“Technology Driven Design”
Outline

◊ What is the PTECH+ Connection
◊ Advantages of the PTECH+ Connection
   ◊ Connection Design
   ◊ Enhanced Torque Capacity
   ◊ Increased Connection Life
   ◊ Extended Fatigue Life
   ◊ Reduced Connection Peak Stress
   ◊ Larger ID For Improved Hydraulics
◊ Testing and Numerical Analysis
What is the PTECH+ Connection?

- The PTECH+ Connection is a proprietary increased torque connection that was designed to outperform other dual shoulder connections in torsion, tension, and fatigue performance.

- With its simplistic design approach, proprietary thread profile, and dual shoulder design, this new connection has the capability to reach increased torques while still maintaining a streamline geometric design.
Advantages of the **PTECH+** Connection

- **DESIGNED FOR PERFORMANCE**
- **ENHANCED TORQUE CAPACITY**
- **INCREASED CONNECTION LIFE**
- **EXTENDED FATIGUE LIFE**
- **REDUCED CONNECTION PEAK STRESS**
- **LARGER ID FOR IMPROVED HYDRAULICS**
Designed for Maximum Performance

- The PTECH+’s enhanced critical cross-sectional areas and shoulder contact areas create a unique design that increases the mechanical properties of the connection. The design also takes advantage of 135ksi specified material yield strength (SMYS) to further increase the performance of the connection design.

- With this increased SMYS the connection designs are essential to assure an acceptable level of fatigue life.

- A special tool joint chemistry is also used to maintain a level of material toughness.
Designed for Maximum Performance

- The PTECH+ thread form design allows for a **Large Single** root radius.

- The **Large Single** root radius considerably reduces peak stresses in the connection and the connections stiffness.

- The combination of tapers and thread forms allows each connection to have smaller ODs and Larger IDs and still maintain a balanced connection which allows for extended wear.

PTECH39+
Enhanced Torque Capacity

- The PTECH+ connection provides the capability to reach maximum torques while still maintaining a streamline geometric design.

- Torque capacities average 65% - 80% greater than API connections of the same dimensions and 10% - 30% greater than most proprietary high torque connections of the same dimensions.
Enhanced Torque Capacity

Torsional Strength Comparison
PTECH* vs. API NC & DS

Maximum Torque (ft-lbs)

<table>
<thead>
<tr>
<th>Connection</th>
<th>Maximum Torque</th>
<th>Strength Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-1/2&quot; X 2-9/16&quot;</td>
<td>28,100</td>
<td>-38%</td>
</tr>
<tr>
<td>NC-40</td>
<td>36,400</td>
<td>-19%</td>
</tr>
<tr>
<td>NC-40 DS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-7/8&quot; X 2-11/16&quot;</td>
<td>38,850</td>
<td></td>
</tr>
<tr>
<td>PTECH 39+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Enhanced Torque Capacity

Torsional Strength Comparison
PTECH + Vs. API FH & FHDS

- 7-1/4" X 3-1/2"
  - 5-1/2 FH: 72,500
  - 5-1/2 FH DS: 73,000 (-13%)
  - PTECH55+: 82,100

- 7" X 4"
  - 5-1/2 FH: 72,500
  - 5-1/2 FH DS: 73,000 (-13%)
  - PTECH55+: 82,100

- 6-5/8" X 4-1/4"
  - PTECH55+: 82,100

Maximum Torque (Ft-lbs)
Enhanced Torque Capacity

Torsional Strength Comparison
PTECH+ Vs. API FH & FHDS

<table>
<thead>
<tr>
<th>Connection</th>
<th>Maximum Torque (Ft-lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-1/2&quot; X 3-1/4&quot;</td>
<td>80,400 (-40%)</td>
</tr>
<tr>
<td>7-1/2&quot; X 3-3/4&quot;</td>
<td>89,000 (-27%)</td>
</tr>
<tr>
<td>7-1/4&quot; X 4-1/4&quot;</td>
<td>112,700</td>
</tr>
</tbody>
</table>

