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Innovative Subsea Shear Joint System

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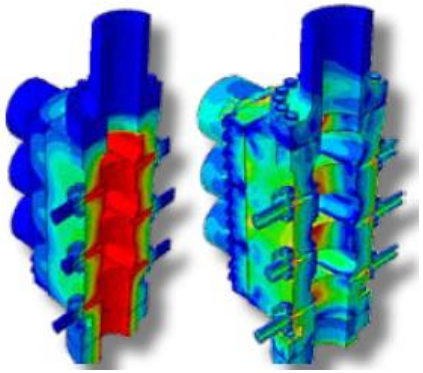
Introduction

- Advanced Engineering Studies
- HPHT Equipment Design and Product Development
- Titanium and Aluminum Oilfield Products
- Advanced FEA Expertise

30K HPHT Autoclave



20K BOP Design Validation

Titanium Rotary Steerable Shaft

Industry Challenges

- 15K Intervention Designs use Steel Shear joints which are too thick to cut with 18-3/4” BOP (1.2MM lb)
- API 17G (3rd Ed.) requires to test to 1.5x RWP (22.5K) making shearing difficult
- New Client and BSEE requirements will require API 17G (3rd Ed.) compliance

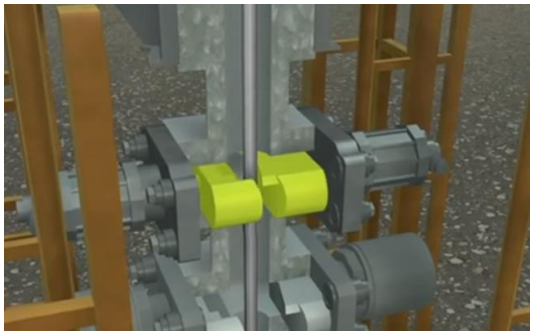
Landing String Concerns

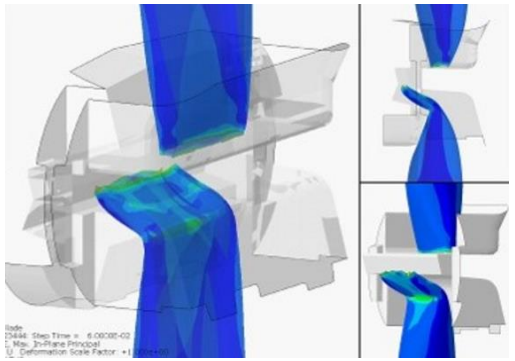
- ALTISS approached a major operator recognizing the limitation of shearing a deep water steel landing string
- Pipe sizing: Steel UD165 Wall = 0.938”

  Titanium Wall = 1.082”
  - Note: 0.938” wall thickness is upper limit for BOP shear capacity
- **Evaluated Titanium Shearing Characteristics**

