells 30,000+ ft.
  ▪ Corrosive Environment
  ▪ High Energy Prices
Use of Titanium in the Oilfield

continued

• Industry Conditions:
  ▪ Temperature
  ▪ Environment
  ▪ Risk
Steps Towards Getting Acceptance of Titanium Components

- Good Understanding of Industry Expectations
- Know Your Technical Driver
- Have a Plan
- Understand This is Not Just Replacing an Existing Steel Component
- Address the Interfaces
- Obtain the Confidence of the User
Examples and Potential Products

- Stress Joints
- Production Risers
- Completion / Workover Risers
- Special Upper joints (SUJ)
- Jumpers
- Drill Pipe
Titanium vs. Steel

PRODUCT COMPARISON ~ TAPERED STRESS JOINTS

MAXIMUM BENDING MOMENT @ SUPPORT
STEEL: 1220 FT-KI PS
TITANIUM: 485 FT-KI PS

STEEL TSJ
7520 lbs @ 65'

TITANIUM TSJ
1100 lbs @ 26'

MECHANICAL & PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th></th>
<th>STEEL</th>
<th>TITANIUM</th>
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</thead>
<tbody>
<tr>
<td>YIELD STRENGTH</td>
<td>80 KSI</td>
<td>110 KSI</td>
</tr>
<tr>
<td>ULTIMATE STRENGTH</td>
<td>93 KSI</td>
<td>120 KSI</td>
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<tr>
<td>MODULUS OF ELASTICITY</td>
<td>30 x 10^6 PSI</td>
<td>16 x 10^6 PSI</td>
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<tr>
<td>DENSITY</td>
<td>.283 lbs/in^3</td>
<td>.160 lbs/in^3</td>
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A Case for Using Titanium Drill Pipe

- Drill pipe: Often the most expensive and maybe the simplest of all tools used in drilling

- Some holes can’t be drilled with conventional drill pipe because the target is too far from the platform or drilling rig.
A Case for Using Titanium Drill Pipe
continued

• Lighter weight pipe may be the answer
  ▪ Ti pipe is light (about 0.57 weight of steel) and strong (120 ksi yield)
    ▶ High strength
    ▶ Lower wall thickness for pipe in top of hole (better hydraulics, lower cost, less weight)
    ▶ Smaller pipe at top of string (lower cost, less weight)
    ▶ Flexibility – Fatigue Life
    ▶ Enabling Technology
    ▶ More cost effective drilling rigs
Technical Issues to Consider

• Before titanium pipe can be used, its properties and performance must be verified.
  
  ▪ Material properties verified
    ▶ Strength
    ▶ Toughness
    ▶ Fatigue Resistance
  
  ▪ Design verified
    ▶ Ti tool joint
    ▶ Steel tool joint
  
  ▪ Handling verified
    ▶ Slips
    ▶ Hanging weight capacity
    ▶ Tongs
Resonant Bending Fatigue Test Machine

Rotational Bending Frame
Drill Pipe Tensile Test
Operational Issues

- Verification of...
  - Elevators
  - Fishing Tools
  - Drilling Fluids
  - Drilling Dynamics
  - Pipe Racking
  - Cost Effectiveness
Slip Test / Tong Marks
The Prize!