PTECH59+
Enhanced Torque Capacity

Torsional Strength Comparison
PTECH* Vs. API FH & FHDS

Maximum Torque (Ft-lbs)

<table>
<thead>
<tr>
<th>Connection</th>
<th>8-1/2&quot; X 4-1/4&quot;</th>
<th>8-1/4&quot; X 4-3/4&quot;</th>
<th>8&quot; X 5-3/16&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-5/8 FH</td>
<td>109,200</td>
<td>-34%</td>
<td></td>
</tr>
<tr>
<td>6-5/8 FH DS</td>
<td>117,300</td>
<td>-25%</td>
<td></td>
</tr>
<tr>
<td>PTECH 68+</td>
<td>146,300</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Increased Connection Life

- Increased Wear Tolerance
- Increase in Fatigue Life
  - Reduced Connection Peak Stress
  - Reduced Connection Stiffness
- Reduced Material Loss Due to Repairs
Increased Connection Life

Tool Joint Cumulative Wear Allowance
From New OD to Min. Premium OD
5-1/2" OD X 2-9/16" ID

- NC-40
  - Wear (in): 0.312
  - Percent wear: -21%

- NC-40 DS
  - Wear (in): 0.531
  - Percent wear: -82%

- PTECH39+
  - Wear (in): 0.969
  - Percent wear: -82%

Percent wear as it compares to PT ECH+ Connection

4" 14.00# S-135 DP Tool Joint
Increased Connection Life

Tool Joint Cumulative Wear Allowance
From New OD to Min. Premium OD
7-1/4” OD X 3-1/2” ID

Percent wear as it compares to PTECH+ Connection
5-1/2” 21.90# S-135 DP Tool Joint
Increased Connection Life

Tool Joint Cumulative Wear Allowance
From New OD to Min. Premium OD
7-1/2" OD X 3-1/4" ID

Wear (in)

Percent wear as it compares to PTECH+ Connection

5-1/2" 24.70# S-135 DP Tool Joint
Increased Connection Life

Tool Joint Cumulative Wear Allowance
From New OD to Min. Premium OD
8-1/2" OD X 4-1/4" ID

Percent wear as it compares to PTECH+ Connection

6-5/8" 27.70* S-135 DP Tool Joint
Extended Fatigue Performance

- The PTECH39+ shows an increase in fatigue resistance of approximately 2.7 times greater than API NC-38 and 1.9 times greater than NC-40.

- A reduction in Tool Joint and Connection Stiffness.

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Connection OD</th>
<th>Connection ID</th>
<th>Connection Stiffness about the CCS</th>
<th>Tool Joint Stiffness</th>
<th>Difference in Connection Stiffness</th>
<th>Difference in TJ Stiffness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTECH 39</td>
<td>4.875</td>
<td>2.688</td>
<td>in⁴</td>
<td>in⁴</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>NC38</td>
<td>5.000</td>
<td>2.125</td>
<td>29.1</td>
<td>29.7</td>
<td>13.9%</td>
<td>15.2%</td>
</tr>
<tr>
<td>NC40</td>
<td>5.500</td>
<td>2.563</td>
<td>41.7</td>
<td>42.8</td>
<td>39.8%</td>
<td>41.2%</td>
</tr>
</tbody>
</table>
Extended Fatigue Performance

- Larger PTECH+ connections have reduced Connection Stiffness of 25% - 43%.