Difficulty of Shearing Steel

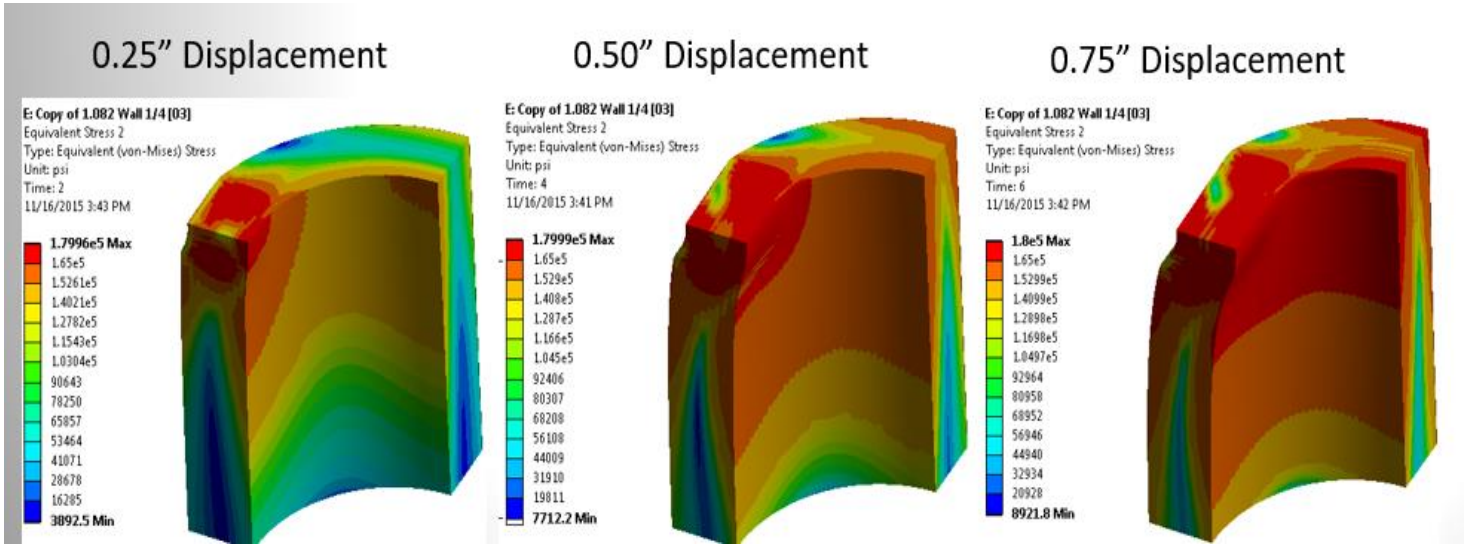
- Industry challenge with heavy wall landing strings
- Steel landing strings with >2.5 MM lb capabilities show unreliable shearability
- Steel tube deforms before failure - making shearing more difficult





Titanium Shear Joint Study - FEA

FEA work to Determine Stress Fracture in pipe wall at Varying Shear Ram Displacements

