Solid Expandable Systems

A Journey to Perfect SES Reliability through Complex Testing

Rich DeLange – Director of OCTG
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  ISO 13679 + API RP 5-EX

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Connection Distortion

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Testing Expandable Connections
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ISO 13679
Procedures for testing casing and tubing connections

Resource Group on Expandables
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Working on a connection testing procedure specifically for expandables
ISO 13679 + API RP 5-EX

- Material
- Manufacturing Samples
- Make and Break Testing
- Connection Testing (4 levels)
- Documentation

Formats from ISO 13679

- Expansion of Samples
- Post Expansion Testing

Formats from API RP 5-EX

“The expansion test shall reproduce the conditions experienced downhole”
Pipe Body and Connection Load Diagrams
11.750 in. OD, 0.582 wall, 50 ksi pre exp, 60 ksi post exp
ISO 13679 Testing Principle

Pipe Body and Connection Load Diagrams
11.750 in. OD, 0.582 wall, 50 ksi pre exp, 60 ksi post exp

Pipe Body VME Pre - Blue Line
Pipe Body VME Post - Red Line

Pressure, psi vs. Axial Load, kips graph
ISO 13679 Testing Principle

Pipe Body and Connection Load Diagrams
11.750 in. OD, 0.582 wall, 50 ksi pre exp, 60 ksi post exp

Pipe Body VME Pre
Pipe Body Collapse Pre
ISO 13679 Testing Principle

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Pipe Body VME Pre  Pipe Body Collapse Pre  Pipe Body VME Post  Pipe Body Collapse Post
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Pipe Body and Connection Load Diagrams
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# RP-5EX Pre-Expansion Test Matrix

<table>
<thead>
<tr>
<th>Test Level</th>
<th>Sample Number</th>
<th>Sample 1</th>
<th>Sample 2</th>
<th>Sample 3</th>
<th>Sample 4</th>
<th>Sample 5</th>
<th>Sample 6</th>
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## RP-5EX Expansion Matrix

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Cone Expansion
Why is Testing Expandable Connections so Complicated?
The Variable Challenge

ISO 13679 Connection Testing Variables

Connection Dimensional Tolerances
Grade of Pipe considerations
Temperature
Gas or Fluid
Thread Compounds considerations
The Variable Challenge

ISO 13679 Connection Testing Variables

- Connection dimensional tolerances
- Grade of pipe considerations
- Temperature
- Gas or fluid
- Thread compounds considerations

RP 5-EX Additional Connection Testing Variables

- Grade of pipe / mill source
- ID Coating and wellbore fluids
- Expansion systems (mechanical, pressure, combination)
- Expansion
  - Constraints (tension or compression or some of both)
  - Fixed-free or fixed-fixed
  - Deviated hole / dogleg
  - Load cycles during expansion process
Example

2,500’ Open Hole 11-3/4 Liner

Expansion Force ~ 400,000 lbf

- 175,000 lb air weight
- Pressure to drive Cone = 1,900 psi = 226,000 lbs End Thrust / Tension behind cone

Every connection’s load change in this example is 400,000 lbs
11.75” DLX expanded FODC-OR samples

- Expanded 4 Samples simulating a 4,000’ liner set at 13,000’
  - 2 Expanded with top of string loads
  - 2 Expanded with bottom of string loads

- Critical section thicknesses were measured before and after expansion with a Coordinate Measuring Machine (CMM)
Pin Connection Section Thickness Changes

Changes in dimensions from the unexpanded condition

- Top values are from the top of liner
- Bottom values are from the bottom of liner

The expanded pins are different at the top and bottom

-12.3%  -9.9%  -9.0%
-9.3%   -7.4%  -6.8%
-9.3%   -7.4%  -10.4%
-7.0%   -7.0%   -7.0%
Box Connection Section Thickness Changes

Changes in dimensions from the unexpanded condition
  • Top values are from the top of liner
  • Bottom values are from the bottom of liner

The expanded boxes are different at the top and bottom

-12.3%
+26.7%
-8.4%
-7.2%
-17.5%
-16.1%
Testing Equipment
“The expansion test shall reproduce the conditions experienced downhole”
DLX Machine
Test Lab

North Cell

The DLX Simulator
650,000 lb$_f$ Tension
525,000 lb$_f$ Compression

Dynamic Expansion
  Fixed-Free
  Fixed-Fixed
Tension & Compression Pre-Loads (maintained during expansion stroke)

3-1/2” thru 13-5/8” pre-expanded ODs
15-foot stroke
Mechanical or Pressure Expansion
Bent Expansions
OCTG Prototype Manufacturing Line

Stations
- Handling Tables
- Horizontal Swage
- Stress Relieve
- Threading
- Inspection
- Magnetic Particle Inspection
- Surface Treatment
Prep Lab

Stations

• Inspection
• Make-Up / Break-Out
  – 3.5” thru 14”
• Welding
• Cone Insertion
• Ultrasonic Measurement
• Strain Gauging
Expansion with Bending

Constant Radius Bending Beam

- 12’ long
- Up to 8” pipe
- Any Deviation
- MOL expansion
- Fixed-Free & Fixed-Fixed
- Allows ISO 13679 testing with Load Frame after expansion
Bending Beam / Load Frame Assembly
Summary of Expandable Connection Complexities

• Expansion creates new product downhole….which new product depends on the variable set
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  o ISO 13679 now
  o API RP 5-EX very soon
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• Test samples must be accurate representations
  o Material
  o Threading process & dimensions
  o Pre & post load conditions
  o Proper constraint……fixed-fixed or fixed-free
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• VME testing required to qualify performance envelopes
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- VME testing required to qualify performance envelopes

- Major variable sets must all be tested to minimize risk
Questions