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<th>Difference in TJ Stiffness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTECH55+</td>
<td>6.625</td>
<td>4.250</td>
<td>77.1</td>
<td>78.5</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>5-1/2 FH</td>
<td>7.500</td>
<td>3.250</td>
<td>135.5</td>
<td>139.3</td>
<td>43.1%</td>
<td>43.6%</td>
</tr>
<tr>
<td>PTECH59+</td>
<td>7.125</td>
<td>4.250</td>
<td>108.4</td>
<td>110.5</td>
<td>25.8%</td>
<td>26.3%</td>
</tr>
<tr>
<td>5-1/2 FH</td>
<td>7.500</td>
<td>3.250</td>
<td>146.0</td>
<td>149.8</td>
<td>25.8%</td>
<td>26.3%</td>
</tr>
</tbody>
</table>
Turns to Make-up

- PTECH39+ Connection
  - 7.5 Turns
- NC-40 Connection
  - 6.5 Turns

- PTECH55+ Connection
  - 8.8 Turns
- 5-1/2 FH Connection
  - 9.8 Turns
- PTECH59+ Connection
  - 9.3 Turns

- PTECH68+ Connection
  - 8.4 Turns
- 6-5/8 FH Connection
  - 9.8 Turns
Reduced Material Loss Due to Repairs

- **PTECH39+ Connection**
  - Material Loss on a total recut is 3”
  - Material Loss on a rechase is 1/2”

- **PTECH55+ Connection**
  - Material Loss on a total recut is 3-1/4”
  - Material Loss on a rechase is 5/8”

- **PTECH59+ Connection**
  - Material Loss on a total recut is 3-7/8”
  - Material Loss on a rechase is 3/4”

- **PTECH68+ Connection**
  - Material Loss on a total recut is 3-15/16”
  - Material Loss on a rechase is 3/4”
Design Testing and Numerical Validation

The PTECH+ Design has gone through the following testing and design validation.

- 3D FEA Analysis of Von Mises Stress distribution.
- Torque to Failure
- Multiple make and breaks
- Comparative fatigue testing
3D FEA Analysis of PTECH+ VME Stress Distribution

- The PTECH+ Design Models were numerically analyzed using ANSYS® X64ed. V12.1 to show the stress in the connection at both minimum and maximum internal gap tolerances due to make-up torque.
- A 3D Method was used to evaluate an overall connection peak stress and SCF instead of typical 2D axisymmetric models.
Torsion to Failure Testing

- The PTECH39+ Connection has undergone torsion to failure testing to verify the design’s calculated torsional strength.
- The connection was tested at both worst case internal shoulder gaps.

![Torque Vs. Turns Graph for PTECH39+](image_url)
Torsion to Failure Testing

- As Tested Torques based on stress analysis of strain gage data.
- Min Gap Ultimate Torque Limit: 42,158 Ft-lbs
- Max Gap Ultimate Torque Limit: 41,521 Ft-lbs

**PTECH39+ Pin & Box Min Gap After Torsion to Failure Testing**
Multiple Make & Breaks

- 100 Make and Breaks were accomplished without any galling on either the pin or box connection.

**PTECH39+**
Pin After 100 M&B

**PTECH39+**
Box After 100 M&B
Torsion to Failure Testing

- The PTECH55+ Connection has undergone torsion to failure testing to verify the designs calculated torsional strength.
- The connection was tested at both worst case internal shoulder gaps.
Torsion to Failure Testing

- As Tested Torques based on stress analysis of strain gage data.
- Min Gap Ultimate Torque Limit: 85,168 Ft-lbs
- Max Gap Ultimate Torque Limit: 82,428 Ft-lbs

PTECH55+ Pin & Box Min Gap After Torsion to Failure Testing
Multiple Make & Breaks

- 100 Make and Breaks were accomplished without any galling on either the pin or box connection.

**PTECH55+ Pin After 100 M&B**

**PTECH55+ Box After 100 M&B**
Comparative Fatigue Testing

- PTECH+ Thread Form shows a considerable enhancement over API Thread Form

**Fatigue Testing**

PTECH39+ (4-7/8" x 2-11/16") Vs. NC-40 (5" x 2-9/16")

- **PTECH39+**
  - Average Cycles: 1,076,947
  - Average Bending Moment: 154,723 in-lbs

- **NC-40**
  - Average Cycles: 556,631
  - Average Bending Moment: 141,648 in-lbs
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