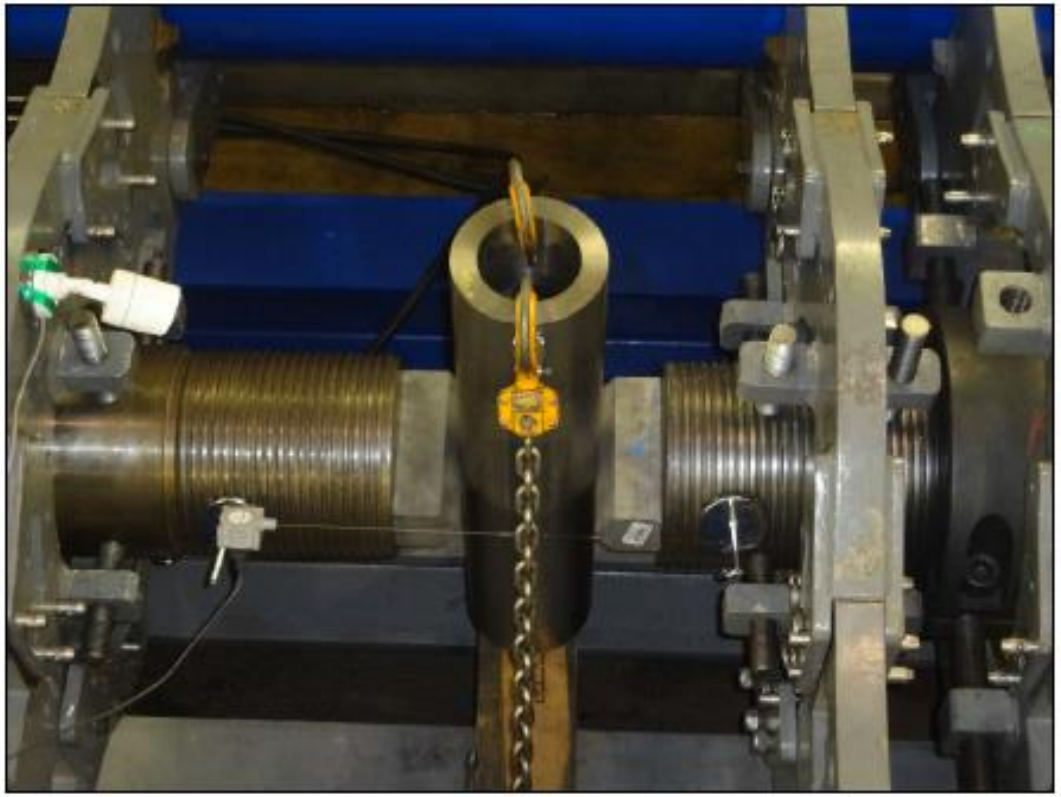


FEA Model Predicts Shearing at 0.75” Ram Displacement

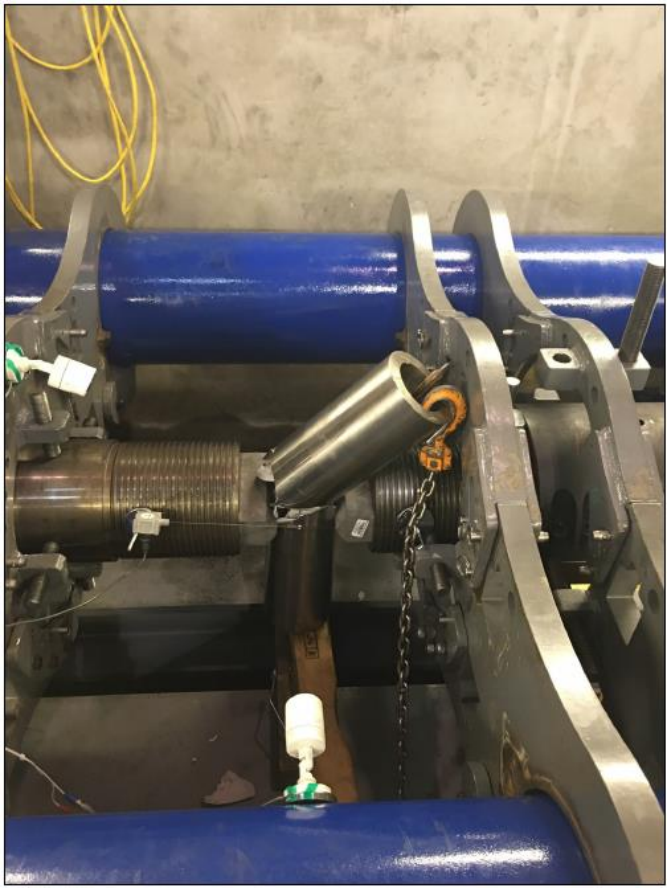
FEA Titanium Shear Results

- Small ram displacements initiates Shearing Fracture
- Theory of “Instantaneous” Crack Propagation
- Next step perform Titanium Shear Test - Validate FEA
  - Performed at MTS – Waller, TX
  - 4.00MM lb Load Frame
  - Generic Shear Blades

Titanium Shear Test Set Up



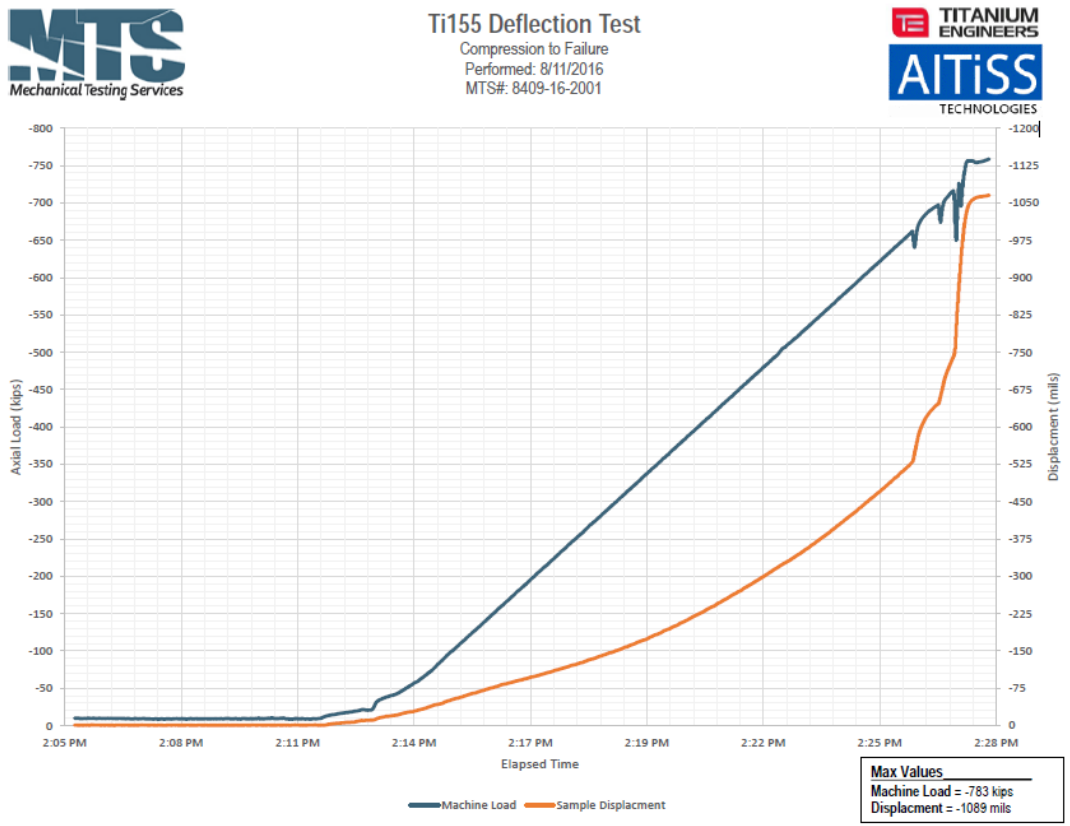
Titanium Shear Test



Sheared at Much Lower Force

Correlated with FEA Study

Shear Test Data



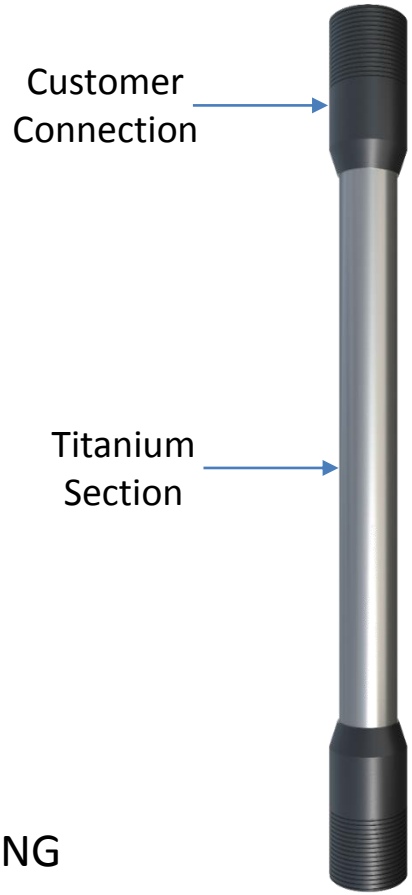
Loading at 50 Kips/Min

Titanium Tube
6.625” OD X 1.082” WT

Fractured at 0.75”
Deflection and 783 kips

Titanium Subsea Shear Joint System

- Titanium alloy with Optimized Fracture Toughness
- Applicable to 5.375” and 7.375” Bore Diameters
- Proprietary Connection between Body and Tool Joint
- Pin to pin Tool Joint can be machined to Customer Specs
- Anti-Galvanic and Corrosion resistant coating protects against Erosion, HCl and HF Acid Treatments



PATENT PENDING

Conclusions

- Titanium Shear Joints requires only Half the Force to Shear with the same pressure and tension ratings compared to Steel
- FEA model estimated force required to shear pipe and accurately predicted deformation at point of failure - validated by full scale testing
- New codes and regulations will require Wall Sections of Shear Joints to 150% of RWP
- Durability and corrosion resistance of Titanium is enhanced with ALTISS' Proprietary Coating